CATAPULT Offshore Renewable Energy

Offshore Wind Programme Board

Cost reduction monitoring framework 2015

Qualitative summary report

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Executive Summary

The Offshore Renewable Energy (ORE) Catapult, in conjunction with The Crown Estate (TCE), developed the Cost Reduction Monitoring Framework (CRMF) in 2014, on behalf of the Offshore Wind Programme Board (OWPB) and the members of the Offshore Wind Industry Council (OWIC). The CRMF qualitative assessment is designed to track the industry's progress towards a target Levelised cost of energy (LCOE) of £100/MWh for projects reaching FID in 2020[1]. This progress is tracked against indicators and milestones that measure development of potential innovations in technology, the supply chain and finance. Results from this year's study are presented in Figure 1.

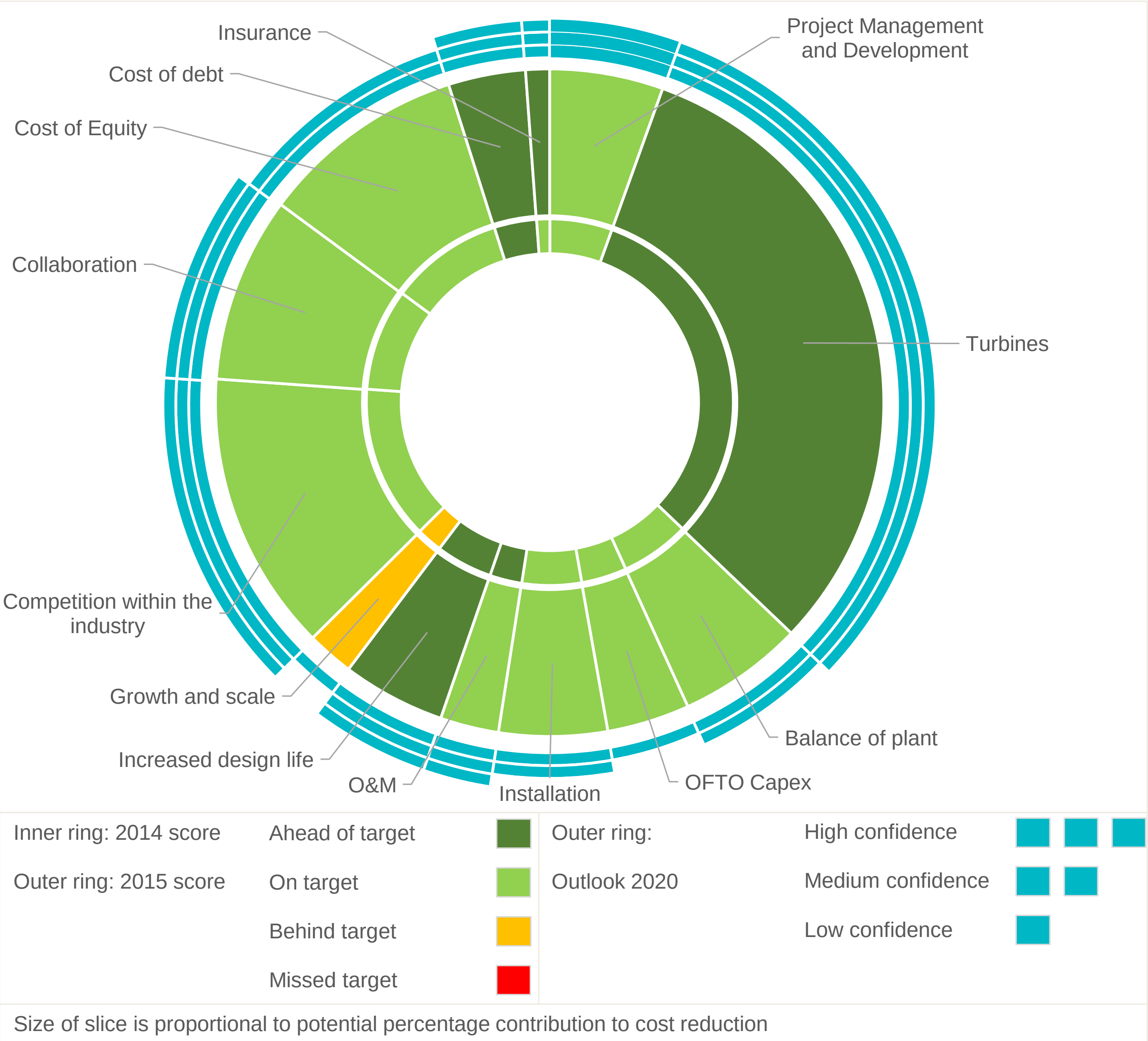

Figure 1 - CRMF 2015 Results

[1] In 2011 real terms.

Figure 1 demonstrates that in 2015, the offshore wind industry is on target to meet a cost reduction target of £100/MWh for wind farms reaching FID by 2020. Indicators assessed as ahead of or on target are expected to meet or exceed their predicted contribution to cost reduction by 2020. There is continued progress in innovations across technology, finance and the supply chain. The outer ring presents confidence in future progress and highlights risks associated with the development of balance of plant (including offshore transmission) and installation technologies and the growth and scale of the industry.

A number of challenges and risks to industry progress were identified in this analysis:

Cost reduction progress 2014-2017

Findings suggest that in 2015, cost reduction is already being achieved through innovations that were not expected to contribute in great quantity to cost reduction until 2017[2]. The cost reduction target of £100/MWh has proved to be a useful milestone for the industry.

Progress in installation and balance of plant

Close attention should be paid to certain balance of plant and installation indicators that are at risk of slower progress in future. These areas are subject to a number of layers of risk, some unforeseen prior to the publication of TCE Cost Reduction Pathways study in 2012, such as decline in the oil and gas markets, lower market volume and increased allocation risk through the introduction of the Contract for Difference (CfD). There is also slower than anticipated progress in demonstration of technologies such as 66kV cables and gravity base support structures.

Risk of uncertainty in political support

November saw positive announcements indicating three further CfD allocation rounds to 2020. Although consultation for this study completed prior to this announcement, respondent's views were that a lack of market visibility could reduce development within the sector which is a risk to cost reduction. For investment in supply chain facilities to continue, there is a commonly described need for early sight of auction dates, administrative price setting and the quantity of funding in the Levy Control Framework (LCF).

Volume post-2020

To alleviate allocation risk in the shorter term, project developers and the supply chain need longer term certainty to ensure they can balance the risk of not achieving CfD.

It is unclear if low regulatory visibility will significantly impact financing costs as we progress to 2020 and beyond. To reduce the risk of falling capital availability in the future, the industry should maintain focus on long term financing partnerships with new capital.

[2] Assumption made by TCE Cost Reduction Pathways report in 2012.

Unintended impacts of the CfD mechanism on the supply chain

Introduction of the CfD mechanism with low allocation levels has increased competition. This is exerting downward pressure on project costs and improving value to the consumer. There are however some indirect impacts of the new support regime that should be addressed:

With smaller than anticipated allocations, uncertainty in the level of budget available within the LCF in the auctions to 2020 and ever tighter administrative price setting, there may well be a slowdown in long term development of technology solutions for more challenging projects. Reducing development risk through policy, as attempted in other EU countries (e.g. the Netherlands), is unlikely to support UK projects reaching FID by 2020, but there may be early lessons learned from these countries that could support long term development of the UK sector.

There may be a disincentive to knowledge sharing and collaboration in preparation for a CfD auction both between developers and in the supply chain.

Investment in site investigation and design offers significant opportunity for cost reduction, however uncertainty in financial support discourages early investment in surveys and FEED studies to optimise design particularly before CfD award. To mitigate the risk of deploying sub-optimal designs, it is important that project developers continue to share best practice on involvement of their supply chains and on site investigation innovations that reduce development costs.

The key findings of this study and subsequent recommendations to the OWPB are presented in Table 1.

Summary finding	Summary recommendation	Owner
Growth and scale		
In the last CfD auction two out of five offshore wind farm project developers were allocated a CfD. All incurred significant costs to get to this stage. With smaller than anticipated CfD allocations and ever tighter administrative price setting, there may well be a slowdown in long term development of technology solutions for the more challenging wind farms. The CfD mechanism also places increased risk on development equity and the	Engage regulators on lessons learned from implementing mechanisms used to reduce development risk in other European countries, such as changes to CfD application eligibility criteria or undertaking state-funded project development activity. Continue to investigate comparisons/collaborations with equivalent European organisations such as the Offshore Stiftung	OWPB

Summary finding	Summary recommendation	Owner
supply chain during project development, which can drive up overall project cost. All supply chain consultations viewed the UK and European markets together and there are a number of other groups in the EU that have a similar remit to the OWPB.	programme in Germany and TKI Wind Opp Zee in the Netherlands.	
Project Management and Development		
There is a tension between delivering detailed work pre-CfD award versus the need for the supply chain to commit earlier by providing more detailed bids in a shorter timeframe.	Undertake a study into novel approaches to site investigation to enable higher quality/lower cost data provision before the pre-qualification questionnaire (PQQ) stage of development e.g. increased use of remote measurement.	OWPB technology and innovation group
Turbines		
Turbine development remains ahead of target. Progress in commercial deployment of nacelle mounted lidar and superconducting generators is however lagging.	Support development and demonstration of technologies (e.g. nacelle mounted-lidar and integration of wind farm control systems, test lab demonstration of superconducting generators). This should be informed by an industry-led forecast of cost reduction opportunities supported by OWPB and key stakeholders.	OWPB technology and innovation group

Summary finding	Summary recommendation	Owner
Balance of Plant		
There has been significant progress in the R&D of 66kV and gravity base structures but the industry is still experiencing delay in commercial deployment. A cable burial specification was released by the Carbon Trust through the Offshore Wind Accelerator (OWA) but there is still no industry-wide array cable standard.	Ensure that demonstration sites are secured to de-risk gravity base structures. To ensure continued progress in deployment of 66kV, ensure lessons learned about early deployment of the technology are disseminated to industry. Prioritise research to enable optimisation of jacket designs.	OWPB technology and innovation group
	Undertake a review of the gaps in cable standards to understand where future efforts should focus.	OWPB grid group
Offshore Transmission Operator (OFTO) Capex		
Transmission technologies face a number of barriers to further development. The OFTO and the project developer have slightly differing incentives that do not always align or drive cost reduction.	Continue work in understanding the true cost reduction potential of optimisation of AC platform design, increased capacity AC cables, lightweight (or distributed) transmission systems and HVDC.	OWPB Grid group
	Investigate the implications of the OFTO regime as a barrier to cost reduction in offshore wind. Propose modifications which would enable greater cost reduction in OFTO infrastructure.	OWPB

Summary finding	Summary recommendation	Owner
Installation		
There is no evidence of investment decisions to commission new floating DP support structure installation vessels in 2015. Development of flexible sea fastenings for jacket support structures is an area of potential cost reduction. Unless vessel suppliers have visibility of a pipeline of subsequent projects for which sea fastenings would be useable, they are not incentivised to develop them.	Investigate the impact of forecast deployment rates and site conditions on the requirement for additional investment in new vessels and evaluate the required improvements and modifications to the existing fleets. Assess what would be required to adequately incentivise the widespread use of flexible sea fastenings for jacket support structure installation.	OWPB technology and innovation group
Operations and Maintenance (O&M)		
There is significant progress in development of condition monitoring techniques and innovative maintenance strategies. Implementation of condition monitoring equipment and the resulting increased understanding of asset performance is valuable, but tracking the implementation of truly condition-based maintenance strategies should be considered.	Undertake a review of the use of condition-based maintenance strategies across the industry to establish best practice. The ORE Catapult O&M case study publications are a potential route to dissemination.	OWPB O&M Group
Design life		
Structural health monitoring is increasing and is an area which could unlock cost savings through design efficiencies and/or life extension.	Develop a collaborative industry led project to increase quality of structural monitoring and encourage data sharing as an input to designs and improved assessment of asset integrity.	OWPB technology and innovation group

<table>
<tr><th>Summary finding</th><th>Summary recommendation</th><th>Owner</th></tr>
<tr><td colspan="3">Competition within the industry</td></tr>
<tr><td>A lack of market certainty can influence investment decisions in the supply chain, as demonstrated by the exit of several major industrial players.

There has recently been significant consolidation in the market, particularly for turbine OEMs.</td><td>Continue to monitor impact of reduced market volume on the supply chain. A simple tool that tracks this could be used by the group to help inform specific actions. This could build on the capability of the online RenewableUK supply chain map.</td><td>OWPB supply chain group</td></tr>
<tr><td colspan="3">Collaboration</td></tr>
<tr><td>Almost all respondents described a trend for reduced intercompany knowledge sharing in future, driven by a competitive (CfD) auction system.

