Energy and Climate Management, 2026, 2(2): 9400034
https://doi.org/10.26599/ECM.2026.9400034

Article

Termination amounts and the enforcement gap in the Contracts for Difference scheme: Insights from offshore wind project finance in the United Kingdom

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Received: 11 June 2025; Revised: 17 January 2026; Accepted: 13 May 2026

ABSTRACT

The Contracts for Difference (CfD) scheme supports low-carbon electricity generation in the United Kingdom by stabilising revenue per unit of output at a pre-agreed strike price. When wholesale prices exceed the strike price, generators make payback payments to the Low Carbon Contracts Company (LCCC), and termination provisions are intended to deter early exit by requiring compensation for expected future paybacks. This study examines a potential enforcement gap in this mechanism. Offshore wind CfDs are commonly held by highly leveraged, non-recourse special purpose vehicles, whose assets and cash flows may be pledged to secured lenders. If a project company enters financial distress or insolvency, the termination amount may be large, but the LCCC's claim for that amount may be weakly recoverable. The study develops a stylised quantitative framework calibrated to publicly available information on large UK offshore wind projects. It distinguishes financial resilience, measured by the debt service coverage ratio, from the termination amount, measured as the present value of expected future paybacks. The analysis identifies two linking channels. The volume channel shows that lower eligible generation can weaken debt-servicing capacity and reduce the termination amount. By contrast, the price channel shows that high wholesale prices can increase the termination amount without directly improving financial resilience. The enforcement gap is most relevant when a large termination amount coincides with financial distress. Although no such generator insolvency cases have been documented under the CfD regime to date, the study highlights the need to strengthen recoverability while preserving project bankability.

KEYWORDS

Contracts for Difference, offshore wind, termination amount, enforcement gap, project finance, creditor priority.

1 Introduction

The Contracts for Difference (CfD) scheme was introduced in the United Kingdom in 2014 to encourage investment in low-carbon electricity generation by providing long-term price stability.[a,b] The scheme is administered by the Low Carbon Contracts Company (LCCC), the government-owned counterparty to CfD contracts[c]. It allows generators to receive support at a pre-agreed strike price, typically over a 15-year contract horizon, depending on technology and contract terms. Under the scheme, generators receive a top-up payment from the LCCC when the market price falls below the strike price and make payback payments when the market price exceeds the strike price. In this way, the CfD stabilises revenue per unit of output, while total revenue remains dependent on the volume of electricity generated.

Other renewable support schemes have also been widely used internationally, including Feed-in Tariffs (FITs), which pay generators a fixed amount per MWh, and Feed-in Premiums (FIPs), under which generators receive market-based remuneration supplemented by policy support. In Germany, renewable support has mainly taken the form of a sliding feed-in premium, which resembles a one-sided CfD because the premium declines as market prices rise, thereby limiting generators' exposure to market-price fluctuations without imposing a symmetric payback obligation[6,7][d]. By contrast, the CfD introduced in the UK is a two-way contract, requiring generators to make

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[a] In the United Kingdom, the main electricity market covers Great Britain, comprising England, Wales, and Scotland, which accounted for 97.2% of the UK population in 2021. By contrast, Northern Ireland participates in the integrated Single Electricity Market with Ireland. Consistent with this institutional distinction, the Contracts for Difference scheme was introduced in Great Britain and does not apply to Northern Ireland.

[b] The predecessor to the CfD scheme was the Renewables Obligation (RO), which was in operation from April 2002 to March 2017. For recent analysis of the RO scheme, see Refs. [1–5].

[c] The LCCC is wholly owned by the Department for Energy Security and Net Zero (DESNZ), which was established in February 2023 and succeeded the energy functions of the Department for Business, Energy and Industrial Strategy (BEIS), UK. BEIS had itself replaced the Department of Energy and Climate Change (DECC) in July 2016.

[d] For recent review studies on FITs and FIPs, see Refs. [8–10].

payments back to the government-owned counterparty when market prices exceed the strike price[e].

Contracts are allocated through competitive auctions, and strategic bidding may arise during the auction process. In particular, an applicant may submit an unsustainably low bid while relying on higher competing bids to set the clearing price, which may lead to non-signature cases in early allocation rounds. For example, two solar farms that were allocated contracts withdrew before signing because the strike prices were too low[11,13][f]. In later rounds, offshore wind strike prices fell to historically low levels. In the third allocation round (AR3), for example, strike prices of £39.65/(MWh) and £41.61/(MWh) in 2012 prices were lower than expected generation costs, potentially reflecting factors including economies of scale, favourable wind resources and shallow water depth[17]. These outcomes have been interpreted as evidence of rapid cost reduction and supply-chain maturation[18]. However, such low strike prices imply substantial foregone revenue when wholesale prices are high, thereby increasing the scale of potential payback obligations.

