

Cost Reduction Monitoring Framework

Quantitative Assessment Report

19 December 2016

Glossary

CAPEX	Capital expenditure	CfD	Contract for Difference
CPI	Consumer Price Inflation	CRMF	Cost Reduction Monitoring Framework
DBEIS	Department for Business, Energy & Industrial Strategy	DECC	Department for Energy and Climate Change
DEFRA	Department for Environment, Food & Rural Affairs	FID	Final Investment Decision
FIDeR	Final Investment Decision Enabling for Renewables	KPMG	KPMG UK LLP
LCOE	Levelised Cost of Energy	MWh	Megawatt hour
OFTO	Offshore Transmission Owner	ONS	Office of National Statistics
OPEX	Operational expenditure	ORE Catapult	Offshore Renewable Energy Catapult
RO	Renewables Obligation	RSPB	Royal Society for the Protection of Birds
TNUoS	Transmission Network Use of System		

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1 Executive Summary

The results of the 2015-16 CRMF Quantitative Assessment show excellent progress with the FID project sample showing that the Industry Target of £100/MWh has been surpassed 4 years ahead of schedule.

1.1 Purpose of the Cost Reduction Monitoring Framework

KPMG has been appointed by the Offshore Renewable Energy Catapult (ORE Catapult) to undertake the 2015-16 Cost Reduction Monitoring Framework (CRMF) Quantitative Assessment providing analysis of the industry average Levelised Cost of Energy (LCOE) for projects taking a Final Investment Decision (FID) or reaching Works Completion in 2015-16 and identifying industry wide trends in the technical, regulatory and financial environment driving cost reductions in offshore wind.

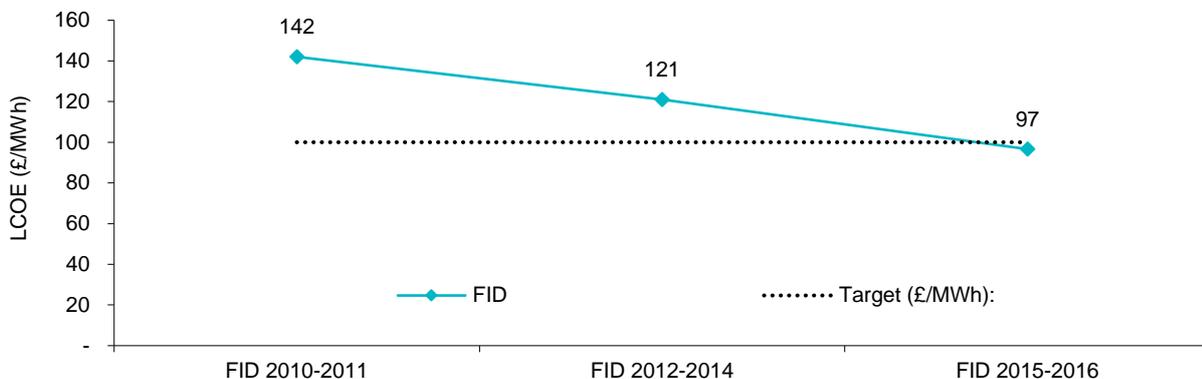
This report is the second CRMF Quantitative Assessment and builds upon the 2010-2014 study published in January 2015¹ which assessed the progress of projects taking FID or reaching Works Completion in the periods 2010-11 and 2012-14.

1.2 Key Findings of the 2015-2016 Quantitative Assessment

Following the methodology as originally set by the 2010-2014 study, projects were split into two samples: 1) projects that took FID between December 2014 and the commencement of the study in 2016 (8 projects); and 2) projects that reached Works Completion in 2015 plus an additional project included in the 2012-14 study to preserve the anonymity of respondents (4 projects).

For projects reaching FID in 2015-16, the industry average LCOE was £97/MWh, down from £121/MWh, the LCOE reported for projects reaching FID in 2012-14 (2011 real)².

Figure 1: FID Sample industry average LCOE



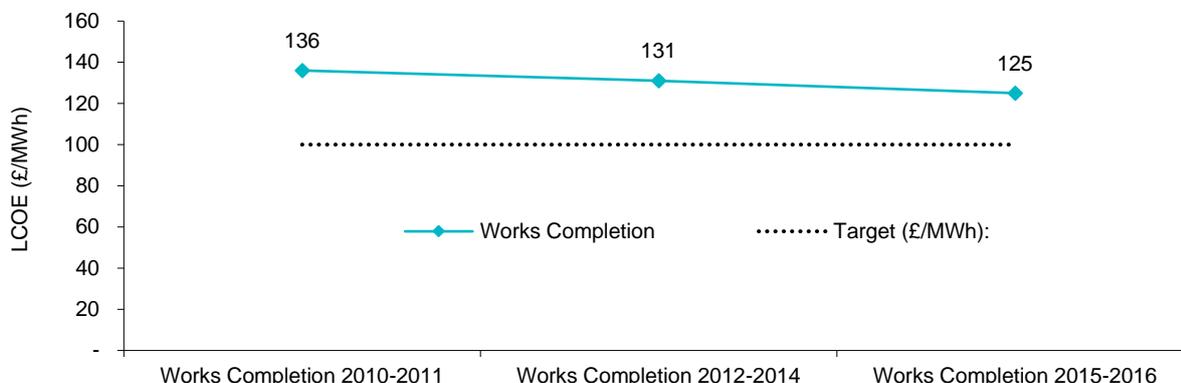
Source: KPMG analysis, Cost Reduction Monitoring Framework: Quantitative assessment report – January 2015.

¹ <https://ore.catapult.org.uk/wp-content/uploads/2016/05/CRMF-Quantitative-Assessment-report.pdf>

² All prices in this report are in 2011 real prices, unless otherwise specified.