There is a continued downward trend in number of contracting packages, with some indication that reduction in contract numbers is not necessarily the route to reducing contingencies throughout the whole supply chain.

There is currently a split in approaches between project developers in their involvement of the supply chain. Those who are seeking to consolidate contracting packages tend also to seek involvement of their supply chain earlier, involving them in more detailed design work.

New approaches like those offered by the BIMCO Wind Time contract form show promise but approaches will need to be suited to specific organisational needs.</td><td>Consider whether an appropriate balance between competition and collaboration is being achieved, and whether the industry is becoming more mature or whether CfD has indirectly increased barriers to knowledge sharing too quickly.

Consider how to ensure that lack of supply chain involvement pre-PQQ in balance of plant does not prevent innovations and optimised solutions.

Consider the impact of number of contracts on contingencies and enable sharing of best practice across the industry.

Consider value of new standard contracts e.g. BIMCO Wind Time. Build on the skills and experience already gained in industry by sharing best practice in the implementation of contracts.

Benchmark supply chain involvement and knowledge sharing</td><td>OWPB supply chain group

OWPB Contracting Group</td></tr>
</table>

Summary finding	Summary recommendation	Owner
The dissemination of anonymised and aggregated sector data through initiatives such as SPARTA are now more crucial than ever in stimulating further knowledge sharing and collaboration in the sector.	activities, such that we can capture industry's progress more actively in this area.	
Cost of equity		
Reducing packages / interfaces / risk during construction is positive for equity and finance, but is not particularly incentivised by current policy. It is unclear if the constraint on the large volume of projects that need funding in the next 3-5 years is on the amount of capital and/or the available skills and expertise to deal with the volume of transactions.	Work to understand the level of contingency better in various approaches to contracting and provide case studies for contract structures. Investigate whether there is likely to be a constraint on human resource or financial capital to process the deals required on projects to 2020.	OWPB finance group
Cost of debt		
A major serial defect could reduce the confidence of investors. The finance community shows higher levels of comfort with technology risk in turbines since last year. The sector remains vulnerable to external market shocks which could lead to a change in current market conditions.	Work to ensure that the balance between innovation and risk is continually understood following release of new technology. Identify further work required to establish comfort on specific risks.	OWPB finance group

Summary finding	Summary recommendation	Owner
Cost of insurance		
Need for proof that post warranty strategy is secure and that the operational data from the asset proves its reliability. This will in turn lead to insurance cost reduction.	Document and ensure continued focus on bottleneck areas that help reduce premiums. e.g. standardisation and universal joints, vessels, spares strategies, vessel sharing, redundancies in the wind farm, buffers in construction schedule, EoW inspections and OFTO performance risk exposure.	OWPB finance group

Table 1 Summary findings and recommendations

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1 Introduction

The Offshore Renewable Energy (ORE) Catapult, in conjunction with The Crown Estate (TCE), developed the Cost Reduction Monitoring Framework (CRMF) in 2014, on behalf of the Offshore Wind Programme Board and the members of the Offshore Wind Industry Council. The CRMF qualitative assessment is designed to track the industry's progress towards a target Levelised cost of energy (LCOE) of £100/MWh at FID 2020. This progress is tracked against indicators and milestones that measure development of potential innovations in technology, the supply chain and finance. This is the second year that the CRMF has reported.

The study is an enquiry focussed on the UK market but it incorporates evidence from activity worldwide, particularly in the EU. This report begins by summarising the methodology in section two before presenting the results in section three and summarising these results in sections four, five and six. Sections seven and eight present a discussion of the findings and recommendations respectively.

A number of other documents provide background to the design of the scheme and further detail on the assessment process:

- Appendix 1, provided as a report titled: PN000113_FRT_002 CRMF 2015 Evidence log. This report contains evidence collected by ORE Catapult to assess progress against the CRMF milestones.
- Appendix 2, provided as a report titled: PN000113_FRT_006 CRMF 2015 Updates to design. This document describes the design of the scheme in detail and provides information on improvements to the CRMF process in 2015.

2 Methodology

The qualitative element of the CRMF is a bottom up, milestone-based framework which seeks to track progress against 66 indicators from 2011 to 2020. Each indicator is weighted according to its cost reduction potential (see Table 3 for weightings). The qualitative assessment draws on and updates TCE Cost Reduction Pathways (CRP) study, published in 2012, presenting a set of annual milestones for each innovation. The CRMF 2015 Qualitative study was delivered in the following phases.

2.1 Design review phase

The 2014 qualitative assessment study provided recommendations for future improvements to the methodology. The ORE Catapult undertook a design review and implemented a number of these improvements and detailed information is provided in Appendix 2. Key changes included:

- Amendments to Offshore Transmission Operator (OFTO) capital expenditure (CAPEX), balance of plant and knowledge sharing milestones to reflect current technology conditions.
- Incorporation of a systematic method to capture the perceived outlook for a 2020 target for each indicator. This complements the retrospective annual view that the indicators provide. ORE Catapult gathered a 1-10 score from contributors to rate confidence in future development. The confidence score was averaged at a respondent level (e.g. project developer etc.) then all contributing sectors were averaged for each indicator. This led to scores within a range of 2.2-8.4. This 2020 outlook scoring falls into three categories:
    - Industry average, gathered from questionnaires;
    - Average with adjustment by ORE Catapult, where justified;
    - Catapult derived only and tested with industry experts.

A definition of the 2020 outlook scoring is provided in Table 2.

Score	Confidence in achieving 2020 target	Presentation of data in findings (Figure 1)
1-4	Low	■
5	Medium	■■
6-10	High	■■■

Table 2 Definition of outlook scoring

2.2 Research and implementation

In the second stage of the project, ORE Catapult gathered evidence from industry through:

- Desktop literature review;
- Consultation with 46 organisations;

- Internal review with ORE Catapult specialists;
- Review in workshops with OWPB working groups.

The evidence was collated from all contributors and is presented in the Evidence Log included in Appendix 1.

The ORE Catapult conducted a review of the evidence provided by industry, scoring each indicator and calibrating the 2020 outlook confidence level.

2.3 Key points to consider

When reviewing the results of the qualitative assessment it is important to note:

- Evidence was gathered before the announcements for a further three CfD auctions before 2020 in November 2015.
- The indicators are weighted for their cost reduction potential. Assessment of level one indicators (e.g. turbines) can mask varying progress in level three indicators (e.g. drive trains) that have lower weightings.
- A confidence rating of 1-10 on the outlook of achieving CRMF innovation targets by 2020 could also be interpreted as the perceived risk of the industry reaching that target.

3 Results

Level 3 indicator scores and weightings from the qualitative assessment in 2015 and the outlook score for the 2020 target are presented in Table 3. The change in score compared to the CRMF qualitative assessment in 2014 is also presented for reference.

Level 1 indicator	Level 2 indicator	Level 3 indicator	Cost reduction potential weighting	L3 2014	L3 2015	L3 change 2014-2015	Outlook
Project Management and Development	Project Management and Development	FEED (optimisation and use of multi-variable array layout tools)	1.30%			→	■■■
Project Management and Development	Project Management and Development	Site selection	1.00%			→	■■
Project Management and Development	Project Management and Development	Site investigation	0.40%			↓	■■■
Project Management and Development	Project Management and Development	Development phase project management	0.50%			↑	■■■
Project Management and Development	Project Management and Development	Floating LIDAR	0.10%			↑	■■■
Turbines	Nacelle	Rating	8.50%			→	■■■
Turbines	Nacelle	Drive train concept	2.30%			↑	■
Turbines	Nacelle	AC power take off design	0.70%			→	■■■
Turbines	Rotor	Optimisation of Rotor Diameter to Rated Capacity	1.20%			→	■■■

Level 1 indicator	Level 2 indicator	Level 3 indicator	Cost reduction potential weighting	L3 2014	L3 2015	L3 change 2014-2015	Outlook
Turbines	Rotor	Blade Design and Manufacture	2.90%				
Turbines	Rotor	Control	2.40%				
Turbines	Integrated design	Integrated design (of turbine and support structure)	1.00%				
Balance of plant	Array Cables	66kv	0.15%				
Balance of plant	Array Cables	Improvement in array cable standards and spec	0.10%				
Balance of plant	Support Structures	Extended (XL) monopiles and improved design standards	1.60%				
Balance of plant	Support Structures	Optimised Jacket design and manufacture	1.50%				
Balance of plant	Support Structures	Suction bucket	0.30%				
OFTO CAPEX	HVAC (near /mid-shore)	Standardisation / distribution of Offshore AC Substation	1.10%				
OFTO CAPEX	HVAC (near /mid-shore)	Overplanting and / or use of dynamic rating	0.80%				
OFTO CAPEX	Far shore	Booster stations (reactive power compensation)	0.30%				

Level 1 indicator	Level 2 indicator	Level 3 indicator	Cost reduction potential weighting	L3 2014	L3 2015	L3 change 2014-2015	Outlook
OFTO CAPEX	Far shore	Compact HVDC systems	0.20%			→	■
Installation	Turbines	Lifting conditions for blades	0.10%			→	■■■
Installation	Turbines	Feeder vessels	0.10%			↓	■
Installation	Support Structures	Lifted GBS with turbine pre-installed	0.10%			→	■■
Installation	Support Structures	Installation process for monopiles through better vessels	0.20%			↓	■■■
Installation	Support Structures	Operational weather windows for monopile installation	1.00%			→	■■■
Installation	Support Structures	Purpose built jacket installation vessels	0.40%			↓	■■
Installation	Support Structures	Flexible sea fastenings	0.20%			→	■
Installation	Support Structures	Floating GBS	0.10%			↓	■■
Installation	Cables	Optimised cable pull in and hang off processes	0.30%			→	■■■
Installation	Cables	Improvements in operational weather limits for cables	0.25%			→	■■■
Installation	Cables	Optimised cable installation	0.40%			→	■■■

Level 1 indicator	Level 2 indicator	Level 3 indicator	Cost reduction potential weighting	L3 2014	L3 2015	L3 change 2014-2015	Outlook
		vessels and tooling					
O&M	O&M	Turbine Condition based maintenance	0.60%			↑	■■■
O&M	O&M	Access solutions from vessel to turbine	0.60%			→	■■■
O&M	O&M	Improvements in transfer from shore to turbine	0.20%			↓	■■■
O&M	O&M	Inventory management	0.10%			→	■■■
O&M	O&M	Offshore crew accommodation	0.10%			↓	■■■
O&M	O&M	OFTO O&M	0.10%			↓	■■■
Increased design life	Increased design life	Increased design life	3.00%			→	■■■
Growth and scale	UK market	UK market	0.45%			↓	■
Growth and scale	EU market (including UK)	EU market (including UK)	0.91%			→	■■
Competition	Turbines	Turbines	3.57%			→	■■■
Competition	Support Structures	Support Structures	0.71%			→	■■
Competition	Electrical	HV topside equipment	0.40%			→	■■
Competition	Electrical	HV cables	0.40%			→	■■■

Level 1 indicator	Level 2 indicator	Level 3 indicator	Cost reduction potential weighting	L3 2014	L3 2015	L3 change 2014-2015	Outlook
Competition	Installation	Competition in Turbine Installation	0.50%			→	■■■
Competition	Installation	Competition in support structure Installation	1.64%			→	■■■
Competition	Installation	Competition in Cable Installation	0.93%			→	■■■
Collaboration	Vertical	Contracting packages / interface management	1.90%			↑	■■■
Collaboration	Vertical	Supply chain involvement	1.90%			→	■■■
Collaboration	Horizontal	Standard contracts	0.53%			↑	■
Collaboration	Horizontal	Knowledge sharing	0.53%			→	■■■
Collaboration	Collaboration	Technical standards	0.53%			→	■■■
Cost of Equity	Capital Availability	Bridge Equity (Construction) (% of total funding)	1.00%			→	■■
Cost of Equity	Capital Availability	Bridge Equity (Operation) (% of total funding)	1.00%			→	■■■
Cost of Equity	Regulatory risk premium	Regulatory risk premium / asset beta	1.00%			→	■■

Level 1 indicator	Level 2 indicator	Level 3 indicator	Cost reduction potential weighting	L3 2014	L3 2015	L3 change 2014-2015	Outlook
Cost of Equity	Construction specific risk premium	Construction specific risk premium	1.00%			→	■■■
Cost of Equity	Operations risk premium	Operations risk premium	1.00%			→	■■■
Cost of Equity	Developer risk premium	Developer risk premium	1.00%			→	■
Cost of debt	Gearing – construction	Gearing – construction	0.56%			↑	■■■
Cost of debt	Gearing-operations	Gearing-operations	0.56%			↑	■■■
Cost of debt	Construction debt margin	Construction debt margin (basis points margin, bps)	0.56%			→	■■■
Cost of debt	Operations debt margin	Operations debt margin (basis points margin, bps)	0.56%			→	■■■
Insurance	Construction phase	Construction phase	0.35%			↑	■■■
Insurance	Operations	Operations	0.35%			→	■■■

Table 3 CRMF 2014 and CRMF 2015 results

4 Technology work stream

This section presents the findings of the qualitative assessment for the technology indicators.