In principle, CfD termination provisions are designed to deter opportunistic exit by imposing a termination amount equal to the discounted value of expected future paybacks. In practice, however, offshore wind CfD project companies are typically highly leveraged special purpose vehicles (SPVs) financed with substantial secured debt. Under insolvency, creditor priority and security enforcement determine whether termination liabilities owed to the LCCC are recoverable. This creates a potential disconnect between contractual obligations and realised recovery in financial distress.

This study identifies a conditional vulnerability in the CfD scheme, referred to as an “enforcement gap”, under which the termination amount may be large in contractual terms but weakly recoverable if the project company enters financial distress and subsequent insolvency. When the market price is high, projects with lower strike prices face larger payback obligations and a larger associated termination amount. However, while the CfD remains in force, higher wholesale prices do not directly improve the project company’s debt service coverage ratio (DSCR), because revenue per unit of output is anchored to the strike price. The deterrent effect of the termination amount may therefore be weakened if a large contractual claim coincides with financial distress and limited recoverability in insolvency.

It is important to emphasise that no generator insolvency cases involving CfD termination amounts have been documented under the UK CfD regime to date. The analysis therefore identifies a conditional vulnerability in the contractual and financing structure, rather than documenting an observed failure of the scheme.

The study makes three main contributions. First, it implements a stylised quantitative framework using scenario-based sensitivity analysis calibrated to publicly available information for large offshore wind projects, demonstrating how the DSCR is affected by varying operating and financing conditions, and how the termination amount is affected by price conditions. Second, it links the DSCR and the termination amount via the volume and price channels and emphasises the distinction between contractual liability and recoverability. Third, it derives policy implications for CfD design, highlighting the need to strengthen the practical recoverability of termination claims while preserving project bankability and limiting increases in financing costs.

The remainder of the study is organised as follows. Section 2 reviews the literature and develops the theoretical framework. Section 3 presents the institutional background. Section 4 explains termination mechanisms. Section 5 provides the quantitative analysis. Section 6 concludes with policy implications.

2 Theoretical framework and literature review

This section situates the insolvency-related enforcement gap within the broader literature on contract theory, corporate finance, and regulatory governance, rather than treating it merely as an institutional detail of policy design. It conceptualises CfDs as long-term public procurement contracts through which the state, acting via the LCCC, and private project companies allocate market price risk through settlement arrangements and termination provisions. This allocation of risk may become fragile when the private counterparty is a non-recourse, limited-liability entity operating under insolvency rules structured by creditor priority. In this setting, insolvency and unsecured losses are not exceptional outcomes, but recognised features of leveraged project finance. The interaction between CfD terms and creditor hierarchy may therefore create a state-contingent incentive to exit the contract when wholesale electricity prices remain persistently above the strike price.

2.1 Project finance, SPVs, and creditor priority

Renewable generation projects are predominantly financed through non-recourse project finance, typically structured around an SPV. As a legally ring-fenced entity, the SPV isolates project-level financial risk and raises senior debt secured against the project’s own assets and expected future cash flows, rather than against the sponsor’s broader balance sheet. Foundational studies emphasise that SPV structures distribute risks and responsibilities across a bundle of contracts, with project bankability depending on whether these arrangements generate predictable and enforceable cash flows sufficient to sustain high leverage[19,20]. Project finance is further characterised as a governance and risk-allocation technology that can mitigate agency and coordination problems in capital-intensive infrastructure, while simultaneously making project outcomes highly sensitive to cash flow priority, covenant design, and creditor enforcement in distress[21].

This financing structure is especially important in renewable energy because large-scale investment often depends on revenue-stabilisation mechanisms that limit exposure to merchant price risk[22]. Within this architecture, CfDs serve as a central revenue-support instrument by transforming volatile wholesale market revenues into more predictable cash flows, thereby increasing debt capacity and reducing financing costs. Empirical evidence supports this interpretation, showing that debt structuring choices,

[e] In an early example, CfD-type contracts were implemented in Nord Pool between 2000 and 2006 to hedge against locational price differences, rather than to support renewable projects[11,12].

