Department for
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Contracts for Difference evaluation Phase 2: annexes

Evaluation of allocation round 3

November 2020

Acknowledgements

The department for Business, Energy and Industrial Strategy (BEIS) commissioned Technopolis Group Ltd, in partnership with LCP Ltd to undertake a process and impact evaluation of the Contracts for Difference (CfD) scheme. This report provides methodological Annexes for Phase 2 of the evaluation. A separate report provides findings from Phase 2 of the evaluation, which assessed the extent to which the CfD Allocation Round 3 (AR3) met its intended objectives.

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Annex A: Methods

Introduction

The overall aim of this evaluation is to assess the extent to which the CfD scheme is on track to meet its objectives. In addition, it aims to assess the effectiveness of delivery processes to help inform policy development around ways in which delivery processes may be improved for future allocation rounds. The evaluation explores five High-Level Questions (HLQ):[1]

1. To what extent, how and why is the CfD scheme contributing to its intended objectives, and do its outcomes, both intended and unintended, differ for different groups (project developers, investors, technology types)?
2. Are the design parameters of the CfD scheme and auction allocations appropriate for achieving the intended objectives?
3. Is the CfD scheme being delivered as intended?
4. Does the CfD scheme present good value for money?
5. What are the implications of the findings for the future contribution of renewable technology to the electricity market?

The invitation to tender (ITT) set out a series of sub-questions under each of the five high-level questions. Following Phase 1, these questions were updated to take account of the evidence needed to inform changes in policy development priorities, as well as to provide more focus on assessing outcomes relevant to AR3. This longer list of more specific evaluation questions, alongside a description of how each will be addressed through various strands of data collection, is provided in the Evaluation Framework (Annex B).

Addressing these questions required a combination of impact, process and economic evaluation. The evaluation is theory-based, with Phase 1 adopting principles of realist approaches to address questions around how differences in context influence how developers respond to the scheme. The methods combine qualitative and quantitative data collection and analysis, including modelling of forecast electricity generation and economic cost benefit analysis to address questions around whether the scheme presents good value for money in comparison to a modelled counterfactual scenario of continued Renewables Obligation (RO) policy.

Phase 2 used a Contribution Analysis framework to synthesise evidence from multiple data sources, and subsequently to draw conclusions on the extent to which the CfD scheme has contributed towards its core intended outcomes.

The results of CfD AR3 were published on the 20th of September 2019 (Annex F: 'Projects awarded in AR3' gives a comprehensive overview of these results).

[1] The evaluation also addresses a series of more specific sub-questions, linked to the five High Level Questions. The full list of questions can be found in Annex B.

Phase 2 Data Collection

Primary research interviews with scheme participants and wider stakeholders formed a key component of new data collection for the evaluation. Phase 2 included a similar mix of primary research interviews and analysis of secondary data sources to Phase 1, tailored to focus on AR3 participants and to address the revised set of evaluation questions (see Annex B). Interviews were carried out during February and March 2020, including a series of semi-structured telephone interviews with:

- Lead developer firms that won a CfD contract through AR3
- Developers with projects listed in the REPD pipeline that may, in theory, have been eligible for an AR3 CfD but did not obtain one
- The wider institutional finance community – organisations known to invest in UK renewables
- Representatives of renewable sector trade bodies.

In addition, analysis of relevant secondary data sources included the Renewable Energy Planning Database (REPD), the LCCC CfD Register, supply chain plans, the Bloomberg Terminal and other relevant project documentation. An outline of each strand of data collection and analysis is provided below.

Interviews with AR3 project developers –Semi-structured telephone interviews were carried out with representatives of all of the lead developer organisations who were successfully awarded contracts in AR3. Interviews were carried out via telephone or video conference calls and lasted around 60 minutes. The interview data was used to address a range of evaluation questions, including process evaluation questions around whether processes for managing the scheme and administration of auctions are perceived by developers as having improved since AR2, in order to help identify areas for potential future improvement. Additionally, the data was used to gather various points of evidence to inform our Contribution Analysis (for impact evaluation), including insight into the impact of the scheme in reducing risks for developing projects in the UK and associated costs of capital.

Representatives of the winning developer firm (or consortium of firms) were identified through engagement with LCCC. As with Phase 1, interviews were typically carried out as a conference call involving more than one individual from each developer organisation in order to capture insight from people with different roles and areas of expertise (up to three people per interview). For example, members of the organisation’s senior management team, overall project manager, finance/commercial development lead, chief technology officer etc.

Representatives of all twelve renewable generation units that won a CfD at AR3 were successfully recruited and interviewed, covering all awarded AR3 technologies. For Offshore wind, some projects are phased into three stages (e.g. three contractually separate generation units, as part of the same overall ‘project’). In these cases, one interview was carried out to cover all phases of the project, as these are led by the same developer firms. Similarly, although four separate Remote Island Wind (RIW) generation units were awarded a CfD, these are led by two developer firms (leading two RIW projects each). Therefore, two interviews were carried out to cover all four RIW projects. In total, 8 separate interviews were carried out; covering all 12 generation units (including 14 individual respondents, as more than one representative of the developer consortia often joined the calls).

Table 1 Interviews conducted with AR3 generation unit developers

Technology	Planned	Completed
ACT	2	2
Offshore Wind	6	6
Remote Island Wind	4	4
Total interviews	12	12

Interviews with non-participating renewable energy developers

In addition to the interviews with developers who won a CfD at AR3, the aim was to carry out around 18 to 20 semi-structured telephone interviews with wider developers of renewable electricity generation units in the UK who do not have a CfD contract (either because of failure at auction or because they had not applied to CfD AR3). The purpose of interviews with these developers was to gain insight on what the experiences of unsuccessful applicants were in applying for CfDs, or reasons why they did not apply at all.

The Renewable Energy Planning Database was used as a sampling frame to select projects that have gained planning permission over the last five years but do not have a CfD. The aim was to carry out interviews with groups of developers of a similar range of technologies to those outlined above, who are in theory eligible for a CfD. Technopolis developed a sampling frame based on our own analysis of the REPD to create a list of planned projects that met the eligibility criteria for AR3 but were not awarded a CfD. In addition, some companies had publicly disclosed that they bid for AR3, in particular for Offshore Wind and Remote Island Wind, and were not successful.

Among developers without a CfD at AR3, nine interviews were completed, out of up to 20 originally planned. The aim of interviews with this group was to gather qualitative insights on the views of developers of different types of technologies who may have applied at AR3 but were unsuccessful. The number and identity of unsuccessful applicants to the CfD scheme is not disclosed by the National Grid ESO which manages the applications (due to licensing conditions), so the population size of unsuccessful applicants is not known. Although the sample of nine achieved interviews was lower than expected, those interviewed represented a good spread of developers across different types of technologies (including Offshore Wind, Remote Island Wind, Tidal Stream, ACT and Bioenergy technologies). The interviews met the aim of providing qualitative insights on the perspective of unsuccessful applicants from different technologies, although they may not be representative of the wider population of all unsuccessful applicants.

Table 6 Interviews conducted with non-CfD renewable energy developers

Technology	Completed
ACT	2
Biomass / Energy from Waste	3
Offshore wind / Remote Island wind	3
Marine Technology / Tidal / Wave	1
Total interviews	9

Interviews with financial investors

Addressing some Phase 2 evaluation questions required gathering evidence from the wider community of third-party financial investors in UK renewables projects, as well as from the lead developer firms themselves. This included answering the following questions:

- HLQ 1 (h): What has been the impact of the scheme on financial investor confidence, and how and why has this occurred?
- HLQ 1 (j): How has this impact on investor confidence subsequently impacted on the hurdle rates of different projects/technologies?
- HLQ 1 (n): Has the CfD been better at attracting overseas investment than the same technologies in other EU/European countries since 2014?
- HLQ 2 (f): Has 15 years of support been the appropriate contract length of subsidy for financing and alignment with other relevant linked timelines?
  => How would changing the contract length affect hurdle rates and investor confidence?

In Phase 1, the approach to contacting investors in CfD projects was primarily through snowballing (i.e. asking the participants interviewed for contacts of their project investors or to forward on our online survey). This achieved a low response rate, partly because many of the developer firms interviewed had debt-financed the development stage themselves (without third party equity investment).

Phase 2 focused on developing a sampling frame of financial institutions and then contacting them directly. The approach to recruitment used is discussed further in pages 11-12 below. The aim was to cover not only organisations known to have invested in specific CfD projects, but also the wider community of financial investors (including those who have not invested but may, in principle, have an interest in doing so) to gain broader insight on the impact that introduction of the scheme has had on investor confidence. In addition, two interviews were carried out with renewable energy sector trade bodies to gather broader views on the extent to which the scheme was meeting its objectives on attracting finance and lowering costs of capital.

Background on renewables investment community

The CfD evaluation Scoping Stage report, Investment Trends in UK Renewable Electricity, explored the profile of investors in CfD projects and how this changed from AR1 to AR2. This was largely based on Bloomberg Terminal data, rather than interviews. This showed that, for Offshore Wind (which makes up the largest proportion of the total amount invested in CfD projects), the type of investor varies little between RO and CfD projects, although there appears to be a higher proportion of investment coming from utility companies in CfD projects. Overall, individual utility firms tend to finance much larger shares of individual projects than other actors. This is due to the 'vertically integrated' nature of utility-backed firms in Offshore Wind development (leading both development and supply of renewable electricity).

Secondary data sources and renewable industry publications (including the Clean Energy Pipeline and Bloomberg) provide information on financial transactions (re-financing) of operational phase renewables projects. Contacting firms known to have invested can give insight into the extent having a CfD boosts attractiveness for post-construction acquisition by institutional investors. This finance can support wider development, for instance, in Offshore Wind projects which are partly equity financed by utilities, as re-acquisition frees locked-in equity and allows investment into new developments. These secondary sources were used to create a list of banks known to have provided debt finance to CfD projects.

Often third-party investors in renewable energy projects are undisclosed, which presents a challenge in identifying the exact profile of investors. Mazzucato and Semieniuk (2018[2]) calculated that for about 56% of utility scale projects globally, the amount of investment is not publicly disclosed (or available through sources such as Bloomberg). Also, looking at project level data (e.g. mergers and acquisitions, equity investments etc.) only captures firms who are known to have invested in specific projects, but omits the views and profiles of investors who have not (yet) invested in CfDs at the development stage but may potentially have a strong interest once they are operational.

A recent report by the City of London Corporation (CLC) as part of the UK Green Finance Initiative "*The Renewable Energy Infrastructure Investment Opportunity for UK Pension Funds*" explores this untapped potential for institutional investors. The report estimates that existing operational UK Solar PV and Wind assets present an investment market in excess of £40bn, with at least a further £25bn of investment opportunity for projects in the pipeline with planning consent which remain to be financed and built. However, the CLC report suggests that the level of investment in renewables by UK-based pension fund managers is currently well below other leading countries – highlighting the scale of potential opportunity for the institutional investor.

Furthermore, the growing maturity of the Offshore wind sector has attracted new investors to enter the market who have traditionally focused on the fossil fuel sector. For instance, oil and gas company Total just announced intention to bid for the next round of crown estate seabed auctions3 and Shell also expressed similar interest[4].

Using the broad categories of investors developed for the Scoping Stage Investment Trends report as a starting point, the table below provides an expanded list of types of investors which were targeted for Phase 2 interview participation, including wider stakeholders that may not yet have invested in CfDs. The target was to carry out 20 semi-structured interviews, covering stakeholders across these groups (in addition to the above interviews with AR3 participants).

Table 7. Types of investors and their roles

Type of investor	Core mode of financing	Comment
Utility firms	May be vertically integrated – both investing in and developing projects. Also involved in equity investment and acquisition of other operational projects.	Recruited via interviews with both successful and unsuccessful applicants for CfD Offshore Wind projects.
Institutional investors (non-bank entities such as pension funds and insurance companies)	Equity/Fixed Income	Huge potential to invest but traditionally reluctant to invest in infrastructure projects. Until now, relatively less active in UK renewables market than other countries.

[2] Mazzucato, M. and Semieniuk, G., 2018. Financing renewable energy: Who is financing what and why it matters. Technological Forecasting and Social Change, 127, pp.8-22.
[3] https://www.rechargenews.com/wind/1846541/oil-supermajor-total-to-enter-uk-offshore-wind
[4] https://www.energyvoice.com/otherenergy/207100/shell-absolutely-looking-at-big-scottish-north-sea-offshore-wind-projects/

Private banks	Debt	Often used by lead developer firm to debt finance the pre-operational development phase of projects.
Public banks (GIB / EIB etc.)	Debt/Concessional finance	Similar role as private banks but more specialist and willing to support relatively higher risk projects.
Syndicated loan (lead arranger)	Syndicated loans are loans in which members of a group of banks take portions of a larger loan and thus minimise the risk that any one individual is exposed to.	Often used to debt finance construction phase of renewables projects, as individual banks not willing to take on construction risk (or allocation risk)
YieldCos	A YieldCo is a company that is formed to own operating assets that produce a predictable cash flow, primarily through long term contracts.	May include members of parent company of lead developer firms in setting up SPVs. Can also attract new investors once operational.
Other energy companies e.g. fossil fuel based.	Becoming active in investing in projects and acquiring renewables firms (e.g. BP purchase of Lightsource Solar company to form Lightsource BP).	Potential to invest in CfDs or take active role in future project developments.

Approach to recruiting investors in UK renewables

The community of potential investors in UK renewables is highly diverse and international. Unlike using REPD to sample the pipeline of developers with potential to participate in AR3, there is no single sampling frame to use to identify, contact and recruit the wider investment community. The planned first step was to consult Gatekeeper organisations, including representative bodies such as the Green Finance Taskforce and/or their subsidiary working group the Green Finance Institute (GFI), to: a) participate in an interview and gain their response to key relevant questions in the evaluation and b) to seek their expert advice on the best way to approach the wider financial sector for further recruitment, including wider engagement with their members. However, following discussion with BEIS, this approach was abandoned because, at the time of fieldwork, the GFI were still in the process of formulating their terms of reference and work plans and it was not considered appropriate to burden the organisation with requests for participation in research during that time.

Technopolis therefore developed a sampling frame of organisations known to have invested in CfD and RO projects through; a) Bloomberg Terminal data on equity ownership of renewable project assets and debt finance deals, and b) grey literature in renewable energy sector trade press on financial investment and mergers and acquisitions.

Seven interviews with financial institutions were carried out, plus two with renewable energy sector representative bodies (nine in total) out of the 20 originally planned. Interviews were carried out through February/March 2020, when the Covid-19 pandemic began spreading in the UK. As banks and other financial institutions were dealing with the economic implications of this crisis, a decision was taken with BEIS to stop fieldwork earlier than planned in order to avoid burdening financial institutions with interview requests during this period.

The aim of interviews with this group was to gather insights on whether the introduction of the CfD scheme had reduced risks for different types of investors and why, as well estimates on the extent to which the CfD reduced costs of capital. The nine respondents interviewed represented institutions covering all of the sub-groups targeted: banks, fund managers, insurance companies, and credit rating agencies, as well as two renewable energy sector trade bodies. Although useful findings were obtained from these interviews across all topics covered, the breadth and depth of qualitative data collected can be considered lower than would otherwise be expected if the full programme of interviews was completed.

Table 7 Interviews conducted with investors and trade bodies

Stakeholder Group	Completed
Financial consultancy	1
Fund Manager	2
Insurance company	1
Private Bank	2
Rating Agency	1
Sector Trade Bodies	2
Total	9

Cost-effectiveness analysis

In Phase 1, HLQ4 evaluation question "Does the CfD scheme represent good value for money?" was addressed through analysis using the DDM to compare outcomes of the current CfD scheme with a modelled counterfactual scenario of subsidising the same level of generation under the Renewables Obligation. This required developing estimates of the cost to consumers per MWh of electricity produced by each technology. This was used to compare overall costs and benefits (£value of energy produced) to a counterfactual scenario assuming the CfD scheme had not been introduced and the RO continued to 2050.

This analysis was updated in Phase 2 to incorporate the outcomes from AR3 (forecast generation capacity) as well as any known changes to AR1 and AR2 projects, such as their timescales for Target Commissioning Dates or amendments to installed generating capacity. Further description of the DDM and the approach to VFM assessment is provided in Annex D.

Phase 2 Approach to analysis and syntheses of results – Contribution Analysis and Process Tracing

Theoretical approach to the evaluation

Phase 1 adopted a mixed methods approach, using principles of realist evaluation to explore how differences in context (e.g. the characteristics of developer firms) influence how they respond to different aspects of scheme design and thus lead to different outcomes. Addressing many of the evaluation questions in this mixed methods study does not require a realist approach. For example, addressing the question: "Have CfDs reduced the impact of renewable deployment on consumer bills relative to the Renewables Obligation?" was primarily based on economic analysis and statistical modelling techniques to estimate the overall costs and benefits of the scheme compared to a modelled counterfactual scenario of continued RO support. This method for assessing overall aggregate impacts of the scheme may be considered more “positivist” than “realist” but is fit for purpose in terms of addressing the question.

In addition, some of the more exploratory process evaluation questions in Phase 1 did not require development of pre-defined theories, or CMOs, in advance of fieldwork and then testing. For example, when exploring: “What improvements can be made to the developer journey through the CfD application and delivery process?” respondents were asked open-ended questions to discuss their experiences of the application process in order to share their unprompted views on what aspects worked well, or not so well, and why. Here, the analysis of findings was based around a ‘bottom-up’ approach to coding and grouping the range of themes emerging, and then to explore how these varied by context (rather than a top-down assessment of whether the findings confirm or refute a pre-defined CMO configuration about the application process). This approach to addressing such questions may be considered more “constructivist” than realist (See Table 2 below).