4.1 Project management and development

4.1.1 Current status

Progress in project management and development is assessed as ‘on target’. Although we have seen incremental improvements over the last year in the way that sites are developed, there is some change in level 3 indicators.

Progress in Front End Engineering Design (FEED) - optimisation and use of multi-variable array layout tools remained ‘on target’, with some evident improvements in multi-variable array layout modelling tools used by project developers. Evidence does however suggest that, although there are continued efforts by turbine OEMs to offer multi-variable modelling services for FEED studies, there is limited uptake by project developers.

Progress in development phase project management is ‘ahead of target’. Project developers now typically use offshore-specific project management systems, and TCE launched a web based knowledge management tool in October in response to industry demand.

The Burbo Bank Extension project completed financing based on energy yield calculations from wind resource data collected from floating lidar units as a primary data source. The use of floating lidar data for ‘bankable’ data provision provides evidence that the industry is ‘ahead of target’ against the pathways outlined in TCE CRP study in 2012. Provided best practice is followed (e.g. OWA roadmap), uncertainties associated with floating lidar measurements, and the associated impact on cost of finance, are expected to be comparable to those associated with offshore met mast measurement, representing a significant cost reduction.

Site investigation fell ‘behind target’ due to slowed progress in site investigation improvements. Respondents cited the tension between delivering detailed work pre-CfD award and the challenge in requiring the supply chain to commit in greater detail in a shorter timeframe. The time and expense is increasing between the request for information (RFI) to request for price (RFP) phases due to decisions being postponed, making tendering more expensive. The supply chain is however beginning to adapt and project developers have evidenced greater use of data from previous projects to inform new project designs e.g. commercial data from tenders and offshore logistics data as inputs to new models for subsequent wind farms.

4.1.2 Outlook

The use of floating lidar is likely to increase. Evidence from project developers suggested that, provided a robust verification was included, floating lidar has proven itself an acceptable and lower cost way to acquire site wind data. There are also a number of ongoing R&D projects seeking to develop lower cost novel site investigation methods such as the use of satellite data for bathymetric mapping and wind resource assessment. Innovations such as these can lead to lower development costs and should alleviate some of the pressure imposed by a more competitive project development environment under the CfD.

The introduction of the CfD is viewed by the supply chain as another layer of risk/competition and is a potential future barrier to increased involvement of the supply chain. Conversely, evidence also suggests that some round 3 project developers have coordinated deeper involvement from the supply chain during the development phase. In other EU countries (e.g. The Netherlands), development risk is reduced through policy that socialises development costs but there is also an opportunity for normalising industry best practice around involvement of the supply chain for development activities.

4.2 Turbines

4.2.1 Current status

Progress in turbine development is assessed as ‘on target’ and maintains a trajectory beyond that which TCE CRP study envisaged in its Technology Acceleration scenario.

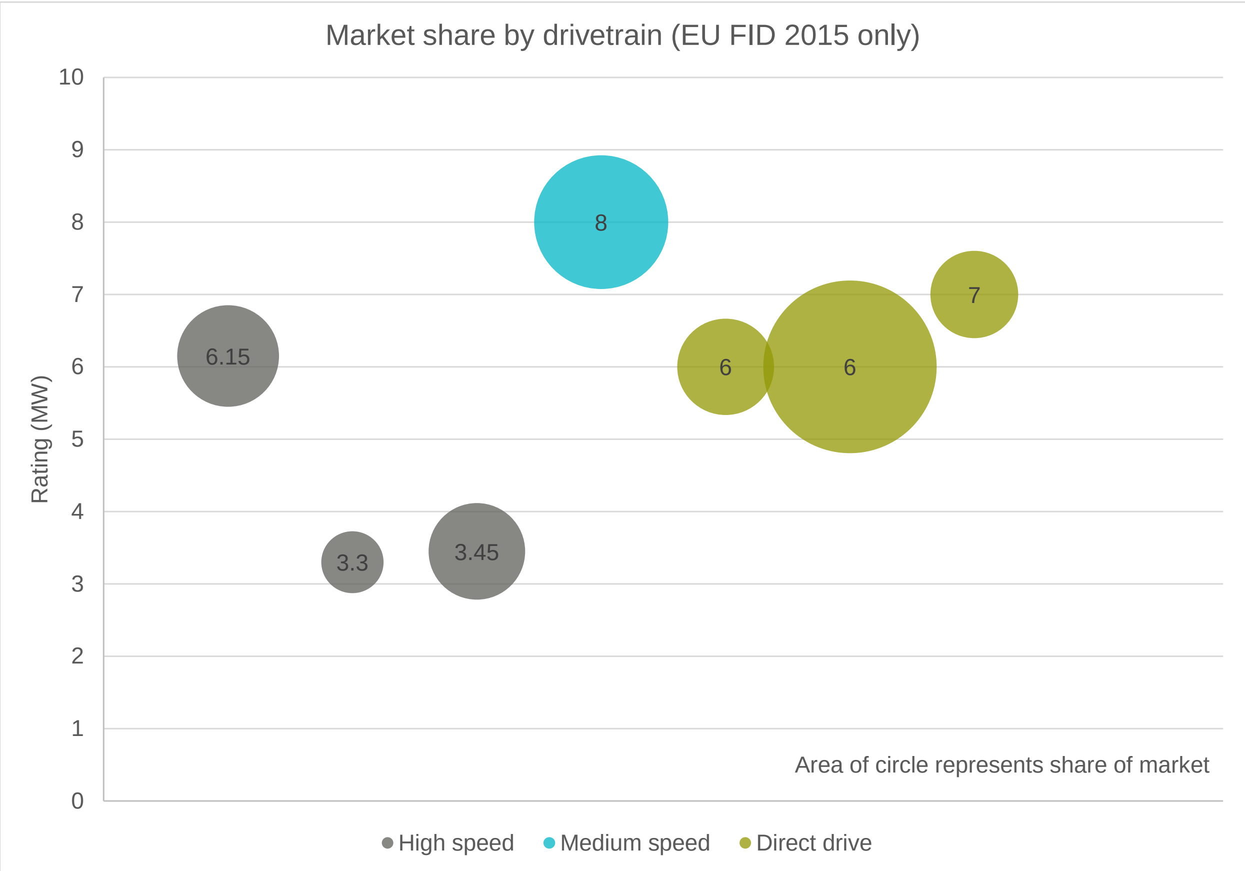

Figure 2 - Market share by drivetrain

The turbine rating indicator remains ‘ahead of target’. By MW reaching FID as shown in Figure 2, 56% of turbines contracted are in the 5-7MW range, up from 31% last year, 29% of turbines contracted were in the 7-9MW range and market penetration of 4MW-class turbines is low. This exceeds the prediction in TCE CRP study of a market penetration of 40% of 6MW-class turbines by FID 2017 and that use of 4MW-class turbines will have diminished. Progress also continues on 10MW+ turbine development with turbine OEMs making statements that suggest work is ongoing. The drive-train concept indicator is assessed as ‘ahead of target’. Figure 2 highlights that projects reaching FID in 2015 support the market trend towards use of direct drive and medium speed drive trains. Turbines using direct drive represent 53% of turbines contracted for projects reaching FID in 2015, up from approximately one third in 2014.

Progress in rotor optimisation is assessed as ‘on target’ overall with blade design and manufacture ‘on target’. Plans for blade manufacturing have continued to unfold, with the Siemens Wind manufacturing site in Hull reaching FID and MHI Vestas announcing plans to build blades for the V164 at the blade R&D facility on the Isle of Wight. This is positive progress for UK content in the supply chain. However, there continue to be risks to the move to serial production of 0-series 6-8MW class turbines, until manufacturing is proven at scale. The build out of 35 SWT-6.0-154 turbines for Westernmost Rough from Esbjerg by Siemens Wind is a strong signal that manufacturing at this scale continues to improve. Blade manufacturing concepts such as the GE (Blade Dynamics) multi-part D78 blade, currently under test at ORE Catapult, also show promising advances in blade manufacture and design. There remains an opportunity for improvements in the next generation of blade coatings, particularly focusing on proven erosion resistance and/or self-healing capability.

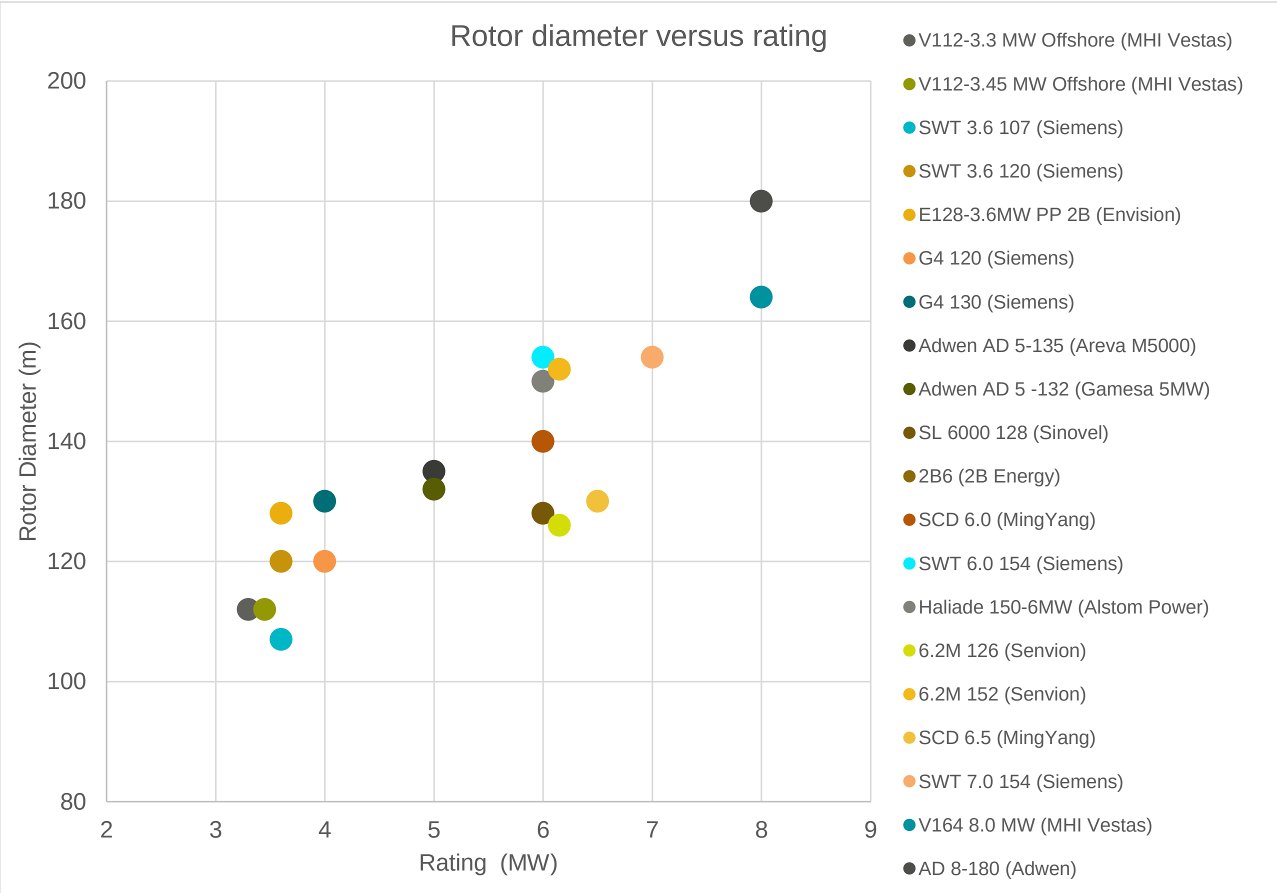

Figure 3 - Rotor diameter versus rating

Turbine OEMs continue to release products with larger rotor diameters (see Figure 3), although projects that reached FID in 2015 did not show an increase due to the relative immaturity of contracted turbines in the 6-8MW range. Despite this, the indicator remained 'on target' because continued evolution of turbine products, particularly steadily increasing rotor diameters, looks likely based on similar development of previous generation (2-4MW) turbine products.

The control indicator remains 'on target', with turbine OEMs stating that they have already developed active control on demonstration projects and implemented these improvements on commercial wind farms. Progress in commercial deployment of nacelle mounted lidar is however less advanced and significant opportunity to gain from increasingly sophisticated control systems remains.

