Deloitte.

Cost Reduction Monitoring Framework: Quantitative assessment report.

A Final Report for ORE Catapult

January 2015

Private and Confidential

This report has been prepared on the basis of the limitations set out in the engagement letter and the matters noted in the Important Notice From Deloitte on page 1.

Contents

Important Notice from Deloitte

This final report (the "Final Report") has been prepared by Deloitte LLP ("Deloitte") for Offshore Renewable Energy Catapult in accordance with the contract with them dated 30th July 2014 ("the Contract") and on the basis of the scope and limitations set out below.

The Final Report has been prepared solely for the purposes of Offshore Renewable Energy Catapult's use, as set out in the Contract. It should not be used for any other purpose or in any other context, and Deloitte accepts no responsibility for its use in either regard, including their use by Offshore Renewable Energy Catapult for decision making or reporting to third parties

The information contained in the Final Report has been obtained from Offshore Renewable Energy Catapult, from offshore wind developers, and third party sources that are clearly referenced in the appropriate sections of the Final Report. Deloitte has neither sought to corroborate this information nor to review its overall reasonableness. Further, any results from the analysis contained in the Final Report are reliant on the information available at the time of writing the Final Report and should not be relied upon in subsequent periods.

This Final Report and its contents do not constitute financial or other professional advice, and specific advice should be sought about your specific circumstances. In particular, the Final Report does not constitute a recommendation or endorsement by Deloitte to invest or participate in, exit, or otherwise use any of the markets or companies referred to in it. To the fullest extent possible, both Deloitte and Offshore Renewable Energy Catapult disclaim any liability arising out of the use (or non-use) of the Final Report and its contents, including any action or decision taken as a result of such use (or non-use).

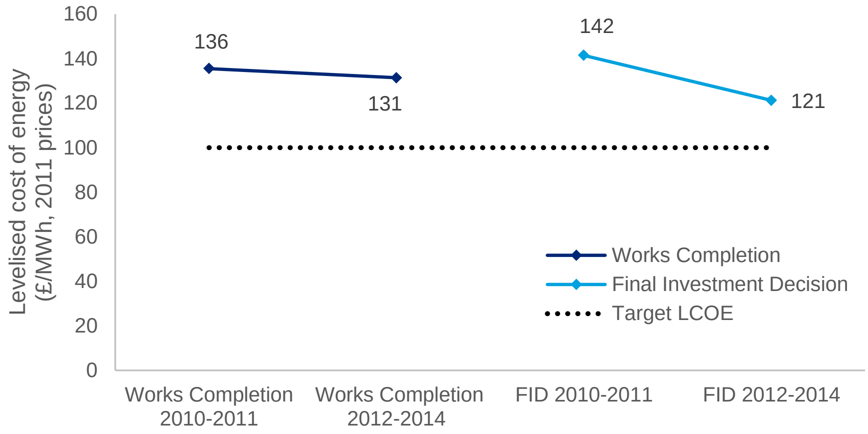
Executive Summary

Deloitte has been commissioned by Offshore Renewable Energy Catapult (ORE Catapult) to collect financial and technical information from UK offshore wind developers and calculate the industry average levelised cost of energy (LCOE[1]) for projects in the years 2010-2014.

This report is the first quantitative assessment report produced as part of this activity. The industry average LCOE reported by the developers for projects reaching Final Investment Decision (FID) and Works Completion is shown in Figure 1. A total of 16 datapoints have been collected and used in this report.

For projects reaching FID, the industry average LCOE was £142/MWh in 2010-2011, and £121/MWh in 2012-2014. For projects reaching Works Completion, the industry average LCOE was £136/MWh in 2010-2011, and £131/MWh in 2012-2014.

Figure 1: UK Offshore wind LCOE, 2010-2014



Source: UK offshore wind developers and Deloitte analysis

Through interviews with offshore wind developers, it appears that progress in reducing offshore wind costs has been made, with small ad-hoc adjustments and improvements driving gradual changes in the LCOE. Four factors have been identified by developers as key in impacting the LCOE over the four-year period:

- **Falling turbine and foundation costs**. Larger turbines, improved technology and efficiency has been driving down costs on £/MWh basis.
- **Challenging supply chain relationships**. Limited bargaining power of some developers relative to concentrated supplier markets, tends to increase costs or reduce quality. Offsetting this, increased competition among suppliers has been noted in some sectors, notably vessels.

[1] The LCOE definition should not be confused with the concept of the Strike Price as defined for the purposes of the Contract for Difference Feed-in-Tariffs as used in the context of the UK Electricity Market Reform. LCOE is an economic concept used for tracking costs of different generation technologies on a comparable basis, whereas the level of the Strike Price is the outcome of a specific set of policy decisions. As such, the underlying cost factors are only one consideration in the determination of the Strike Prices.

- **Lack of required skills and expertise.** Some developers have found it challenging at times to access the required skills and expertise for project development and/or implementation. No systematic improvement in workforce experience has been noted.
- **Significant cost of delays.** Supply chain failures (such as risk allocation through contractual arrangements) and adverse weather have knock-on effects throughout the construction phase. Developers find these risks difficult to mitigate and no dominant contractual and risk allocation strategy has been identified.

1 Background to the report

1.1 Introduction

The UK is a leading global player in offshore wind power generation with installed capacity being higher than any other country in the world.[2] This sector has developed in the UK through a series of licensing rounds coordinated by the Crown Estate, the landlord and owner of the seabed.