The mixed methods used in the evaluation have therefore adopted elements of constructivist, positivist and realist approaches to address each evaluation in the most fit-for-purpose way. below provides a brief overview of these three approaches.

Table 2. Theoretical approaches evaluation.

	Constructivism	**Positivism**	**Realism**
Philosophical underpinning	The real world is constructed, since our observations are shaped and filtered through human senses. It is not possible to know for certain what the nature of reality is	The real world is independent from the researcher, from which we can directly observe and derive “facts”’	Acknowledges that all enquiry and observation are shaped and filtered through the human senses, therefore, no such thing as ‘final’ truth. Nonetheless it is possible to work towards a closer understanding of the nature of reality
Research Methods	Qualitative	Quantitative	Mixed
Types of questioning	Open-ended questions, ethnography, analysis of narrative, text and/or image data	Closed questions, pre-determined approaches, numeric data	Both, open and closed questions and both qualitative and quantitative data analysis
Research Practices	Studies the context or setting of participants Constructs meaning from the experience of participants Involves researcher in collaboration with participants Validates the accuracy of findings	Observes and then measures information numerically Tests or verifies theories or explanations Employs statistical procedures to assess overall outcomes	Develops a rationale for mixing methods Assumes that nothing works everywhere or for everyone, and that context makes a difference to programme outcomes Tests or verifies pre-defined theories and then refines these in response to emerging findings

Source: Technopolis: adapted version of summary table from Realist Impact Evaluation, an Introduction. Methods Lab. Gill Westhorp 2014

Overall approach to developing and testing the Theory of Change

Our approach to developing, testing and refining a Theory of Change for the scheme in Phase 2 was based around a synthesis of evidence from various strands of evidence using a Contribution Analysis framework, as outlined by John Mayne (2012[5]):

"Contribution Analysis (CA) is based on the existence of, or more usually, the development of a postulated theory of change for the intervention being examined. The analysis examines and tests this theory against logic and the evidence available from results observed and the various assumptions behind the theory of change and examines other influencing factors [alternative theories]. The analysis either confirms – verifies – the postulated theory of change or suggests revisions in the theory where the reality appears otherwise. The overall aim is to reduce uncertainty about the contribution an intervention is making to observed results through an increased understanding of why results did or did not occur and the roles played by the intervention and other influencing factors".

In essence, CA aims to draw defendable conclusions on what contribution a programme has made to observed outcomes, over and above alternative explanations. For example, the contribution that introduction of the scheme has made to lowering the LCOE of Offshore Wind in the UK, over and above external factors such as the reduced supply chain costs. Whereas the central questions posed by Pawson & Tilley's (1997) realist approach are: *"What works, for whom, in what respects, to what extent, in what contexts, and how?"* (i.e. less focused on what overall impact a programme has had).

Is it really realist?

There are a number of reasons why a true realist approach may be considered a less appropriate theoretical framework for Phase 2. These reasons are summarised below.

Realist evaluation is concerned with unravelling the "inner mechanisms" at work in different contexts. This entails refining the ToC into one or more Context-Mechanism-Outcome (CMO) configurations, where Contexts are made of resources, opportunities and constraints available to the beneficiaries; Mechanisms are choices, reasoning or decisions that individuals take based on the resources available in their context; and Outcomes are the product of individuals' behaviour and decision making. The developers of this approach have traditionally applied this to evaluation of social programmes where outcomes depend on individual decisions and behaviour change.

For example, the success of the Smart Meters programme in achieving outcomes relating to energy efficiency among households, largely depends on individuals engaging with the Smart Meter information and then deciding to change certain behaviours e.g. to use their tumble dryer less often or buy a more efficient kettle. The CfD scheme is not primarily a behaviour change programme and outcomes are determined less by individual choices and reasoning. While differences in outcomes are important to explore (such as which types of developers win contracts and why) they are not primarily driven by the 'inner mechanisms' at work in individual reasoning and choices, but rather, the design rules of the scheme itself. For example, from the developer's perspective, there is a large pipeline of renewable energy projects with planning permission where the lead developer would benefit from obtaining a CfD (including Solar, Onshore Wind, Tidal Stream technologies etc). The reason they do not obtain a CfD is not driven by individual choice, but rather because of factors relating to the design of the scheme, such as the lack of Pot 1 auctions since AR1, or because the LCOE of that technology is too

[5] Contribution Analysis: Coming of Age? Evaluation 2012 18: 270. Sage

high to enable them to compete on cost with Offshore wind and win contracts. Therefore, for Phase 2, it was proposed that theory testing and development moves away from a realist approach based on testing CMOs to the application of a Contribution Analysis framework, as outlined below.

Overview of Contribution Analysis (CA) approach

CA is a theory-based approach designed to reduce uncertainty about the contribution the intervention is making to the observed results. This is achieved through an increased understanding of:

- **Why the observed results have occurred (or not)** – for example, reduced LCOE of Offshore Wind in the UK.
- **The roles played by the intervention over and above other internal and external** factors – for example, the theory is that the CfD scheme reduces the costs of capital, which lowers overall project costs. Other external factors may also play a role (e.g. the industrialisation of wind turbine manufacturing and lower supply costs), however, we can conclude that the CfD scheme also made a significant contribution to lowering costs.

CA helps to build a credible contribution story - about making a well-reasoned case and drawing a plausible conclusion. This answers questions such as, "*Is it reasonable to conclude that policy X was an important influencing factor in driving change?*" (Mayne, 2008).

CA is a useful approach in impact evaluations where experimental or quasi-experimental designs (that might answer these questions) are often unfeasible or impractical (as is the case with the CfD scheme) but there is an interest in assessing whether observed outcomes can confidently be attributed to the intervention. It is more commonly used to draw qualitative conclusions around the plausibility of attribution, rather than quantifiable levels of impact (e.g. the effect size of an intervention). However, it may be used to inform assumptions that underpin wider quantitative modelling. For example, as we can reasonably demonstrate that the CfD scheme has played a role in reducing hurdle rates for investors, this was used to inform assumptions in the VFM modelling.

CA is theory-based as it is built around exploring the plausibility that the programme Theory of Change holds true. In the section below, we provide an overview of the CA framework and steps followed to describe which aspects of the ToC were be tested in this way. Firstly, the six stages below provide an overview of the iterative nature of developing, testing and refining this ToC, and how that fits around each of the three phases of evaluation. This follows Mayne's (2012[6]) recommended six steps process:

Setting out the attribution problem to be addressed: This step involves identifying the key outcomes and impacts that the programmes intend to improve or change, with a clear rationale. The 'attribution problem' we address is the extent to which core intended outcomes (such as reduced cost of capital for investing in renewable energy projects) can be attributed to the scheme or would have happened anyway (outlined further in CA Framework below).

1. **Develop a Theory of Change (ToC):** the CfD Evaluation Feasibility Study led by UCL (2017) provided an initial draft programme level Theory of Change and Policy Map for the scheme (see Annex B of Phase 1 report).

[6] Contribution Analysis: Coming of Age? Evaluation 2012 18: 270. Sage

2. **Populating the Theory of Change with existing data and evidence**: this step involved gathering existing evidence about the ToC, with further consideration of the underlying assumptions, risks and other external influencing factors. Evidence from the three Scoping Stage work strands was used to further develop and refine the draft ToC developed by UCL.

3. **Assemble and assess the intervention logic:** this step develops the use of new research to assess the intervention logic in reality. The Phase 1 primary research interviews with CfD contracted project developers provided evidence in support of the ToC for certain groups of developers. For example, there was clear evidence of support among developers who had won a CfD that the 15-year price stabilisation contract: provided more certainty of revenue, helped to reduce risk (and cost of capital) and contributed towards falling costs (particularly for Offshore wind). Phase 1 also began to explore alternative explanations for the gross outcomes observed (e.g. that reduced LCOE of Offshore Wind is, in part, driven by technological innovation and economies of scale).

4. **Seek out additional evidence**: Phase 2 gathered additional evidence, such as interviews with the wider investment community as well as credit rating agencies. This provided new insights on ways in which the CfD scheme helps developers to reduce costs of capital (e.g. through increased gearing ratios) and the relative contribution of the scheme to reducing risks for investors (and costs for developers) over and above external factors.

5. **Revise and strengthen our understanding of the intervention logic**: as new evidence becomes available, the claims made by the theory can be tested and refined in an iterative process. A Synthesis Phase in 2020/21 (Phase 3) is intended to triangulate results across all strands of the evaluation (including follow-up interviews with AR1 and AR2 participants in summer 2020), to revisit the scheme's initial ToC and the contribution it had made to both observed outcomes and the likelihood of achieving its longer-term objectives. The precise aims and scope of Phase 3 are currently under review.

Assessing contribution claims in the Theory of Change

Picking up from insights gathered through Phase 1 testing of CMO1, the overall programme theory of change explored through CA is that the CfD scheme will:

> *Increase investor confidence to attract greater investment at a lower cost of capital and from a wider pool of sources.*

There are a number of causal links implied within this one sentence, with different outcomes to observe. The core causal links that will be explored through the CA are summarised below.

1. The scheme 'inputs' (e.g. the offer of a 15-year, inflation linked price stabilisation contract), will lead to:

2. Increased confidence among investors (through providing more certainty over future revenues by reducing risks related the fluctuation of wholesale prices). This in turn leads to:

3a. Attracting greater investment due to the increased confidence among investors and decreased risk assumptions which lowers investment hurdle rates and costs of capital.

3b. Attracting investment from a wider pool of sources (including institutional investors) with the subsequent effect of more competition among investors and subsequently offering developers lower interest rates for finance. This leads to the following intended outcomes:

4. Lower costs of capital for developers. This reduces overall project costs. The reduction in LCOE enables developers to bid at lower strike prices. Which in turn leads to:

5. Lower strike prices, of Pot 2 techs, lower levels of support payments, and ultimately:

6. Reduced costs to consumers.

A hurdle rate is the minimum rate of return on a project or investment required by a manager or investor[7]. The hurdle rate describes the appropriate compensation for the level of risk present - riskier projects generally have higher hurdle rates than those with less risk. In order to determine the rate, the following factors may be taken into consideration: risks, cost of capital and returns for similar investments, and anything else that may affect the investment. In the context of an investor deciding whether to provide finance for a renewable development project with a CfD, this may be considered as "*the minimum required rate of return required by investors from a CfD asset, taking into account a risk premium which includes the costs of capital, project and policy risks, and returns for an alternative similar investment*".

The described causal links can be represented within an overall Logic Chain for the CfD scheme. The refined Theory of Change diagram, which builds upon findings from Phase 1 and the original Policy Map from UCL, is outlined below.

[7] As defined in Investopedia

Figure 1. Theory of Change Diagram

Approach to synthesising evidence to assess strength of contribution claims

The approach followed BEIS' general good practice points for assessing causal claims in theory-based evaluation, including:

- A clear hypothesis is developed and agreed
- Clear statement in advance of evaluation implementation (e.g. fieldwork, analysis) of what evidence you expect to see to refute and to strengthen the credibility of your hypothesis. In this case, following a Contribution Analysis approach, this involved developing alternative hypotheses on what external factors may have attributed to change in outcomes (beyond the CfD scheme itself)

- For each evidence statement, in advance of evaluation implementation, state the causal claim test(s) that will be used and identify the quality of evidence you would expect to see
- Assessment of the evidence collected against those statements to make a judgement about causal claims.

Process Tracing was used as a method for assessing causal claims within our overarching Contribution Analysis framework, as described below.

Process Tracing

Process Tracing makes causal inferences by identifying types of ‘clues’ that would either support or reject programme hypotheses if observed. This can be used in combination with Contribution Analysis to develop a series of clues (types of evidence) that would support contribution claims around whether observed outcomes (such as reduced strike prices for Offshore Wind) may be attributable to features of the CfD or other external factors (such as technology innovation and economies of scale from industrial production of Offshore Wind, etc). The approach also allows an evaluator to highlight evidence of which features of the programme have positively influenced results.

A Process Tracing framework provides transparency, in advance of fieldwork, of what criteria will be used to judge whether programme theories are true or not and how conclusions will be drawn. In theory, this means reporting of end results is less open to cherry-picking and bias, as the criteria for drawing conclusions on whether hypotheses are true/false have been agreed in advance.

There are four types of causal tests commonly used in process tracing: hoop, straw-in-the-wind, smoking gun and double decisive. These tests define the “clues” that we would expect to observe if the hypotheses are true. The tests are based on the principles of certainty and uniqueness; in other words, whether the tests are necessary and/or sufficient for inferring the evidence. Tests with high uniqueness help to strengthen the confirmatory evidence for a particular hypothesis, by showing that a given piece of evidence was sufficient to confirm it. Tests with high certainty help to rule out alternative explanations by demonstrating that a piece of evidence is necessary for the hypothesis to hold true (Befani and Mayne 2014[8]).

The Process Tracing framework for Phase 2 is provided in Annex C. Some illustrative examples of Process Tracing tests are provided below.

Hoop tests – weaken the hypothesis if not found, but are not sufficient to confirm the hypothesis. These are pieces of evidence that we would ‘expect to see’ if the given hypothesis is true. For example, one contribution claim is that the CfD leads to an intended outcome of attracting investment from a wider pool of sources. One test of this would be to use Bloomberg data to assess whether the profile of investors in Offshore Wind farms has changed since introduction of the CfD scheme, through new entrants to the market such as institutional investors (i.e. pension fund managers and insurance companies). The difficulty to pass a hoop test (making the hoop smaller or larger) can be adjusted to increase uniqueness and disconfirmation power based on the quality and granularity of data which is available for a hoop test.

[8] Befani, B. and Mayne, J. (2014) ‘Process Tracing and Contribution Analysis: A Combined Approach to Generative Causal Inference for Impact Evaluation’, IDS Bulletin 45.6: 17–36

Hoop tests do not provide strong evidence to prove the Theory of Change (as it may be the case that institutional investors would have been attracted to the market anyway due to the maturity of the Offshore Wind industry, rather than because of the CfD itself). However, they are nevertheless an important first step, because if the evidence does not 'jump through the hoop' of demonstrating change in the profile of investors, then it suggests the intended outcome has not happened.

Straw-in-the-Wind – evidence that lends more support to causal claim in the hypothesis but not sufficient in itself to confirm it if observed, or to reject it if not observed. For example, interviews with international utility firms claiming they would not have developed an Offshore Wind project in the UK unless the CfD scheme had been introduced. Evidence based on such 'straw-in-the-wind' tests alone may be considered 'shaky' given the potential for positive confirmation bias, in terms of project managers wishing to portray an overly positive picture in order to influence continuation of the policy. Nevertheless, a straw-in-the-wind test can contribute to the overall evidence and may be part of a doubly decisive test which is constructed from a number of other tests.

Smoking gun – evidence that provides a convincing cause-and-effect type contribution story. It strengthens the hypothesis if observed but does not disprove the hypothesis if not observed (although may slightly weaken it). These are pieces of evidence that we would ideally 'like to see' if a given hypothesis is true but may in practice be difficult to uncover. For example, developers share documented evidence (e.g. extracts from their project business cases or commissioned secondary analysis) which show lower WACC is achieved under CfD projects compared to investment in similar projects with a ROC.

Double-decisive – strengthens or confirms the hypothesis if observed and if not observed the hypothesis is rejected or significantly weakened. For example, taking account of all data sources on forecast project costs and benefits, the Net Present Value of benefits under the CfD scheme is positive (in terms of overall reduced costs to consumers in comparison to the RO).

Process Tracing may be combined with Bayesian updating to mathematically estimate the probabilities of hypotheses being true or false based on whether each evidence test has been observed. This involves the specification of prior probabilities for the hypotheses being true according to each evidence test (in advance of fieldwork) and then the updating of these to posterior probabilities based on what evidence is actually observed. This can be well suited to evaluation of programmes based on a relatively small number of cases and evidence tests. However, in projects with large numbers of interviews and multiple strands of data sources and tests, Bayesian updating may overcomplicate the process given the assigned probability scores for each test are based on subjective judgement. When conclusions on a contribution claim are based on multiple tests across different strands of evidence, the overall scores are more sensitive to errors in judgement of individual tests and risk providing what can seem like arbitrary numbers that are difficult to interpret. This is the case for the CfD evaluation and, therefore, Bayesian updating was not applied.

The approach proposed for Phase 2 for synthesising evidence across multiple tests was based around developing a series of rules to categorise the types of tests that must be passed to satisfy conditions for being considered strong/weak evidence in support of either the contribution claim (Programme hypothesis) or Alternative hypotheses. The framework of rules for categorisation is provided in the box description below. This categorisation has been informed by a mixture of the approach taken in BEIS Evaluation of the Transitional Arrangements for Demand-Side Response: phase 3 study, as well as the Evaluation journal article *Making rigorous causal claims in a real-life context* by Delahais and Toulemonde (2017)9. Delahais and Toulemonde describe four additional tests for assessing the strength of supporting evidence in theory-based evaluation:

Authoritative source is a piece of evidence which has already passed a thorough test under the responsibility of credible authorities (e.g. peer reviewed papers) in so far as the point at issue is not in dispute among differing authorities. An example would be UN IRENA reports or a Bloomberg NEF report showing the LCOE of Offshore Wind is reducing internationally.

Signature is when X causes Y therefore it may operate so as to leave a signature (a trace, a fingerprint) that unequivocally points towards to X. For example, if the CfD is more attractive to institutional investors, then we would expect to see more instances of them investing in Offshore Wind projects with a CfD compared to similar projects with a ROC. In practice, this is similar to a 'Smoking Gun'.