[f] Regarding this strategical behaviour, bidders facing a non-delivery penalty are more likely to reveal their true costs suggested by Ref. [14]. Non-delivery penalties have also been proposed in renewable support auctions in other countries[15,16].

covenant packages, and broader risk-allocation strategies materially affect lender behaviour and project viability in renewable project finance[23]. This perspective also aligns with the broader literature on public-private partnerships (PPPs), which identifies contractual risk allocation as a central determinant of whether private incentives remain aligned with public policy objectives.

For the present study, the significance of this financing architecture lies in the fact that contractual obligations are not enforced in isolation. Their practical value depends on how claims are ranked and recovered once a project company enters distress. The SPV structure therefore links CfD performance not only to contract design, but also to the hierarchy of claims embedded in project finance.

2.2 Incomplete contracts and termination risk

CfDs can also be analysed through the contract-theoretic and PPP literature on contractual incompleteness, renegotiation, and termination. Incomplete contract theory emphasises that long-term agreements cannot specify efficient obligations for every possible future state, leaving residual control rights and renegotiation environments to shape outcomes ex post[24–27]. The PPP literature builds on these insights by treating renegotiation and early termination as recurring features of long-lived infrastructure contracts and by highlighting the importance of contract design in balancing adaptability with protection against opportunism[28,29].

Empirical evidence from infrastructure concessions shows that renegotiation is often systematic and politically mediated, reinforcing the view that enforcement and continuation are shaped not only by contractual text, but also by institutional constraints and bargaining conditions[30–32]. In the context of CfDs, the relevant stress scenario arises when wholesale electricity prices diverge persistently from the contractual benchmark, especially when market prices remain well above the strike price. In such circumstances, the scheme entails a larger transfer from generators to the CfD counterparty, increasing the salience of payback obligations and potentially strengthening incentives for strategic exit or renegotiation pressure.

The key implication is that contractual vulnerability cannot be understood solely from the formal terms of the CfD. It depends more fundamentally on how residual control rights, termination provisions, and enforcement institutions jointly shape the feasible set of actions and the distribution of bargaining power in extreme market conditions. This insight is particularly relevant where the contractual counterparty is a leveraged SPV whose incentives are conditioned by financial distress and creditor claims.

2.3 Limited liability and default incentives

The mechanism examined in this study can also be understood through agency theory under limited liability, with particular attention to how debt enforcement and creditor priority shape behaviour in distress. Limited liability truncates the downside borne by equity while preserving the upside, thereby generating the classic moral hazard and risk-shifting incentives associated with leveraged firms[33]. In SPV-based non-recourse project finance, these incentives interact with debt contracts, control rights, and insolvency procedures in ways that directly affect project-level incentives under financial stress[34].

From this perspective, default, restructuring, and continuation are not simply accidental outcomes. They may arise endogenously through bargaining and enforcement when continuation reallocates cash flows away from equity and towards creditors[35,36]. Related research on PPP finance similarly emphasises that financial structure and creditor priority shape effective control rights and continuation decisions, making the ranking of termination obligations relative to secured debt central in distress scenarios.

The issue examined here can therefore be framed as an incentive-compatibility problem. If termination liabilities owed under the CfD rank behind senior secured debt, sustained high-price conditions can widen the gap between the public objective of maintaining settlement discipline and the private incentives facing leveraged project companies. Put differently, high wholesale prices increase the value of the payback stream owed to the LCCC, while insolvency may weaken the recoverability of the corresponding termination claim. From this perspective, insolvency is not merely a peripheral legal contingency, but a possible state-contingent outcome shaped by contractual design and claim priority.

2.4 Regulatory commitment and comparative evidence

CfDs also operate within broader regulatory and legal institutions that shape the credibility of commitment and, therefore, the practical enforceability of long-term contractual obligations. The regulatory governance literature emphasises that such arrangements are embedded in political and institutional constraints. When market or fiscal conditions shift, enforcement difficulties, renegotiation, or practical non-performance may emerge as recurring features of the contractual environment rather than as exceptional breakdowns[31,32].

Comparative experience from renewable support schemes illustrates this point. Spain's retroactive reforms to its feed-in tariff framework demonstrate how fiscal and distributional pressures can induce governments to revise policy commitments unilaterally, undermining investor confidence and generating extensive litigation[37]. Investors frequently relied on the Energy Charter Treaty as the principal legal basis for claims, illustrating that disputes in renewable support schemes often centre on enforcement and remedies rather than on the formal existence of contractual commitments. Although these cases concern government-led revision rather than investor-initiated exit, they provide a useful parallel: renewable support mechanisms are most vulnerable when extreme market or fiscal states interact with institutional constraints on enforcement[38].