However, to achieve further deployment, there needs to be a significant reduction in the cost of deploying offshore wind technology. Electricity from offshore wind currently costs significantly more than from other sources of generation, such as gas fired generation or onshore wind. Current offshore wind farm projects have previously been estimated to cost around £140/MWh.[3] In 2011, the UK Government directly linked the size of the offshore wind market with cost reduction stating that costs need to fall to £100/MWh for 18GW of offshore wind capacity to be delivered by 2020.[4]

In this context, the Offshore Wind Programme Board (OWPB) has requested that The Crown Estate develops a standard industry framework for monitoring and reporting industry's progress on reducing its levelised costs.

This document is the first quantitative assessment report on the LCOE of offshore wind generators in the UK. It has been based on a quantitative tracking approach of offshore wind projects reaching specific milestones (FID and Works Completion) over the period 2010 to 2014.

In parallel with this quantitative assessment, a report tracking industry progress against a framework of pre-agreed qualitative milestones to 2020 is expected to be published by ORE Catapult.

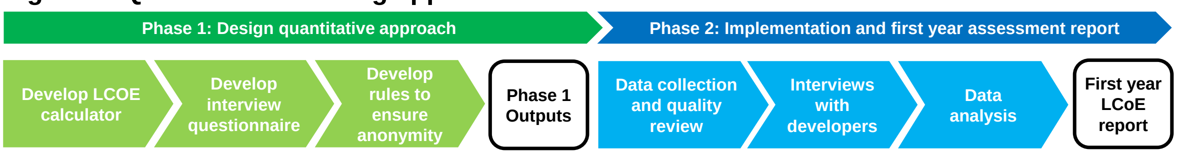
1.2 Approach and methodology

This section outlines the approach and methodology used in designing and implementing the quantitative tracking framework for the offshore wind LCOE.

1.2.1 Quantitative workstream overview

Figure 2 summarises the overall approach to designing and implementing the quantitative assessment of offshore wind LCOE, leading to the results included in this report.

Figure 2: Quantitative tracking approach



2 'Offshore wind operational report' 2013, The Crown Estate, page 3

3 'Offshore wind cost reduction – Pathways study' May 2012, The Crown Estate

4 'UK Renewable Energy Roadmap' 2011, Department of Energy and Climate Change

The design phase of the quantitative approach was carried out during Summer 2014 and involved three key outputs:

- **LCOE calculator.** Deloitte worked with the OWPB Steering Group to develop a template spreadsheet which, when populated with technical and financial data for an offshore wind project, would calculate the LCOE for that project, at a specific financial milestone as defined by the user. The spreadsheet was circulated to offshore wind developers, who then completed a separate version for each offshore wind project and each financial milestone, within a reporting period.

- **Interview questionnaire.** Deloitte developed a set of questions that enabled the developers to assess, from a qualitative and backward-looking perspective, the factors driving the LCOE of their individual projects.

- **Anonymity rules.** A set of anonymity rules was designed to ensure that developers were able to share their confidential information with Deloitte, and to enable Deloitte to aggregate and anonymise the information for the purposes of this report.

In addition, ORE Catapult supported the project by engaging with all the developers whose projects reached FID or Works Completion in the reporting period, to maximise the number of projects included in the assessment and therefore provide the most representative assessment of the actual LCOE in those years.

The implementation phase of the quantitative approach was carried out between September 2014 and early 2015. During this phase, Deloitte collected the results from the LCOE calculators from individual developers (a screenshot of a blank results template is shown in Appendix B), and following the anonymity rules, calculated the industry average LCOE.

Deloitte also carried out a review of the LCOE calculators, typically directly on developers' premises, to ensure that these have been completed consistently across developers.[5] In a number of cases this review has led to an adjustment to the LCOE Calculator to ensure consistency between the LCOE results.

1.2.2 Challenges

There were a number of key challenges identified as part of developing and implementing a quantitative tracking approach for offshore wind LCOE information. These challenges included collecting data on a consistent and comparable basis, preserving anonymity and confidentiality of individual developers, and understanding the complex drivers of LCOE changes.

[5] Deloitte has been able to review the vast majority of the completed LCOE calculators, but two of them have not been reviewed, due to time constraints. For the avoidance of doubt, the data provided by developers in the implementation phase has been reviewed for consistency, existence of outliers and overall 'sense', in line with the data quality review process agreed with ORE Catapult. However, Deloitte has not audited the developers' systems that were used to produce the data and is not issuing an audit opinion

Consistency and comparability of financial data

The LCOE data collected from individual developers needed to be consistently reported, for the industry average to be meaningful. In particular, the information about individual projects needed to use the same project boundaries, price base and avoid duplication of costs. To ensure such consistency, the following principles were applied:

- **Limited flexibility of the LCOE calculator.** The calculator was designed in a way that limited the flexibility with which developers could enter the information, to minimise the potential risk of errors. In addition, a clear definition of LCOE was used (see Figure 3).
- **Checklist.** The LCOE calculator had an in-built checklist that flagged the most likely potential issues with the input data, such that developers could review and address them appropriately.
- **Review by Deloitte.** Whilst Deloitte did not receive the actual LCOE calculators for the majority of the projects, review sessions were arranged with individual developers to carry out a review of the LCOE calculator directly on developers' premises.

Figure 3: LCOE Definition

In this report the offshore wind LCOE is defined as "the ratio of the net present value of total capital and operating costs of a generic plant to the net present value of the net electricity generated by that plant over its operating life".[6]

- Generation costs include all capital, operating, and decommissioning costs incurred by the developer over the lifetime of the project, including transmission costs.
- Developers were requested to input their own project-specific Weighted Average Cost of Capital (WACC), which was then used in the discounting when calculating the project LCOE. However, a default value[7] has been provided in case a developer chooses not to disclose their project-specific WACC.