Convergent triangulated sources are independent from one another in so far as they stem from stakeholders having different vested interests. Pieces of evidence originating from such sources are mutually reinforcing as far as they converge.

Consistent chronology is never a sufficient argument for confirming a contribution claim, but it may be used for refuting an assumed contribution. For example, if data shows trends in reduction of LCOE of Offshore Wind since the introduction of the CfD scheme.

Our view is that the four strengths of evidence tests above should not be considered a replacement for the four Process Tracing tests, but certain elements of them may complement a Process Tracing framework to provide an additional filter for drawing conclusions on strength of evidence. As described above, the Process Tracing tests have been designed to provide a framework of four mutually exclusive categories on a spectrum of how necessary and/or sufficient observing each is for supporting or refuting a hypothesis. The four tests listed above are less mutually exclusive and appear to serve a different, albeit complementary, purpose of considering the strength or reliability of each source of evidence. For example, it is feasible (and likely) that one robust strand of evidence could be both a 'Signature' and based upon an 'Authoritative source' whilst also being 'Triangulated' with other sources.

The 'Consistent chronology' test serves a similar purpose to a 'Hoop test', although only relates to one factor: timing. As there are other forms of evidence that can usefully serve as initial checks of whether or not a hypothesis can be true, the proposed framework here retains the 'Hoop test'. Similarly, 'Signature' serves a similar purpose to a 'Smoking Gun'. Overall, it is proposed that the four, well established Process Tracing tests are used as the basis of categorising types of evidence.

However, the framework also took account of 'Triangulation' and 'Authoritative source' in the rules for assessing strength of evidence in support of a contribution claim. Many of the strands of evidence in the Process Tracing framework that rely on interview data are considered to be 'Straw-in-the-wind' tests. Phase 2 interviewed a range of different stakeholders, who have different views towards the scheme, including developers who were successful in being

[9] Thomas Delahais/Jacques Toulemonde (2017) Making rigorous causal claims in a real-life context: Has research contributed to sustainable forest management? In Evaluation, Vol 23, Issue 4, pp. 370 – 388

awarded a CfD at AR3, those who were unsuccessful, wider institutional investors and supply chain firms. Considering whether or not, and why, key findings are triangulated and expressed by all groups (as well as secondary data sources) provides another useful filter for considering their reliability in supporting the programme hypothesis. Similarly, considering whether or not a given hoop, or straw-in-the-wind test finding is based upon an 'Authoritative source' (such as peer reviewed publications) provided another factor to consider when making judgements on its likely 'strength of evidence'.

A table of rules for determining the relative strength of evidence in support of each contribution claim in the CA/PT framework were developed. The 'overall syntheses' was carried out against each 'contribution claim' – which links to each of the key outcomes being assessed in the Theory of Change. Analysis of Process Tracing tests was carried out at a case-by-case level i.e. each individual interview will be coded to demonstrate whether they provide findings in support of the contribution claim or alternative hypotheses.

A credible 'contribution story'

To draw conclusions from multiple strands of evidence, the core aim of CA is to make a reasonable and robust case that a programme has indeed made a difference. Development of this 'contribution story' entails:

- Providing a well-articulated presentation of the context of the programme and its general aims, along with the strategies it is using to achieve those ends
- Presenting a plausible program theory leading to the overall aims (the logic of the program has not been disproven, i.e. there is little, or no contradictory evidence and the underlying assumptions appear to remain valid)
- Describing the activities and outputs produced by the program
- Highlighting the results of the contribution analysis indicating there is an association between what the program has done and the outcomes observed
- Pointing out that the main alternative explanations for the outcomes occurring, such as other related programs or external factors, have been ruled out, or clearly have had only a limited influence

The Phase 2 findings report provides this 'contribution story' narrative and refines the ToC accordingly. This was used in weighing up evidence to address the following core evaluation questions:

- HLQ 1 (h): What has been the impact of the scheme on financial investor confidence, and how and why has this occurred?
- HLQ1 How has this impact on investor confidence been reflected in the hurdle rates/how are investors defining hurdle rates?
- HLQ 1 (j): How has this impact on investor confidence subsequently impacted on the hurdle rates of different projects/technologies?
- HLQ 1 (n): Has the CfD been better at attracting overseas investment than the same technologies in other EU/European countries since 2014?
- HLQ4 b) b): Have CfDs which were allocated via auction rounds reduced the impact of renewable deployment on consumer bills relative to the Renewables Obligation?

Approach to analysis of semi-structured interview data

The semi-structured telephone interviews with renewable project developers (with and without CfDs) and financial institutions produced a large volume of qualitative data that required careful organisation and management for structuring the analysis processes. This sub-section provides an overview of our approach to collating, transcribing, verifying, managing and analysing this data.

All interviews were audio recorded (with respondent's consent) and then transcribed into individual Word documents. The software package Trint[10] was used to provide an automated first draft of each transcription, which were then cross-checked by interviewers for any inaccuracies. Nvivo, a qualitative data analysis software package, was used to store and analyse the data. This involved identifying different concepts within the dataset, and subsequently assigning these different concepts to different "nodes", or themes of interest. A list of nodes was developed to code examples of responses in the transcripts which support each PT test; either in support of the programme ToC or the alternative theories, or indeed, new explanations of why certain outcomes have arisen that were not previously taken account of. This allowed for both a 'top-down' analysis of results against the pre-fieldwork CA/PT Framework, as well as allowing for a 'bottom-up' emergence of new theories to arise from the data. One output from the Nvivo analysis was a set of tables that assessed the frequency of cases where respondents gave evidence in support of each Process Tracing test.

[10] https://trint.com

Annex B: Evaluation Questions and Phase Covered

High Level Questions (HLQ)		
HLQ 1	**Sub questions**	**Whether addressed in Phase 1 for AR1/AR2 and/ or Phase 2 for AR3.**
To what extent, how and why is CfD contributing to its intended objectives, and do its outcomes, both intended and unintended, differ for different groups (project developers, investors, technology types)?	(a): What capacity is on track to be delivered within agreed milestones, and how much has been invested in it?	Addressed in both Phases
	(b): To what extent has CfD contributed to meeting the 2020 renewables target?	Addressed for Phase 1
	(c) How does this contribution compare with that projected under the RO?	Addressed for Phase 1
	(d): How does the CfD support the development of a mature and competitive industrial supply chain for renewable technology?	Preliminary findings on supplier relationships provided in Phase 1
	(e): To what extent and how have Pot 2 auctions led to greater developments in the less established technologies?	Addressed by Phase 1
	(f): To what extent are CfDs accessible to a broad range of generators	Addressed by Phase 1 report

	(g): To what extent and how are CfDs providing suitable support for emerging near-market technologies (i.e. those at technology-readiness level 7)?	Addressed by Phase 1 report
	(h): What has been the impact of the scheme on developer confidence, and how and why has this occurred?	Addressed in both Phases
	(i) What has been the impact of the scheme on financial investor confidence, and how and why has this occurred?	Addressed in both Phases
	(i): How has this impact on investor confidence subsequently impacted on the hurdle rates of different projects/technologies?	Addressed in both Phases
	(k): What are the costs associated with CfD participation for different developers and technologies (administrative, capital, operating and supply chain)?	Partly addressed by Phase 1 report, then de-prioritised.
	(l): How do these costs compare with technologies and developers participating in similar international schemes?	Partly addressed by Phase 1 report, then de-prioritised.
	(m): What would have happened to Offshore Wind support costs under the Renewables Obligations had it not been replaced by the CfD?	Addressed in both Phases
	(n): Has the CfD been better at attracting overseas investment than the same technologies in other EU/European countries since 2014.	Question de-prioritised

High level question 2	Sub questions	Whether addressed in Phase 1 or Phase 2
Are the design parameters of the CfD scheme and auction allocations appropriate for achieving the intended objectives?	a): How has competition between technologies, and the division of auctions into pots of technologies, impacted on different technologies? Has an appropriate level of competition been achieved?	Addressed by Phase 1 report
	b): Was the initial classification of technologies in Pot 1 and Pot 2 effective in supporting the development for emerging technologies?	Addressed by Phase 1 report
	c): How would have the auction outcomes differed had all technologies been competing rather than being split into pots?	Question de-prioritised
	d): Are the CfD delivery incentives (eligibility requirements, Non-Delivery Disincentive, Milestone Delivery Date, Target Commissioning Window, Long Stop date) suitable to encourage projects to deliver at all stages of delivery?	Addressed by Phase 1 report
	e): Are administrative strike prices meeting their intended objectives as set out in the strike price methodology? If not, why?	Question de-prioritised
	f): Has 15 years of support been the appropriate length of subsidy for financing and alignment with other relevant linked timelines?	Addressed in Phase 2

	g): How does the complexity of the scheme, perceived or actual, affect participation and engagement in the scheme? Does this differ for different types of developers and technologies?	Addressed in Phase 1.
	h): Is the chosen auction type (pay-as-clear) effective in driving competition and achieving cost reductions?	Addressed in Phase 1 and Scoping Stage review

High level question 3	**Sub questions**	**Whether addressed in Phase 1 for AR1/AR2**
Is the CfD scheme being delivered as intended?	a): Do stakeholders understand how the auction works? Does this understanding differ for different stakeholder groups?	Addressed in regard to developers for Phase 1.
	b): Are the risks in the CfD contract appropriately allocated between developers and Government/consumers? Is enough and the right information supplied for those bearing risks?	Issues or risk on agreeing strike prices and MDD terms covered in Phase 1
	c): What improvements can be made to the developer journey through the CfD?	Addressed in both Phases
	d): Do BEIS assumptions on load factors and other assumptions match the assumptions made by developers?	Question de-prioritised

High level question 4	Sub questions	Whether addressed in Phase 1 for AR1/AR2
Does the CFD scheme present good value for money?	a): Do the costs and benefits of CfD identified in the answers to the questions above demonstrate that the CfD is providing good value for money for consumers?	Addressed in both Phases
	b): Have CfDs which were allocated via auction rounds reduced the impact of renewable deployment on consumer bills relative to the Renewables Obligation?	Addressed in both Phases

High level question 5	Sub questions	Whether addressed in Phase 1 for AR1/AR2
What are the implications of the findings for the future role of the CfD in assisting the deployment of renewable technology?	a): What do developers see as the future role of the CfD in the renewables market?	Addressed in Phase 3 (re views on CPPAs)
	b.) What would be the implication of removing some of the price insulation	Addressed in Phase 3
	c.) To what extent will renewables be able to deploy without CfD support? What might the CPPA market look like in the future?	Addressed in Phase 3 (re views on CPPAs)
	d.) What scope is there for CfD developers to benefit from additional contracts for capacity or balancing services?	Addressed in Phase 1

	e.) Will the CfD be necessary in the long-term	Addressed in Phase 3 (re views on CPPAs)
	f): What would implications of storage in the CfD scheme be?	Addressed in Phase 1.

Annex C: Process Tracing Results

Introduction

Annex A: Methods provides discussion of the rationale for using Process Tracing (PT) as a method for testing contribution claims within an overall Contribution Analysis approach. This Annex provides a breakdown and discussion of findings for each test. Annex A provides a ToC diagram to illustrate how the scheme's inputs and activities are expected to translate through to intended outputs and outcomes. The core strand of programme theory that PT was used to test was that CfDs:

> *Increase investor confidence to attract greater investment at a lower cost of capital and from a wider pool of sources.*

There are a number of causal links implied within this one sentence, with different outcomes to observe. The core causal links that were explored through the PT tests are summarised below.

1. The scheme 'inputs' (e.g. the offer of a 15-year, inflation linked price stabilisation contract), will lead to:

2. Increased confidence among investors (through providing more certainty over future revenues by reducing risks related the fluctuation of wholesale prices). This in turn leads to:

3a. Attracting greater scale of investment due to the increased confidence among investors and decreased risks.

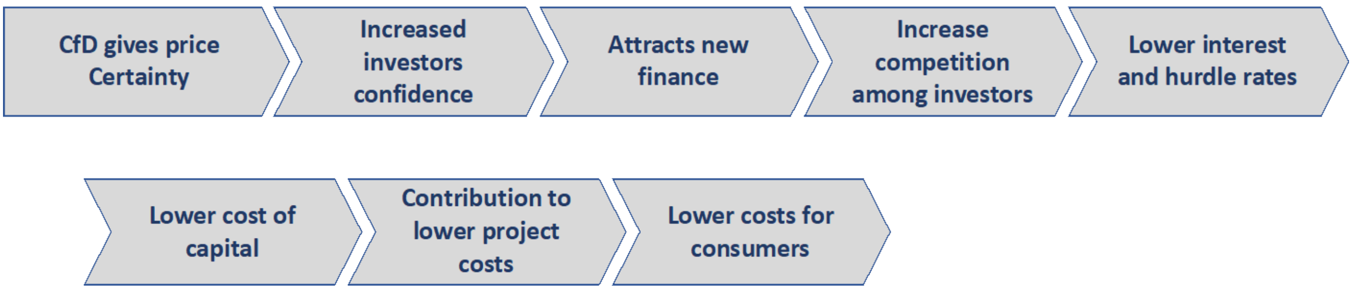
3b. Attracting investment from a wider pool of sources (including institutional investors) with the subsequent effect of increasing competition among investors which leads to offering developers lower interest rates for finance. This leads to the following intended outcomes:

4. Lower costs of capital for developers. This reduces overall project costs. The reduction in LCOE enables developers to bid at lower strike prices. Which in turn leads to:

5. Lower strike prices, of Pot 2 techs, lower levels of support payments, and ultimately:

6. Reduced costs to consumers.

Figure 2. ToC Flowchart of causal links



A series of PT tests were designed to assess causal links in this programme theory of change. In addition, a series of ‘Alternative Hypothesis’ (AH) tests were developed to assess the extent to which a range of external factors, beyond the scope of the CfD scheme, had contributed towards observed outcomes such as increased investment in Offshore wind - for example, technology cost reduction and maturity of the Offshore wind sector internationally.

The rest of the Annex provides a breakdown of results for each PT test.

Contribution claim: increased confidence to invest

The first three Process Tracing (PT) tests were focused on the first causal link of the ToC - that the introduction of the CfD Scheme has contributed towards increased confidence for developer firms and their investors to invest in developing renewables projects in UK. The contribution claim is that because the 15-year CfD price stabilisation mechanism provides more certainty over future revenues, by reducing risks related to the fluctuation of wholesale prices, this reduced risk makes the UK market more attractive for developers and investors to participate.

Evidence to be observed if true

Interviews with developers and investors were used to explore the theory that the CfD Scheme’s 15-year price stabilisation mechanism has contributed towards increased confidence to make investment decisions. The hypothesis tested here is that by reducing risks from price fluctuation, this makes the UK market more attractive to invest in developing renewables projects (in comparison to the previous RO regime). Responses were analysed to assess the extent to which they gave support for meeting this claim and were coded into whether or not they met three types of PT tests, categorised according to the three main groups of respondents:

- **Interviews with AR3 developers (PT1)** – responses gathered in support of the contribution claim from developers who had won a CfD at AR3 were classed as evidence for meeting a ‘Straw-in-the-wind’ test, as whilst these responses increase the plausibility of the hypothesis, they do not firmly prove it. It is feasible that those who won a CfD want to give a positive view of CfDs in order to support policy continuation.
- **Interviews with developers of eligible projects not winning at AR3 (PT2**) - responses gathered in support of the contribution claim from developers who had not won a CfD at AR3 were classed as evidence for meeting a ‘Smoking Gun’ test, as this further strengthens the hypothesis if observed. It is less likely that those who have been unsuccessful in winning a CfD would say it has had a positive effect on increasing confidence to invest, unless they genuinely agree that, overall, the scheme’s price stabilisation mechanism has had a positive effect on increasing confidence to invest when comparing to the RO.
- **Interviews with financial investor institutions (PT3)** - Similar to interviews with AR3 developers, responses gathered from financial institutions in support of the contribution claim were classed as evidence for meeting a ‘Straw-in-the-wind’ test. Again, whilst these responses also increase the plausibility of the hypothesis, they do not firmly prove it. Those who are interested in investing in projects with CfDs could feasibly want to give a positive view to influence policy continuation.

Examples of evidence in support of contribution claims

Using Nvivo, interview transcripts were coded for instances where each respondent gave responses that align with types of evidence which indicated support for the contribution claim. These responses were then categorised into Nvivo 'nodes' to record and count the prevalence of cases that gave evidence in support of passing each PT test.

The coding of transcripts was carried out on a case-by-case basis - with each case representing one interview with a stakeholder organisation. In many cases, more than one individual person participated in the interview. For example, in interviews with organisations leading the development of a an AR3 generation unit, two or three representatives of the organisation often participated in the same interview.

Within each case, interview transcripts were coded for instances where responses indicated support for the contribution claim (as in example quotes below). The table below provides a breakdown of the total numbers of cases in support of PT tests 1, 2 and 3, by their respective sub-groups.

Table 3. No of cases in support of contribution claim: increased confidence to invest

Groups interviewed	No. of cases in support of contribution claim	No. of cases interviewed
Developers with a CfD at AR3 (PT1)	6	8
Developers without a CfD (PT2)	6	9
Financial Institutions (PT3)	7	7
Totals	19	24

Examples of responses that were classed as evidence in support of the claim are quoted below, taking each of the three groups of respondents in turn.