For projects reaching Works Completion in 2015-16, the industry average LCOE was £125/MWh down from £131/MWh, the LCOE reported for projects reaching FID in 2012-14.

Figure 2: Works Completion Sample industry average LCOE



Source: KPMG analysis, Cost Reduction Monitoring Framework: Quantitative assessment report – January 2015.

1.3 Key Drivers of LCOE 2015-16

KPMG undertook interviews with the developers of participating projects to gain a better understanding of which issues have been material to the costs of offshore wind during the period. Developers participating in this assessment were of the view that the UK Government had stimulated global cost reduction, in particular via the FID Enabling for Renewables programme which awarded CfDs to 5 offshore wind projects. Developers noted that this programme provided certainty for the industry and enabled the project pipeline, proving the CfD concept, stimulating investment appetite and allowing a maturing of the supply chain.

A number of cost drivers were discussed with developers, however the issues predominantly fell into 6 major categories:

1.	Financial structures: The offshore wind market has witnessed a step change in perceived market maturity, which has improved developer’s ability to obtain external finance at more favourable rates both via debt and equity structures.	↓
2.	Supply chain cost reduction: Increased competition amongst the supply chain has been material in decreasing supply chain margins. Further, competition between developers, primarily due to declining subsidy levels has resulted in the realisation of cost efficiencies, driving project costs down.	↓
3.	Key component innovation: Increases to turbine size enabling larger rotors, higher blade tip height and a larger wind swept area have allowed for a cheaper capital expenditure (CAPEX) per megawatt hour (MWh) produced on a net basis.	↓
4.	Consenting and environmental permitting: The current UK consenting and environmental permitting legislation presents a risk for developers, for example, the recent consultation on the Special Areas of Conservation in relation to harbour porpoise have had an impact on investor confidence.	↑
5.	UK content requirements: Whilst developers largely understand and appreciate the need for a focus on the local supply chain, they have found the implementation of the guidelines around UK content to be challenging.	↑
6.	Other technical issues: The Ofgem ‘Reference Plant’ threshold for assessing OFTO transfer, intended to be an industry average cost of building an OFTO, is perceived to set the	↑

<p>'average' value too low making it difficult to obtain. Moreover, the method of cost assessment leaves little incentive for developers to innovate and drive efficiencies.</p> <p>Developers also noted the long term revenue risk created by the timing mismatch between the 20 year Transmission Network Use of Service (TNUoS) licence, 15 year Contract for Difference (CfD) term and the average 24 year asset life.</p>

2 Background to the Cost Reduction Monitoring Framework

2.1 The £100/MWh Challenge

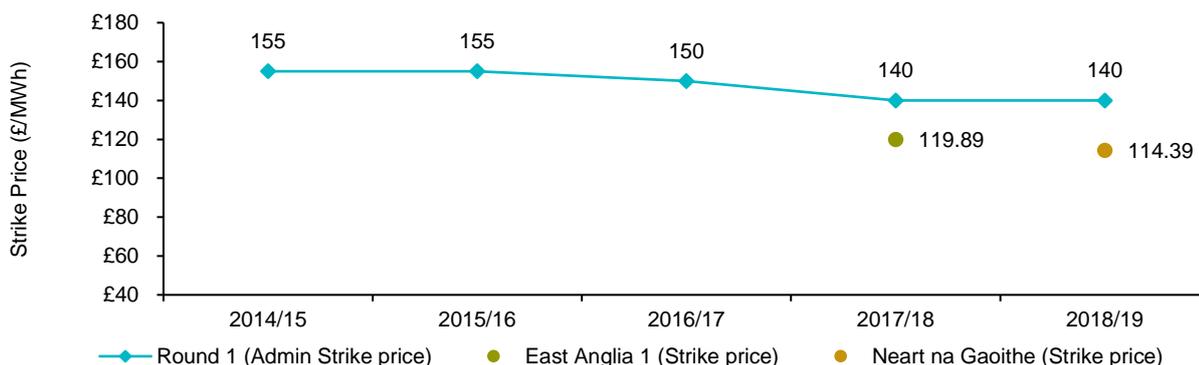
In 2011, in order to justify continued Government support for offshore wind, the Cost Reduction Pathways set a cost reduction target of achieving £100/MWh (the ‘Industry Target’) for offshore wind projects taking FID in 2020. The offshore wind industry has made tremendous progress in reducing costs from an industry average FID LCOE of £142/MWh in 2010-11 to £97/MWh in 2015-16, surpassing the industry target of £100/MWh, 4 years ahead of schedule.

2.2 Cost Reduction under CfDs

CfD strike prices can also help inform our assessment of industry progress to date. In 2013, the Government published the first administrative strike prices. These strike prices were based on independent data collection and consultation with industry and showed a strike price trajectory of £155/MWh for projects commissioning in 2015-16 falling to £140/MWh for projects commissioning in 2018-19 (2012 real).

The first competitively allocated CfDs were awarded in 2015. Two projects with a combined capacity of 1.162GW received CfD contracts at the clearing strike prices of their delivery year of £114.39/MWh and £119.89/MWh³ (2012 real)⁴.

Figure 3: UK Historic strike price trajectory



Source: KPMG analysis.

³ Neart na Gaoithe, the recipient of the CfD at £114.39/MWh has latterly had its CfD terminated.