LCOE is calculated on a pre-tax basis and expressed in real 2011 prices for all years.[8]

Anonymity and confidentiality for individual developers

A set of rules has been applied in selecting the minimum number of projects used for calculating the industry average LCOE, so as to preserve anonymity of individual projects and developers' financial data. This was particularly important given the limited number of projects reaching the relevant financial milestones during 2010-2014.

---

6 DECC (2012) Electricity Generation Costs. October 2012.

7 Baseline value of 9.24% (pre-tax, real), based on The Crown Estate (2012) Offshore Wind Cost Reduction Pathways Study

8 The LCOE definition should not be confused with the concept of the Strike Price as defined for the purposes of the Contract for Difference Feed-in-Tariffs as used in the context of the UK Electricity Market Reform. LCOE is an economic concept used for tracking costs of different generation technologies on a comparable basis, whereas the level of the Strike Price is the outcome of a specific set of policy decisions. As such, the underlying cost factors are only one consideration in the determination of the Strike Prices.

The rules have been designed to address the key concerns around the confidential information that individual developers have, or may be able to gain access to. The rules also addressed the need to recognise the relative size of individual projects, and the potential ability of individual developers to "back-calculate" third party confidential information from their own information and the industry average figure.

The rules also cover the way that information can be aggregated across multiple years so as to preserve individual project anonymity, particularly given that the number of datapoints available for this report has been limited in some years. The detailed set of rules is presented in Appendix A.

Understanding the drivers of LCOE changes

To disentangle the drivers of offshore wind LCOE, a narrative interview was carried out with individual developers to understand the key qualitative factors behind the cost of energy of offshore wind.[9] During these interviews, a number of project-specific issues were identified, as well as a number of themes that were common across a number of developers.

In this report, it has been important to maintain the confidentiality of the information provided by developers. The qualitative drivers of LCOE are therefore commented on only where more than one developer has highlighted them, and then only on an anonymous basis. The drivers of the LCOE are described further in Section 3.

1.3 Projects covered in this study

The complete list of the projects covered by the first quantitative assessment report on the LCOE is shown in Table 1 and Table 2. Only projects that reached the relevant financial milestone (FID or Works Completion) have been included.

Table 1: List of offshore wind projects: FID

Project name	Capacity (MW)
Dudgeon	402
Gwynt y Mor	576
Humber Gateway	219
Teesside	62
West of Duddon Sands	388.8
Westermost Rough	210

9 As with the LCOE calculator reviews, the narrative interviews have been carried out with the vast majority of the developers.

Table 2: List of offshore wind projects: Works Completion

Project name	Capacity (MW)
Greater Gabbard	509
Gunfleet Sands 1&2	172.8
London Array 1	630
Ormonde	150
Robin Rigg A&B	180
Sheringham Shoal	316.8
Teesside	62
Thanet	300
Walney 1&2	367.2
West of Duddon Sands	388.8

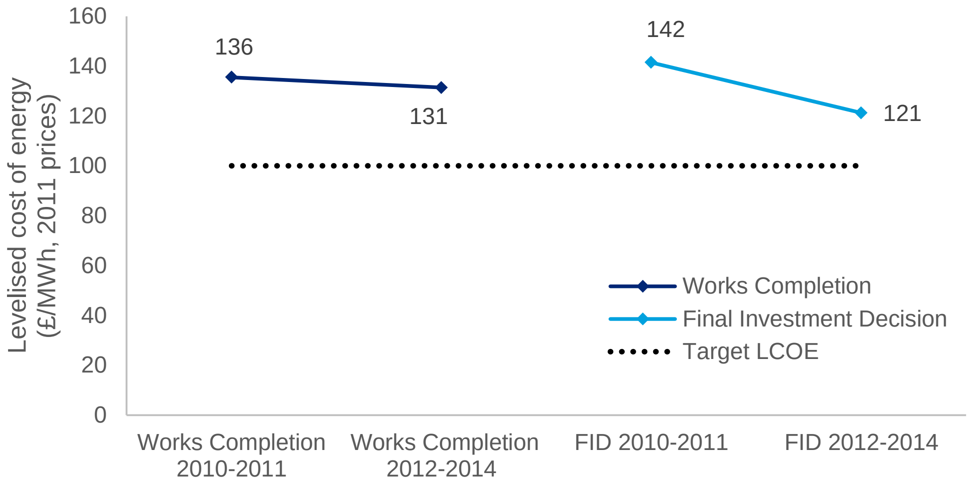
2 CRMF Quantitative Assessment Results

2.1 Offshore wind LCOE 2010-2014

The main results from the quantitative assessment of the LCOE are shown in Figure 4. The two blue lines show the LCOE for projects reaching a specific financial milestone, FID and Works Completion.

For projects reaching FID, the industry average LCOE was £142/MWh in 2010-2011, and £121/MWh in 2012-2014. For projects reaching Works Completion, the industry average LCOE was £136/MWh in 2010-2011, and £131/MWh in 2012-2014. All results are presented in 2011 prices, for comparability with the previous estimate of £140/MWh, by the Crown Estate.[10]

Figure 4: Summary LCOE results[11]



Source: Offshore wind developers data and Deloitte calculations

The average offshore wind industry LCOE reported by the developers has been below £140/MWh during 2010-2014. There also appears to be a downward trend in the LCOE both for projects reaching Work Completion and for projects reaching FID. However, given the limited number of datapoints, this result could be driven by a single project outlier.