Interviews with AR3 developers (PT1):

> *I think the CfD stabilisation mechanism has played a key part in encouraging wider institutional investors to invest. Some of the risks that were there 10 years ago have been resolved.*
>
> *From our perspective, we very much see the CfD and its price stabilisation mechanism as incredibly important now and also going forward for the build out of Offshore wind. If you compare to the ROC system, I think there is a growing concern around the effect on the market with low-cost renewables which means that price stabilisation is really important to get these projects built. I think developers and investors want to see a stable pipeline. They want the certainty of returns …they need that revenue certainty. I think it has attracted a lot of interest in the market.*
>
> *Yes, it does (increase confidence). That's a key enabler to make the projects happen. To compare with RO is not something we look at, but from an Offshore*

wind perspective on achieving Financial Close, the CfD is a key enabler. It does what it's meant to do.

The merchant element of the ROCs might have prevented some financial players like pension funds to participate. The CfD offers inflation protection which they like. For some of the players, these kinds of investments might have been a little bit of a red flag before (under RO).

Interviews with developers of eligible projects not winning at AR3 (PT2):

I think without having a CfD contract in place makes it a lot harder (to reach Financial Close). Not to say it can't be done but it's a lot harder. A CfD contract, it makes things a lot easier because for an external lender, they could see that the electricity price risk has been taken off the table.

That it gives fifteen years certainty over price, that is what has been the most attractive.

In our view, a project with a CfD is more bankable, i.e. it is more well-received by the external commercial banks. …This Energy from Waste facility is quite capital intensive. We are talking at least 200 to 400 million pounds per facility depending on size. … (this requires) a big loan from the external lenders. They want to de-risk the project as much as they can, and this is where the CfD comes in. The CfD will top up from the wholesale market price to the strike price. And on that basis, the commercial lenders are very comfortable with that because it just de-risks them from the wholesale market.

Interviews with financial investor institutions (PT3):

I think there was a core group of banks that were very comfortable with ROCs regime. And then the CfD came into effect and that it's much more attractive to a wide range of banks and investors than the ROC regime. It takes away any merchant or power price exposure. And that's where I think it really make it more attractive for financing.

I think that the CfD has helped, compared with the ROC regime, because in the ROC regime there was still a merchant component right from day one, which is not the case in CfD. So there is higher visibility. So overall, considering the capital costs between debt and equity, I think it's cheaper for CfD project than for a ROC project.

The CfD made the UK more attractive to invest in from the perspective of an institutional investor, without a shadow of doubt.

Discussion of findings

The majority of AR3 developers gave responses that supported the claim that the 15-year CfD reduces risks from price fluctuation, and this makes projects with a CfD more attractive to investors (emphasised more strongly by Offshore wind developers). Some ACT developers, and one RIW developer, said that overall, the RO was more attractive for securing investment in their technologies, given the allocation risk associated with CfDs (this point is discussed further in the section below covering the Alternative Hypothesis (AH1)).

Two thirds of the interviewed developers without a CfD at AR3 gave similar responses supporting the contribution claim e.g. the 15-year CfD reduces risks from price fluctuation, and this makes projects with a CfD more attractive to investors. However, there were more respondents in this group who highlighted the allocation risk associated with CfD design, and that this had decreased investment in certain types of technology. On balance, the majority still supported the principle that the CfD's central feature - a 15-year price stabilisation contract, increased confidence to invest (among technologies that are able to secure a CfD).

All of the financial institutions interviewed gave responses that showed support for the theory that the CfD 15-year price stabilisation contract, increased confidence to invest.

Contribution Claim: CfDs attract greater levels of investment in Offshore Wind (PT4)

Interview findings support the claim that the CfD’s price stabilisation mechanism contributed towards attracting greater investment in Offshore wind. The fourth Process Tracing test (PT4) focused on triangulating this claim with other secondary sources. For this claim to be true, we would expect secondary data sources on investment trends in the UK Offshore wind sector to show an increase in the value of investment introduction of CfD scheme and/or that the scale of investment by firms developing Offshore wind generation units had increased.

This is an example of a Process Tracing *Hoop Test*. Data showing an increase in the scale of investment since the introduction of the CfDs does not necessarily mean that this trend is attributable to the CfD scheme itself (it may have occurred if the RO continued, due to the wider market maturity of the Offshore wind sector). Nevertheless, this test acts as a check that is worth exploring, because if the data suggests there has been no increase in investment (or a decline) since introduction of the CfD Scheme then the hypothesis is refuted or needs to be revised. It is therefore an initial ‘hoop’ that the claim needs to jump through for the hypothesis to pass. In Process Tracing terms, hoop tests are ‘necessary but not sufficient’ on their own to prove the theory.

The secondary data confirms the claim that the scale of investment grew since the introduction of the CfD. Using data from RenewablesUK[11] on the generating capacity of Offshore wind projects in the UK that are either operational or under construction and cross-referencing it with information from the LCCC CfD Register, we can see that among the top ten largest projects by installed capacity[12], nine were awarded a CfD and one is supported under the RO. The list of these projects is presented in Table 2 below.

Table 4 List of the 10 largest offshore wind projects in the UK (operational or under construction)

Name	Inst. Capacity (MW)	Region	Support scheme
Hornsea Project Two	1386	Yorkshire & Humber	CfD
Hornsea Project One	1218	Yorkshire & Humber	CfD
Dogger Bank A	1200	North East	CfD
Dogger Bank B	1200	North East	CfD
Dogger Bank C	1200	North East	CfD

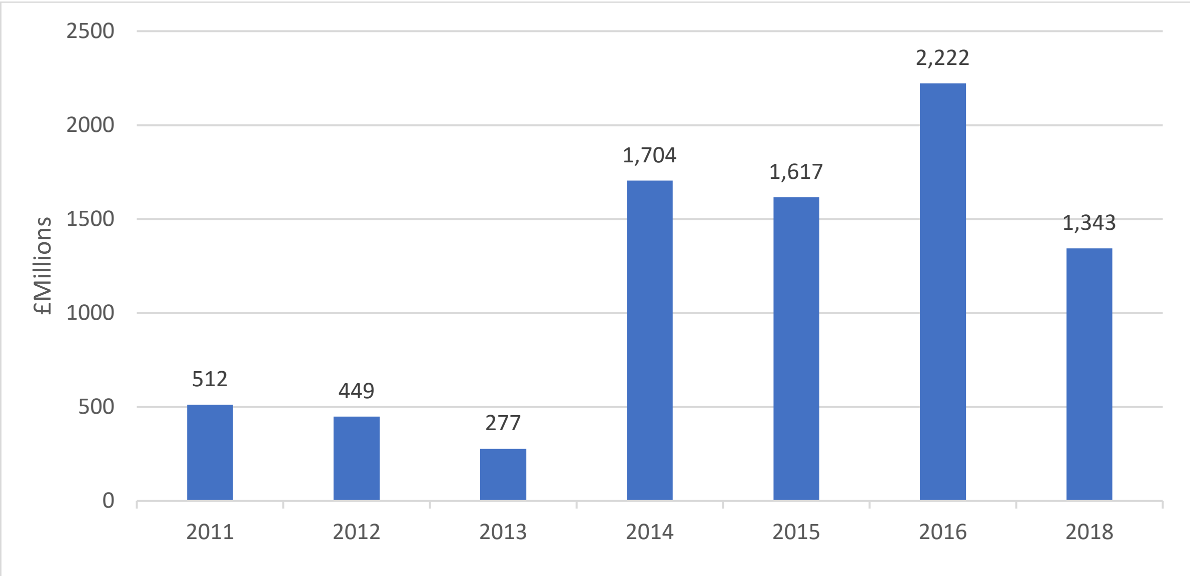
[11] RenewablesUK Database of Wind Energy Projects: https://www.renewableuk.com/page/UKWEDSearch
[12] Considering projects that are operational, under construction or were awarded a CfD or a ROC.

Name	Inst. Capacity (MW)	Region	Support scheme
Moray Firth Eastern	950	Scotland	CfD
Triton Knoll	860	East Midlands	CfD
East Anglia ONE	714	East of England	CfD
London Array Phase One	630	South East	RO
Beatrice	588	Scotland	CfD

Source: RenewablesUK and LCCC, recreated by Technopolis.

Secondary data also confirms that the average financial investment in Offshore wind projects grew in scale. Eurobserv'ER gathers data from closed financial deals on Offshore wind projects and makes them available in aggregate form. Although it is not possible to disaggregate the data to compare CfD- and RO-supported projects, there is a clear increase in the average size of the deals since 2014 that favours the hypothesis that financial investment in CfD-based project is, on average, larger[13].

Figure 3 Average asset finance[14] investment in offshore wind in the UK (GBP million/project)



Contribution Claim: attracting investment from a wider pool of sources (PT5)

Interviews with developers and investors were used to explore the claim that the CfD was a contributing factor towards widening the pool of developers and institutional investors to invest in UK renewables development (particularly the Offshore wind sector). This is similar to the first

[13] Note that the data for 2018 may not include all the Offshore wind projects awarded a CfD in AR2, which reached Financial Close after the analysis by Eurobserv'ER in 2018

[14] Source: EurObserv'ER Barometer. Funded by EU.2018. Asset finance covers all investment into utility-scale renewable energy generation projects. The underlying data is deal-based and covers all closed deals in the respective year. This means that for all included projects the financial deal was agreed upon and finalised, so the financing is secured.

contribution claim (that CfDs increased confidence and made the UK market more attractive). However, in this PT we explore the next causal link in the ToC to look for more explicit statements in support of the theory that this attracted new entrants to the market such as institutional investors (e.g. pensions fund managers and insurance companies) that had not previously financed or purchased equity in UK renewables assets.

Examples of the types of responses that were coded as supporting evidence are given below table 5, for each category of; developers who won a CfD at AR3, developers without a CfD and institutional investors. This included examples where the organisation stated the CfD was a crucial factor for the own organisation's decision to invest, as well as whether they felt the CfD had contributed towards wider investors being attracted overall. Observing this type of evidence was classed as passing a "*Straw-in-the-Wind*" test as it lends support to the contribution claim, but such interview findings alone do not definitively prove it (without triangulation with other authoritative data sources on the changing profile of investors).

The table below provides a breakdown of the total numbers of cases in support of PT test 5, by their respective sub-groups.

Table 5. No of cases in support of contribution claim: attracting investment from a wider pool of sources (PT5)

Groups interviewed	No. of cases in support of contribution claim	No. of cases interviewed
Developers with a CfD at AR3	5	8
Developers without a CfD	6	9
Institutional investors	4	7
Totals	15	24

Example responses from each sub-group

Interviews with developers who had won a CfD at AR3:

> *I think there's more investors in general coming in to show an interest in these projects (Offshore wind). A lot of it to which the CfD has contributed to.*
>
> *Investors need to see certainty of revenue. And so the CfD has generated more interest among wider, international investors.*
>
> *The European Credit Agencies have taken more and more interest in UK Offshore wind. It's partly due to the size of the investment opportunity. Offshore wind projects are big, multi-billion-pound infrastructure projects now. There aren't many other infrastructure projects around at that scale in the UK which also offer the type of stable guarantees of a CfD. Although I think the CfD stabilisation mechanism has played a key part in encouraging wider institutional investors to invest.*

Interviews with developers of eligible projects not winning at AR3:

> *I think lenders are a lot more trained on CfD and I'm sure that most of them are happy to lend, especially to Offshore wind …. you can look at news articles, people going in like there's no tomorrow.*

> *The CfD and the 15-year price stabilisation contract was a key factor in deciding to invest at scale in developing the UK. Without that, then, there are other jurisdictions that we could have spent our money in [Developer who was unsuccessful at AR3, but had a CfD from AR1].*

Interviews with financial institutions:

> *If you just look at the composition of bank groups from the ROCs to the CfD, you'll see that there's a significant increase in the number of institutions who are looking at the sector. And in particular, the pension funds who have provided institutional investment. And a lot of the Asian banks, Japanese banks and the Chinese and Korean. I've seen probably an increase in the ticket sizes15 that people are willing to do as well. So, where you had merchant exposure in the past, it might have limited people's overall ticket sizes on transactions. As these projects got bigger and the debt sizing requirements have gone up, the sponsors have still been able to get their transactions away because they have been able to tap more banks and state larger tickets as well.*

> *Players like us are not equipped to deal with merchant risk. We don't have a team of traders. We may have some sort of view formed with consultants of where prices could go, but that's not an informed view and we're not equipped to deal with that. So, if the prices change, we would just have to take the hit. So even when the CfD is at £50 per megawatt hour, it still is an extremely, extremely useful contract for people like us to invest in Offshore wind because of the visibility of the tariffs.*

> *I think there was a core group of banks that were very comfortable with ROCs regime. And then the CfD came into effect and that it's much more attractive to a wide range of banks and investors than the ROC regime. It takes away any merchant or power price exposure. And that's where I think it really make it more attractive for financing.*

> *It attracts every financial institution and their dog along to try to finance those deals.*

Discussion of findings (PT5): CfD attracted investment from a wider pool of sources

Overall, the majority of respondents supported the claim that introduction of the CfD scheme played a contributing factor towards attracting a wider pool of investors, as well as international developer firms (for Offshore wind). The total numbers in support are slightly lower than those agreeing with the first causal link in the ToC (that the CfD price stabilisation is attractive to investors and has increased confidence in comparison to the RO regime). Where there was uncertainty over whether the introduction of CfD had caused new entrants to be attracted, this was primarily due to the view that this reflected wider global trends, for example, because the

[15] 'Ticket size' refers the value of individual investments.

Offshore wind sector is maturing, and the size and scale of investment opportunities have increased. This is discussed further in the section below on external contributing factors.

Developer firms who disagreed that the introduction of the CfD had attracted a wider pool of investors or developer firms, were primarily those with a focus on developing technologies other than Offshore wind. In these cases, the main point expressed was that because other technologies have had less opportunity to win a CfD since AR1 (e.g. solar, onshore wind, marine technologies etc) the introduction of the CfD scheme had been followed by a relative decline in participation by firms who specialise in investing in or developing these technologies. Therefore, when envisaging a counterfactual scenario where the RO had continued as before, they felt the overall profile of participants investing in UK renewables development would have been wider.

PT6 attracting investment from a wider pool of sources (secondary data sources)

PT test 6 aimed to triangulate interview evidence with secondary data sources on the profile of investors in AR3 generation units as an additional check on whether participants had diversified. The pre-fieldwork plan was to analyse sources such as the Bloomberg Terminal to determine which types of financial institutions had invested in AR3 projects awarded a CfD and assess whether there were new entrants (a Hoop test). However, at the time of writing, the projects awarded a CfD at AR3 have not yet reached their Final Investment Decisions (FID). It is therefore too early to confirm what the profile of investors in these projects will be, and this test is currently inconclusive.

The Phase 1 report used Bloomberg data to analyse the profile of parent companies owning and investing in AR1 and AR2 projects and compare this with the profile of owners of the same types of technologies awarded a ROC. This suggests there was a slightly higher proportion of large international utility companies investing in UK Offshore wind since introduction of the CfD (for example, Iberdola, Equinor, Vattenfall, and Orsted). Phase 1 interview findings also corroborate the claim that introduction of the CfD scheme was a contributing factor for international utility firms to invest at large scale in the UK.

Looking forward, one category of new entrants to the UK Offshore wind development sector may be major oil and gas companies. Shell, Total and ENI have reported their intention to invest in Offshore wind and have expressed interest in participating in the Crown Estate Round 4 seabed leasing round for Offshore wind development.[16]

Contribution Claim: CfDs contribute towards lower costs of capital for developers (PT tests 7, 8, 9 and 10)

PT test 7 aimed to test the next causal link in the ToC chain – having shown that; a) the price stabilisation mechanism reduces risks related to the fluctuation of wholesale prices, we then assume that b) this will translate through to lower hurdle rates for investors and c) this in turn means developers have lower costs of capital in financing project development and operational phases.

[16] https://uk.reuters.com/article/uk-shell-windpower-britain/shell-shrugs-off-brexit-to-eye-foothold-in-uk-offshore-wind-market-idUKKCN1QB1GW

https://www.oilandgasvisionjobs.com/news-item/oil-giants-hover-as-uk-starts-offshore-wind-lease-round

https://www.csomagazine.com/sustainability/eni-capitalise-next-auction-uk-offshore-wind-farms

The first test of this claim was to check authoritative data sources on factors driving cost reduction. BEIS' Cost of Electricity Generation report[17] (2020) shows that since 2016, renewables costs have declined in comparison to gas powered generation (particularly in the case of Offshore wind). Across most renewable technologies, increased deployment has led to decreased costs via learning and innovation, which has then incentivised further deployment, and technology development. The report estimates that lower hurdle rates for investors have also contributed to the decline in renewables costs. The hurdle rates and other costs stated in this report were used to underpin the modelled estimates of costs and benefits from the CfD scheme, as described in Annex D: Value for Money Assessment.

PT tests 9 and 10 similarly aimed to assess further secondary data sources to identify whether the CfD reduced hurdle rates for investors through either:

- Developers sharing documentation which show lower WACC is achieved under CfD projects compared with the RO e.g. extracts from their project business cases or commissioned secondary analysis (PT9).
- Analysis of Bloomberg Terminal data on the financial deals agreed for Offshore wind projects. This searched for information on the interest rates applied by banks for debt finance for Offshore wind project development (PT10).

Limited and inconclusive evidence was gathered from these two routes, as the interest rates applied for individual financial deals are commercially sensitive and typically not disclosed. Regarding PT9, one developer shared a report from analysis they had commissioned to a consultancy firm which suggested the introduction of CfDs reduced WACC for Onshore wind projects at AR1. During interviews, most respondents were able to discuss views on the extent to which CfDs reduced costs of capital (see the section below on PT8 for results) but could not disclose commercially sensitive information on the precise interest rates agreed with investors who had provided finance.