Progress in integrated design is 'behind target'. Although the cost reduction potential of integrated design is technically proven[3], there is yet to be a commercial project that reaches FID with a fully integrated design (tower and foundation/support structure). Progress in this area looks unlikely based on current contracting approaches. However more than one developer described a desire, and work ongoing to remove the requirement for a transition piece from monopile based designs and some designs for more flexible installation have been implemented with a focus on 'design for installation' increasing in importance.

4.2.2 Outlook

The market for offshore wind farms, greater than 500MW in size, is unlikely to demand a 5MW turbine by 2020 because the majority of projects currently reaching FID are already utilising 6MW+ machines. There is however a possibility of a floating turbine market that demands this size of turbine, at least for initial demonstrator scale projects of relevance pre 2020.

There is limited evidence that generators using superconducting elements will be integrated into turbine products for projects that reach FID by 2020. Direct drive and medium speed gearbox configurations are likely to continue to dominate the market. Hydraulic drive train technology remains in testing as part of the MHI Vestas SeaAngel product of which two demonstrators have been installed. No commercially available turbines currently use hydraulic drive train concepts, and a route to European market is not described in evidence.

As rotor size increases with larger turbines, blade weight will increase. This threatens the validity of current design and manufacturing methods and accentuates issues such as blade erosion (which is related to tip speed). This highlights the requirement for new materials and slender blades in order to limit extreme loads and increased use of aero-elastic tailoring for passive load reduction. The industry continues to push the envelope of coatings resistance to blade erosion, supported by R&D programmes. Turbine OEMs could also challenge and improve wind turbine certification standards, using deeper understanding of component behaviour and failure modes to improve the fidelity of validation tests which will drive more reliable and optimised designs through the reduction of design margins.

[3] See project FORCE: Offshore wind cost reduction through integrated design undertaken by DNV-GL, 2014

There is a split industry opinion on the performance of blade upgrades versus improvements in the aerodynamic design of the blade. As there are improvements in power curve testing, the application and understanding of blade upgrades to operational wind farms will also improve.

There are currently 10MW+ drive trains in the design and development stages, however greater market certainty is required to ensure such technologies continue to receive investment and are brought to market efficiently.

A driver for integrated design in the future may be the move towards full EPC contracts and project finance requirements. Conversely, if turbine OEMs don't take on more risk of the balance of plant infrastructure, progression in integrated design will be limited.

4.3 Balance of Plant

4.3.1 Current status

Progress in balance of plant is assessed as 'on target', but there is significant variation in the progress of level 3 indicators.

The score for the XL monopile indicator advances to 'ahead of target' against an 'on target' score last year, despite a challenging pathway set in last year's study. Progress is evidenced through the announcement of monopiles weighing 1100 tonnes contracted for the Galloper wind farm. DONG Energy also installed monopiles over 6.5m in diameter on the Westernmost Rough wind farm. Novel piling and noise mitigation techniques for these larger monopiles are also well into the demonstration phase.

Progress in optimised jacket design and manufacture is assessed as 'behind target', as increasing envelope of application of monopiles continue to put pressure on jacket uptake. Purpose-built facilities are however well progressed and are preparing for a spike in demand from a number of near term projects, which are planning to use jacket structures.

Suction bucket support structures remain 'on target' with project developers planning to deploy suction bucket structures on projects in the near future. Demonstration projects (suction bucket and suction bucket jacket) have already taken place.

Progress in array cables is assessed as 'behind target', despite positive developments over the last year. A cable burial specification was released by the Carbon Trust through the Offshore Wind Accelerator (OWA) but there is still no industry-wide array cable standard.

Development of 66kV cables continues but the requirement for type testing in advance of commercial deployment delays progress. An ongoing R&D project aims to qualify a number of 66kV cables and they were commercially available by the end of 2015. Cigre also runs a working group to develop standards for 66kV[4] cables. Although final results are due in 2-3 years, initial findings are being utilised within Cigre to support development of standards.

[4] Technical working group is titled: Recommendations for additional testing for submarine cables from 6 kV (Um = 7.2 kV) up to 60 kV (Um = 72.5 kV)

4.3.2 Outlook

The outlook for XL monopiles is positive and it is anticipated that deployment will continue on relevant site types. Results from R&D projects that will feed in to future monopile designs are anticipated in early 2016 (PISA, SLIC & Vibropiling studies). There is however a limited pool of capable vessels and manufacturing facilities for XL monopiles which is expected to constrain future supply.

The industry is less optimistic about the outlook for jacket manufacture reaching the 2020 target. The main barrier appears to be maintaining visibility of consistent demand for jacket structures sufficient to feed existing facilities and to justify continued investment in future facilities. Therefore a potential squeeze in jacket manufacturing in the next 2 – 5 years is anticipated and the 2020 outlook remains uncertain. It was also clear from the evidence that there is a continuing challenge in optimisation for cost of design, weight of steel, manufacture and installation.

While there is optimism that sufficient cable specifications and standards are in development to meet the project specific needs of sites in 2020, 66kV technology is not without risks. First movers on 66kV cables are likely to be on the continent, with TenneT, the grid operator in the Netherlands, recently mandating 66kV use on offshore wind farms that connect to the grid. Project developers cited a hesitance to adopt 66kV cable technology before it gains track record, due to low manufacturing capacity and the marginal project specific cost benefit offered by the technology. Project finance structures may also influence future uptake as financiers perceive 66kV to be higher risk than established 33kV technology.

4.4 OFTO CAPEX

4.4.1 Current status

Progress in OFTO Capex is assessed as ‘on target’, but there is significant variation in the progress of level 3 indicators.

Progress in compact HVDC systems is assessed as ‘behind target’, with little uptake likely for projects reaching FID by 2020, although evidence suggests that two are considering the technology at the FEED stage in the UK. The distance from shore at which a developer might consider HVDC is shifting as the capability of HVAC technology is stretched. With the announcement of second generation compact offshore HVDC platforms (such as from Siemens Transmission Solutions), the relationship between technology, distance and cost becomes less clear.

Progress in AC reactive power compensation platforms (booster stations) is assessed as ‘on target’, and respondents cited no perceived barriers to the technology being deployed, although none have installed the technology yet. Projects are considering booster stations at the FEED stage in the UK, with DONG Energy at Hornsea 1 contracting Ramboll to supply the design for a booster station mid-way to shore.

Progress in standardisation of AC platforms is assessed as ‘on target’, however there is currently some uncertainty across industry as to whether it is too soon to standardise the technology at a system level. There is work ongoing on a ‘reference design’ for offshore substations and projects reaching FID to date have achieved standardisation on voltage, rating or size and some subsystems are standard components. TenneT releasing an ITT for five standardised offshore substations following DONG’s contract to deliver the same in 2014 is considered positive progress.

Progress in lightweight (or distributed) transmission systems is assessed as ‘on target’, and it is likely that the technology will be contracted on a UK project in 2016, with installation in 2018. OFGEM have now approved amendments to SQSS grid codes enabling acceptance of the technology.

Progress in overplanting and dynamic rating is assessed as ‘on target’. Although no projects reaching FID in 2015 will construct with oversized generating capacity, there is evidence suggesting use of dynamic rating, although it is yet to be widely adopted.

4.4.2 Outlook

A low industry score for the outlook of compact HVDC technology reflects the perception that projects reaching FID in the UK before 2020 are unlikely to use the technology, although other markets, such as Germany, are likely to continue development. A hub and spoke approach to offshore grid development is also unlikely in the UK due to the project-specific focus of the OFTO regime.

Despite significant cost reduction opportunities from de-centralised solutions like lightweight transmission systems, there is some evidence of concerns around increased costs elsewhere in the value chain. While lightweight systems promise the avoidance of larger heavy lift vessels (used for AC substation installation), the influence on other parts of the installation scope could offset some of the potential cost savings.

The relationship between the CfD mechanism and ‘nameplate capacity’ of a project means that overplanting has not necessarily been incentivised for developers to date. The OFTO and the project developer have slightly differing objectives that do not always align or drive cost reduction, so the future of overplanting in the UK is uncertain.

4.5 Installation

4.5.1 Current status

Progress in installation is assessed as ‘on target’, but there is significant variation in the progress of level 3 indicators.

Progress in blade installation is assessed as ‘ahead of target’, surpassing the target of 12 m/s by 2020. Some lifting equipment now offers over 15 m/s however not all projects are achieving this limit due to varying operating limits for cranes and vessels.

Progress in fast feeder vessels is assessed as ‘on target’ with some developers considering this approach in detailed FEED studies on projects further from shore where applicable.

Progress in gravity base structures (GBS) with turbine pre-installed is assessed as ‘behind target’, and progress in floating GBS is assessed as ‘missed target’. Although no commercial-scale projects reached FID in 2015, demonstration sites for GBS are known to be at the concept stage. There is some evidence of progress towards full scale demonstration of floating GBS in 2015. GBS are relevant to a limited number of projects only, but in at least one instance it is being actively considered where site conditions are suitable.

Indicators that track progress in monopile installation continue to highlight divergent progress where the purpose built monopile installation vessels indicator is assessed as ‘missed target’, and the operational weather windows for monopile installation indicator is assessed as ‘ahead of target’. There is no evidence of orders placed for new-build floating dynamic positioning (DP) monopile installation vessels due to lack of longer term pipeline visibility to justify investment. Project developers and vessel suppliers are however adapting logistics concepts for their project to suit market availability of vessels.

Respondents gave several references to limits of 1.5 – 2.0m Hs for monopile installation already being considered ‘standard practice’. This surpasses an industry target of 1.7m Hs for 2015 which is likely exceeded on some projects. This does however vary throughout the construction phase or with levels of project experience.

Progress in purpose built jacket installation vessels falls ‘behind target’, as predicted in the CRMF 2014 study with the vessel market remaining largely unchanged from last year. There are also no vessels currently on order that could carry and install 6 jackets. While new large jack-up wind turbine installation vessels (WTIV) (e.g. Scylla) are coming into the market, the predicted move to next generation floating DP vessels has not materialised.

Progress in flexible sea fastenings is assessed as ‘behind target’. Unless vessel suppliers have visibility of a pipeline of subsequent projects for which the fastenings would be useable, they are not incentivised to retain the sea fastenings so they are usually scrapped, hence a large potential cost reduction opportunity remains.

Progress in cable pull-in and hang-off processes is assessed as ‘ahead of target’, with at least one UK project committing to use a next generation cable installation/mechanical protection systems. While the cable installation process has seen improvements, the exit of Technip from the market has slowed progress. The inclusion of ‘walk to work’ access systems to improve access during cable installation is positive.

Progress in operational weather limits for cables is assessed as ‘on target’, with industry viewing 1.5m Hs as achievable. Furthermore there is a clear technology pathway to gradually increase this limit through the implementation of new vessels and tooling.

4.5.2 Outlook

The technology pathway and the potential benefit to installation weather windows of moving beyond limits of 15m/s for blade lifting is not certain due to performance limitations of vessels or related lifting equipment.

It does not look likely that a feeder vessel order will be placed in 2016 and at present the technology available may significantly increase the sensitivity of installation to weather (significant wave height) limits. The concept could be relevant for round 3 projects but the move to fewer 6-8MW structures versus many 3-4MW structures would likely lead to less cost reduction potential from this innovation.

GBS may become more attractive in the future as a means of increasing local content for the benefit of a wind farm supply chain plan. Due to the increasing size of turbines and support structures it is unlikely that any concept requiring the single lift of a complete turbine will take place without significant investment and testing of new vessels or installation methodologies.

It is unlikely that the 2020 target will be met for improvements in monopile installation vessels or an increase in weather windows to 2.5Hs due to lack of investment in new floating DP vessels. The increasing size of monopiles also places pressure on the vessel market to supply and it is likely that project developers will continue to use a combination of existing floating DP installation vessels (such as Seaway Heavy Lifting vessels) and high capacity jack-up WTIV for monopile installation. Respondents also mentioned that upgrades to existing vessels to extend their capabilities is likely for support structure installation vessels.

As XL monopile support structures are lowered from vessels through the splash zone, there is a significant technical challenge in absorbing the wave energy incident on the monopile, which may challenge market available technology. The extended use of capable jack-up vessels for monopile installation highlights use beyond that envisaged previously so, while the new-build market has not materialised, the market is likely to cope with demand to 2020 in light of a reduced market size.

The purpose-built jacket support structure installation vessel indicator is expected to slip further to ‘missed target’ next year. There is a limited selection of vessels available with the capacity to install several jacket support structures and/or to operate in deeper (>40m) water. As with monopile installation, it is likely that the industry will continue to rely on existing vessels up to 2020 but may struggle to cope with increased jacket sizes subsequently. A spike in demand for jacket installation vessels in the European market in the 2017-2019 timeframe may also present a challenge for the supply chain.