⁴ Source: Low Carbon Contracts Company

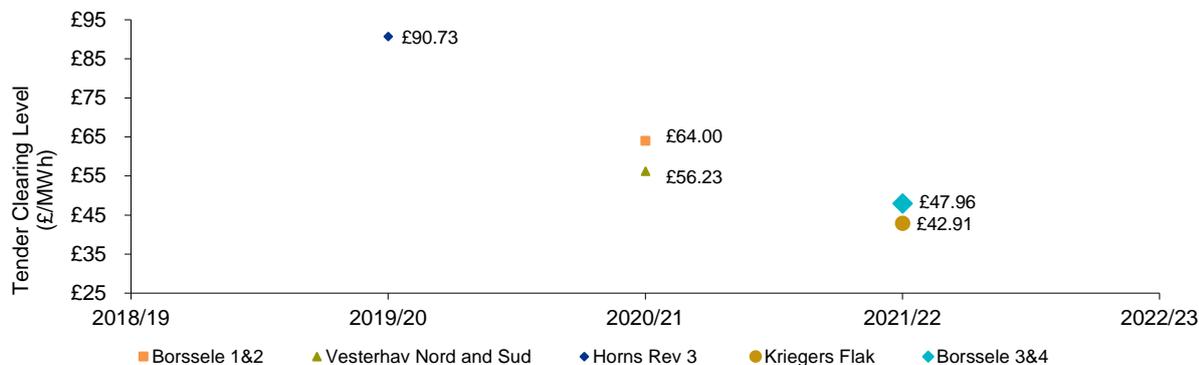
2.3 Future Industry Progress

Since 2011, the Secretary of State has continued to challenge the industry to reach and go beyond the industry target. This is highlighted by the expectation of future CfD strike prices being set at £105/MWh for projects commissioning in 2021/22 falling to £85/MWh for projects commissioning by 2025/26 (2012 real).

The Government has announced that it will make funding available for up to three further CfD auctions in this Parliamentary Period. Subsequent to the interviews being undertaken with developers under the Cost Reduction Monitoring Framework, Government has announced the first of these CfD auctions will be launched in April 2017 supporting 1-2GW of offshore wind with up to 10GW of further offshore wind deployment by 2030 provided the Government's cost reduction expectations can continue to be met.

The pending CfD auction is widely expected to be oversubscribed and will likely drive a competitive CfD strike price. In light of recent European tender results (see Figure 4), there are strong indications (despite the clear differences in the regulatory frameworks underpinning the jurisdictions) that the Government's future strike price trajectory can be met.

Figure 4: Recent EU tender clearing prices



Source: KPMG analysis

As this CRMF study analyses data provided as LCOE in 2011 real terms, Annex 4 contains a table converting the LCOE to strike prices in 2012 real terms so that progress against the Government's future cost reduction trajectory can be assessed in the context of CfDs.

3 2015-2016 Quantitative Assessment

3.1 Approach and Methodology

KPMG has worked with ORE Catapult to update the model created for the 2010-2014 CRMF Quantitative Assessment, referred to as the LCOE calculator. When populated with project data submitted by developers included in the samples, the LCOE calculator derives an LCOE for each project.

For the 2015-16 CRMF Quantitative Assessment, the LCOE calculator was circulated to developers of offshore wind projects that reached FID or Works Completion in 2015 or early 2016⁵.

Figure 5: Offshore wind projects included in the 2015-16 FID sample:

Project Name
Rampion
Race Bank
Galloper
Walney ext. I & II
Burbo Bank Extension
Beatrice
Hornsea I
East Anglia I

Figure 6: Offshore wind projects included in the 2015-16 Works Completion sample:

Project Name
Westermost Rough
Gwynt y Mor
Humber Gateway
West of Duddon Sands

In order to preserve the confidentiality of responses, KPMG observed the anonymity rules set out in Annex 3. This meant that West of Duddon Sands was included in the Works Completion sample with a 50% weighting. A full list of developers and capacity included in the study is contained in Annex 1.

⁵ Burbo Bank Extension was included despite reaching FID in 2014 as it took FID in December and missed the cut off for the 2012-2014 study.

The developers populated an LCOE calculator for the offshore wind project(s) for which they were requested to submit and the results, including LCOE, CAPEX, OPEX and generation data, were returned to KPMG.

KPMG analysed the results and undertook a qualitative interview with each of the developers. In this interview, KPMG asked a series of questions about environmental, regulatory and technical factors to seek to understand the context for the cost reduction being observed in the offshore wind market.

3.2 Quantitative Assessment 2010-14 Findings

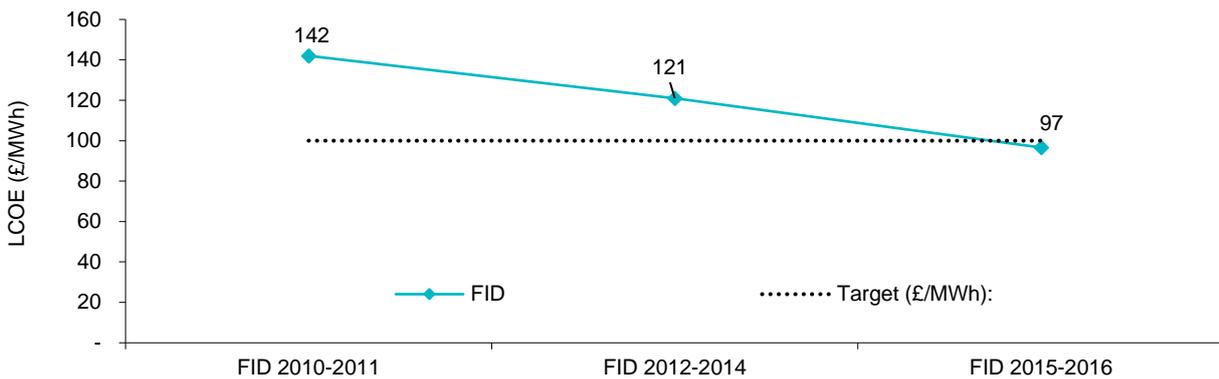
The 2010-2014 study found a downward LCOE trend for projects reaching FID with an industry average LCOE of £142/MWh in 2010-11 and £121/MWh in 2012-14.