Beyond the Spanish FIT reform, the public procurement literature shows that long-term public-private contracts are often not fully self-enforcing in practice. The frequency of renegotiation in infrastructure concessions highlights the scope for opportunistic behaviour by both governments and concessionaires once sunk investments have been made[39]. Renegotiation is strongly associated with institutional conditions, shocks and contract design, is further confirmed in Ref. [40]. More recent PPP literature suggests that such renegotiation persists across different institutional settings[41,42]. In addition, the project-finance literature emphasises that the practical enforcement of contractual payment and termination rights depends on the structure of the project company and its financing arrangements, including lender protections and creditor priority, rather than on contractual face value alone[43]. Although these studies are not directly equivalent to the CfD framework, they support the point that the practical value of formal contractual entitlements may be shaped by renegotiation dynamics and by the financial structure through which claims are enforced.

2.5 Research gap and contribution

Existing research has examined renewable project finance, CfD design, and renegotiation risk in long-term infrastructure contracts, but these literatures have largely developed separately. The project finance literature focuses on bankability and risk allocation, the CfD literature on auction design and revenue stabilisation, and the PPP literature on contractual incompleteness, renegotiation, and termination. Much less attention has been paid to how these issues interact when a CfD-supported project is financed through a highly leveraged SPV subject to priority-based insolvency rules.

This gap matters because the deterrent effect of CfD termination provisions depends not only on the contractual size of the liability, but also on its recoverability in distress. In sustained high-price states, payback obligations to the CfD counterparty may become substantial, yet their recoverability may be weakened if termination liabilities rank behind secured creditors. This study addresses that gap by developing an integrated framework linking CfD design, project-finance structure, and insolvency-related recoverability, and by providing a stylised quantitative illustration of how contractual exposure and practical recoverability may diverge under plausible stress conditions.

3 Institutional background and financing structure

This section sets out the institutional background needed to interpret the study's analysis of CfD payment obligations and their recoverability under financial distress. The empirical focus is the CfD scheme, with particular attention to Allocation Rounds 1 to 4 (2015–2022), because these rounds include large-scale offshore wind projects with well-documented contractual terms and increasingly observable financing structures. Although the scheme has evolved over time through changes in auction design, pot structure, and governance, the core settlement and termination features relevant to the present mechanism remain broadly comparable across these rounds. The section first outlines the CfD settlement mechanism, auction design, and offshore wind strike-price outcomes. It then explains the creditor hierarchy relevant to insolvency, describes the SPV-based financing structures commonly used in offshore wind projects, examines the likely position of the LCCC in insolvency, and finally contrasts this with the supplier-obligation and mutualisation arrangements used elsewhere in the scheme.

3.1 CfD settlement, auction design, and offshore wind strike prices

Under the CfD scheme, a generator sells electricity into the wholesale market but is settled against a pre-agreed strike price. When the wholesale market price falls below the strike price, the LCCC makes a top-up payment to the generator. When the market price exceeds the strike price, the generator makes a payback to the LCCC. Scheme payments are funded through a levy on licensed electricity suppliers and are ultimately passed through to consumers. The development of UK offshore wind has depended not only on technological learning, but also on a policy architecture that reduces investor risk and supports declining financing costs over time[44].

Contracts are allocated through competitive auctions. Before each allocation round, the government sets administrative strike prices and budget envelopes for different technology groups, reflecting differences in technological maturity and policy priorities[g]. Eligible projects then submit sealed bids specifying the price at which they are willing to deliver electricity. These bids are ranked from lowest to highest, and contracts are awarded until the relevant budget is exhausted. Because the auction uses a pay-as-clear format, successful projects receive a strike price determined by the clearing outcome, subject to the relevant administrative cap[45][h]. In practice, clearing prices in the early rounds were typically below the administrative strike prices, consistent with strong competitive pressure and relatively conservative caps[18,48,49][i].

For offshore wind, clearing prices fell sharply across the first four allocation rounds[j]. AR1, awarded in 2015, produced clearing prices of £119.89/(MWh) for the 2017/18 delivery year and £114.39/(MWh) for 2018/19. In AR2, awarded in 2017, these prices declined to £74.75/(MWh) for 2021/22 and £57.50/(MWh) for 2022/23. The downward trend continued in AR3, awarded in 2019, with clearing prices of £39.65/(MWh) for 2023/24 and £41.61/(MWh) for 2024/25. In AR4, awarded in 2022, the clearing price fell further to £37.35/(MWh) for the 2026/27 delivery year. This pattern reflects rapid cost reductions, large project scale, and favourable site characteristics, particularly in major offshore wind developments such as Dogger Bank[17,18].