---

[10] 'Offshore wind cost reduction – Pathways study' May 2012, The Crown Estate

[11] The results for the Works Completion and FID are staggered in Figure 4, such that projects reaching FID in 2010-2011 are shown on the same x-axis level as projects reaching Works Completion in 2012-2014.

This is not intended to suggest that all projects that reach FID in 2010-2011 would also complete in 2012-2014 (some projects take longer to develop), the figure intends to indicate that these are most closely comparable in terms of the overall development of the LCOE over time.

On balance, the "oldest" projects (on the left hand side of Figure 4) are those that reached completion in 2010-2011, while the "newest" ones (on the right hand side of Figure 4) are those that reached FID in 2012-2014.

It appears that developers have most recently been willing to reach FID only for projects that have a materially lower LCOE than in 2010-2011. At the same time, the outturn LCOE for projects reaching Work Completion has been declining at a lower rate. This suggests that the forecasts used by developers for FID may have been more optimistic than the outturn costs, although again this observation could be driven by the limited number of observations.

To determine whether the results for 2010-2014 are indeed consistent with a long-term reduction in the LCOE, these results will require future observations to confirm this trend.

2.2 Methodology considerations

Due to the limited number of datapoints available for the period 2010-2014, the results could not be reported for each individual year in that period. Instead, they have been combined into two groups of years, with 2010-2011 presented as the first datapoint, and 2012-2014 as the second datapoint.

In addition, there were insufficient datapoints for projects reaching FID in the 2012-2014 period, therefore the anonymity rule 4b has been applied (see Appendix A.4).

ORE Catapult expects this to be the case in the next reporting period (2015), and consideration needs to be given to whether yearly overlaps will then be required. Depending on the number of new projects reaching FID and/or Works Completion during 2015, such reporting may need to be carried out on an annual or bi-annual basis. This remains the decision of ORE Catapult.

3 Qualitative drivers of LCOE

This section presents an overview of the key external factors that have influenced the offshore wind LCOE over the past few years. The information has been based on an analysis of quantitative data reported by developers, as well as subsequent interviews with those developers[12] and qualitative information obtained through the interviews and captured in the questionnaire.[13]

At a high level, the LCOE is driven by three key factors: the direct costs, the discount rate and the volume of electricity generated. In addition, the timings of the costs and electricity generated also have an impact on the LCOE. For example, projects that avoid delays benefit from electricity being generated earlier. Both of these factors contribute to a reduction in the overall LCOE.

In this section, the drivers of LCOE are categorised into tangible and intangible factors. Tangible factors typically only affect the direct costs of the offshore wind farm, with examples ranging from the capex and labour costs to exchange rates. Intangible factors such as contractual arrangements may impact either the direct costs, e.g. through increasing the costs if there is an additional piece of equipment that needs to be purchased for the project, or the volume of the electricity generated (on a discounted basis), e.g. as a result of unexpected delays to the project.[14]

3.1 Tangible factors

This section describes the tangible factors that impact the LCOE of offshore wind, focusing particularly on the physical components and conditions of a wind farm, as well as on the relevant input costs. It outlines those factors that that have been reported by developers as providing significant cost and risk impacts.

3.1.1 Physical characteristics of offshore wind development

Turbines and foundations

Turbines and foundations have been generally reported as the greatest factor in project costs. This is as expected given their large share in the total capex.

12 To ensure that all information obtained from individual developers remains confidential, the factors in Section 3 include those that have been mentioned by more than one developer as being material for the development in the LCOE in the reporting period. None of the factors described in Section 3 can be attributed to a single developer or a single project.

13 The qualitative questionnaire used for the assessment of the external drivers of LCOE is provided in Appendix B. The questions focus on a retrospective assessment of the LCOE drivers, and are intended to complement (but not duplicate) the forward-looking analysis carried out in a separate qualitative report commissioned by ORE Catapult.

14 During the interview process, developers were asked to comment on how they perceive their own costs relative to the industry standard. Most developers were unable to provide a clear comparison, citing lack of published industry-wide information (an issue that this study aims to address). A number of developers based their perception of their relative costs on the economies of scale achieved, as well as their own prior experience in the industry.

- Turbine size is a major driver of LCOE: as turbine size increases, there are direct economies of scale as turbines become more efficient, as well as an indirect reduction in costs through fewer foundations per MW of capacity being required.

- The choice of foundation technologies (jackets or monopiles) and the size appropriate to the site conditions is also a significant driver of overall costs. However, developers have not identified significant changes in the foundations technologies that would have driven a material change in the LCOE in the recent past.

Given the significance of both turbine and foundation costs, these were most often reported as factors in which new technologies were implemented by individual developers, in a bid to drive down costs.

Developers expect these costs to be reduced on a £/MW basis in the future, due to technological improvements expected in the market (leading to improved efficiencies and high capacity factors), increased turbine size and a greater level of competition in supply.

Site conditions and location

Site-specific factors, such as the distance from construction and O&M ports, water depth, wind speed, sea bed conditions and tidal range all contribute to the overall capital cost of projects.

- **Distance to shore.** Most developers reported that they expected that these conditions were expected to provide greater challenges in construction, and thus greater installation costs, the further offshore the site was, and the more adverse the conditions, i.e. challenging seabed conditions, deeper water, greater tidal range.

- **Wind speed.** Developers have also indicated that there was a trade-off in the wind speeds at a particular site: on the one hand, it tended to make the construction phase more challenging and potentially more costly, but on the other hand it increased the load factor of the wind farm and thus the volume of electricity generated.