A similar downwards trend was identified for projects reaching Works Completion, where the industry average LCOE was £136/MWh in 2010-11 and £131/MWh in 2012-14.

3.3 Quantitative Assessment 2015-16 findings

In the 2015-16 Quantitative Assessment, KPMG has observed a continued cost reduction trajectory with projects reaching FID in 2015-16 achieving an industry average LCOE of £97/MWh.

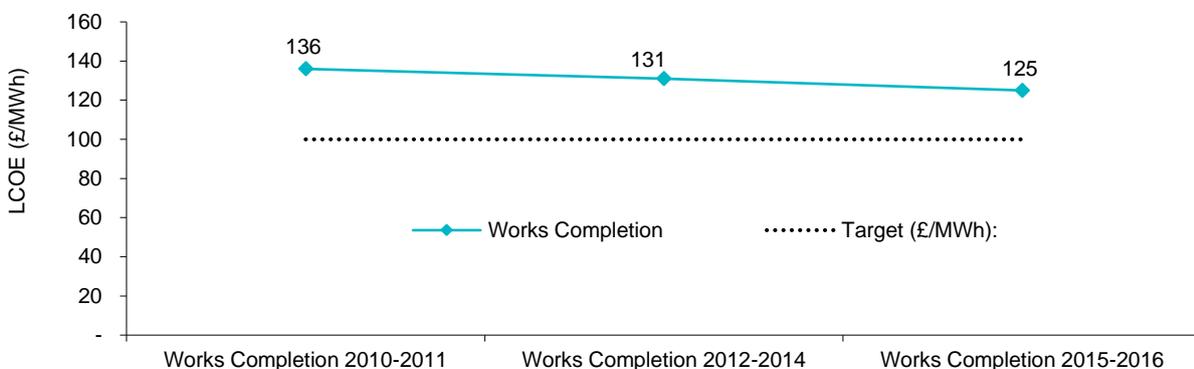
Figure 7: FID Sample industry average LCOE



Source: KPMG analysis, Cost Reduction Monitoring Framework: Quantitative assessment report – January 2015.

For projects reaching Works Completion in 2015-16, the industry average LCOE was £125/MWh.

Figure 8: Works Completion Sample industry average LCOE



Source: KPMG analysis, Cost Reduction Monitoring Framework: Quantitative assessment report – January 2015.

The general trends have followed the same pattern as shown by the 2010-14 results, as the LCOE has continued to decline at a similar rate for both FID and Works Completion from 2012-14 to 2015-16 as they did from 2010-11 to 2012-14.

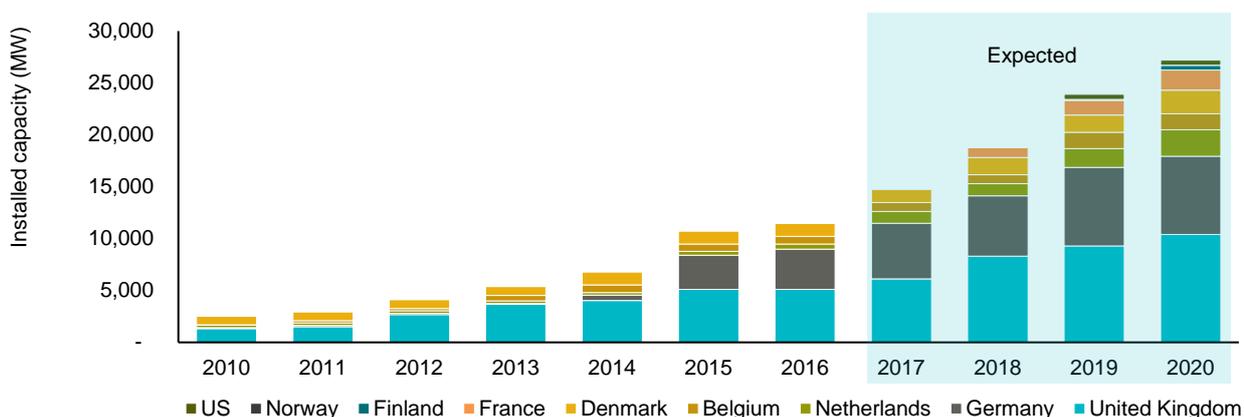
The decline in LCOE has been much greater for projects reaching FID in 2015-16 in comparison to projects reaching Works Completion in the same timeframe, this is shown by the LCOE for FID projects reducing by 20.1% in comparison to 4.6% for Works Completion projects.

Developers credited this success to the deployment momentum created initially by the UK Government and latterly, across North Western Europe. This momentum allowed for industry collaboration and synergies to be sought, learnings to be embedded and the rapid industrialisation of the supply chain.

Several developers noted the UK Government’s FID Enabling for Renewables programme, which awarded CfDs to 5 offshore wind projects, providing the certainty and pipeline to catalyse a step-change in the industry by allowing a maturing of the supply chain and proving the CfD concept.

More broadly, as the cumulative installed capacity across the world has increased, industry has been able to leverage the learnings across jurisdictions delivering on the cost reduction targets as set out.

Figure 9: Global installed capacity



Source: KPMG analysis.