Regarding PT10, information is available via Bloomberg on which banks have provided debt finance to most Offshore wind projects with a CfD or ROC and the total £value of loans. However, in most cases, details of the interest rates applied to debt finance deals were not disclosed. There were two cases where this information was available. This suggested that interest rates applied to debt finance for Triton Knoll (which has a CfD) were lower than the rates applied to Beatrice (which has a ROC). Although this is in line with the theory of change (what we would expect to see), we cannot form any conclusions over whether this represents a trend given it is based on only two projects.

PT test 8: Interview findings on contribution to reduced costs of capital

PT test 8 used interview findings to assess the claim that CfDs contribute towards lower cost of capital for developers. The types of responses coded as evidence in support of this claim were those where respondents suggested that either; the CfD led to their own organisation reducing hurdle rates when investing in renewables projects, in comparison to similar projects with ROCs, or that they believed introduction of the CfD had contributed towards lower interest rates being applied by financial investors more broadly in the sector and that this had contributed towards lowering costs of capital for developers. The responses coded for this PT also supported a second link in the ToC (that the increased population of banks and other

[17] https://www.gov.uk/government/publications/beis-electricity-generation-costs-2020

financial institutions providing finance to Offshore wind projects increases competition among lenders, further contributing towards lower interest rates being offered).

Examples of these responses are given below table 6 for each category of; developers who won a CfD at AR3, developers without a CfD and institutional investors. Observing this type of evidence was classed as passing a "*Straw-in-the-Wind*" test as it lends support to the contribution claim, but such interview findings alone do not definitively prove it (without triangulation with other authoritative data sources).

Table 6 No of cases in support of contribution claim: CfDs reduce costs of capital

Groups interviewed	No. of cases in support of contribution claim	No. of cases interviewed
Developers with a CfD at AR3	4	8
Financial Institutions	4	7
Developers without a CfD at AR3	3	9
Totals	10	24

Developers with a CfD at AR3:

Having that revenue certainty opens you up to more financial institutions, and almost by definition, if there are more institutions then the cost of capital will fall [as competition among lenders leads to offering more attractive rates]. So that gets factored into a 1 to 2 percent reduction to hurdle rates.

It certainly has an impact on the terms of debt finance applied by banks. They do seem to have improved since ROC projects. It is clear it has had some effect on reducing the costs of capital.

To some extent, overall, there is a trend that the cost of capital decreased which can be attributed to the CfD. But maybe also its because projects are being built on time and budget, most of the time, so that kind of technology risk decreased. Also, CfD revenues provide more certainty, probably, than ROCs.

I think the CfD plays a part [in reducing costs of capital]. It all comes down to risk profile. The market is maturing, and investors are becoming more comfortable with the risks and trust the developers to deliver the projects and manage the risks. I think with the CfD, we understand that instrument. The contract's been pretty stable since its first come out. I think it's a combination of those things.

Financial institutions:

I think yes, more investors were more comfortable with the CfD. Broadly speaking, I would suggest there is potentially a 75 to 100 basis points reduction and return requirement under a CfD …. every investor will be slightly different. The CfD was definitely seen as something that was more robust. There is less merchant risk and people could accept lower returns on that basis.

I think that the CfD has helped, compared with the ROC regime, because in the ROC regime there was still a merchant component right from day one, which is not the case in CfDs. So there is a higher visibility. So overall, considering the capital costs between debt and equity, I think it's cheaper for a CfD project than for a ROC project.

The cover ratio that you become comfortable with is probably lower. Therefore, you put more debt in. So the gearing is on average higher overall for CfDs. It achieves exactly the objective of the CfD which is to reduce the cost capital. So the WACC goes down.

Say there is one country where there is price stabilisation, and another country where there's no price stabilisation. In the country with price stabilisation, you can get more debt. You can also get lower returns to equity investors because there is visibility. So, you need a lower tariff than in the land where, you know, there's a lot of risk and there are high equity returns.

Developers without a CfD at AR3:

I guess it does affect your overall cost of capital because you're not asking those equity investors to take risk on the wholesale price curves, and I'd say generally investors seem to be slightly less nervous about the forward wholesale market curves than they were perhaps five years ago. But I think that the CfD is incredibly important, probably more so for debt investors, because it means that you're no longer trying to finance a project in which the amount of debt you can raise is determined by a very pessimistic forward price on wholesale electricity. And instead, you have effectively guaranteed forward curve, which you can use to increase the amount of debt and reduce the overall cost of capital.

I think it's probably not so much about the hurdle rate. I think it's due to increasing your ability to improve the amount of debt in the project.

Having a CfD provides that certainty and that was a lot bankable. And what this means is that the cost of capital for us to borrow funds from the lenders would decrease. And it helps us a lot. [Developer with a CfD from previous Allocation Round who was unsuccessful at AR3].

Discussion of findings PT8: CfDs contribute towards lower cost of capital

A slight majority of financial institutions supported the claim that CfDs contribute towards lower costs of capital. This group were also most likely to provide a quantitative estimate of how much of an impact CfDs have on lowering their hurdle rate to invest (when comparing to similar projects with ROCs). The views of financial institutions may be considered most relevant to addressing the question of whether or not the CfD has reduced costs of capital because they represent the banks and fund managers that decide what levels of interest are provided when making investment deals and are in a position to say whether having a CfD effects their decisions.

Among the three financial institutions who did not give clear responses in support of this contribution claim, the main reason was not because they disagreed that CfDs may contribute towards lowering costs of capital, but rather they were unsure of the extent to which costs reductions could be attributed to the CfDs or to other factors that have lowered risks for investors (such as technology maturity).

A common explanation given by both developers and institutional investors on how the CfD contributes towards lowering costs of capital was that it enabled developers to access a greater proportion of debt finance at lower rates. This means the developer firm is less reliant on equity investment from third parties as part of the project's overall financial structure (equity investment was described as commonly requiring higher rates of return). This enabled developers to increase gearing ratios (higher proportion of debt vs equity) contributing towards lower costs of capital overall.

Around half of developers with a CfD at AR3 agreed with the PT8 hypothesis that CfDs contribute towards lower costs of capital, as did a third of developers without a CfD. Among those who did not agree, the main reasons given were either:

- While they recognised costs of capital may have decreased since introduction of the CfD scheme, they were unsure whether or not this could definitively be attributed to the CfD over and above wider market trends such as maturity of the Offshore wind sector reducing risks; and
- Developers focused on non-offshore wind technologies who emphasised the point that it was more difficult to obtain a CfD than a ROC, due to competition of auctions and allocation risk. Therefore, this had increased risks for developers and investors to invest in undertaking early planning and project development work.

Contribution claim: the competitive nature of CfD auctions contributes to lowering costs (PT test 11)

As described in the main report, strike prices for projects awarded a CfD have reduced significantly since AR1. The AR3 strike prices are around one third of what they were in AR1 - with a drop from around £120/MWh down to around £40/MWh for Offshore wind and ACT.

PT test 11 used interview findings to assess whether the competitive nature of bidding at auctions drives developers to offer their lowest feasible strike prices (rather than just lower costs of capital enabling a reduction in overall project costs).

Responses from developers supporting the claim that the competitive nature of auctions has played a significant contribution towards the trend of reducing strike prices provide a convincing contribution claim (*a Smoking Gun* PT test). It may be less prone to being stated if untrue, as the implication of this is that without competitive auctions (as for RO) developers unnecessarily increase profit margins. Examples of the types of responses coded as evidence in support of the contribution claim are provided below table 7, for each of the three main groups of respondents.

Table 7 No of cases in support of contribution claim: competitive auctions contribute towards lowering costs

Groups interviewed	No. of cases in support of contribution claim	No. of cases interviewed
Developers with a CfD at AR3	6	8
Financial Institutions	5	7
Developers without a CfD at AR3	4	9

Totals	15	24

Developers with a CfD at AR3:

I suppose the main difference with ROCs is that you weren't forced to go into a competitive auction process. And I think it's fair to say that the competitive auction process has accelerated cost reduction much more quickly than if we just stayed in a status quo.

It's primarily the competitive auction environment that led to falling strike prices. Everyone needed to optimise. Moreover, in a couple of the projects the supply chain was forced to reduce costs as well.

I think you're seeing the same in other countries as well (falling strike prices for Offshore wind). The common denominator is the competitive processes. And certainly, the auction designs are all different, but when you try and model it it's showing the same change effectively. From our perspective, there was not one area in the business case we left unturned. All the money that was hiding down the socks was tipped out; every potential source of revenue was looked at. As a policy instrument it's been effective, absolutely.

Financial institutions:

I think the general view is that the structure of having that six-gigawatt cap meant that there was more competition and that drove the prices down even further.

Regarding the six-gigawatt - I think there's no doubt this had an impact…. By giving clearer guidance (on budget and capacity), I think from a government point of view, it's probably successful in creating competitive tension which is ultimately going to drive down pricing.

I think cost reduction has been phenomenal. But I think subsidy reduction has almost outstripped that and it's got to levels, due to the competitive nature of the auction, in which people with substantial sum of development expenditure are having to bid at levels that make them broadly economic, but far from the returns they thought they were going to get when they went into those projects originally. But they are so scared about not getting a CfD and potentially having to wait two years, and the corporate PPA market not being developed enough, that they just have to bid at this level. Competition is a great thing and is reducing the prices to the consumer and so on, but I actually worry (with its impacts) in terms of deployment.

There is a question mark as to whether the competition has been so high that people are making very big bets. Developers are making aggressive bets and they might not make the returns that they were making in the past. And I think that's just a normal consequence of a market getting crowded in the long term that adjusts because if people lose money in this round, they won't lose in the next round because they've learnt.

Developers without a CfD at AR3:

Oh, significantly. I think that (competition) had a huge impact on the way that the whole supply chain works together to optimise costs and therefore bring down prices … because of the competitive nature and because of the allocation risk *involved. When the CfD was introduced that was one of its goals, and it has definitely worked.*

The competition promoted by CfD auctions was the main driver of the cost reductions. Of course, there is technological development, but competition was very important.

CfDs promoted cooperation between developers and supply chain. Back in the days when it was Renewables Obligation and I was developing projects, I would go and speak to your manufacturers to procure the equipment that you need… It was very much a seller's market. They would say, "This is the price. This is when you can have your equipment". And then with the CfD, that's completely changed, because you need to focus on a price and getting your price as low as possible. Then everyone has to look at how they can optimise the project and work together instead of saying that's what it is, take it or leave it.

Discussion of findings (PT 11): competitive auctions contribute towards lowering costs

Overall, the majority of respondents agreed that the competitive nature of CfD auctions was a strong contributing factor in driving the reduction of strike prices between AR1 to AR3. Developers described two main ways in which competition drives lower strike prices. Firstly, developer firms will provide closer scrutiny to their business case to identify any ways in which project costs can be reduced in order to submit a competitively priced bid. This then affects the wider supply chain (for example, turbine manufacturers being aware Offshore wind development in the UK is now a highly competitive market and subsequently working with developers to find ways of lowering costs to increase chances of the project winning a CfD).

Some respondents stated that the 6GW capacity cap at AR3 may have further increased competitive tensions for this round, contributing towards the reduction in strike price since AR2. Some also felt that this had led to such low bids, and consequently such low margins of return, that it may raise risks of non-deployment. This point was raised by both financial institutions and some non-offshore wind developers who had a won a CfD at AR3 and were now finding it challenging to reach financial close at the strike price awarded. This risk is reflected in findings from the Phase 1 report, which described how some non-offshore wind projects awarded a CfD at AR1 and AR2 were unable to reach financial close at the price awarded and subsequently had their contracts terminated.

Just under half of developers without a CfD also gave responses supporting the view that competition in auctions leads to lower strike prices. Among the half who did not give responses in support of this contribution claim, most did not disagree that competition may have played a role but were unsure or did not give a clear answer either way. Some of these respondents had developed projects under the RO but had never won a CfD and were therefore not as well placed to comment on the extent to which different factors contributed towards the lower strike prices achieved.

Alternative Hypotheses: Role of External Contributing Factors

A series of Process Tracing tests were also developed to gather evidence on the extent to which external factors outside the CfD scheme had contributed towards observed outcomes of increased investment and lower strike prices (for example, technology development and maturity of the Offshore wind sector globally). Note that cases coded as agreeing with these claims were not treated as mutually exclusive from the programme theory tests. It was common for respondents to state that increased investment in the UK Offshore wind sector and lower strike prices have been driven by a combination of factors, of which the CfD has played a contributing role.

In addition, a PT test was developed to explore the Alternative Hypothesis (AH1) that while the price stabilisation aspect of CfDs are welcome (if obtained), developers/investors would have had greater levels of confidence in investing under the RO. For this test, interview responses were coded for examples where respondents indicated that while price stabilisation is welcome, it has not increased their confidence to invest in comparison to the RO. This is because certain features of the RO design (such as its 20-year contract length and/or its reduced allocation risk), meant that it was more attractive than the CfD scheme overall for developers of some technologies.

Examples are given below of responses from developers in support of AH1; that the CfD scheme had not increased confidence to invest, because investing in UK renewables projects would have been equally (or more) attractive under the RO. None of the financial institutions interviewed gave responses in support this claim. From their perspective, investing in projects with CfDs was generally considered more attractive than projects with ROCs, given the increased certainty over returns.

Developers with a CfD at AR3:

> *In this particular instance (RIW project), no it didn't increase confidence. It was the only route to market available for Remote Island Wind (now RO is closed) so there was no other alternative. It was that, and not so much the price stabilisation mechanism, that made the CfD attractive.*
>
> *The ROC regime provides a lot more confidence because it was specifically designed for a technology demonstration. A CfD as it currently is supposedly for a new emerging technology or for less established technology, but it is very commercially driven as you can see from the prices that have cleared. The fact that you had to compete with commercial projects provided that negative impact. If it was definitely just for new technologies that would provide a lot more confidence.*
>
> *I think the one thing that is clear with the CfD as opposed to ROCs is CfD are really, really difficult for small and medium sized developers. Under the old ROC regime, it was worth doing because you knew you would get the power price and you would get a ROC …. So not only would small and medium sized companies work for free (to develop projects), but advisors would work for free knowing it had a reasonable chance of going ahead. You just don't get that with CfD because the chances of going ahead is so much less certain.*

Developers without a CfD at AR3:

> *Based the current price, the CfD hasn't really helped to make UK market more attractive. We are talking about the mid-high 40s, sort of a clearing price. This is not really attractive. But the principle of the CfD, which is to eliminate the risk from the wholesale market for investment is attractive. The principle is attractive, but the actual implementation and the actual result of that is putting a dent on the attractiveness.*

CfDs worked to attract investors to certain types of technology, the cheaper types of technology. So as far as biomass was concerned, I think once the second round of the CfD was over, biomass was dead as far as investors were concerned.

It hasn't made UK more attractive for Tidal. Because since the removal of the ringfence (at AR2), the CfD is not useful to us at the moment.

I think the RO was good. It was probably a bit too good in the beginning. I mean you were you buying an asset and the payback period was like nine months with the RO…. But it was probably, you know, perhaps a bit of a gravy train. That's the main reason why was changed in the end, because it was just too good. And for taxpayers, it wasn't good enough.

Table 8 No of cases in support of AH1: RO was equally or more attractive to investors than the CfD scheme

Groups interviewed	No. of cases in support of contribution claim	No. of cases interviewed
Developers with a CfD at AR3	4	8
Financial Institutions	0	7
Developers without a CfD at AR3	5	9
Totals	9	24

Discussion of results (AH1)

The range of responses given closely correlate with the types of technology that developer firms focus on. Offshore wind developers were more likely to highlight ways in which the CfD is more attractive and had a positive effect on their investment decisions (supporting PT1). However, developers of non-offshore wind technologies (including RIW, onshore wind, ACT and marine technologies) emphasised that because they struggle to compete with Offshore wind on price, the CfD scheme had decreased confidence to invest, compared with the RO. However, there was some acknowledgement that the central feature of CfDs (price stabilisation) was attractive, for developers of technologies that can obtain one.

Developers of non-Offshore wind projects commented on the consequences of including Offshore wind in Pot 2 for other less established technologies. It was felt that some form of ringfenced support is needed to enable non-offshore wind projects to advance towards commercialisation. For example, through the use of minimum budget allocation, or a revised Pot structure, to support investment, technology innovation and future cost reduction.

Overall, we cannot conclude that the CfD made no impact on increasing confidence to invest in renewables development and therefore the theory tested in in this alternative hypothesis has not been met. There is strong support for the counter claim that the CfD has increased investment in technologies that are awarded CfDs (particularly Offshore wind). Consideration of whether or not the CfD has attracted increased investment varies according to types of technology and their prevalence of winning CfDs.

Alternative Hypothesis Two: investment in Offshore wind primarily driven by external sector trends (AH2)

Process Tracing test 'Alternative Hypothesis 2' (AH2) assessed the alternative theory that whilst there has been increased investment, and cost reduction, in Offshore wind, this is primarily driven by external contributing factors, such as technology innovation and maturity of the sector globally, rather than by the CfD scheme specifically. Note that cases coded as agreeing with this claim were not treated as mutually exclusive from PT1 (agreeing the CfD increases confidence to invest). It was common for respondents to state that increased investment in the UK Offshore wind sector has been by a combination of factors, of which the CfD has played a contributing role.

Examples of the types of responses coded in support of AH2 are given below, for each of the main sub-groups interviewed.