- **Weather.** Adverse weather conditions (above those expected) were reported to cause project delays by a number of developers. The severity of these delays was often linked to the above locational factors, particularly sea bed conditions and tidal effects. This risk was largely mitigated through weather forecasting using historical data.

- **Ports.** Availability of suitable ports is also an important driver of costs, through a number of channels: the requirement to upgrade / develop ports, vessel transport time and the ability to use the ports at required times, e.g. not being restricted by the tidal range. Changes to ports and waterside infrastructure may in some situations have the potential to reduce construction delays by removing bottlenecks, although this is highly location-specific.

Relationships between capex, opex, and physical site conditions

Based on the technical and financial information collected from developers, a statistical analysis was carried out in order to assess the statistical relationships between the costs and physical characteristics of sites, notably distance to the shore, water depth and average wind speeds.

- **Capex and opex.** There is a negative correlation between capex and opex for individual offshore wind farms: for projects with a higher capex (£/MW), the ongoing opex (£/MW/year) tends to be lower and vice versa. For an additional £1m of capex costs, the opex is reduced by around £43,000 per year.

- **Water depth and wind speed.** There is a positive correlation between the water depth at the site and the average wind speed, with additional 10m of water depth associated on average with additional 0.4m/s wind speed. This confirms the expectation that there is a trade-off between the greater challenges involved in constructing a wind farm in deeper waters, and the higher wind speeds.

Manufacturing and installation costs

Installation costs, particularly for cabling, were noted as a significant cost component by most developers. Unexpected costs, however, were often not attributed directly to the installation itself, but to indirect factors, such as delayed delivery by suppliers, poor supply quality, damage to components during installation and inadequate transport support.

Where direct costs factors were identified as key drivers of LCOE, these were largely attributed to issues in the design phase, the use of unconventional methods and/or technologies in the installation of certain components, and/or the installation of new technologies.

3.1.2 Input costs

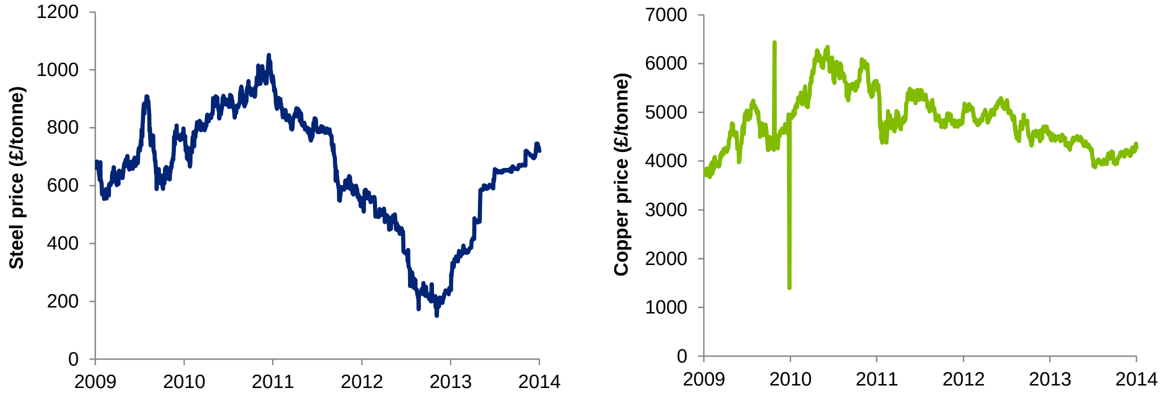
Raw materials and fuel

Most developers reported that they hedge against the price of materials (particularly steel, but also copper) to reduce their exposure to price fluctuations in the market.

However, in cases where developers only hedged prices, but not volume, some projects remained exposed to a risk of increased material costs due to further unexpected material requirements.

Whilst most developers noted that they were hedged against fluctuations in fuel prices, this was generally not seen as a significant factor, relative to other O&M costs. Historical fluctuations in the price of steel and copper are shown in Figure 5.

Figure 5: Historical steel and copper price movements



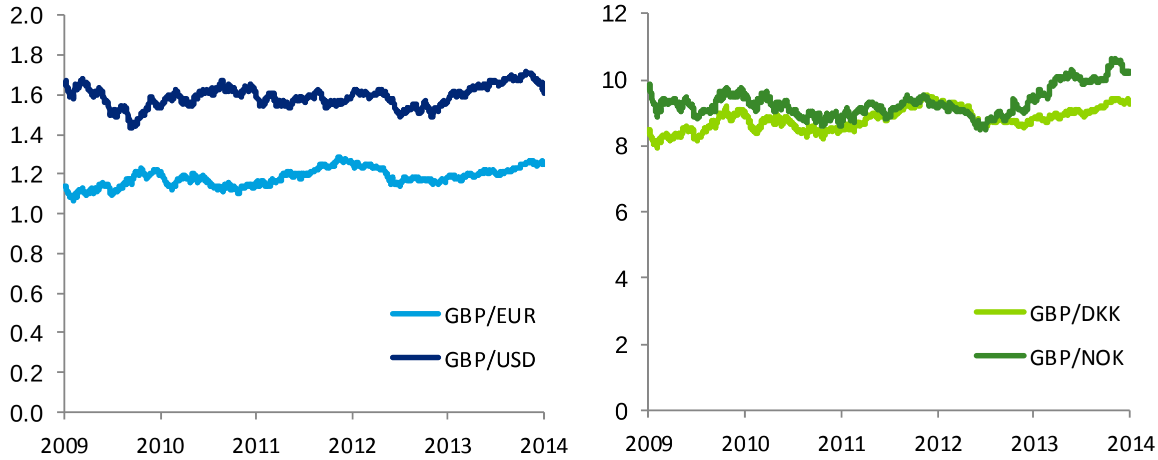
Source: Bloomberg

Currency and foreign exchange risk

Developers typically hedged their exposure to the fluctuations in the currencies relevant for their project, often centrally through their organisation.