These AR3 and AR4 clearing prices were below BEIS's published offshore wind levelised cost estimate of £51.73/(MWh) for projects commissioning in 2025, expressed in 2012 prices[17].[k] The low AR3 outcomes are primarily attributed to large project scale, such as Dogger Bank, and favourable site conditions, which allow higher load factors without proportionately higher construction costs[17][l]. These low strike prices are central to the present analysis. While the CfD stabilises revenue per unit of

[g] The pot system allocates eligible technologies into separate auction categories to group projects with similar levels of technological maturity and cost. However, the structure and coverage of these pots have changed considerably across allocation rounds in response to policy priorities, budget decisions, and shifts in the relative competitiveness of different technologies. As a result, the pace of deployment and cost reduction has been uneven across technologies.

[h] Details of the allocation methodology are provided in Refs. [45,46]. A graphical illustration is provided by Ref. [47].

[i] Eight renewable projects received CfDs non-competitively under the Final Investment Decision Enabling for Renewables scheme, at bilaterally agreed strike prices higher than those later achieved in competitive auctions[50,51]. Auctions have been widely used in renewable support schemes. For a recent review, see Ref. [52].

[j] The strike prices in these CfD allocation rounds are expressed in 2012 prices.

[k] The offshore wind levelised costs are estimated at £57/(MWh) for projects commissioning in 2025, expressed in 2018 prices[17]. This figure is converted into 2012 prices using the Consumer Price Index published by Ref. [53].

[l] The four Dogger Bank projects accounted for 5.0 GW out of the 5.5 GW of offshore wind capacity awarded in AR3.

output at the strike price, projects awarded lower strike prices face larger payback obligations when wholesale prices remain materially above that level. The larger the gap between the strike price and the market price, the greater the expected stream of future paybacks owed to the LCCC and, if the contract is terminated, the larger the associated termination amount. Therefore, low offshore wind strike prices awarded through competitive auctions matter not only because they reduce subsidy costs, but also because they can increase the termination amount owed to the LCCC in sustained high-price states.

3.2 Creditor hierarchy and insolvency priority

Under the Insolvency Act 1986, claims in liquidation are paid according to a strict order of priority[m]. The highest-ranking group consists of secured creditors with a fixed charge. Fixed-charge holders are often banks and other asset-based lenders who hold security over specified business assets, typically including property, plant, machinery, and vehicles. These assets are not normally sold in the ordinary course of business. Fixed charges are registered with Companies House and entitle the lender to enforce its security and recover value from the charged asset in the event of the company's insolvency[n].

The second-ranking group consists of preferential creditors. These typically include employees and staff with claims for arrears of wages and holiday pay. The third group comprises secured creditors with a floating charge[o]. Assets subject to a floating charge often include stock, raw materials, work-in-progress, and fixtures and fittings. Unlike assets under a fixed charge, these assets may be traded in the normal course of business. Floating charges are also registered with Companies House and give lenders priority over unsecured creditors, although they rank behind fixed-charge holders and preferential creditors.

The fourth group consists of unsecured creditors. These include creditors who have lent funds or extended credit without taking specific assets as collateral, such as suppliers, trade creditors, contractors, and customers. The fifth and lowest-ranking group consists of shareholders, who are residual claimants and have no entitlement to distribution until all creditor claims have been satisfied in full.

For the purposes of this study, the key implication is straightforward. Where project assets and cash flows are already encumbered in favour of secured lenders, unsecured contractual claims face a materially weaker recovery position in insolvency. This priority structure is therefore central to the present analysis, because it determines whether a termination liability owed to the CfD counterparty is likely to be recoverable in practice once a project company enters financial distress.

3.3 SPV structures and financing of offshore wind projects

This subsection explains the financing structures of the developers awarded CfD contracts. In AR3, 5 GW of offshore wind capacity across four projects secured CfD contracts, as shown in Table 1. CfD contracts are awarded to developer entities that are typically established as SPVs. An SPV is incorporated as a separate legal company with its own balance sheet to ring-fence project risks and limit financial spillovers to the sponsor or parent company. An SPV may also facilitate the formation of a joint venture when two or more participants work together to deliver a specific project. In the present case, three developers are joint ventures owned by *SSE, Equinor, and Eni Plenitude*, while the fourth is a subsidiary company wholly owned by *RWE*.