Developers with a CfD at AR3:

> *I think there's more and more investors in general coming in to show an interest in these projects (Offshore wind). There's a lot of it which CfD has contributed to. A lot of it has just to do with the general kind of macro-economic background and the kind of corporate social responsibility agenda that more and more corporations are trying to align themselves with. There's no shortage of people wanting to invest in these assets.*
>
> *We're in a moment in time where we've had record low interest rates. So what we've seen as a consequence of that is relatively cheaper financing costs. As well as that there's quite a bit of competition in the lending community, which also helps. So there's probably more lenders in the space then there was 5, 10 years ago. And that together with the kind of macro low interest rate that we're experiencing, has helped to lower the cost of debt.*
>
> *I think the CfD plays a part. It all comes down to risk profile. The market is maturing (for Offshore wind), and investors are becoming more comfortable with the risks and trust the developers to deliver the projects and manage the risks. I think the CfD, we understand that instrument. The contract has been pretty stable since it first come out. I think it's a combination of those things.*
>
> *Overall, there is a trend that the cost of capital decreased which can be attributed to the CfD. But maybe it's also just because projects (Offshore wind) are being built on time and budget, most of the time, so that kind of technology risk decreased.*

Financial Institutions:

> *I would suggest that a combination of both high international liquidity and the CfD itself have worked to bring WACC down. But also, essentially Offshore wind is now becoming more of an established infrastructure in its own right. It's delivering at scale and that's attracting larger infrastructure investors as they get more comfortable with, first of all, the operational risk on offshore wind. But then even pushing into the construction risk. As we get more and more projects delivered on*

time on budget and they're operating successfully, and capacity factors are higher than expected. And it's actually being seen as a good sector to invest in.

Going more widely in the macro environment, low to negative interest rate in other countries in Asia, particularly in Japan, has meant that some of the institutions that have looked further afield to get their returns and renewables has been a stable of investment for them. Pension Funds are in a low yield environment. They need to look around for alternative investments and yet they're not getting the returns from investing in government or corporate bonds, so they're looking to another risk class where they think that they can get slightly higher yields.

Frankly, it benefits investors because they're big projects (Offshore wind). People love renewables generally; it ticks the box ESG wise18.

Developers without a CfD at AR3:

I think it's (increased investment) more due to with the general market condition. Investors are spreading their net wider to try to find projects which will give them the returns that they want. In what's obviously a relatively low return climate as a whole.

The turbine manufacturers are facing a supply chain war with each other where they have to cut each other's throats to keep their production lines running…. The turbine supply market is effectively supplying with very little margin whatsoever but a great deal of risk, and that is to keep their production lines going. So that needs to be taken into account (in considering factors contributing towards cost reduction).

I doubt if the CfD has had any effect (on lowering costs of capital). That's just a personal opinion but I don't think it will have done. I think its the economies of scale, the plants are getting bigger, as well as the technologies are more developed.

Table 9 No. of cases in support of AH2: Investment primarily driven by external factors

Groups interviewed	No. of cases in support of contribution claim	No. of cases interviewed
Developers with a CfD at AR3	4	8
Developers without a CfD	3	9
Institutional investors	4	7
Totals	11	24

[18] Environmental, Social and Governance (ESG) - refers to a class of investing that is also known as “sustainable investing.” This is an umbrella term for investments that seek positive returns as well as long-term positive impact on society, environment and the performance of the business.

Discussion of findings (AH2): Investment primarily driven by external factors

The majority of Offshore wind developers with a CfD, as well as institutional investors, supported the AH2 hypothesis that recent trends in both; a) increased investment and b) lower costs of capital, have been driven by a combination of external market factors, as well as the CfD scheme. The main external contributing factors discussed include:

- Maturity of the Offshore wind sector – with an increased track record of projects being built on time and providing expected returns, perceived risks for investors have reduced
- Technology development and economies of scale – through industrial scale manufacturing of larger, more efficient wind turbines
- Global macro-economic factors – low central bank interest rates, internationally, and lower returns from Government bonds have influenced institutional investors to diversify their portfolio and invest in new assets, such as Offshore wind
- Increased awareness of the climate change agenda, influencing financial institutions to invest in clean energy projects, as part of the corporate guidelines on Environmental, Social and Governance (ESG) investments.

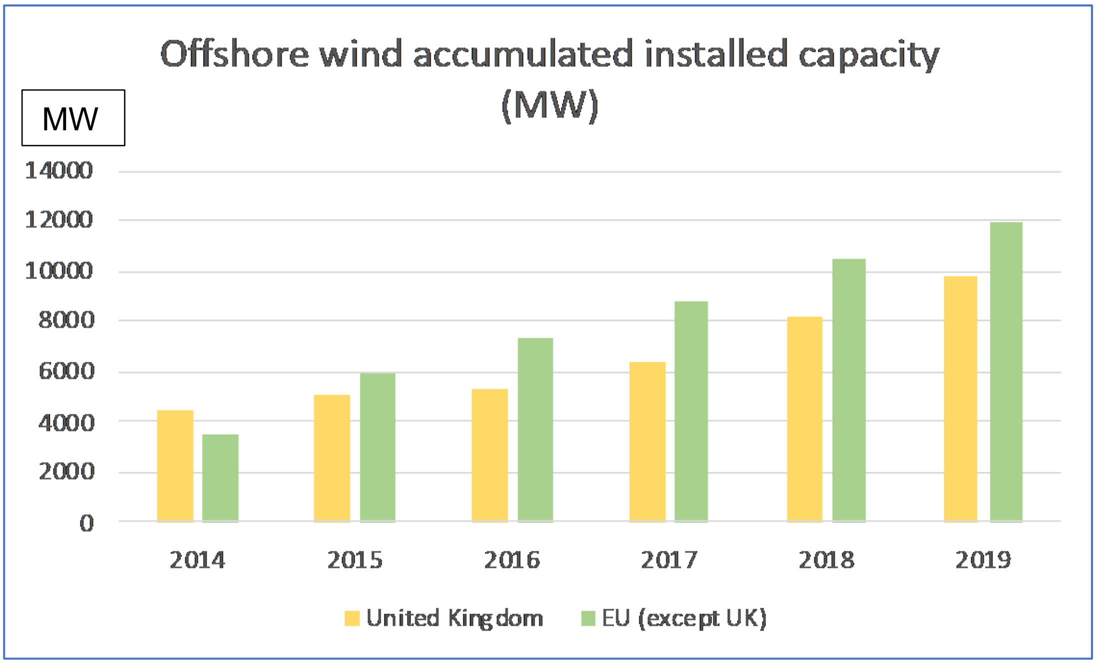
Although less than half of respondents supported the AH2 theory that external factors were the main drivers of increased investment and reduced strike prices in Offshore wind, this does not mean those who did not give such responses disagreed with this view. The cases where no AH2 responses were coded were primarily developers of non-Offshore wind projects. In these cases, respondents were either uncertain or did not give a clear view on factors related to Offshore wind investment. As this topic was not as relevant to them it was not discussed at length in these interviews.

Contribution Claim: Increased investment and cost reduction in Offshore wind is in line with international trends (AH3).

PT test AH3 used secondary data sources to assess whether the rate of increased investment in UK Offshore Wind, since introduction of the CfD scheme, is in line with international trends across Europe. This test was classed as a "*Straw-in-the-wind*" PT test, as observing this evidence lends support to the claim that investors are driven by the maturity of the industry, internationally, rather than UK specific CfD policy. Although this increases the plausibility of the alternative hypothesis, it does not disprove that CfDs played a role in attracting investment to the UK. Other countries also have a range of renewable energy auctions and investment support policies to encourage investment.

The EU funded EurObeserv'ER statistical series was used as an authoritative source for trends in annual increases in installed generating capacity for Offshore wind. EurObserve'ER is primarily based on collating data on renewable energy generation from EU member states' national statistics offices. The bar chart below shows the accumulated installed capacity of Offshore wind for the UK annually since 2014, compared with the rest of EU member states combined (not including the UK).

Figure 4 Trends in UK and EU installed Offshore wind capacity



Source: Data from EurObserv'ER (2020), with chart created by Technopolis

This data suggests that rate of increased installation of Offshore wind projects in the UK has followed a similar trend to increases across Europe. This lends some support to the claim that investment increases partly reflect wider market trends on the maturity of Offshore wind. The chart also shows that the UK is a relatively large market for Offshore wind. The installed generating capacity in the UK for 2019 represents around 80% of the capacity of all other EU members states combined.

This data was cross-checked for reliability with other authoritative sources on international trends of Offshore wind generation capacity. The International Renewable Energy Agency (IRENA) Renewable Energy Statistics 2020 Data Series[19] shows an almost identical trend to the chart above when comparing the UK to the rest of Europe.

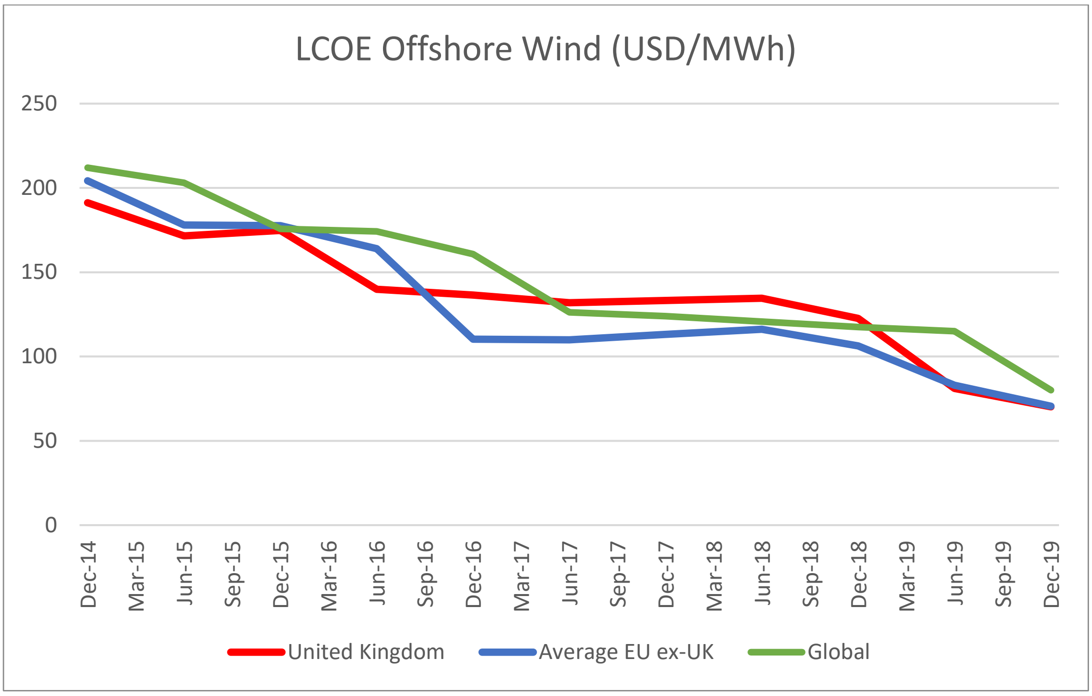
AH4: Assessing trends in cost reduction of Offshore internationally

Similar to AH3 above, the PT test, 'Alternative Hypothesis 4' (AH4) assessed secondary data sources to compare trends in the reduced Levelised Cost of Electricity (LCOE) for Offshore wind in the UK with other countries internationally. Observing evidence that UK cost reduction is in line with international trends would suggest reduced costs are driven by the maturity of the industry internationally, rather than just UK specific CfD policy.

Data sourced from the Bloomberg Terminal (2020) shows that since 2014, the LCOE of Offshore wind has decreased by 65% on average, for other European countries and globally. A similar rate of reduction was observed in the UK in the same period, with LCOE falling from USD 191,21/MWh in December 2014 to USD 70,19/MWh in December 2019 (a 63% decrease), suggesting that the LCOE changes in the UK follows a broader global trend (see Figure 22).

[19] https://www.irena.org/publications/2020/Jul/Renewable-energy-statistics-2020

Figure 5 Levelised Cost of Electricity (LCOE) Offshore Wind



Source: Technopolis analysis of Bloomberg Terminal data (2020)

Although this lends support to the claim that UK cost reduction in Offshore wind has followed international trends, this does not mean the reductions in the LCOE for Offshore wind can be wholly attributed to technology innovation and commercialisation. According to estimates by the International Energy Agency (IEA 2017) for Offshore wind farms, one third of the LCOE comes from capital expenditure, and around one half from the cost of financing these wind farms. Therefore, policy measures aimed at reducing the cost of capital (such as the CfD) can also contribute towards reductions in the overall costs of renewable energy deployment. Several other countries also hold competitive auctions to support renewables deployment, plus provide various other forms of subsidy. The role of other forms of government support, internationally, in reducing the LCOE of Offshore wind is discussed in more detail in a separate report, delivered as part of the scoping stage to the CfD evaluation[20].

Contribution Claim: the CfD contributes to reduced costs for consumers overall (PT12)

PT test 12 is based on the overall economic analysis that, taking all of the above steps in the causal pathway into account, the introduction of the CfD scheme is a more cost-effective policy for supporting deployment of renewable electricity than the RO. Using the Dynamic Dispatch Model (DDM), based on all forecast project costs and benefits, the evidence that we would expect to observe to pass this PT test was that the Net Present Value of benefits under the CfD scheme is positive (in terms overall reduced costs to consumers). This was classed as a *Double Decisive* PT test because it is the type of evidence that both supports the programme theory if found and would weaken/disprove it if not found.

The results of this test are detailed in Annex D. The key findings are the reduction in costs to the consumer due to the CfD projects auctioned in AR1, AR2 and AR3 is estimated at around

[20] Rapid Evidence Assessment: The Role of Auctions and their Design in Renewable Energy Deployment. Technopolis 2018.

£3bn (higher and lower demand reference case, present value terms) in comparison with supporting the same projects under the RO. The scenarios tested produced upper and lower bound estimates of £2bn and £5bn.

With up to 85GW of projected future CfD projects (excluding nuclear) also included prior to 2050, the potential consumer cost savings of the CfD regime through to 2050 are estimated at around £10bn (higher and lower demand) compared to the RO scheme, with a range of £5 bn to £15 bn in the scenarios tested. The lower support costs under the CfD regime are primarily driven by the lower hurdle rates assumed compared to under the RO, which are supported by the qualitative evidence gathered from interviews.

Conclusions

Overall, there is strong support for the scheme's Theory of Change that the offer of a 15-year price stabilisation contract reduced risks for investors by reducing exposure to wholesale price volatility, which lowered hurdle rates for developers. This was reported to have increased access to the provision of finance from a wider pool of investors, resulting in competition among lenders and more attractive interest rates being offered. CfDs play an important role in enabling finance deals that would not happen otherwise. CfDs also contribute towards increased gearing ratios, which further contributes to bringing cost of capital down and, hence, to the reduction of strike prices.

Whilst respondents did clearly attribute cost reductions to the price stabilisation mechanism provided by CfD, they also highlighted the difficulty in isolating the precise size of the effect in reducing overall costs from other contributing factors and broader sector trends. The competitive nature of auctions in particular, was highlighted as an important driver for reducing strike prices. Additionally, wider macro-economic factors, such as lower interest rates in international markets have contributed towards attracting financial investors to invest in the UK renewables sector (Offshore wind at least). Finally, as more CfD projects have been implemented over time, investors have got more comfortable with the risks, attracting yet more investor institutions and offering more attractive rates.

The impact of the CfD scheme in supporting investment and cost reduction in Offshore wind was described by developers as its main success story. However, the extent to which the CfD scheme has increased investment in other technology sectors varied according to the level of opportunity available to those technologies to be allocated a contract, and whether they can compete on cost with Offshore wind. For example, developers focused on marine, ACT and other bioenergy technologies emphasised that introduction of the CfD scheme was followed by decline in investment in these renewable energy technologies, compared with the previous RO regime.

Annex D: Value for Money Assessment

Introduction

Addressing core evaluation questions such as: "Does the CfD scheme represent good value for money?" required developing estimates of the equivalent support levels that would have incentivised the same level of low-carbon deployment under the RO scheme. This was used to compare overall costs and benefits to a counterfactual scenario assuming the CfD Scheme had not been introduced and the RO continued.

This analysis was carried out using BEIS's Dynamic Dispatch Model (DDM). The analysis compared the costs of supporting low-carbon deployment through the CfD regime to a counterfactual assuming the RO scheme had continued.

Overview of the Dynamic Dispatch Model

The Dynamic Dispatch Model (DDM) is a comprehensive fully integrated power market model covering the GB power market over the medium to long term. The model was developed by LCP for BEIS in 2011 and has undergone continuous development since then to reflect market developments and policy reforms and improve functionality.

The DDM has two main purposes: modelling the electricity dispatch from GB power generators and modelling the investment decisions in generation capacity in GB, both out to 2050. Based around data on the GB power market, users can study the evolution of the sector under the influence of various policy and cost regimes using bespoke scenarios.

Outputs include: wholesale electricity market prices, generation mix, capacity levels, emissions and spend on low carbon electricity generation based on inputs including fossil fuel price projections, demand, technology costs, low carbon support levels and build rates. It also produces consumer cost and system cost outputs which allow for comprehensive and consistent Cost-Benefit Analysis.

The DDM considers electricity demand and supply on a half hourly basis for sample days, allowing for plant dynamics and operating constraints. Investment decisions are modelled using an agent-based approach, which includes detailed simulation of the annual Capacity Market auctions. Investment decisions are based on projected revenue and cashflows allowing for policy impacts and changes in the generation mix. The full lifecycle of power generation plant is modelled, from planning through to decommissioning.