Developers, OEMs and the supply chain universally agreed that existing sea fastening arrangements for jackets are inefficient and wasteful. Technology is not a major hurdle, and if there was a sufficiently empowered owner driving collaboration, flexible sea fastenings could be used on future projects.

It is unlikely that a continued upwards trajectory for cable installation weather windows will continue indefinitely but the 1.8m Hs target by 2020 is achievable.

4.6 O&M

4.6.1 Current status

Progress in operations and maintenance (O&M) is assessed as ‘on target’.

Progress in turbine condition monitoring has advanced to ‘ahead of target’, with more than 20% of EU projects reaching FID in 2015 considered to be using integrated turbine condition-based maintenance. Turbine OEMs and project developers described an increased awareness of the power of enhanced data and analytics, and described a general trend towards increased use of condition monitoring systems, however there is uncertainty in the uptake of truly condition-based maintenance strategies. Turbine OEMs have invested significantly in prognostics and the analysis of condition monitoring data, and capability in this area is increasing.

Improvements in transfer from shore to turbine fell back to ‘on target’, although this indicator is close to achieving the milestone required to be ‘ahead of target’, with second or third generation CTVs being used on around half of all projects. The use of smaller, earlier generation CTVs on new projects is decreasing and third generation designs (World Marine Offshore Windserver and Umoe Mandal Wavecraft) have been used on commercial projects.

Offshore crew accommodation fell back to ‘on target’, which reflects that whilst service vessels are starting to be used, the concept is still far from standard practice for all projects. The majority of operators are actively considering the concept of offshore crew accommodation and turbine OEMs (Siemens and MHI Vestas) are already implementing it.

OFTO O&M fell back to ‘behind target’, although limited evidence was provided by OFTOs. A single OFTO evidenced use of condition monitoring to justify movement from OEM recommended O&M to reliability centred maintenance, which is an important first step but does not represent a full shift to a condition-based maintenance approach to OFTO O&M. There is however significant progress in third party service providers entering the OFTO O&M market.

4.6.2 Outlook

Implementation of condition monitoring equipment and the resulting increased understanding of asset performance is valuable, but truly condition-based maintenance strategies have not yet been implemented on a commercial wind farm.

A step change is anticipated to larger service vessels with offshore accommodation for projects in development beyond approximately 70km from shore. This development implies inclusion of walk to work systems, enabling an increase to 2.5 – 3.0m Hs limit for turbine transfer. Both reduction in CTV transfer time and an increase in the significant wave height limits for access play a significant role in justification of larger service vessels.

Currently, an OFTO asset is purchased as an integrated set of components, rather than a system integrated based on its through life cost. OFTO platforms designed to optimise O&M and availability are needed to deliver cost reduction by 2020 but are not currently incentivised.

4.7 Design life

4.7.1 Current status

Progress in design life is assessed as continuing ‘ahead of target’, with the majority of project developers assuming a 25 year design life, although some project developers mentioned a 20 year design life on their wind farms.

4.7.2 Outlook

Design life is likely to be influenced when the first projects reaching the end of their intended design life and experience around life extension and decommissioning is gained. The use of structural health monitoring to gain an improved understanding of real world performance has increased. It is an area which could unlock significant cost savings through design efficiencies and life extension and should remain a focus for the industry.

5 Supply chain work stream

This section presents the findings of the qualitative assessment for the supply chain indicators.

5.1 Growth and scale

5.1.1 Current status

Progress in growth and scale is assessed as ‘behind target’.

To achieve a 10GW pipeline of operational projects by 2020, it is assumed a build out of up to and including 5GW is required by 2015.

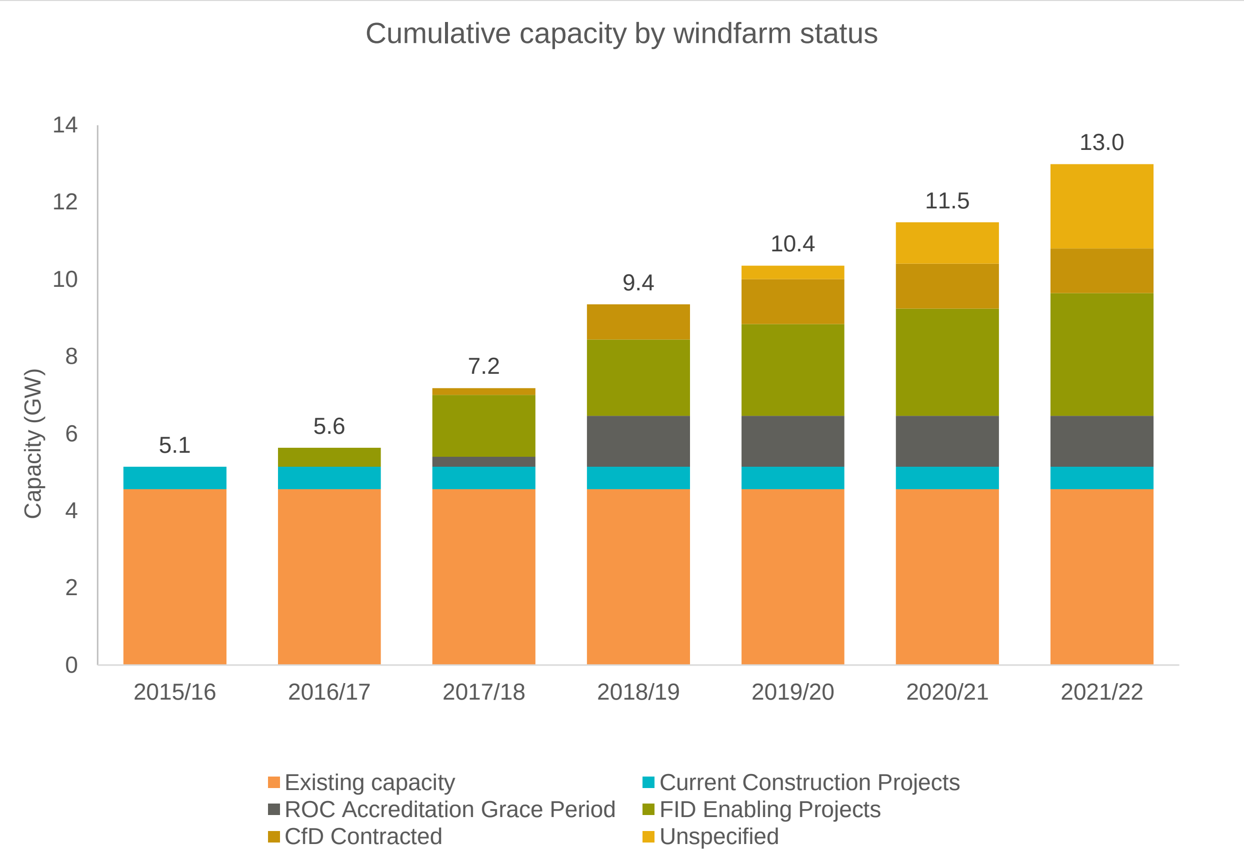

Figure 4 - Cumulative capacity by windfarm status

As of the end of November, an installed base of 5.08GW was fully commissioned[5], showing positive progress on last year’s reported 4.04GW. The milestones also demand that the UK market achieved a further budget (500-1000MW) through a 2nd allocation round, which has not occurred. A 10GW 2020 pipeline does however exist (see Figure 4) but places the UK market behind expectations. Progress is summarised in Table 4.

The recent announcement by the UK Government of three further CfD allocation rounds is positive. It is important to note that the allocation of further capacity under auction rounds is

[5] 4C Offshore Wind Overview Report, November 2015

crucial in order to secure projects reaching FID up to 2020 (the pipeline of 10GW installed capacity by 2020 implies projects taking FID up to ~2017).

UK Market Scorecard	2015 Target	2015 Actual	Impact on score
Operational	5,000MW	5,078MW	Suggests on target
Pipeline to 2020	10,000MW	10,400MW	Suggests on target
Capacity allocated under 2nd allocation round	500 – 1,000MW	0 (no allocation round held)	Suggests behind target

Table 4 UK market factors that impact scoring

Last year's study reported 7.52GW fully commissioned projects in the EU and the European Wind Energy Association (EWEA) expected 23.50GW by 2020 in their forecast central scenario which placed the indicator 'behind target'. As of July 2015, the reported installed capacity in the EU is 10,394MW[6] and the EWEA central scenario market forecast is at 23,493MW. Progress against the 2 key elements of this indicator is presented in Table 5.

EU Market Scorecard	2015 Target	2015 Actual	Impact on score
Operational	10,000GW	10,394MW	Suggests on target
Pipeline to 2020	25,000MW	23,493MW	Suggests behind target

Table 5 EU market factors that impact scoring

The forecast pipeline has not increased to meet a 25GW target by 2020. Although scored as 'behind target', the lack of change from last year's result highlights positive progress in maintaining a consistent predicted pipeline.

5.1.2 Outlook

The low to medium confidence in the UK and EU reaching build out targets by 2020 is based on the low visibility of the amount of capacity expected to be made possible by future CfD allocation rounds in the UK. The size of the overall Levy Control Framework and the share allocated to Offshore Wind are yet to be agreed. Similarly, the UK Government has announced that future rounds will depend on continued cost reduction, but the extent of cost reduction required in order to meet this condition is not yet clear.

[6] The European offshore wind industry - key trends and statistics 1st half 2015 A report by the European Wind Energy Association - July 2015

In the context of recent announcements by Government, the market forecast is unlikely to increase from the current 10GW forecast (based on projects reaching FID).

5.2 Competition

5.2.1 Current status

Progress in Competition is assessed as ‘on target’, with no change across any of the level 3 indicators since last year. There is however a continued trend of consolidation. Positive progress this year includes publication by DECC of an agreed methodology for measuring the UK content of UK offshore wind farms.

Turbine

Progress in turbine competition is assessed as ‘on target’, with the number of players in the market consistent with the trajectory assumed by TCE CRP study in 2012. Siemens, MHI Vestas, Adwen and Senvion remain the only turbine OEMs with’ available products and an offshore track record, however only 3 of these have signed contracts to supply turbines for EU projects reaching FID in 2015 and several developers see competition as predominantly between two players in the 7-8MW class of turbine. Joint ventures in the turbine supply chain have strengthened product offerings and have led to increased competition due to progress in new jointly developed turbine designs:

MHI Vestas are trialling the 7MW SeaAngel prototype and continue development of the V164 8MW product, continuing to win orders in 2015.

Adwen will begin type testing the AD 8-180 8MW turbine drive train in 2016.

The 6MW Alstom Haliade turbine is now demonstrated in an offshore environment.

Concerns were raised in last year’s qualitative assessment with respect to the demand for UK content in the supply chain being a potential limitation on competition in turbine supply. While Siemens (with a future UK supply base) does continue to dominate, MHI Vestas has secured two contracts to supply projects reaching FID in 2015[7].

Support structure

Progress in competition in support structures is assessed as ‘on target’, however the supply of XL monopiles is still potentially as low as three experienced suppliers. There is a hesitancy across industry to use low-cost (non-European) suppliers, but there are several references to macroeconomic changes (e.g. the price of steel) being likely to impact this trend in the future.

Electrical

Progress in both HV topside equipment and HV cables competition is assessed as ‘on target’, with at least 4 main suppliers of electrical equipment for HV topsides and significantly more fabricators working on substation platform design, integration and manufacture. While there are a sufficient number of HV topside equipment suppliers to meet the ‘ahead of target’ milestone

[7] MHI Vestas will supply the V112 and V164 turbines to Rampion and Walney Extension Phase 1, respectively

for this indicator, it is marked ‘on target’ due to a low level of competition in some areas such as higher voltage cables (>150kV).

Installation

Competition in WTIV supply remains ‘ahead of target’ with more than 15 wind turbine installation vessels on the market. There is evidence of at least 2 new build WTIVs forecast to enter the market in the next 1 – 2 years. This is lower than the number of new builds previously envisaged. The industry has however surpassed targets for total number of vessels and the number of new builds remains limited. In the context of a smaller market, supply is likely sufficient to meet demand although there is still concern about availability of WTIVs when moving to water depths of 40-50m (e.g. Fred Olsen are carrying out a leg and boom extension for the Brave Tern and Bold Tern vessels).

Competition in Heavy Lift Vessels (HLV) for support structures remains ‘on target’, with 15 WTIV capable of support structure installation and 5 HLVs capable. There is limited progress in 2015 with no floating DP support structure installation or fast feeder vessels on order. Despite some notable new jack up WTIVs, the number of vessels capable of lifting the next generation (over 1000t) monopile structures remains small. There is one new build HLV (Rambiz 4000) on order but it is anticipated that this will work primarily on substation installation as it is over specified for turbine support structure installation.