Dogger Bank A and B reached financial close in November 2020, and Dogger Bank C reached financial close in December 2021[54,55]. With a total capacity of 3.6 GW, Dogger Bank is expected to produce 18 TWh of electricity annually. Of the total funding of £8.5 billion provided by 29 banks and three export credit agencies, £7.3 billion took the form of senior debt, comprising £2.3 billion for Dogger Bank A, £2.5 billion for Dogger Bank B, and £2.5 billion for Dogger Bank C. Senior debt is commonly secured by collateral and ranks ahead of unsecured debt in the event of insolvency. Although the detailed terms of these funding arrangements are not publicly available, the scale and structure of the financing indicate that these debts are likely to fall within the category of secured claims, whether through fixed charges or floating charges, under the UK insolvency framework.

The financial positions of these developers at the end of March 2021 are presented in Table 2, based on the statements of financial position filed with Companies House. At that stage, the projects were still under development, with delivery years of 2023/24 for Dogger Bank A and Sofia, and 2024/25 for Dogger Bank B and C. Using Dogger Bank A as an illustration, property, plant and equipment totalled £652.0 million out of total assets of £961.4 million, while loans and borrowings totalled £812.0 million out of total liabilities of £970.2 million; recorded capital contributions were £10.1 million. The charge-register entries further show that

Table 1 The ownership structure of the four offshore wind projects awarded in AR3. Sources: BEIS.

Project	formerly known	Capacity (MW)	Strike prices (in 2012 prices)	Developer (SPV)	Holding companies
Dogger Bank A	Creyke Beck A	1,200	£39.65	Doggerbank Offshore Wind Farm Project 1 Projco Limited	SSE Renewables (40%), Equinor (40%) and Eni Plenitude (20%)
Dogger Bank B	Creyke Beck B	1,200	£41.61	Doggerbank Offshore Wind Farm Project 2 Projco Limited	
Dogger Bank C	Teesside A	1,200	£41.61	Doggerbank Offshore Wind Farm Project 3 Projco Limited	
Sofia Offshore Wind Farm	Teesside B	1,400	£39.65	Sofia Offshore Wind Farm Limited	RWE (100%)

[m] The Insolvency Act 1986 is available at https://www.legislation.gov.uk/ukpga/1986/45/contents.

[n] Companies House registers company information and makes it available to the public in the UK.

[o] A proportion of the proceeds of assets available for floating charge holders is also set aside for unsecured creditors. This is known as the "prescribed part" and is intended to boost the chances of unsecured creditors receiving a return, however small.

Table 2 Statement of financial position for selected offshore wind project SPVs (£ million).

	Statement of financial position at the end of March 2021			
	Doggerbank Offshore Wind Farm Project 1 Projco Limited (£ million)	Doggerbank Offshore Wind Farm Project 2 Projco Limited (£ million)	Doggerbank Offshore Wind Farm Project 3 Projco Limited (£ million)	Sofia Offshore Wind Farm Limited (£ million)
Assets				
Property, plant and equipment	652.0	220.5	–	334.8
Other assets	309.4	319.5	99.2	92.1
Total assets	961.4	540.0	99.2	426.9
Liabilities				
Loan and borrowing	−812.0	−378.0	−53.2	−388.8
Other liabilities	−158.2	−168.7	−56.3	−81.1
Total liabilities	−970.2	−546.7	−109.5	−469.9
Net assets/(liability)	−8.8	−6.7	−10.3	−43.0
Equity				
Hedge reserve	−8.1	−6.7	−11.9	−42.6
Capital contribution	10.1	6.6	5.4	0.0
Retained earnings	−10.8	−6.6	−3.8	−0.4
Total equity	−8.8	−6.7	−10.3	−43.0
Charges (fixed and/or floating) registered at Companies House	Yes	Yes	Yes	Yes

Sources: Annual financial statements (year ended 31 March 2021) filed with Companies House, UK. Doggerbank Project 1 Projco Limited: [07791991-ABIDJL5U]; Doggerbank Project 2 Projco Limited: [07914510-AAGVQ8S0]; Doggerbank Project 3 Projco Limited: [07791977-AAGVQ8SJ]; Sofia Offshore Wind Farm Limited: [07791964-AB595ZIA].

lenders had registered fixed and/or floating charges over project assets. This is consistent with a senior secured lending structure in which creditors hold priority claims over project assets and cash flows, ranking ahead of unsecured creditors in liquidation.