3.4 Quantitative Assessment 2015-16 trends

Water Depth, wind speed and distance to port

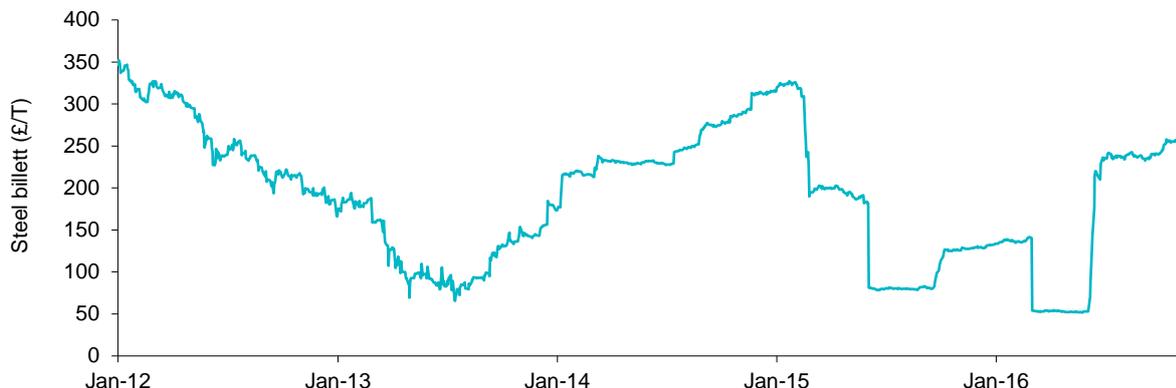
Overall, a positive correlation was identified between LCOE and both distance to port and water depth with a negative correlation identified between LCOE and wind speed.

According to the results received, water depth had the most significant impact compared to distance to port and wind speed.

Commodity price movements

Most developers reported that they hedge against the price movements in key commodities (in particular, steel) at the point of FID, however, there were some cases where developers have remained exposed to the risk of increased material costs or indeed, have benefited from a reduction in the costs of materials.

Figure 10: Historic steel prices



Source: Reuters Eikon.

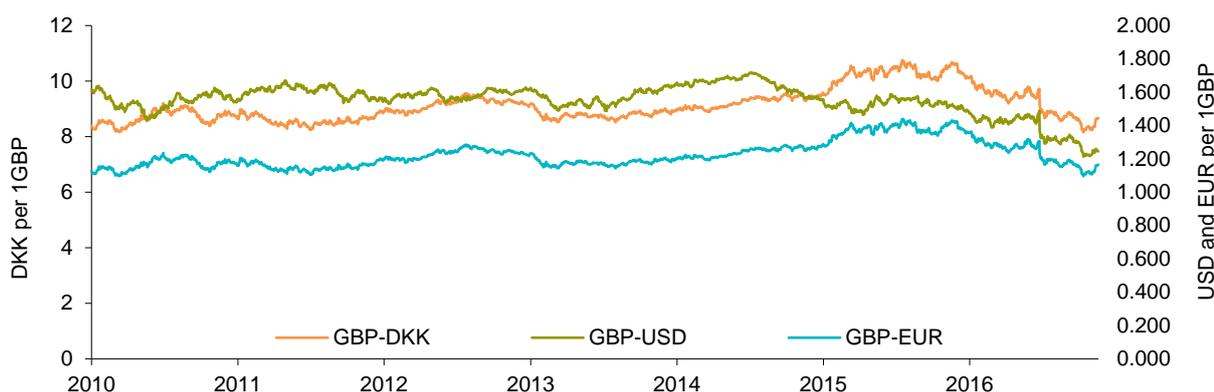
Figure 12 shows that the price of steel declined in the period 2014-16. Whilst it has not been possible to isolate the exact volume of steel in each project, given the volume of steel contained in key components such as foundations and turbines, exposure to steel prices is likely to be several hundred million pounds per project. As such, this is likely to have had a significant impact in reducing projected CAPEX for each project and in turn enabling a reduction in the overall LCOE.

Foreign exchange price movements

Developers have typically had a significant proportion (up to 50%) of their costs denominated in foreign currency. These currencies are typically Euros, Danish Krone, Norwegian Krone and, to a lesser extent, US Dollars.

Those that relate to CAPEX are typically hedged by developers at the point of FID, often centrally through their organisation. However, some developers noted they have ongoing foreign denominated OPEX requirements which, especially following Brexit, has left them in a detrimental position. For example, the GBP-EUR decreases between 01 January 2016 and 01 November 2016, would have contributed to an increase in CAPEX of 10%, all other things being equal.

Figure 11: Historic foreign exchange movements



Source: Reuters Eikon.

As can be seen from the foreign exchange prices, the pound reached its strongest point at the start of 2016, however, it then weakened over the remaining period. There was a particular impact post-Brexit, which caused the pound to weaken significantly against each of the other currencies examined.

The analysis of CAPEX costs from the results shows that the proportion of CAPEX in foreign currencies has declined between the Works Completion and FID projects from >50% to <40%, indicating that the

exposure of projects to foreign currency fluctuations is reducing. Given the small sample sizes, it is difficult to draw conclusions with certainty but the new requirement for developers to use a greater proportion of UK content in the construction of offshore wind projects may partly explain this difference.

It should be noted, however, that not all developers provided a response for the percentage of CAPEX and OPEX spent in foreign currencies, therefore the overall impact of the foreign currency movements could not be determined.

4 Trends in the Levelised Cost of Energy

4.1 Factors affecting LCOE reductions in period 2015-16

Based on KPMG's interviews with developers, a number of key trends were identified, which have impacted the LCOE, either positively or negatively, in the period 2015-16. These are discussed in detail below:

1. Financial structures

Over the past two years since the first Quantitative Assessment, offshore wind has witnessed a material maturing of the market. This has resulted in an extremely competitive financing environment, both for equity and debt.

Due to the scale of investment required in offshore wind, many developers choose to employ a capital recycling program, attracting external equity for up to 75% of the capital requirement. Historically this was only possible following a substantial period of operations, or with a construction wrap being offered by the strategic investor, to de-risk the investment.