Competition in cable installation vessels[8] remains ‘ahead of target’. Alongside a fleet of at least 20 vessels or barges with offshore wind project experience, one operator recently launched a new purpose-built cable installation vessel and at least two others are on order for delivery in the next 1 – 2 years.

5.2.2 Outlook

Turbine

The existing pipeline of EU projects looks likely to be sufficient to sustain the current number of turbine OEMs, but in general turbine supply is seen as less competitive than tier 1 suppliers in other industries. This situation looks unlikely to change significantly before 2020. Non-EU turbine OEMs may enter the market but evidence suggests that this is not likely until after 2020.

Newer turbine concepts from outside the market leaders have also reached the demonstration phase, such as the 2B6 from 2B Energy. Although it is unlikely that these concepts will have a significant market share by 2020 to be considered driving competition, they are a positive contribution to turbine technology innovation.

Support structure

The low level of demand from the oil and gas industry for support structure (particularly jacket) fabrication at present, a lack of investment in the supply chain, and the current and future

[8] Progress in both export and array cable laying vessels is covered by this indicator.

direction of raw materials (steel) markets will impact future growth in this area of the supply chain.

If all projects that have specified the use of jackets in the current pipeline move to construction, there is the possibility of a highly competitive serial jacket manufacturing market (tending towards under-supply) in the coming few years.

Electrical

There remains a possibility that non-EU HV topside equipment suppliers may enter the market, particularly from Japan, which could drive increased levels of competition. The level of competition in HV cables is unlikely to increase unless low-cost suppliers enter the market

Installation

Figure 5 highlights that shortage of suitable WTIV is possible as the demand for new vessels with greater lifting capacities and working depths increases and as turbine sizes increasing beyond 8MW. A further limiting factor could be increased demand for the highest capacity jack up vessels for support structure installation, reducing the pool of vessels available for turbine installation. There is also some evidence of European players looking for (and winning) work in non-EU markets. The installation competition indicator could therefore drop down from ‘ahead of target’ in subsequent years.

A lack of market certainty can influence investment decisions as demonstrated by the exit of several major industrial players. The financial strength of organisations, particularly those that rely on offshore wind as a core business, may continue to be a risk for the industry. Also the competitiveness of the wider vessel supply market is closely related to the general downturn in the oil and gas market. Market factors such as these are likely to lead to further consolidation in the vessel supply chain.

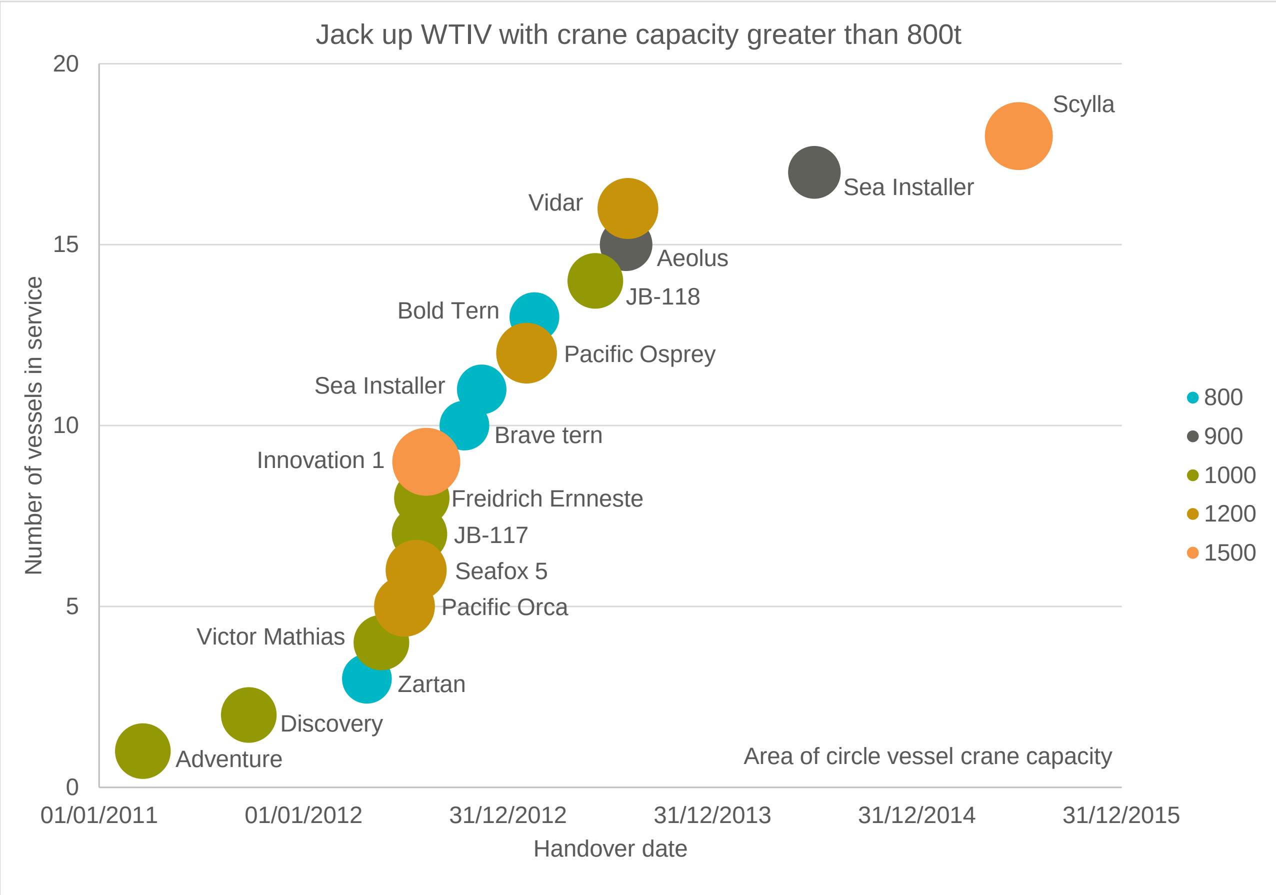

Figure 5 - Jack up WTIV with crane capacity greater than 800t

5.3 Collaboration

5.3.1 Current status

Collaboration is assessed as 'on target' overall with some variation in level 3 indicators.

Progress in number of contracting packages is assessed as 'on target', due to 3 projects reaching FID in 2015 closing with less than 5 packages. It is however unclear from the evidence if a trend in the industry to fewer packages is leading to reduced contingencies. For instance, there was some indication that a reduction in contract numbers is not necessarily the route to reducing contingencies throughout the whole supply chain.

There is a split in approaches between project developers in their involvement of the supply chain. Those who are seeking to consolidate contracting packages tend also to seek involvement of supply chain earlier and in more detailed design work. The indicator for supply chain involvement remained 'on target'. Evidence suggested however that balance of plant and installation contractors tend to be involved less for contribution to wind farm design and instead feel pressure for more accurate costs in less time with less information provided. This contrasts evidence that suggested that round 3 projects in development have had significant involvement from their whole supply chain during the project FEED stage.

Despite warnings last year that standard contracts would fall to ‘behind target’, progress is assessed as ‘on target’, due to increased use of adapted LOGIC forms and standard clauses and the introduction of BIMCO Wind time.

Progress in knowledge sharing and technical standards remains ‘on target’ and ‘ahead of target’ respectively. Many respondents were actively participating in a number of Knowledge Sharing Forums, (including OWA, OWPB, OWIC, SPARTA, ORE Catapult O&M forum, BLEEP and G9) and some respondents were able to describe tangible operational benefits and cost reductions gained as a result of the knowledge gained.

5.3.2 Outlook

Existing framework agreements are a vehicle for securing more commitment from the supply chain early but this is not representative of the whole industry. It is unclear if there is a consistent move towards greater pre-PQQ involvement of suppliers on projects in development beyond those that reached FID in 2015.

There are a number of approaches to contracting strategies in the industry and it is likely this trend will continue. The 2020 CRMF milestone for cost reduction assumes reduction in contracting package is optimal for cost reduction but this is not always the case in practice. The finance community are however in general supportive of the trend towards ~3 EPCI[9] contracts and they see this trend as an opportunity to reduce costs.

It is unrealistic to aim for a completely standardised approach to contracting because the industry risks wasting time in negotiating a standard approach that will never suit every organisation. New approaches like those offered by The BIMCO Wind Time show promise but approaches will need to be suited to specific organisational needs.

Almost all respondents described a trend towards reduced intercompany knowledge sharing in future, driven by a competitive (CfD) auction system. The dissemination of anonymised and aggregated sector data through initiatives such as SPARTA are now more crucial than ever in stimulating further knowledge sharing and collaboration in the sector.

Opportunities exist for improvements in targeted areas where new standards would be of benefit and in the dissemination of new guidelines and standards across the industry to drive rapid acceptance and uptake.

[9] Due to OFTO regime in the UK, it is unlikely that the number of contracting packages will reduce to much less than 3.

6 Finance work stream

This section presents the findings of the qualitative assessment for the finance indicators.

6.1 Cost of equity

6.1.1 Current status

Progress in cost of equity is assessed as ‘on target’, which is positive following concerns in last year’s report that this indicator could fall behind by 2016.

Capital availability for both operational projects and projects in construction has increased beyond the demands of the market, leading to an ‘on target’ score. The Green Investment Bank (GIB) reached its equity fund target of £1bn for operational projects which is a significant milestone. There is also a number of targeted offshore wind funds set up and in development such as the EIG Mezzanine Fund.

There is increasing interest from new sources of equity beyond utilities for construction of offshore wind projects due to the relative attractiveness of the returns for construction phase equity, technology and construction risk becoming better understood through track record and institutions entering as they see others enter the market (collective confidence).

Respondents generally were of the view that progress in technology innovation (e.g. purpose built vessels to increase weather windows) has provided a targeted approach to risk reduction. Although track record is building, the construction risk premium indicator falls ‘behind target’ this year but progress is expected in 2016. This is evident particularly in the shift of cable issues down the agenda for many respondents across the industry. The current improvement is assumed to be offset by the risk of working in a new market environment (deeper water sites, further from shore, new technology).

Previously the qualitative assessment anticipated a reduction in operations risk premium in projects reaching FID from 2015 onwards. Although there is no clear evidence that operations risk premiums have dropped, initiatives such as SPARTA and the ORE Catapult O&M forum were cited as giving confidence that the industry is making progress.

Developer phase risk premium remains ‘on target’ because there is no evident shortage of equity or debt capital and there have not (recently) been any major technical issues effecting investor confidence.

The finance community views the CfD as a positive move for the sector in driving down costs, although delayed announcements, changes to policy and the recent removal of LECs for green electricity generators has had a negative impact on the cost of equity and investor confidence.

The regulatory risk premium indicator is assessed as ‘on target’ due to progress in set up of the Low Carbon Contracts Company (LCCC) and, although first CfD payments are yet to be made, there are no indications yet of any specific risks emerging.

Evidence suggests allocation risk is consistently viewed as greater than any perceived technology risk. The finance community highlighted that private equity for the development phase of a project is now unobtainable due to the increased allocation risk under the CfD regime. Throughout the project developer community there is also an awareness of the chance that projects in early development (consent post 2020) may not receive a CfD contract. This is covered in more detail on page 35.

6.1.2 Outlook

Increased diversity in the equity market offers more certainty that it won't fall away in the short term. The continued work of the GIB will support this trend and its involvement is consistently cited across the sector as increasing investor confidence and improving liquidity. There is however still a risk that construction equity availability could lessen due to:

The large volume of projects that need funding in the next 3-5 years (including those awarded early CfDs, first auction winners and future auction rounds), although it is unclear if the constraint is on the amount of capital or the available skills and expertise to deal with the volume of transactions. As more debt funding becomes available, utilities may struggle to find equity (the GIB equity fund is for operational projects).

The ability of utilities and financial institutions to spread risk through their corporate facilities as offshore wind becomes a core asset in the context of their wider energy or infrastructure portfolio.

A major global financial crisis or a serial engineering defect reducing investor confidence.

Other energy sectors have seen utilities sell down entire ownership of projects and this is possible for offshore wind but unlikely in the short term. It is likely that some retention (at least 15-25%) by utilities will be required, as a condition of funding from equity partners and lenders, out to 2020.

Interviewees across the finance sector suggested that construction and operations phase risk premium may reduce but that track record will need to continue to build in order for this to happen. The finance community shows increased levels of comfort with technology risk in turbines, showing progress on last year. The insurance community also cited that compared to other industries, turbine OEMs have been particularly effective at delivering in accordance with their warranty agreements.