Historical fluctuations in the exchange rate of pound sterling are shown in 6.

Figure 6: Historical foreign exchange rate movements



Source: Oanda, website accessed 10 September 2014

3.2 Intangible factors

3.2.1 Supply relationships

Market competition

Developers generally reported that competition within the supply chain was limited, and this led to higher costs of supply. This was particularly noted in the supply and installation of turbines, foundations and cabling.

Some developers have also indicated improvements in competition in specific segments of the supply chain over the past five years, although they differed in their assessment of the materiality and importance of more competition. Vessel availability has been cited most frequently as an example of increased competition in the recent years.

Developers indicated that this lack of competition could be driven by a number of factors.

- **Lack of competitors**. Lack of competition among potential suppliers was cited by a number of developers, who indicated that either only a limited number of suppliers (often one or two) were available, or that they were not UK-based. Developers suggested that a greater degree of competition is expected to drive down costs and help to reduce transportation and logistics costs.

- **Industry immaturity**. Any given project typically relies on bespoke designs, which limits the ability for the industry to compete, as compared to an industry with a greater degree of standardisation.

- **Lower cost pressure on suppliers.** A number of developers have indicated that they considered themselves facing a greater degree of cost pressure relative to their suppliers, particularly given the publicity of the offshore wind sector.

This lack of competition has led to increased costs in a number a ways, including through higher input costs (as suppliers have a greater bargaining power), lower quality, and less favourable contractual terms from the perspective of the developers. These are considered in further detail below.

Contractual agreements

Given the limited competition in the supply market, a number of developers (but not all of them) reported they found it difficult to negotiate favourable contract terms, as they had limited bargaining power. As a result, the risk of any supply failures or delays was often borne largely by the developers, rather than by the suppliers.

Many developers reported that, if the supply chain had been more competitive (particularly for turbines and cable installation), they would have expected to bear less of the risk of any supply issues. This is because contractors would have more of an incentive to provide high-quality services in the required timeframe. This would have translated into lower additional costs and higher revenues (above those expected), due to a reduction in unexpected supply failures and any resulting delays to the construction period.

Some developers have commented on the fact that a way to mitigate this risk would be for the developer to exercise a greater degree of control over the project – for example by taking some of the work in house, or by adjusting the contractual approach. However, no single dominant contractual strategy has emerged yet as the preferred approach.

Industry experience

Supply chain constraints and the relative immaturity of the offshore wind industry were noted by a number of developers as driving competition for a scarce labour force with the required level of technical skills and qualifications.

This lack of qualified personnel has impact costs in a number of ways.

- **Higher labour costs**. Whilst most developers did not report that wages in the industry have risen significantly for the period 2010-2014, labour costs are perceived to be higher than what is expected for the level of industry expertise and service received; and

- **Lower productivity**. Lack of industry expertise has been noted by most developers as a significant cost component, due to poor performance during the construction phase. This also has an impact on the O&M costs through sub-optimal maintenance and operation.

Most developers reported that they expected this to improve as the industry matured and the workforce developed the necessary technical skills. Some developers are mitigating this risk by supplier monitoring, taking some of their O&M activity in-house and by setting up employee training programmes.

3.2.2 Other factors

OFTO cost recovery

Most developers did not provide detailed information regarding the recovery rate on the OFTO transmission asset. Some, however, did report slight under-recovery, due to a small number of disallowed costs. These were not deemed to be significant.

Decommissioning costs

Whilst developers have put in place plans for plant decommissioning in line with the DECC requirements, little significance has been attributed to these costs.

Coordination and Cost of delays

Any delays caused through the supply chain, or due to adverse weather conditions (both discussed in Section 3.1.1) were reported as having indirect effects on the construction process and its associated timelines. This was particularly significant for the availability of vessels for various stages of the installation process, with developers reporting that it was often difficult to secure vessels once a given timeline was missed, and this then led to further construction delays and additional costs.

As a consequence of such delays, most developers who had reached Works Completion reported that they were faced with a trade-off between foregoing revenues by missing the expected project completion date, or incurring additional costs during the construction phase in order to keep to the original completion date.

3.3 Concluding remarks

Developers identified a number of factors that have influenced the changes in the LCOE over the period 2010-2014, including in the tangible cost elements, as well as supply relationships and other intangible factors.

Some developers indicated that they were able to reduce specific cost elements, but only in relation to very specific components of the overall costs, and such reductions are unlikely to be replicable across the industry.

Some developers have also faced unexpected cost increases, typically due to project-specific issues. Avoidance of such cost increases in the future could further reduce the outturn LCOE.

However, the overall conclusion has been that progress in reducing offshore wind costs has been tentative, with small ad-hoc adjustments and improvements driving relatively modest changes in the LCOE. Developers have not identified a major ‘game changer’ in the industry that has impacted the overall LCOE of offshore wind.

Appendix A Technical assumptions and methodology

This appendix provides additional detail on the technical assumptions and methodology used in the quantitative tracking process.