Taken together, these examples show that major offshore wind CfD projects are commonly held in ring-fenced SPVs and financed through substantial secured debt. This financing structure is central to the present analysis because it implies that, in insolvency, a large share of project assets and cash flows may already be encumbered in favour of senior creditors before any unsecured contractual claim by the CfD counterparty is considered.

3.4 The position of the LCCC in insolvency

This subsection considers the position of the LCCC, as the CfD counterparty, in the event of the generator's insolvency. For the purposes of the present analysis, the central issue is that, where a generator becomes insolvent, the LCCC's claim for the termination amount is likely to rank as an unsecured contractual claim. If so, the practical recoverability of that claim may be materially weaker than its contractual value, particularly where the project company's assets and cash flows are already encumbered in favour of secured lenders.

Under the CfD Standard Terms and Conditions, if the contract is terminated, the generator is liable for a termination amount calculated by reference to the discounted value of expected future paybacks[56]. According to Condition 51.6, after a termination event has occurred, the CfD counterparty shall give notice to the generator terminating the contract through a "Default Termination Notice". According to Condition 52.4, the CfD counterparty shall then calculate the termination amount and issue a further notice to the generator specifying that amount, together with the principal inputs used in the calculation. The termination amount is intended to deter generators from terminating the contract after the Milestone Delivery Date by requiring them to compensate the LCCC for the expected value of future paybacks that would otherwise have arisen if the CfD had remained in force.

If the generator continues trading and remains able to meet its obligations after the termination event, the termination amount is, in principle, recoverable as a contractual claim. However, the position becomes more complicated when the termination event is itself linked to insolvency. Under Condition 53.1(A), a termination event arises where the generator is dissolved, becomes insolvent, or is unable to pay its debts within the meaning of Section 123 of the Insolvency Act 1986. In such circumstances, a termination amount is calculated and claimed by the LCCC, but there is no assurance that it will be recoverable in practice.

The reason is that, in the absence of registered security in favour of the LCCC, the termination amount is likely to constitute an unsecured debt of the generator. In that case, the LCCC would rank as an unsecured creditor in the event of liquidation or another insolvency process. This interpretation is also consistent with the observation that no charges in favour of the LCCC appear to be registered against the relevant project companies at Companies House, whereas fixed and/or floating charges are registered in favour of lenders. Under these circumstances, secured creditors would have priority over the LCCC in claiming against the assets and cash flows of the project company. As a result, even where the termination amount is contractually substantial, actual recovery may be low once higher-ranking claims have been satisfied.

This point is especially important in the case of offshore wind SPVs financed through non-recourse project finance. As discussed in Section 3.3, these entities are typically highly leveraged and their principal assets, together with associated revenue streams, may already be pledged in favour of senior lenders. In such a setting, the termination amount claimed by the LCCC may exist as a valid contractual claim, but its effective value depends on whether sufficient unencumbered value remains after secured creditors have enforced their claims.

In practice, project SPVs may enter administration, restructuring, or other enforcement processes rather than proceeding directly to liquidation. However, this does not remove the central concern. If the termination amount remains an unsecured contractual claim, its recoverability will still depend on its effective priority relative to secured creditors, the extent to which any set-off or netting is available, and the amount of residual unencumbered value after enforcement costs. In addition, administration or restructuring may interrupt, defer, or reduce settlement-related payments through legal standstills, refinancing arrangements, contractual disputes, or debt write-downs. Accordingly, recoveries for the LCCC may remain constrained even where insolvency proceedings do not culminate in formal liquidation.

It is also possible that step-in rights or sponsor support could reduce disruption. Step-in rights may allow another party to preserve operations and maintain the value of the underlying generating assets. Sponsor support may, in some cases, provide additional liquidity or facilitate restructuring. However, neither mechanism fully resolves the issue identified here. Step-in rights do not, by themselves, secure the LCCC's claim, and sponsor support is not generally mandatory in non-recourse project finance and is often limited in scope. Consequently, where project assets are heavily encumbered and enterprise value is impaired, the expected recovery of an unsecured termination claim may remain low even if the underlying asset continues to operate.

The key implication is that the deterrent effect of the termination amount depends not only on its contractual size, but also on its recoverability in distress. A large termination liability may, in principle, discourage early exit from the CfD. However, if the generator is insolvent and the LCCC ranks behind secured creditors, the practical recoverability of that liability may be materially weakened. This divergence between contractual liability and practical recoverability constitutes the enforcement gap examined in this study.