Recent changes to policy (Early closure of the RO, LECs and introduction of CfD) has increased the relative scarcity of development expenditure. The size of projects (particularly round 3) means the quantity of capital at risk is often in excess of £50m for a single project. Any confidence provided by higher visibility of the regulatory process may be outweighed by the increase in quantities of capital at risk by developers.

Under the CfD regime, respondents urged clarity of a long term commitment from government if it wants to secure route to market for floating wind technology.

6.2 Cost of debt

6.2.1 Current status

Progress in cost of debt is assessed as ‘ahead of target’, due to the gearing and cost indicators surpassing even the 2020 targets (i.e. Far beyond the 2015 targets). Although the debt margin is measured in this study, the main drivers for reduced cost of finance in this area are record low interest rates and the lack of returns available in other infrastructure sectors, factors which are outside of the industry’s control.

In the 2014 qualitative assessment, it was noted that the introduction of Basel III has not had a sizeable impact on the debt market and that market liquidity may increase. Although a number of European banks have not been able to offer the tenor required in offshore wind, it has given room for non-EU banks to enter the market. The availability of debt capital is increasing due to an increase in banks entering the market, the learnings available from previous transactions and a lack of other transactions in the wider infrastructure market.

As the size of projects increases, fewer transactions are available in larger sizes and banks continue to meet these requirements. Where banks are not offering more than £150m in debt funding for a particular deal, club deals are emerging and debt is often syndicated after the deal has completed. This capital is available for construction as well as operations, for example Nordsee 1 completed its construction deal with 10 commercial lenders.

The role of the European Investment Bank (EIB) in financing offshore wind farms has lent credibility to the sector, which has given banks that are new to the sector additional comfort. For attracting finance to projects in excess of £1.5bn, the need for the EIB is particularly strong. Respondents cited its role as both increasing liquidity and reducing the cost of debt within deals.

Progress in debt gearing is assessed as ‘ahead of target’. Interviewees also stated that it is becoming commonplace for levels of gearing for debt during both operation and construction to be around 70-75%. In October 2015, Galloper reached FID with debt finance making up part of the funding through the construction phase. Nordsee 1 also secured 70% debt for the construction phase, due to begin in 2016.

Evidence from interviews suggests that during operation, debt margins could be as low as 215 basis points, rising to around 235 towards the end of the debt tenor’. For construction projects, slightly higher levels of debt margin were cited with some indication that they could reach lower than this on some of the smaller wind farm projects. This places the indicator well ‘ahead of target’ against the scenarios previously envisaged, however the current state of the global financial market is a more significant driver than any industry-specific initiative.

6.2.2 Outlook

The outlook for availability of debt is positive however the sector faces a number of risks. Although club deals and syndication of debt is occurring, there is still a risk that a secondary market is not available as quickly as it is needed. Current investor concern for the lack of deal flow in the global market has driven availability up for offshore wind and there is a risk that this could fall away in the medium term.

During interviews, green bonds were cited as a growing and efficient way of raising finance for utilities. This would help lower tax and give tighter spreads for the company issuing them.

Due to the relatively high risk inherent in construction and operation of offshore wind assets, it is likely that financial institutions will mandate utilities to retain ownership of at least 15%. There is a view that utilities could retain up to 25% equity share in an offshore wind project without impacting their credit rating. Holding a share greater than 50% would be likely to have a negative impact on credit rating, while the range of 25% to 50% is more of a grey area, with the specifics of OFTO financing and contracting packages being critical. Some of the finance community were confident that it is possible to achieve 20% gearing for projects reaching FID in 2020. Levels in the thermal power generation sector have historically reached 5% but it is not clear that this trend will be supported in offshore wind.

Construction and technology risk are still very high on the finance communities' agenda. A single serial default or a long delay due to a construction issue could be detrimental to the current high confidence in the sector. There is an increasing uptake in long term service agreements from turbine OEMs but some are shifting to in-house O&M. The cost savings associated with this will have to be proven to convince financiers of the benefits.

Yield compression is also a key feature of the current market condition. As interest rates stay low, there is a downward pressure on returns so the supply of cheap finance is high. This scenario is positive but the sector remains vulnerable (as do other infrastructure sectors) to external market shocks which could lead to a change in current market conditions.

6.3 Cost of insurance

6.3.1 Current status

The absolute level of offshore wind premiums will depend upon the total capex for the project (construction insurance) and the annual revenues that the project is expected to accrue (business interruption insurance), as well as perceived risk for the project. In addition, operations premiums will continue to be a function of the level of deductible that the operator is willing to take on.

Progress in insurance is assessed as 'ahead of target' across both insurance for construction and operations, which is consistent with anticipated progress.

The construction premiums cost indicator has advanced from 'on target' to 'ahead of target'. The evidence suggests that construction premiums have dropped and continue to track lower than the milestone of £40k/MW in TCE CRP study. Calculated as a percentage of project costs, the increased size of wind farms is likely to be in part responsible for this reduction.

Operational insurance is normally the second largest operating cost[10] after the maintenance contracts for an owner operator. Progress in the cost of operations premium has remained 'ahead of target', with insurance premiums for the operations phase remaining consistent with last year, at approximately £13-14k/MW/annum installed, highlighting progress in this indicator.

6.3.2 Outlook

Turbines are not perceived as the highest risk area for insurers. Concern was expressed from insurers at the fact that a major claim in offshore wind (such as a business interruption claim due to export cable failure) could change the relative attractiveness of the sector and increase pricing in a very short timeframe. Respondents cited that this risk is accentuated because there is no clear recourse against the OFTO if it does not meet its obligations. This disconnect leaves the sector open to future risk.

The end of warranty period is challenging for an insurance company serving a wind farm. An insurer will require proof that the post warranty strategy is secure and that the operational data from the asset proves its reliability. This will in turn lead to insurance cost reduction. The insurer will look at warranty extensions for inclusion of aspects such as logistics, maintenance strategies, demobilisation etc. Other bottleneck areas that could help reduce premiums include standardisation and universal joints, vessels, spares strategies, vessel pooling, spares clubs, redundancies in the wind farm and buffers in construction schedules.

The relative attractiveness of offshore wind is currently high compared to other insurance market sectors. Should there be increased demand from other markets, supply of insurance to offshore wind projects may become less attractive for insurers. A major catastrophe elsewhere in the world could also place financial pressure on insurers and this could impact premiums in offshore wind.

[10] Depending on the level of OFTO charges incurred, which could be even more substantial than insurance.

7 Industry challenges and risks

This section provides an overview of key challenges and risks to industry progress, identified in this analysis.

Cost reduction progress 2014-2017

TCE CRP study suggested that there would be relatively little reduction in LCOE by 2014, in its three scenarios: Slow Progression, Technology Acceleration and Supply Chain Efficiency. As we advance to 2017, the latter two scenarios predicted rapid cost reduction between 2014 and 2017, subject to higher volumes (18GW in the UK). The Slow Progression story (12GW in the UK) assumed limited progress. The sector has however continued to achieve cost reduction, despite reduced volume and further CfD auction rounds will continue to drive this.

Findings suggest that in 2015, cost reduction is already being achieved through innovations that were not expected to contribute in great quantity to cost reduction until 2017[11]. Limited positive changes to the Level 1 indicators between 2014 and 2015 should be interpreted as the industry advancing because the annual milestones demand progress so the same score in 2015 means that there has been progress since 2014. The cost reduction target of £100/MWh has proved to be a useful milestone, despite a reduction in market volume and changes in the global economic context, such as sustained low interest rates and the decline in the oil and gas market.

Progress in installation and balance of plant

Close attention should be paid to certain balance of plant and installation indicators that are at risk of slower progress in future. These areas are subject to a number of layers of risk, some unforeseen prior to the publication of TCE CRP in 2012, such as decline in the oil and gas markets, lower market volume and increased allocation risk through the introduction of the CfD. There is also slower than anticipated progress in demonstration of technologies such as 66kV cables and gravity base support structures.

Risk of uncertainty in political support

November saw positive announcements indicating three further CfD allocation rounds to 2020. Although consultation for this study completed prior to this announcement, respondent's views were that a lack of market visibility could reduce development within the sector which is a risk to cost reduction. Both developers and supply chain companies are in need of market certainty to enable investment in demonstration projects and manufacturing facilities. The industry also has peaks and troughs due to development timelines which can be a high barrier to entry. Despite this, many in Europe are taking on the risk of investment in bespoke facilities. For this to continue, there is a commonly described need for early sight of auction dates, administrative price setting and the quantity of funding in the Levy Control Framework (LCF).

[11] Assumption made by TCE Cost Reduction Pathways report in 2012.

Volume post-2020

There remains uncertainty in the market beyond the end of the current LCF in 2021. To alleviate allocation risk in the shorter term, project developers and the supply chain will need longer term certainty to ensure they can balance the risk of not achieving CfD.

It is unclear if low regulatory visibility will significantly impact financing costs as we progress to 2020 and beyond. The involvement of the EIB in financing projects has delivered positive progress to date but a balance will need to be found between their involvement versus the inclusion of new private investors to allow them to gain track record (hence reduce future costs). To reduce the risk of falling capital availability in the future, the industry should maintain focus on long term financing partnerships with new capital.

Unintended impacts of the CfD mechanism on the supply chain

Introduction of the CfD mechanism with low allocation levels has increased competition, demonstrated through reduced LCOE. This is exerting downward pressure on project costs and improving value to the consumer. There are however some indirect impacts of the new support regime that should be addressed.

Allocation risk remains high on the industry's agenda in the UK and it was consistently cited through interviews that there is no clarity on the level of budget available within the LCF in the auctions to 2020 and an extension of the LCF beyond 2021. In the last CfD auction two out of five offshore wind farm project developers were allocated a CfD. All incurred significant costs to get to this stage.

With smaller than anticipated allocations and ever tighter administrative price setting, there may well be a slowdown in long term development of technology solutions for the more challenging projects. Adding to this uncertainty is the increasing number of project developers considering departure from the offshore wind industry[12] and limited chance of private equity entering into the development phase of a wind farm. Reducing development risk through policy, as attempted in other EU countries (e.g. the Netherlands), is unlikely to support UK projects reaching FID by 2020, but there may be lessons learned from these countries that could support long term development of the UK sector. A review of these lessons learned and of eligibility criteria for applying for a CfD would be beneficial for the sector.

There may be a disincentive to knowledge sharing and collaboration in preparation for the auction both between developers and in the supply chain. It could also be a barrier to smaller new entrants that may have innovative solutions. There is however contradictory evidence of projects currently in development successfully managing deeper involvement with their supply chain. The balance between collaboration and competition is a difficult one to strike and the latter example may be a positive sign of the industry maturing. Respondents did however consistently cite that the CfD regime was discouraging knowledge sharing between project developers and the supply chain.

[12] In 2015, Repsol and Statkraft announced slowdown in support to offshore wind developments. Centrica is also seeking to divest its wind assets.

Investment in site investigation and design offers significant opportunity for cost reduction, however uncertainty in financial support discourages early investment in surveys and FEED studies to optimise design particularly before CfD award. It is also unclear if novel approaches to site investigation (e.g. floating lidar) will yield improved data or only lead to the provision of the same data but at lower cost. Tight delivery timescales under the CfD also give less space for design iteration and innovation. To mitigate the risk of deploying sub-optimal designs, it is important that project developers continue to share best practice on involvement of their supply chains and on site investigation innovations that reduce development costs.

Future CRMF development

All supply chain consultations viewed the UK and European markets together and future progress in the UK will be closely linked to the EU market. Germany, UK and the Netherlands will each deliver similar market volumes over the next 10-15 years. These synergies should be the basis for future OWPB collaboration and the CRMF is a platform through which to facilitate cooperation. There are, for example, a number of other groups in the EU that have a similar remit to the OWPB such as the Offshore Stiftung programme in Germany and TKI Wind Opp Zee in the Netherlands.

For continued support, the industry needs to demonstrate cost reduction. Recent policy announcement increases the significance of a quantitative LCOE assessment as part of the CRMF 2016 study. The results of the CfD auction in March ‘15 supported the findings of CRMF 2014 giving confidence that the methodology is providing accurate and relevant results.

8 Recommendations

Recommendations are presented alongside the findings of this report in Table 6.