A.1 Data comparability

The offshore wind LCOE has been calculated from individual developers' financial and project data. To ensure consistency in reporting across developers, and across projects, developers were required to provide the financial data in a consistent manner, as follows:

Boundaries. The LCOE Calculator provided to developers was structured in a way so as to avoid double-counting individual financial cost elements, or to avoid missing certain costs. Furthermore, a number of built-in checks were included to assess whether any of the cost data provided differed significantly from a pre-determined range.

Project financial milestones. The offshore wind LCOE results have been calculated for each project, at one or two specific milestones (depending on whether one or both milestones fall within the reporting period of 2010 to 2014). The definitions of these two milestones, for the purposes of the CRMF quantitative workstream, are set out below.

- Final Investment Decision **(**FID) is defined as the point of a project life cycle at which all consents, agreements and contracts that are required in order to commence project construction have been signed (or are at or near execution form) and there is a firm commitment by equity holders, and in the case of debt finance, debt funders to provide or mobilise funding to cover the majority of construction costs.[15]

- Works Completion is defined as the point at which the full capacity of the wind turbines is energised / operational.[16] This typically takes place a few months after the wind farm becomes operational and it may precede a formal handover of the project.

A.2 Financial data conventions

Developers were given a degree of flexibility in the way some of the key financial data was provided. This section presents the key methodology assumptions underlying the way the financial data was expected to be provided by the developers.

- **Prices.** Developers had the flexibility to input their financial data in real or nominal prices, as they considered appropriate, given their internal reporting standards. However, for the calculation of the LCOE, all financial data was converted into real 2011 prices, using UK CPI data. The inflation rate used in the LCOE Calculator is based on the average year

[15] BVG associates (2012) Offshore wind cost reduction pathways. Technology work stream. May 2012. http://www.thecrownestate.co.uk/media/5643/ei-bvg-owcrp-technology-workstream.pdf

[16] The Crown Estate, Offshore wind - Simple Levelised Cost of Energy Model, 'Contents', July 2013. EC Harris (2012) Offshore Wind Cost Reduction Pathways. Supply Chain Work Stream. May 2012.

consumer price inflation (as opposed to, for example, end-of-year inflation). This is based on the assumption that all costs (capex, opex and decommissioning) are uniformly distributed within each individual year.[17]

- **Currency.** All financial data provided by developers was provided in pounds sterling. In addition, developers were requested to provide information on the proportion of costs denominated in other currencies, such as euros or Danish krone. This was used to assess the potential exposure of developers to currency fluctuations (although it was noted that much of this risk is expected to have been hedged by developers), but not for calculating the LCOE. This information has only been only for the purposes of the narrative assessment of the potential exposure of developers to currency fluctuations.

- **Financial / calendar years.** Financial data for individual projects was collected on an annual basis. However, developers had the flexibility to provide their costs in financial or calendar years. For comparability when converting the values into real 2011 prices, it is assumed that any capital expenditure was split uniformly over the year (so that fractions of financial data from individual years can be converted into the 2011 prices where necessary).

A.3 Risk reporting

Individual developers were likely to assess risk differently and reflect this view in different assumptions when preparing their own internal financial models. It was expected that the majority of the risk inherent in offshore wind investment decisions will be reflected by the developers in the combination of three elements: the contingency, the energy yield and the cost of capital (or 'hurdle rate').

For comparability across projects and over time, the LCOE Calculator uses the following approach:

- **Contingency.** For projects at FID, developers have been requested to report the contingency they attribute to the project as a separate element. For projects at Works Completion, it is assumed that there is no additional contingency required (as the project has been completed).

- **Energy yield.** Developers have been requested to report their estimated energy yields using a standardised load factor at P50, i.e. the energy yield that is expected to be exceeded with a probability of 50%.

- **WACC.** Developers have been requested to report the WACC they used in their investment assessment (at FID or at Works Completion as appropriate). If no WACC is provided, the LCOE calculator uses a default WACC value of 9.24% (pre-tax, real).[18]

[17] This is a modelling assumption on when costs are incurred by individual projects, and it represents the best view based on collecting cost data on an annual basis.

[18] Baseline WACC figure from The Crown Estate (2012) Offshore Wind Cost Reduction Pathways Study.

A.4 Anonymity rules

Four main rules needed to be followed in order to preserve the anonymity of individual projects. The rules have been designed to address the key concerns around the current and past ownership of individual projects (which determines the information that individual developers have, or may be able to gain access to), and the relative size of individual projects. These rules are set out below.

1. **Data confidentiality.** No developer will receive data or sensitive information from another developer either directly or through an intermediary. This will be ensured through entering into appropriate NDAs between the consultant and the developers.

2. **Reporting the project list.** This report contains only publicly available information about the individual projects. This means that the full list of projects should be included, regardless of whether or not these have been included in the actual LCOE reported.

3. **No backward engineering.** It should be impossible for any developer (or an external party) to backward-engineer an individual developer's confidential information from the combination of their own information and the information contained in the industry average LCOE that is published. There are three aspects to this rule, all of which need to be simultaneously satisfied.

    a. **Three-project rule.** The industry average LCOE figure (in £/MWh) will need to be composed of at least three individual projects, with no ownership overlap between them. This is the minimum number of projects that ensures that no individual developer can backward engineer another developer's LCOE from the combination of their own information and the published LCOE figure.

    b. **Ownership history.** It is necessary to verify the current *as well as past* ownership of each individual project, to develop an understanding of which projects' financial information individual developers currently have access to, or may have previously had access to. Only projects for which there is no current or historical ownership overlap can be counted as individual projects towards the 'three-project rule'.

    c. **Relative size of projects.** To maintain individual developer confidentiality, the 'three-project rule' as set out above, is only sufficient if the capacity of individual projects is broadly similar. If there are significant outliers (either one very large project or one very small project) in the industry average, then it is "almost possible" for some of the developers to backward-engineer another developer's LCOE. As a rule of thumb, the total contribution of any combination of two projects in the industry average should not be greater than 80%.