Modelling of renewable support regimes

The DDM models the impact of all major GB electricity supply policies including small scale Feed-in Tariffs, the Renewables Obligation (RO), Contracts for Difference (CfDs), Carbon Price Support, the Capacity Market and Industrial Emissions Directive. It has been developed in parallel with the UK's Electricity Market Reforms (EMR) and was used by BEIS (then DECC) and National Grid to model the CfD regime as part of the initial EMR delivery plan.

The CfD and RO support regimes are modelled in detail, with the flexibility to vary support levels by technology and commissioning year. Different CfD contract types are modelled, including exposure to the intermittent market reference price (IMRP) and the baseload market reference price (BMRP). Investment decisions factor in the policy support payments, contract length and hurdle rate adjustments assumed under each regime. The impacts on dispatch and wholesale price are also modelled, with the short run marginal cost of plant adjusted to account for policy support payments.

Model quality assurance

The DDM has undergone extensive quality assurance:

- Internal & external (BEIS) back-testing has been performed to verify that the model replicates historic results to a high level of accuracy. Back-testing on the initial release was conducted over a four-year period and showed very close agreement of prices across the period, along with additional back-testing performed in September 2019 on the reference cases used within this report. Extensive back-testing was also conducted with the introduction of the new "look-forward" dispatch algorithm in 2015.

- External reviews of the modelling methodology and results have been conducted by external experts. David Newberry, (Professor of Economics at Cambridge University and Head Energy policy research group) conducted a quality assurance on both the methodology and the models results. Subsequently, BEIS's "Panel of Technical Experts" reviewed the model as part of its report on National Grid and DECC's EMR analysis in 2013.

A full QA of the underlying model code was performed in 2014 by PWC. All model updates undergo thorough regression testing, and any changes to the model are independently reviewed by model experts in both LCP and BEIS.

Approach and key assumptions

The modelling covered the period from 2016 to 2050, and considered two groups of CfD supported generators:

- Generators allocated CfDs via allocation rounds 1, 2 and 3 (primary focus);

- Generators projected to be allocated CfDs in the future, based on BEIS's 2019 reference cases

Nuclear and potential future CCS CfD contracts were outside the scope of this analysis, and no variation in their support was modelled.

Generators allocated a CfD contract under the FIDER (Final Investment Decision Enabling for Renewables) were assumed to have been supported under the RO scheme in the counterfactual modelling, but these projects were not a focus of the analysis.

The modelling assumes that BEIS policy objectives would have remained the same if the RO scheme had continued, and the same level of renewable deployment would have been targeted and the same technologies supported. As a result, the analysis focuses on the costs of supporting the same level of deployment under the RO scheme, rather than seeking to model any differences in deployment.

With the same level of deployment, we also assume the same project costs for the supported plant under the two regimes. Falls in capital costs, as has recently been observed for Offshore wind, are assumed to be due to the level of deployment (and wider global factors), rather than the type of low-carbon support regime.

These and other key assumptions that feed into the modelling are summarised below.

Table 10. Key modelling assumptions

Assumption	CfD regime modelling scenarios	RO counterfactual modelling scenarios
Capacity mix	Held constant in all runs, in line with BEIS reference case.	Held constant in all runs, in line with BEIS reference case.
Eligibility for support	Same set of contracts assigned in all runs, in line with BEIS reference case.	Same set of contracts assigned in all runs, in line with BEIS reference case.
Contract length	15 years (except biomass cofiring and conversions, whose support ends in 2027)	20 years (except biomass cofiring and conversions, whose support ends in 2027)
Support levels for plant with allocated CfD contracts (AR1, AR2, AR3, FIDER)	Strike prices as per awarded contract.	RO banding calculated to achieve the equivalent level of return as the CfD contract (accounting for different hurdle rates). Based on model outputs, and taking into account contract length, adjusted hurdle rate and projected levels of generation and wholesale market income
Support levels for projected future new build allocated a CfD contract	Strike prices are calculated, based on model outputs, to achieve the required hurdle rate. Plants are then assigned the highest strike price calculated for any plant with the same technology and online year.	RO banding levels are calculated, based on model outputs, to achieve the required hurdle rate. Plants are then assigned the highest banding calculated for any plant with the same technology and online year.
Zero or negative support	Generators are willing to take a CfD strike price that is below expected wholesale income levels due to the reduced risk that a CfD contract provides. In this case we calculate the CfD strike price to represent the point of "indifference". For example: strike price of £45/MWh is sufficient to cover a generator's costs and meet its required hurdle rate. However, it is expected to earn £55/MWh in wholesale income if it is unsupported. In this case the generator may be indifferent at a strike price of, say, £50/MWh, as this is high enough to cover its costs (of £45/MWh) and also represents the same risk-adjusted return as the £55/MWh it will earn unsupported. In this case we set the strike price is set to £50/MWh. This level of support is still desirable from a consumer-	Generators would not accept a negative RO support level, as they would rather operate unsupported. In cases where expected wholesale income is sufficient to cover the project's costs, the plant operates unsupported.

	perspective, as the expected CfD support payments are negative.	
Support mechanism	Two-way CfD, generators are paid (or pay) the difference between their strike price and reference price. Wind and solar use the intermittent market reference price (IMRP); other technologies use the baseload market reference price (BMRP). BMRP is set using the season-ahead baseload wholesale power price.	Generators receive a fixed payment for every MWh of generation, based on banding level x ROC buyout price (and adjusted for headroom). The ROC buyout price varies year to year according to the RPI.
Hurdle rates	As per BEIS 's latest assumptions, accounting for reduced risk under CfD regime (full detail in section 6 of main document).	As per BEIS latest assumptions (full detail in Chapter 6 of main report).
Commodity prices (gas, coal, oil)	Scenarios based on BEIS 2019 published projections.	Scenarios based on BEIS 2019 published projections.
Capital costs	Held constant between runs, as per BEIS reference case.	Held constant between runs, as per BEIS reference case.
Social discount rate	3.5%	3.5%
All other input assumptions	As per BEIS reference case.	As per BEIS reference case.

Overview of Scenarios

Six comparison scenarios have been explored to understand the sensitivity of the results to key assumptions. Each of the scenarios includes a CfD baseline run and a RO counterfactual run. The scenarios are:

- CfD baseline vs RO counterfactual under central assumptions21
- CfD baseline vs RO counterfactual under low commodity prices
- CfD baseline vs RO counterfactual under high commodity prices
- CfD baseline vs RO counterfactual with lower hurdle rate differences (-0.5%)
- CfD baseline vs RO counterfactual with higher hurdle rate differences (+0.5%)
- CfD baseline vs RO counterfactual where RO support levels are higher due to reduced price discovery & competition (equivalent to a 5% rise in strike price)

The results are presented in Chapter 2 of the main report.

[21] Note that under central assumptions we assume that projects supported under RO have higher hurdle rates than under CfDs

Methodology for Commodity Price scenarios

Commodity prices (gas, coal, oil and carbon) are a key input assumption for the modelling. They are an important driver of wholesale electricity prices, with the gas and carbon prices currently the largest components. Commodity prices are therefore particularly important when calculating the required levels of support (RO bandings and to a lesser extent CfD strike prices), and when modelling the support payments over the course of a project's contract.

As a result of this importance, we have tested two scenarios for variations in commodity prices. Under Scenario 2 BEIS's low commodity price projections are used for both the CfD baseline and RO counterfactual, and under Scenario 3 BEIS's high commodity price projections are used.

When calculating the required levels of support under these scenarios, it is important to base these calculations on what would have been a "best view" at the time the support was set. For example, if calculating the required RO banding for a plant in 2020 in the low commodity price scenario, the best view would not be that the low-price projection continues – there has not yet been enough evidence to be confident that low prices will persist. However, when calculating support levels in 2040 within the low scenario, we have now had over 20 years of low prices so would expect this trend to continue.

To deal with this problem, a blend of results from a central commodity price run and a run with low or high commodity prices are used to form a "best view" of wholesale income and generation in calculating support levels. The weighting of the central run in this view decreases over the years.

This was parameterised using historical BEIS commodity price forecasts (8 years of data, 2012-2019), which were used to analyse the correlation between changes in short-term commodity prices and changes in the BEIS long-term projections.

The analysis showed, as expected, a correlation between short-term price increases/decreases and movements in BEIS's long-term projections. These long-term movements are relatively small, with the previous central projection accounting for 91% of the updated long-term central projection. This 91% parameter is used in the modelling, defining the divergence away from the original central projection for each year in the low or high scenarios.

For example, after one year where the price follows the original low/high price projection, the new long-term projection is made up of 91% weighting from the original central long-term forecast and 9% weighting from the original low/high long-term forecast.

In addition, we assume a 10-year period over which prices trend back to this updated long-term assumption, after 2-year flat period to represent market forwards (so 12 years in total to get to the long-term projection).

Two illustrative examples of this are shown below, showing the updated "best view" of gas prices in 2020 and 2030 under low and high scenarios. Note: We do not run a separate scenario with this blended projection for every modelled year (as this would have required an impracticable number of runs), so instead we blend the outputs from the central run and low/high price run in the same way.

Figure 6. Gas price projections for modelling – 2020. Source: LCP analysis using 2019 BEIS commodity price projections

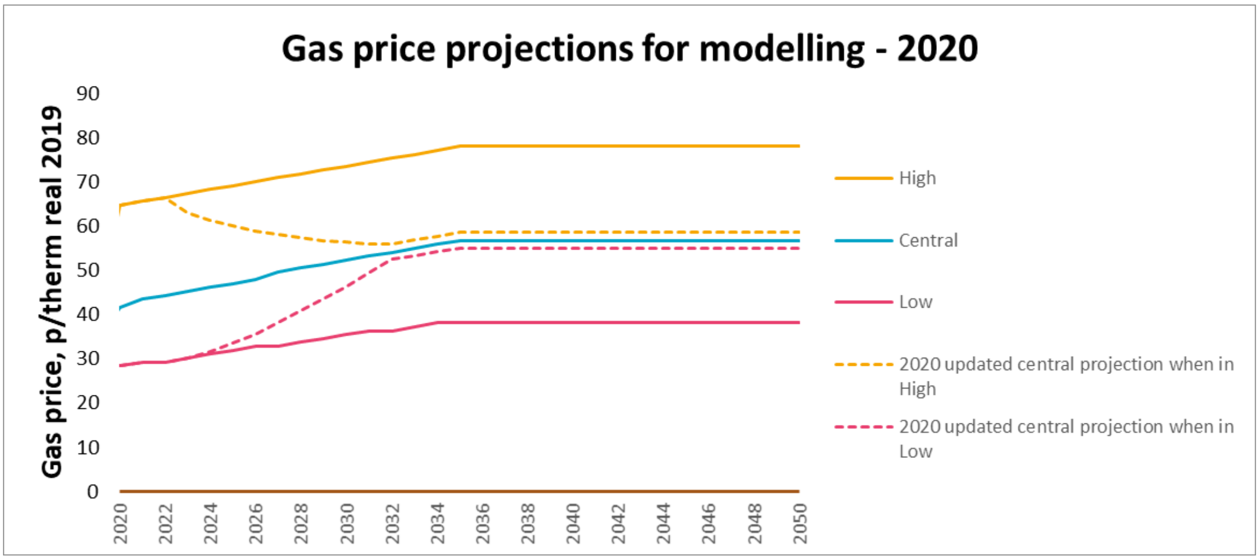
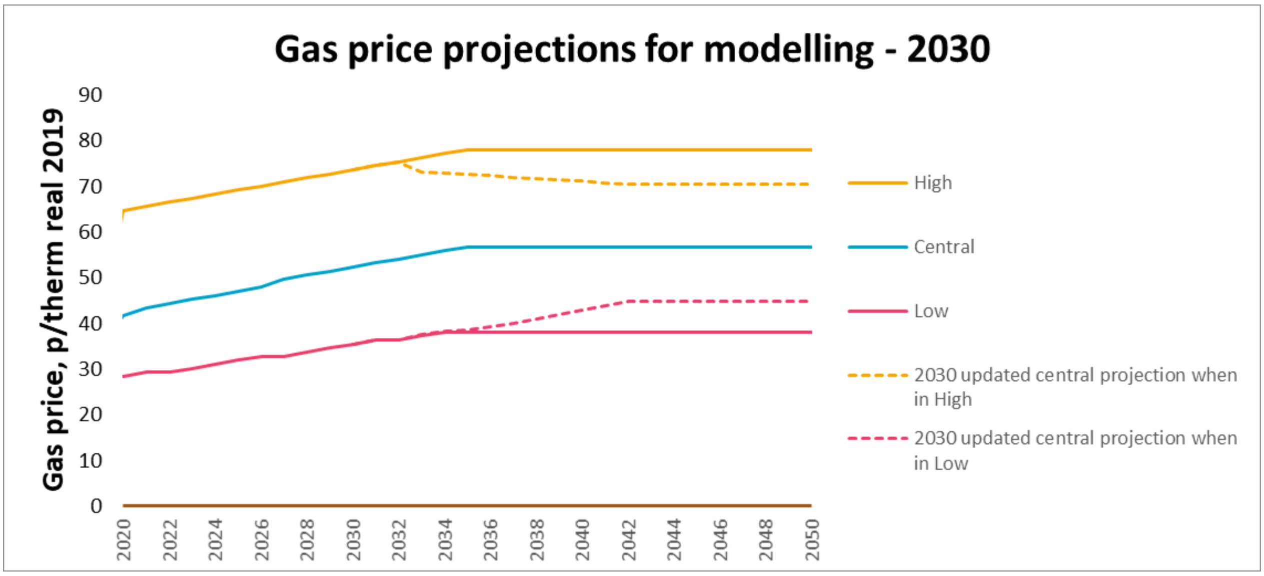


Figure 7. Gas price projections for modelling – 2030. Source: LCP analysis using 2019 BEIS commodity price projections



Hurdle rates

A "hurdle rate" is the minimum rate of return on a project or investment required by a project manager or investor. The hurdle rate reflects the appropriate level of compensation required for the level of risk present; riskier projects generally have higher hurdle rates than those that are less risky. Therefore, investors in renewables projects considered to have relatively high risk, will charge a higher interest rate on their investment, raising overall project costs. The CfD scheme aims to reduce certain risks to developers and investors from exposure to fluctuation in the wholesale electricity prices. The 15-year CfD provides more certainty over levels of future revenue, which reduces risks, and therefore contributes towards lowering the hurdle rates applied by developers.

The hurdle rates of supported projects are a key modelling assumption. In particular, hurdle rate differences are important between the two support regimes (CfD and RO). Lower hurdle rates are assumed under the CfD regime because of the reduced risk to investors. This is the primary driving factor in the CfD regime representing value for money relative to the RO. Evidence from the interviews corroborated assumptions in the reference case that CfD-supported plants are given lower hurdle rates than similar projects under the RO (within a range of up to 2 percentage points lower). The qualitative interviews do not provide sufficiently representative quantitative evidence to form the basis of these assumptions (though the ranges broadly align with the assumptions used). As a result, we use the latest assumptions in the BEIS reference cases and test the sensitivity of results to changes in these assumptions (see table below). The interview findings outlined in Chapter 4 of the main findings report give more explanation as to how the CfD affects investment decisions and ways in which this contributes towards lowering costs.

Hurdle rate changes are tested under two scenarios. Under Scenario 4, hurdle rate differences between the two regimes are reduced by 0.5% and under Scenario 5, they are increased by 0.5%.

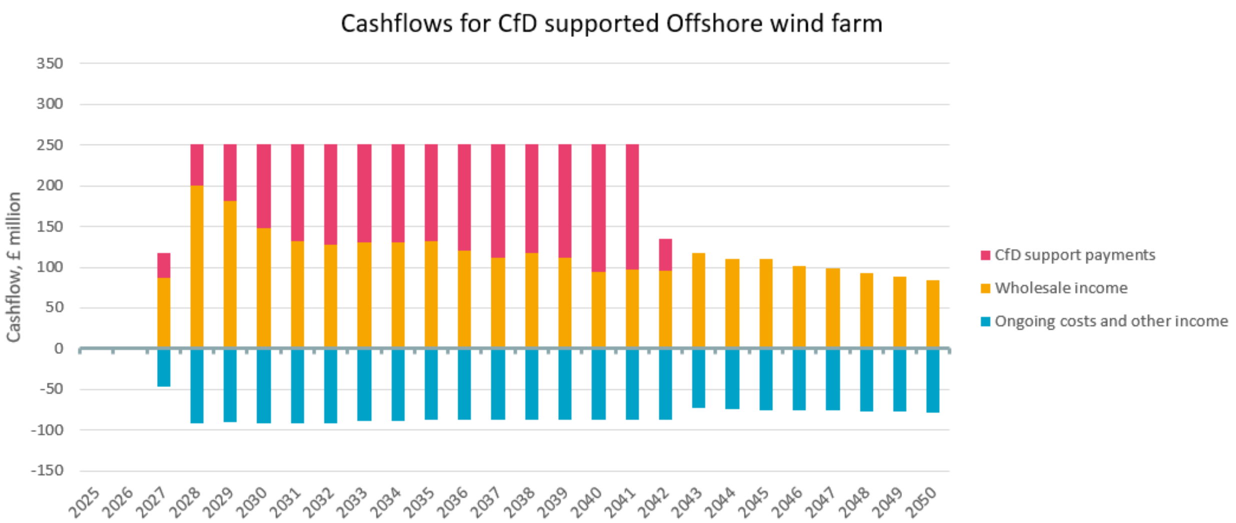
Calculated support levels

The support levels (CfD strike prices and ROC bandings) are a key input to each run. They are calculated for each run based on model outputs of a previous run. The support levels are set to a level where the generator achieves its required hurdle rate, considering all revenues and costs over the lifetime of the project. Model runs were iterated to achieve alignment between the support levels assumed in the run and those calculated from the model run outputs.