However, of late, both strategic and financial investors perceive that offshore wind has become a less risky investment class, able to produce long-term and stable cash flows, hence, they have adopted a greater risk appetite for investments in the sector. Many industry participants referred to a 'wall of capital' being available, even as early as FID. Moreover, as competition intensifies, implied discount rates are being pressured lower across the industry.

Furthermore, over this same period, industry has seen material advances in the availability of project level debt financing. KPMG understands that Galloper, Beatrice and Dudgeon have all been project financed during 2015-16 with up to 75% net leverage being introduced⁶ and several other Holding Company level structured financings also occurring over the period.

This has meant that the industry weighted average cost of capital for offshore wind projects has declined significantly, meaning that the applicable discount rates for the LCOE for more recent projects is likely to have fallen in comparison to older projects, though KPMG note that this is not necessarily the case for all developers (see Annex 2).

2. Supply chain cost reduction

Developers perceive that margins in the supply chain have been reducing due to an increase in the number of experienced suppliers. Developers view that this has been exacerbated by falling RO banding, the introduction of strike prices under the CfD regime and due to increasing competition in the offshore wind industry. Overall, they believed that this was a material external contributor to the LCOE reductions observed.

Further to this, developers believe that their enhanced relationships with suppliers born of collaboration on innovation and industry development has had a material impact on their ability to work together to deliver technical innovations which have resulted in material LCOE reductions.

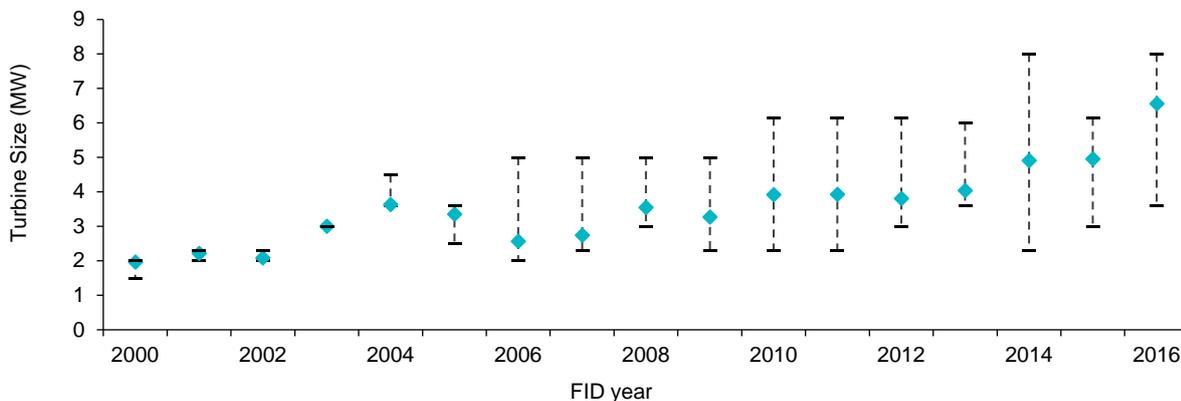
There was some concern raised by a number of developers that these relationships with the supply chain, that have been developed whilst collaboration across the industry has been fostered, may negatively suffer as the industry becomes competitive. This could have a negative impact on the trends of improvement that have been identified over this reporting period.

⁶ Wind Power Offshore, Galloper Wind Farm, Dudgeon Offshore Wind, KPMG analysis

3. Key component innovation

Since the inception of offshore wind, industry has continually sought efficiency gains via innovation in key components, most notably the scaling of turbines.

Figure 12: Turbine rating taking FID



Source: KPMG analysis.

As turbine rating has increased, so too has the rotor diameter, blade length, tip height and wind swept area. Whilst turbine CAPEX per MW has increased as a result, the net cost including the number of foundations, number of lifts, cabling and ongoing O&M, has decreased relative to the increase in power output per turbine. Overall, this has been a material factor in reducing the LCOE for projects that have reached FID or Works Completion in the period of 2015-16 in comparison to those reaching FID or Works Completion in the period of 2010-14.

Whilst turbine size was the most material innovation cited by developers, it should also be noted that several other key components have evolved over the period including the contracts for jacket foundations at East Anglia One and Beatrice and the planned use of Suction Bucket Jackets on one third of Hornsea One. By reducing the steel content and the drilling requirement, each of these innovations should reduce the LCOE of offshore wind.

4. Consenting and environmental permitting

Developers identified that permitting risk has increased, in particular with reference to UK consenting and environmental permitting legislation. This was exemplified by the recent Judicial Review of four Scottish projects' consents by the Royal Society for the Protection of Birds (RSPB) and the consultation launched by the Department for Environment, Food and Rural Affairs (DEFRA) on Special Areas of Conservation in relation to harbour porpoise.

Efforts to overcome such risks are proving increasingly costly and, due to the historic and current UK regulatory regimes, are undertaken entirely at the developer's risk. One industry participant noted that the complexities this presents for a project with such a long lead time and high development expenditure means "starting development on a UK site today just would not happen."

5. UK content requirements

Whilst industry widely understood and accepted Government's moves to encourage long term economic benefits to UK PLC including the guidelines around the use of local supply chain content in projects, developers felt the manner in which it was being implemented had several implications:

- i. Whilst the UK Supply Chain Guidance now provides clarity around how developers will be assessed in relation to their fostering of innovation, competition and skills, the requirements are not viewed as prescriptive and leave room for interpretation. Moreover, under the RO and FIDeR, requirements were not written, with some developers noting pressure to use a local supplier(s) or to require they obtained a greater UK content percentage. Developers viewed that greater clarity from Government over their aspirations for industry would help them to deliver on this objective; and
- ii. Developers noted that the guidelines for the use of UK content had, in some instances, put them in a weaker negotiating position against the supply chain. In these instances, developers perceived that supply chain costs charged by UK contractors may not have declined as much as they should.