Summary finding	Summary recommendation	Owner
Growth and scale		
In the last CfD auction two out of five offshore wind farm project developers were allocated a CfD. All incurred significant costs to get to this stage. With smaller than anticipated CfD allocations and ever tighter administrative price setting, there may well be a slowdown in long term development of technology solutions for the more challenging wind farms. The CfD mechanism also places increased risk on development equity and the supply chain during project development, which can drive up overall project cost. All supply chain consultations viewed the UK and European markets together and there are a number of other groups in the EU that have a similar remit to the OWPB.	Engage regulators on lessons learned from implementing mechanisms used to reduce development risk in other European countries, such as changes to CfD application eligibility criteria or undertaking state-funded project development activity. Continue to investigate comparisons/collaborations with equivalent European organisations such as the Offshore Stiftung programme in Germany and TKI Wind Opp Zee in the Netherlands.	OWPB
Project Management and Development		
There is a tension between delivering detailed work pre-CfD award versus the need for the supply chain to commit earlier by providing more detailed bids in a shorter timeframe.	Undertake a study into novel approaches to site investigation to enable higher quality/lower cost data provision before the pre-qualification questionnaire (PQQ) stage of development e.g. increased use of remote measurement.	OWPB technology and innovation group

Summary finding	Summary recommendation	Owner
Turbines		
Turbine development remains ahead of target. Progress in commercial deployment of nacelle mounted lidar and superconducting generators is however lagging.	Support development and demonstration of technologies (e.g. nacelle mounted-lidar and integration of wind farm control systems, test lab demonstration of superconducting generators). This should be informed by an industry-led forecast of cost reduction opportunities supported by OWPB and key stakeholders.	OWPB technology and innovation group
Balance of Plant		
There has been significant progress in the R&D of 66kV and gravity base structures but the industry is still experiencing delay in commercial deployment. A cable burial specification was released by the Carbon Trust through the Offshore Wind Accelerator (OWA) but there is still no industry-wide array cable standard.	Ensure that demonstration sites are secured to de-risk gravity base structures. To ensure continued progress in deployment of 66kV, ensure lessons learned about early deployment of the technology are disseminated to industry. Prioritise research to enable optimisation of jacket designs.	OWPB technology and innovation group
	Undertake a review of the gaps in cable standards to understand where future efforts should focus.	OWPB grid group

Summary finding	Summary recommendation	Owner
Offshore Transmission Operator (OFTO) Capex		
Transmission technologies face a number of barriers to further development. The OFTO and the project developer have slightly differing incentives that do not always align or drive cost reduction.	Continue work in understanding the true cost reduction potential of optimisation of AC platform design, increased capacity AC cables, lightweight (or distributed) transmission systems and HVDC.	OWPB Grid group
	Investigate the implications of the OFTO regime as a barrier to cost reduction in offshore wind. Propose modifications which would enable greater cost reduction in OFTO infrastructure.	OWPB
Installation		
There is no evidence of investment decisions to commission new floating DP support structure installation vessels in 2015. Development of flexible sea fastenings for jacket support structures is an area of potential cost reduction. Unless vessel suppliers have visibility of a pipeline of subsequent projects for which sea fastenings would be useable, they are not incentivised to develop them.	Investigate the impact of forecast deployment rates and site conditions on the requirement for additional investment in new vessels and evaluate the required improvements and modifications to the existing fleets. Assess what would be required to adequately incentivise the widespread use of flexible sea fastenings for jacket support structure installation.	OWPB technology and innovation group

Summary finding	Summary recommendation	Owner
Operations and Maintenance (O&M)		
There is significant progress in development of condition monitoring techniques and innovative maintenance strategies. Implementation of condition monitoring equipment and the resulting increased understanding of asset performance is valuable, but tracking the implementation of truly condition-based maintenance strategies should be considered.	Undertake a review of the use of condition-based maintenance strategies across the industry to establish best practice. The ORE Catapult O&M case study publications are a potential route to dissemination.	OWPB O&M Group
Design life		
Structural health monitoring is increasing and is an area which could unlock cost savings through design efficiencies and/or life extension.	Develop a collaborative industry led project to increase quality of structural monitoring and encourage data sharing as an input to designs and improved assessment of asset integrity.	OWPB technology and innovation group
Competition within the industry		
A lack of market certainty can influence investment decisions in the supply chain, as demonstrated by the exit of several major industrial players. There has recently been significant consolidation in the market, particularly for turbine OEMs.	Continue to monitor impact of reduced market volume on the supply chain. A simple tool that tracks this could be used by the group to help inform specific actions. This could build on the capability of the online RenewableUK supply chain map.	OWPB supply chain group

Summary finding	Summary recommendation	Owner
Collaboration		
Almost all respondents described a trend for reduced intercompany knowledge sharing in future, driven by a competitive (CfD) auction system. There is a continued downward trend in number of contracting packages, with some indication that reduction in contract numbers is not necessarily the route to reducing contingencies throughout the whole supply chain. There is currently a split in approaches between project developers in their involvement of the supply chain. Those who are seeking to consolidate contracting packages tend also to seek involvement of their supply chain earlier, involving them in more detailed design work. New approaches like those offered by the BIMCO Wind Time contract form show promise but approaches will need to be suited to specific organisational needs. The dissemination of anonymised and aggregated sector data through initiatives such as SPARTA are now more crucial than ever in stimulating further knowledge sharing and collaboration in the sector.	Consider whether an appropriate balance between competition and collaboration is being achieved, and whether the industry is becoming more mature or whether CfD has indirectly increased barriers to knowledge sharing too quickly. Consider how to ensure that lack of supply chain involvement pre-PQQ in balance of plant does not prevent innovations and optimised solutions. Consider the impact of number of contracts on contingencies and enable sharing of best practice across the industry. Consider value of new standard contracts e.g. BIMCO Wind Time. Build on the skills and experience already gained in industry by sharing best practice in the implementation of contracts. Benchmark supply chain involvement and knowledge sharing activities, such that we can capture industry's progress more actively in this area.	OWPB supply chain group OWPB Contracting Group
Cost of equity		
Reducing packages / interfaces / risk during construction is positive for equity	Work to understand the level of contingency better in various approaches to contracting and	OWPB finance group

Summary finding	Summary recommendation	Owner
and finance, but is not particularly incentivised by current policy. It is unclear if the constraint on the large volume of projects that need funding in the next 3-5 years is on the amount of capital and/or the available skills and expertise to deal with the volume of transactions.	provide case studies for contract structures. Investigate whether there is likely to be a constraint on human resource or financial capital to process the deals required on projects to 2020.	
Cost of debt		
A major serial defect could reduce the confidence of investors. The finance community shows higher levels of comfort with technology risk in turbines since last year. The sector remains vulnerable to external market shocks which could lead to a change in current market conditions.	Work to ensure that the balance between innovation and risk is continually understood following release of new technology. Identify further work required to establish comfort on specific risks.	OWPB finance group
Cost of insurance		
Need for proof that post warranty strategy is secure and that the operational data from the asset proves its reliability. This will in turn lead to insurance cost reduction.	Document and ensure continued focus on bottleneck areas that help reduce premiums. e.g. standardisation and universal joints, vessels, spares strategies, vessel sharing, redundancies in the wind farm, buffers in construction schedule, EoW inspections and OFTO performance risk exposure.	OWPB finance group

Table 6 Summary findings and recommendations

Appendix 1 CRMF evidence log

https://ore.catapult.org.uk/industry-report

Appendix 2 Updates to design of CRMF

• Introduction

This appendix explains amendments to the final design for the qualitative element of the Cost Reduction Monitoring Framework (CRMF) as used in the 2015 study. The CRMF 2014 qualitative study provided recommendations for future improvements to the original methodology. The ORE Catapult undertook a design review and implemented a number of these improvements, detailed here.

This note follows on from report titled CRMF Final design, published by DNV-GL in 2015, which should be read in conjunction.

• Evidence gathering improvements

An electronic questionnaire was created to ensure a consistent, reliable and secure way to gathering sensitive information from participants. This proved successful.

Following a recommendation from the CRMF 2014 qualitative assessment to ensure early review in workshops with OWPB working groups, the ORE Catapult engaged all of the OWPB working groups to present initial results. This served as an excellent way to validate the findings of the study and gather further input for the analysis.

• Indicator improvements

Recommendations were made in the CRMF 2014 qualitative assessment to review a number of indicators within the CRMF study. These were reviewed by ORE Catapult at the outset of the CRMF 2015 qualitative assessment and the subsequent amendments are listed in Table 7.

Table 7 Indicator Improvements

Level 3 indicator	Justification	Recommendation	Outcome
Extended (XL) monopiles	Pathways assumed that monopiles would only be used for on Site Type A. Now monopiles likely to be used for 6MW and possibly 8MW turbines in water depths up to ~35m. This is a much broader issue than just the piling methods.	Broadening existing XL MP indicator milestones to include enabling technologies like vibro-piling would be more efficient than creating a new indicator Also, the anticipated potential reduction (which takes into account the likely market share in 2020)	Broadened XL MP indicator to include novel piling methods as well as noise mitigation methods

Level 3 indicator	Justification	Recommendation	Outcome
		therefore needs to be adjusted.	
EU Market	500MW+ projects may drive economies of scale but more salient point is that the milestones for growth and scale provide an inaccurate picture of actual vs planned growth	Refine outlook to 2020 for the "Growth and scale" indicator: EU market. The revised methodology for a probabilistic outlook will help ensure realistic result and sensible final key message about growth and scale	Included info about strategic procurement approaches and impact of market size on cost reduction within the 2020 vision
Standardisation of Offshore AC Substation	Existing related indicators include "Standardisation of Offshore AC Substation" and "Overplanting and/or use of dynamic rating" Potential to include distributed transmission on projects FID to 2020 but significant demonstration needed to get it to this stage N.B. only Siemens and 2B developing this concept	Adapt the Standardisation of Offshore AC Substation indicator, 2020 outlook and milestones to include other forms of platform size reduction including distributed transmission systems.	Added milestone and 2020 vision for distributed system
Knowledge sharing	Data sharing mentioned in Pathways as a prerequisite for sustained innovation Closest innovation from Pathways is within supply chain section and carried forward as a CRMF 2014 indicator "knowledge sharing" Not covered as an indicator in CRMF 2014 but there is clearly an opportunity to infer lessons on O&M for next generation sites through data sharing	Given that the "knowledge sharing" indicator covers this field, suggest revising 2020 vision and indicators to ensure capture of data sharing processes used to drive operational improvements	Refined milestones and outlook

Level 3 indicator	Justification	Recommendation	Outcome
DC array (as part of DC take off)	No longer realistic in the 2020 timeframe and unlikely to develop given market size, not weighted for LCOE impact	Remove indicator	Indicator not measured

• Introduction of a 2020 outlook method

The CRMF 2014 qualitative assessment contained a summary of the risks to future progress in realising cost reduction by 2020 across the indicators. This complemented the retrospective annual view that the indicators provide. Following publication of last year's study, ORE Catapult developed a systematic method to capture the perceived outlook for a 2020 vision for each indicator.

ORE Catapult gathered a 1-10 score from contributors to rate confidence in future development. The confidence score was averaged at a respondent level (e.g. project developer etc.) then all contributing sectors were averaged for each indicator. These scores were weighted according to the levelised cost of energy (LCOE) weightings for each indicator[13]. Scores were collected through questionnaires and interview and average scores ranged between 2.2 and 8.4 for level 3 indicator outlooks.

There were some outlook scores that proved challenging to collect due to a lack of response from participants or due to the nature of an indicator. Where there was a limited response from participants, some outlook scores could appear to be biased due to a small sample size. Where the indicator was difficult for participants to rate, ORE Catapult provided a score and tested this with industry experts. The outlook scores were reviewed in detail by ORE Catapult and where appropriate made amendments to the industry rating gathered. Details on amendments to each outlook are provided in the evidence log to the study, Appendix 1.The 2020 outlook scoring falls into three categories:

- Industry average, gathered from questionnaires;
- Average with adjustment by ORE Catapult, where justified;
- Catapult derived only and tested with industry experts.

A definition of the 2020 outlook scoring is provided in Table 8 Definition of outlook scoring.

[13] The finance indicators were only weighted at their level 2 equivalent indicators in the CRMF 2014 qualitative assessment. These weightings were used to calculate the outlook for the finance work stream of the study.

Table 8 Definition of outlook scoring

Score	Confidence in achieving 2020 target	Presentation of data in findings
1-4	Low	■
5	Medium	■■
6-10	High	■■■

• Key points to consider

When reviewing the results of the qualitative assessment it is important to note:

- Evidence was gathered before the announcements for a further three CfD auctions before 2020 in the November 2015 Energy Policy Reset Speech.
- The indicators are weighted for their cost reduction potential. Assessment of level one indicators (e.g. turbines) can mask varying progress in level three indicators (e.g. drive trains) that have lower weightings.
- A confidence rating of 1-10 on the outlook of achieving CRMF innovation targets by 2020 could also be interpreted as the perceived risk of the industry reaching that target.

Contact

ORE Catapult
Inovo
121 George Street
Glasgow, G1 1RD

T +44 (0)333 004 1400
F +44 (0)333 004 1399

Info@ore.catapult.org.uk

www.ore.catapult.org.uk