Cashflows for an illustrative 1000MW CfD-supported Offshore wind farm are shown below. It has a calculated strike price of £51.8/MWh, which allows it to cover its hurdle rate of 6.3%. Note that upfront construction costs have been excluded due to their scale.

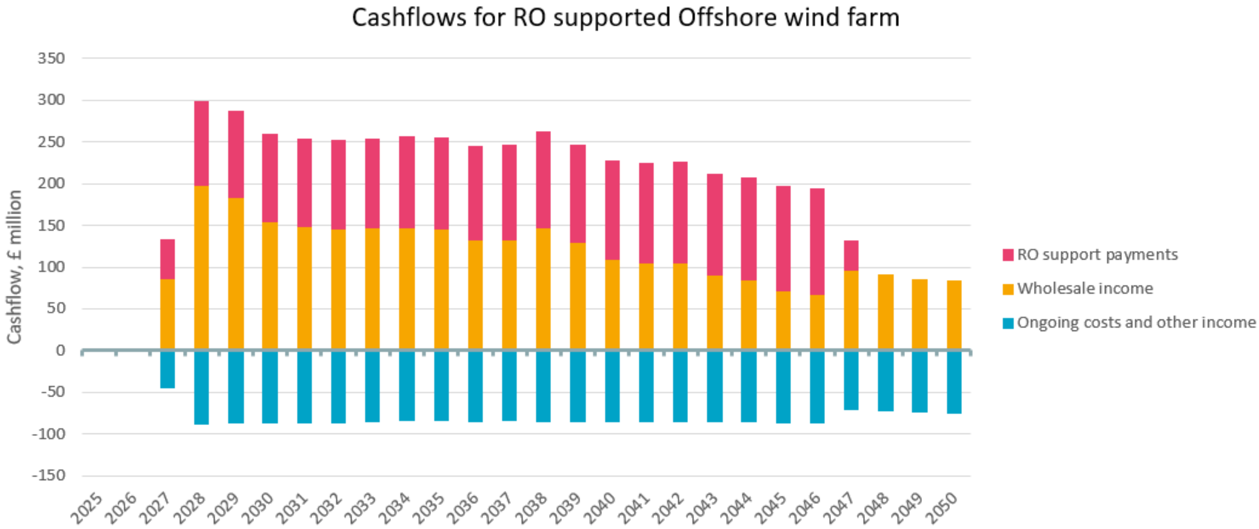
Example of support level calculation for an illustrative Offshore wind plant.

Figure 8. Cashflows for CfD supported Offshore wind farm. Source: LCP analysis from DDM outputs



For the project to achieve the higher hurdle rate of 7.7% under the RO scheme, it was calculated that it would require 0.37 ROCs/MWh. The cashflows with this level of support are shown below. The support payments are over £470m higher than under the CfD regime without discounting (£2.23bn vs £1.76bn) and around £250m higher with a 3.5% social discount rate applied (£1.54bn vs £1.29bn).

Figure 9. Cashflows for RO supported Offshore wind farm Source: LCP analysis from DDM outputs



Calculated support levels used in modelling

The calculated support levels for the CfD baseline and the RO counterfactual runs under the higher demand reference are shown below (levels under lower demand are very similar). These were calculated to incentivise an identical level of capacity in both runs.

Figure 10. CfD strike prices in baseline run. Source: LCP analysis using outputs from BEIS DDM

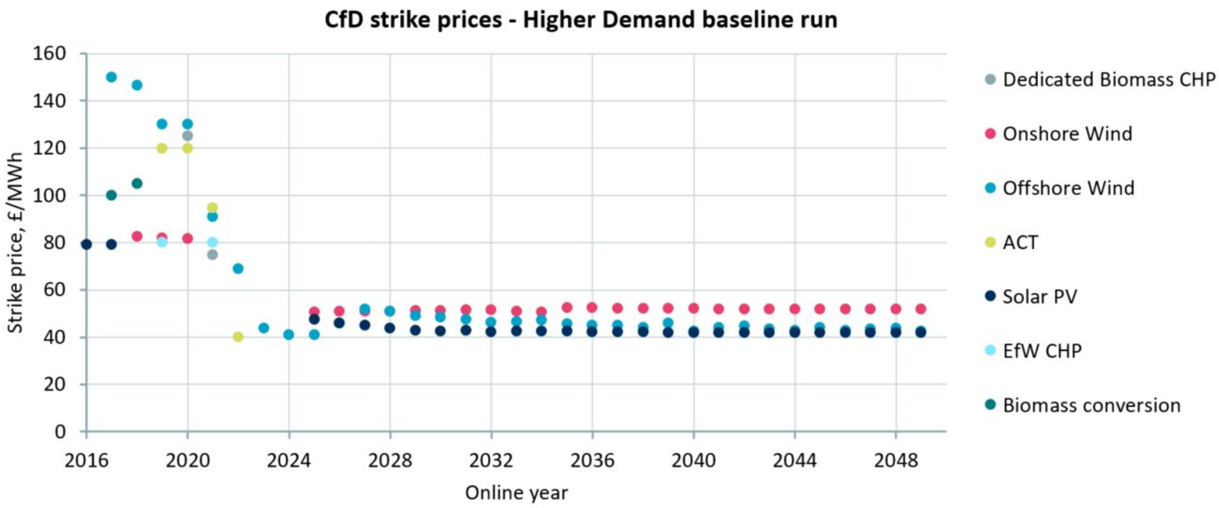
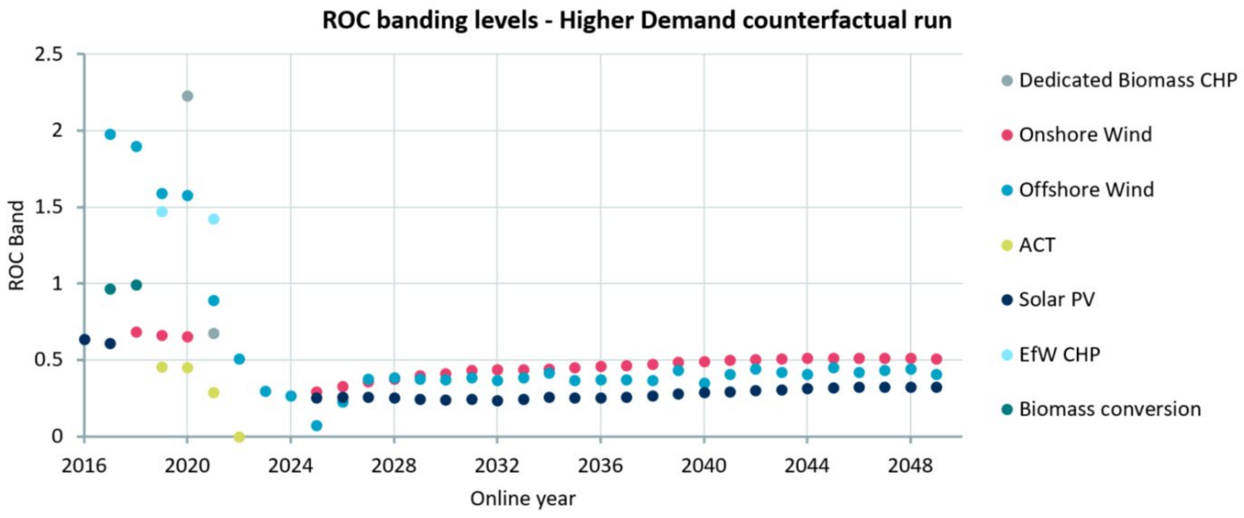


Figure 11 ROC banding levels in counterfactual run. Source: LCP analysis using outputs from BEIS DDM



Summary of results for all scenarios

The tables below summarise the results of each of the five scenarios for both higher and lower demand. It shows the change in support costs associated with moving from the baseline (with CfD regime in place) to a counterfactual under which the RO scheme had continued. These changes are represented as £bn NPV figures for the 2016-2050 period (using a 3.5% social discount rate) in real 2019 terms.

All five scenarios show an increase in support costs under the counterfactual where the RO had remained in place, indicating that the CfD regime represents value for money. The main reason for this is the higher hurdle rates assumed under the RO regime.

Higher Demand

Table 11. Higher demand scenario results: Change in support costs under RO counterfactual. NPV for 2016 to 2050 period in £bn 2019 real. Note: All figures have been rounded to the nearest £1bn, so the figures presented may not add up precisely to column totals

NPV £bn real 2019 (2016-2050)	**Scenario**				
	1	**2**	**3**	**4**	**5**
Baseline run	**CfD central**	**CfD high commodity prices**	**CfD low commodity prices**	**CfD central**	**CfD central**
Counterfactual run	RO central	RO high commodity prices	RO low commodity prices	RO +0.5% hurdle rate	RO -0.5% hurdle rate
AR1 support cost	2	2	1	2	1
AR2 support cost	1	1	0	1	0
AR3 support cost	1	2	1	1	1
AR1, AR2 & AR3 support cost	3	5	2	4	2
Future projects support cost (excl. Nuclear & FIDER)	7	8	6	12	3
Total support cost (incl. future projects)	10	13	8	15	5
Wholesale cost impact (incl. future projects)	1	0	-2	0	2

Total consumer impact	10	13	7	15	7

Lower Demand

Table 12 Lower demand scenario results: Change in support costs under RO counterfactual. NPV for 2016 to 2050 period in £bn 2018 real. Note: All figures have been rounded to the nearest £1bn, so the figures presented may not add up precisely to column totals

NPV £bn real 2019 (2016-2050)	Scenario				
	1	**2**	**3**	**4**	**5**
Baseline run	CfD central	CfD high commodity prices	CfD low commodity prices	CfD central	CfD central
Counterfactual run	RO central	RO high commodity prices	RO low commodity prices	RO +0.5% hurdle rate	RO - 0.5% hurdle rate
AR1 support cost	2	2	1	2	1
AR2 support cost	1	1	0	1	0
AR3 support cost	1	2	1	1	1
Total AR1, AR2 & AR3 support cost	3	5	2	4	2
Future projects support cost (excl. Nuclear & FIDER)	7	9	6	11	4
Total support cost (incl. future projects)	11	14	7	16	6
Wholesale cost impact (incl. future projects)	-1	-1	-2	-1	-1
Total consumer impact	10	13	5	14	6

Level of uncertainty in this analysis

As with all modelling of future outcomes, there is a significant degree of uncertainty in the projections. To understand this uncertainty, we have tested variations in the key assumptions that drive the differences between the costs of the two regimes, such as hurdle rate differences and wholesale price levels.

However, a number of uncertainties remain. This analysis has focused on estimating the changes in cost of supporting a fixed level of low-carbon deployment under the two regimes. The level of deployment, and the mix of technologies deployed, has been held constant, in line with BEIS's latest reference case. The magnitude of the savings under the CfD scheme would likely vary materially under a different level and mix of low-carbon deployment.

The analysis of future projects does not include nuclear or gas CCS. Under some scenarios, CCS could form a significant proportion of future support, but the precise structure of this support is not clear.

Below we have outlined the key modelling outputs and discussed our level of confidence around them:

- **CfD strike prices**. CfD strike prices for the AR1, AR2 and AR3 projects are known. Strike prices for potential future CfD projects have been calculated based on cost assumptions and modelling outputs, so there is a degree of uncertainty in these. The project costs and hurdle rates are the main driver and therefore the main area of uncertainty. In the near to medium term (2020s) we have a reasonable degree of confidence, as the cost and hurdle rate assumptions produce strike prices that are consistent with what has been observed in AR2 and AR3. We obviously have less confidence in the longer term, as costs in particular are uncertain.
- **RO bandings.** The RO bandings– which determine the £/MWh support payments received under the RO regime – have all been calculated for each technology in each year. For AR1, AR2 and AR3 projects, the bandings are set at a level that would provide the equivalent risk-adjusted return to their CfD contract. Therefore, the main area of uncertainty here is the hurdle rate assumptions, and in particular the difference between the two regimes. Due to this uncertainty, we have run scenarios to test the sensitivity of results under higher and lower hurdle rate differences. In the longer term, the RO bandings are subject to the same uncertainties as CfDs – project costs and hurdle rates – but in addition are also determined using the projected wholesale prices over the term of the contract. We have tested the sensitivity of the results under higher and lower commodity prices to test the robustness of results to this uncertainty.
- **CfD/RO support payments.** For the reasons discussed above, we are more confident in the CfD strike price assumptions than in the RO banding assumptions. However, once these have been determined, the level of support payments associated with the RO are reasonably certain (£/MWh, so only vary with the level of generation and the RO buy-out price inflating with RPI), whereas CfD support payments are much less certain. The reason for this is that CfD support payments vary depending on outturn wholesale prices. So if wholesale prices are lower than expected, CfD support payments will be higher than expected, but if wholesale prices are higher than expected CfD support payments will be lower than expected. Again, we have tested this area of uncertainty by running scenarios with higher and lower commodity prices.

Annex E: Note on Weighted Average Cost of Capital (WACC)

The influence of gearing ratios on Weighted Average Cost of Capital (WACC)

To calculate influence of each category of capital in the total cost of capital, consider the Weighed Average Cost of Capital (WACC) formula below:

$$WACC = \frac{E}{(E+D)}Re + \frac{D}{(E+D)}Rd\ (1-T)$$

Where:

- E = Equity value,
- D = Debt value,
- Re = Cost of equity
- Rd = Cost of debt (interest rate)
- T = Corporate tax rate

Depending on the cost difference between equity and debt, increasing the debt share can have a large effect on the cost of capital. The following table presents WACC simulation of a hypothetical project in different scenarios of leverage ("leverage" refers to the use of debt to increase returns from an investment or project), all considering corporate taxes of 20%. The table shows that increasing the leverage of a project may significantly reduce the WACC, which has a significant impact on the Levelized Cost of Energy (LCOE).

Table 13 Simulation of impact of leverage on WACC

		Return on equity					
D/(E+D)	**Interest rates**	**10%**	**11%**	**12%**	**13%**	**14%**	**15%**
	3%	6,2%	6,7%	7,2%	7,7%	8,2%	8,7%
	4%	6,6%	7,1%	7,6%	8,1%	8,6%	9,1%
	5%	7,0%	7,5%	8,0%	8,5%	9,0%	9,5%
50%	**6%**	7,4%	7,9%	8,4%	8,9%	9,4%	9,9%
	3%	5,4%	5,8%	6,2%	6,6%	7,0%	7,4%
	4%	5,9%	6,3%	6,7%	7,1%	7,5%	7,9%
	5%	6,4%	6,8%	7,2%	7,6%	8,0%	8,4%
60%	**6%**	6,9%	7,3%	7,7%	8,1%	8,5%	8,9%
	3%	4,7%	5,0%	5,3%	5,6%	5,9%	6,2%
	4%	5,2%	5,5%	5,8%	6,1%	6,4%	6,7%
	5%	5,8%	6,1%	6,4%	6,7%	7,0%	7,3%
70%	**6%**	6,4%	6,7%	7,0%	7,3%	7,6%	7,9%

Annex E: Note on Weighted Average Cost of Capital (WACC)

The LCOE is an estimate of the revenue required per unit of electricity to recover the costs of building and operating a power plant during its assumed lifecycle. In other terms, it is the price of energy to which the net present value (NPV) of the project equals zero. If the energy selling price is higher than the LCOE, than the project generates positive economic returns. Reducing the WACC will contributes to bring LCOE down and, therefore, to reduce strike prices.

Annex F: Projects awarded in AR3

The table below provides further details of each of the ACT projects awarded a CfD at AR3.[22]

Table 14 Advanced Conversion Technologies Projects AR3

Advanced Conversion Technologies Project Name	Capacity (MW)	Strike Price (£/MWh)	Delivery Year	Equivalent homes Powered	Region
Bulwell Energy Limited	27.50	39.65	23/24	51,000	England
Small Heath Bio Power Limited	6.10	41.611	24/25	11,000	England
Total ACT	**33.60**			**62,000**	

The table below provides further details of each of the RIW projects awarded a CfD at AR3.

Table 15 Remote Island Wind Projects AR3

Remote Island Wind Project Name	Capacity (MW)	Strike Price (£/MWh)	Deliver y Year	Equivalent homes Powered	Region
Costa Head Wind Farm	16.32	39.65	23/24	16,000	Scotland
Druim Leathann Windfarm Limited	49.50	41.611	24/25	48,000	Scotland
Hesta Head Wind Farm	20.40	39.65	23/24	20,000	Scotland
Muaitheabhal Wind Farm	189.00	39.65	23/24	182,000	Scotland
Total RIW	**275.22**			**266,000**	

The table below provides further details of each of the Offshore wind projects awarded a CfD at AR3.

22 22 Data for the Tables from official AR 3 Allocation Results Note. Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/838914/cfd-ar3-results-corrected-111019.pdf

Table 16 Offshore Wind Projects AR3

Offshore Wind Project Name	Capacity (MW)	Strike Price (£/MWh)	Delivery Year	Equivalent homes Powered	Region
Doggerbank Creyke Beck A P1	1,200.00	39.65	23/24	1,505,000	England
Doggerbank Creyke Beck B P1	1,200.00	41.611	24/25	1,505,000	England
Doggerbank Teeside A P1	1,200.00	41.611	24/25	1,505,000	England
Forthwind	12.00	39.65	23/24	15,000	Scotland
Seagreen Phase 1	454.00	41.611	24/25	570,000	Scotland
Sofia Offshore Wind Farm Phase 1	1,400.00	39.65	23/24	1,756,000	England
Total Offshore wind	**5,466.00**			**6,857,000**	

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