6. Other technical issues

Under the 'generator build' OFTO model, Ofgem conducts a forensic assessment of OFTO costs to assert a 'transfer value' for the assets.

The determined OFTO transfer value is considered to be a risk to projects. This is due to the belief held by developers that they would be unlikely to break even on their CAPEX outlay upon the sale of the project's OFTO assets.

Developers highlighted that the methodology of OFTO benchmarking employed by Ofgem makes it very difficult for them to meet these benchmarks. This has impacted future project assumptions as developers have been forced to increase the disallowable percentage of OFTO recovery, increasing project costs as a result. This has driven the LCOE higher.

Moreover, developers noted that whilst costs over the reference plant threshold were not recoverable, savings beyond that of the reference plant were not being netted against this. This reduced the impetus for developers to innovate and drive efficiency. One developer gave an example whereby using a more expensive substation structure would lead to net lower CAPEX and reduced losses by allowing the installation of a lower cost cabling solution. However, as the substation structure overspend would be unrecoverable, the developer opted not to use this more efficient technical solution.

A specific point raised by several developers was regarding TNUoS charges. Developers noted that there is a discord between the 20-year offshore TNUoS charges, in comparison to project asset lives, which currently average 24 years. This gives the project revenue uncertainty in the last 4 years of its life, increasing investment risk. This discord becomes more material with the introduction of CfD contracts, as they cover a 15 year period, whilst the RO scheme offered revenue support for a 20-year period. Uncertainty around cost recovery and perceived investment risk will now be extend to the final 9 years of a project's life, as opposed to the final 4 years in the case of ROC accredited offshore wind farms.

4.2 Update on key trends from 2010-14 assessment

The 2010-14 assessment identified four key factors, which had an impact on costs and hence an impact on the overall LCOE. Each of these points were discussed with developers as part of the 2016 CRMF Quantitative Assessment to determine the changes that the industry has observed on these key points.

1. Falling turbine and foundation costs

Developers of projects examined in the 2010-14 assessment reported that larger turbines and improved technology and efficiency had reduced costs on a £/MWh basis.

This trend has continued in 2015-16, as stated in section 4.1.3. Developers identified turbine scaling as a key reason for the reduction in LCOE identified.

Further to this, the 2010-14 assessment identified that both turbines and foundations were the two areas in which the developers would most often implement new technologies in a bid to drive down costs and to gain a competitive advantage.

This was echoed by developers interviewed for this reporting period, stating that turbines and foundations represented a large proportion of CAPEX and so represented the biggest opportunity for savings.

2. Challenging supply chain relationships

In the 2010-14 assessment, the supply chain was identified as a key area that increased costs within the industry.

This was due to the limited bargaining power of some developers due to the very concentrated supplier markets. This led to either increases in costs or a reduction in quality, both of which led to a higher LCOE.

It was believed that this was offset somewhat by an increasing competition among suppliers in some specific sectors such as vessels.

In the 2015-16 assessment, developers believe that this has changed considerably from the prior assessment period as stated in section 4.1.2. Developers in particular believe that they now have much more bargaining power as subsidy compression has driven down margins. Developers also believe that supply chain availability is now much improved. A specific example of this has been the ability to access additional vessels at short notice to overcome any delays in construction.

3. Lack of required skills and expertise

In the 2010-14 assessment, developers identified that a key challenge which they faced was the difficulty encountered in accessing the required expertise for project development and/or implementation.

The developers in the 2010-14 assessment stated that there had been no systematic improvement within the industry which had improved workforce experience and thus the same challenges remained at the end of the reporting period that were present at the beginning of the period.

For the 2015-16 assessment, developers stated that this issue had become much less of an issue in this timeframe, with experience and resource sharing catalysing a greatly improved pan-European workforce. Developers did not report any major outlying complaints.

Developers reported that the decline in the oil and gas sector that has occurred in the 2015-16 period has not yet had a discernible impact on the supply chain or skills available within the market. However, they have noted that there is a potential for improvements if the decline in the oil and gas market persists in the long term.

A key concern raised by developers is that they are unsure of the impact that Brexit will have on the labour market. The developers have stated that the ability to source skilled workers from the European market is key for them to construct and operate their wind farms. Developers identified that this could pose a risk if they are unable to utilise this market in a post-Brexit world.

4. Significant cost of delays

Construction delays were identified as a key area which limited the reduction in LCOE for the 2010-14 assessment.

The particular point identified by developers was that there were instances of supply chain failure and adverse weather conditions which led to delays in the construction phase or an increase in costs to the developer to maintain project milestones.

Most developers also stated there appeared to be an inappropriate risk allocation in many of the contractual arrangements with suppliers, which made it difficult to make claims against suppliers in instances of underperformance. These developers stated that there was no clear contractual and risk allocation strategy identified within the industry.

For developers interviewed in the 2015-16 assessment, the changes from the prior reporting period vary from project to project. According to developer views, the use of a multi-contract strategy is creating cost efficiencies and, hence, in theory boosts project cash flows. Many developers noted that with a move to competition, a shift to a multi-contracting strategy is logical, however, it would come with renewed pressures on risk allocation.

At the same time, financiers seem to be more comfortable with EPC contracted projects as these have minimal interface risks and lower associated delay costs. The appetite for debt financing in multi-contract projects is yet to be tested as no UK offshore wind project has sought external debt whilst utilising a multi-contract strategy (without contractual de-risking e.g. a construction wrap).

4.3 Concluding remarks

Overall the projects assessed in the 2015-16 period have shown that the trend in declining LCOE has continued, with both FID and Works Completion LCOE declining at a similar rate as was observed in the prior assessment covering the 2010-14 period.

The offshore wind industry has met the 2020 LCOE Industry Target of £100/MWh ahead of schedule, with the average LCOE of the FID projects reviewed in this assessment, already surpassing this target.