4. **Enlarging the dataset.** To ensure that the minimum number of projects is achieved for each datapoint that is reported in the final report, it may be necessary to enlarge the dataset. This could be done in two ways:

    a. **Combining years together.** This will involve identifying combinations of consecutive years that ensures that in each group of years, there is a sufficient number of projects owned by different developers to ensure individual project confidentiality (through the 'No backward engineering' rule set out above).

b. **Adding datapoints from earlier years.** In some cases, it may be necessary to expand the set of projects used to calculate the industry average LCOE by adding (in reverse chronological order) projects from earlier years, until the required number of projects is reached, and such that the ‘No backward engineering’ rule is satisfied. The weight given to projects from earlier years will be 50% of that given to the in-year projects.

Appendix B Template for LCOE results

LCOE calculator Results: [Project name] at Works Completion

Export results to PDF

LCOE Calculator results

Category	**Unit**	**Result**
Project name	-	[Project name]
Project milestone	-	Works Completion
Project milestone reached	year	
Project milestone reached	month	
Distance to construction port	km	
Distance to O&M port	km	
Water depth, average for the site	meters	
Average wind speed at the site	m/s	
Capex	£/MW	
Opex	£/MW/year	
Share of capex in non-£ currencies	%	
Share of opex in non-£ currencies	%	
Project capacity	MW	
Project average annual generation	MWh/year	
LCOE	£/MWh (2011 prices)	
Developer Comments	-	[Please enter any qualitative comments here]

Source: LCOE Calculator

Appendix C Developer interview questionnaire

This questionnaire focuses on the qualitative factors that have been material for the quantitative assessment of the offshore wind LCOE. Developers were asked to provide narrative information that sheds additional light on the level of LCOE, as well as factors that have resulted in changes in the LCOE produced by offshore wind farms in the UK in recent years.

C.1 Open-ended questions

1. Factors impacting costs
    a. What do you consider to be the most significant cost factors in offshore wind developments (e.g. specific capex components, technology changes, supply chain factors)?
    b. What site-specific issues or challenges do you consider had specific impacts on your project costs that would not have affected other developers?
    c. How have these factors evolved since 2010?
2. Risks
    a. What do you consider to be the most significant risk attached to your project and how did this impact your costs (e.g. through mitigation)?
    b. Have these risks and the associated costs changed between FID date and Works Completion date?*[19]

C.2 Detailed questions

3. Physical and technical challenges
    a. How has the distance of your project from the construction port and/or O&M port, turbine size, and average wind speed, water depth or any other technical challenges specific to the site impacted the overall project costs?
    b. How much of an impact do you think the duration of the construction period had on the project costs?*
    c. Have you adopted any new technologies in your project? If so, how much of an impact did this have on the project costs?
4. Capex and opex factors
    a. Do you consider your capex or opex was higher or lower relative to the industry standard? If so, why?
    b. Which of the cost items have seen the largest increase and/or decrease over the past few years?
        i. Capex: turbine, support structure, services;
        ii. Opex: O&M, insurance, transmission charges
    c. Do you consider any of the following to be major factors behind the capex or opex costs of your specific project:
        i. commodity prices, such as steel and copper;

[19] Questions marked with an asterisk (*) are only relevant for developers whose particular project reached both FID and Works Completion within the observation period.

   ii. transportation infrastructure and logistics, for example vessels and helicopters supporting installation or O&M activities and harbour availability;
   iii. fuel prices, in particular diesel;
   iv. labour costs, workforce availability and qualifications (for example, installation or O&M);
   v. uncertainties in costs that would require higher capex or opex contingency;
   vi. competition in the supply chain;
   vii. delivery by suppliers (e.g. delays to construction);
   viii. foreign currency exchange rate movements (please consider your exposure to different currencies, their fluctuation and any hedging strategies employed).

5. OFTO
   a. Please elaborate on the expected recovery rate on the OFTO transmission asset.
   b. What has driven the over- / under-recovery of OFTO transmission asset costs?
6. Decommissioning
   a. Have you considered decommissioning costs to be a significant factor in the total costs? If so, what measures have you undertaken to reduce the level of risk associated with decommissioning?
   b. Have you or DECC identified any specific issues related to decommissioning when developing the decommissioning plan?
7. Financing
   a. How do you consider your internal hurdle rate compares to the rest of the industry? How does it compare to the default assumption in the model?
   b. What do you consider to be the main drivers behind the difference between your internal hurdle rate and the default assumption? In particular, have access to capital markets, cost of debt, cost of equity, gearing of your project had a material effect on any divergence?
   c. Where such considerations have had an impact, what do you understand to be the factors behind these? Are they specific to the project or do they reflect wider market conditions?

C.3 Closing questions

8. Other factors
   a. Are there any other factors that we have not explored above that you consider important in the overall costs of the project?
   b. Could you please provide any additional comments that you believe would provide useful background to the narrative underpinning the quantitative assessment of the LCOE?
9. Model and process feedback
   a. Do you have any comments on the LCOE Calculator and the associated documentation, such that these could be improved in the future?
   b. Do you have any comments on the CRMF quantitative workstream implementation process, and any suggestions for future improvements?