The 2015-16 CRMF Quantitative Assessment identified that the main drivers of LCOE reduction over the period have been:

- The UK Government's FID Enabling for Renewables programme, through which 5 offshore wind projects secured early CfD contacts. This programme stimulated investment momentum in the industry by providing certainty and by enabling the development of the project pipeline necessary to allow a maturing of the supply chain;
- Industry maturity has resulted in an extremely competitive financing environment, both for equity and debt. Developers' ability to obtain external finance at favourable rates both via debt and equity structures has increased materially;
- Lower supply chain costs as a result of increased competition amongst contractors. Further, competition between developers, primarily due to declining subsidy levels has resulted in the realisation of cost efficiencies, driving project costs down; and,
- Key component innovation i.e. turbine size increases enabling larger rotors, higher blade tip height and a larger wind swept area has allowed for lower CAPEX per MWh produced on a net basis.

The key barriers to cost reduction in the 2010-14 assessment, appear to have seen significant improvement, in particular the improving supply chain relationships and improving skills base in the market. According to developer responses the areas where further improvements could be effected:

- Regulatory barriers, e.g. consenting and environmental permitting legislation presents a risk for developers and impact investor confidence;
- Developers largely understand and appreciate the need for a focus on the UK supply chain, they have found the implementation of guidelines around UK content to be challenging and believe it puts them in a weaker negotiating position against UK contractors;
- The Ofgem 'Reference Plant' threshold for assessing OFTO transfer, intended to be an industry average cost of building an OFTO, is perceived to set the 'average' value too low making it difficult to obtain. Moreover, the method of cost assessment leaves little incentive for developers to innovate and drive efficiencies.
- The long term revenue risk created by the timing mismatch between the 20 year TNUoS licence, 15 year CfD term and the average 24 year asset life.

If these cost reduction barriers were improved in future years, further LCOE improvements should be expected.

Appendix 1 CRMF Quantitative Assessment Methodology

LCOE calculator:

The LCOE of each offshore developer has been calculated using the financial and technical data of twelve offshore wind projects. The lists of projects are shown in the two tables below.

Figure 13: Offshore wind projects included in the 2015-16 FID sample

Project Name	Capacity	FID date
Rampion	400MW	May 2015
Race Bank	546MW	June 2015
Galloper	336MW	October 2015
Walney ext. I & II	649MW	October 2015
Burbo Bank Extension	256MW	December 2014
Beatrice	588MW	May 2016
Hornsea I	1,197MW	February 2016
East Anglia I	714MW	February 2016

Figure 14: Offshore wind projects included in the 2015-16 Works Completion sample

Project Name	Capacity	Works Completion date
Westermost Rough	210MW	May 2015
Gwynt y Mor	576MW	May 2015
Humber Gateway	219MW	May 2015
West of Duddon Sands (50% weighting)	389MW	October 2014

Appendix 2 Approach to Assumptions and Analysis

To ensure that the data supplied by each developer were consistent with each other the following assumptions were made.

Indexation

To ensure that the financial data is consistent with the 2014 CRMF report, the indexation base date has been taken to be 2011 for each project. This ensures that the financial data supplied is comparable between each project in this report and the projects that have been reported in the previous assessment.

Project financial milestones

The offshore wind LCOE results have been calculated at one of two specific milestones. The definitions of these milestones are set out below:

- Final Investment Decision (FID) is defined as the point of a project lifecycle which all consents, agreements and contracts that are required in order to commence project construction have been signed. There must also be a firm commitment by equity holders and debt providers to provide funding to cover the majority of construction costs.
- Works Completion is defined as the point at which the full capacity of the wind turbines is categorised as energised/operational. This typically takes place a few months after the turbines become operational and may precede a formal handover of the project.

Currency

All financial data was supplied in pounds sterling. In addition, each developer was asked to provide information regarding the proportion of costs that was in a foreign currency such as Euros or Danish krone. This was used to determine the exposure to currency fluctuations that each project had (although it was noted that most projects would have hedged foreign currency), but was not calculated as part of the LCOE.

Discount Rates

The model was set with a discount rate of 9.00%, which discounted CAPEX, OPEX and future power generation at 9.00% per annum to the project base date. This was taken to be an appropriate approximation for the discount rate for each project. By setting the discount rate as the same value for each project it allowed comparability of each dataset provided by the developer.

KPMG notes that 9% may not be reflective of all projects in the UK and the LCOE is very sensitive to the discount rate assumption. KPMG has undertaken some analysis to calculate the LCOE range for projects based on a range of discount rates.

Figure 15: LCOE versus Discount Rate matrix

Discount rate	7%	8%	9%	10%	11%	12%
FID sample £/MWh	87	92	97	102	107	113
Works Completion sample £/MWh	111	118	125	132	139	146

Appendix 3 Anonymity Rules

The following rules have been followed in order to ensure the anonymity of each individual project. These rules have been designed to address the key concerns around current and past ownership of each project along with the relative size of individual projects.

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 data point 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 data points 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 4 LCOE to Strike Price Conversions

KPMG has calculated the below strike prices using the results supplied by developers including asset life, capacity, annual generation, CAPEX, OPEX and LCOE.

KPMG has supplemented this information with the Department of Energy and Climate Change (DECC) Updated Energy Projections 'Reference' Wholesale Price scenario, deflated from 2015 nominal terms to 2011 real terms using the Office of National Statistics (ONS) Consumer Price Inflation (CPI) 'all goods' publication and the assumed discount rate for the CRMF Quantitative Assessment of 9%.

Figure 16: LCOE to Strike Price conversion

	LCOE (£/MWh 2011 real)	Strike Price (£/MWh 2012 real)
FID sample	97	108
Works Completion sample	125	141

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