3.5 Supplier default, mutualisation, and institutional comparison

No generator insolvency cases involving CfD termination amounts have been documented under the CfD regime to date. Therefore, the position of the LCCC in relation to insolvent generators remains uncertain in practice. However, the regulatory treatment of the relationship between the LCCC and electricity suppliers is more explicitly defined and provides a useful institutional comparison.

Under the CfD scheme, the LCCC is required to make payments to generators when the wholesale market price falls below the strike price. These costs are funded through a statutory levy on all licensed electricity suppliers, known as the Supplier Obligation. According to the Energy Act 2013, Condition 9.9 states that if an electricity supplier fails to comply with this obligation, the resulting shortfall is recovered by the LCCC as a civil debt[p]. This suggests that, if an electricity supplier enters liquidation, the LCCC would be treated as an unsecured creditor in relation to that unpaid amount.

However, the CfD framework also contains a mechanism designed to address this risk. According to the CfD (Electricity Supplier Obligations) Regulations 2014, Condition 17 states that losses arising from supplier default are met through a mutualisation process, under which the shortfall is spread across non-defaulting suppliers according to their market shares[q]. The institutional treatment of supplier default is therefore relatively clear: even where the initial claim against a defaulting supplier may rank as an unsecured civil debt, the scheme includes an additional mechanism to socialise the loss across the wider supplier base.

A similar issue arose under the CfD scheme's predecessor, the Renewables Obligation (RO). Under the RO, non-compliant suppliers were required either to present Renewables Obligation Certificates or to make buy-out payments. According to the Electricity Act 1989, Condition 27F states that, where a supplier failed to make the required payment, the resulting shortfall could be recovered by the authority as a civil debt[r]. The report confirmed that, in such circumstances, the authority was treated as an unsecured creditor and that little or no funding was likely to be available at the end of the liquidation process[57]. In response to this problem, mutualisation was introduced under the Renewables Obligation Order 2015 to cover shortfalls arising from supplier non-compliance. If mutualisation was triggered, compliant suppliers were required to make additional payments to cover the deficit[s].

The relevance of this comparison is that supplier default risk under both the CfD and the RO is recognised institutionally and, at least in part, addressed through mutualisation. In the RO, this issue became practically significant. Mutualisation was triggered for the first time in 2017–18, when the shortfall reached £58.6 million and exceeded the relevant threshold[t]. In 2020–21, the shortfall reached its highest level at £218.3 million, as 28 suppliers failed to meet their obligations. These examples show that unsecured recovery risk in electricity support schemes is not merely theoretical.

For the purposes of this study, the key contrast is that the CfD appears to contain a clearer loss-sharing mechanism for supplier default than for generator insolvency. In the supplier case, the scheme includes a route through which losses may be mutualised

[p] The Energy Act 2013 is available at https://www.legislation.gov.uk/ukpga/2013/32/contents/enacted.

[q] The Regulations 2014 is available at https://www.legislation.gov.uk/ukdsi/2014/9780111116784/contents.

[r] The Electricity Act 1989 is available at https://www.legislation.gov.uk/ukpga/1989/29/contents.

[s] The Order 2015 is available at https://www.legislation.gov.uk/ukdsi/2015/9780111138359/contents.

[t] The thresholds for triggering mutualisation are £15.4 million for England and Wales and £1.54 million for Scotland[58].

across the wider market. By contrast, where an insolvent generator owes a termination amount to the LCCC, no equivalent mutualisation mechanism appears to apply. This asymmetry is important because it suggests that the scheme is institutionally better protected against supplier non-payment than against the weak recoverability of the termination amount in the case of generator insolvency.

4 Termination pathways and enforcement relevance

This section distinguishes the main pathways through which a CfD may end and shows why only some of them are central to the enforcement mechanism examined in this study. In particular, the key distinction is between early-stage termination, which does not usually generate a termination liability, and post-milestone termination, where the contractual deterrent depends on the recoverability of the termination amount. The section therefore begins with non-signature and pre-milestone non-delivery cases before turning to post-milestone termination and insolvency, where the study's central enforcement concern becomes most relevant.

4.1 Failure to sign the contract

One form of project exit arises before the contract is signed. In AR1, *Wick Farm Solar Park* (solar PV, 19.1 MW, £50.00/(MWh)) and *Royston Solar Farm* (solar PV, 13.78 MW, £50.00/(MWh)) were awarded contracts but withdrew before signature[49]. These are commonly referred to as non-signature cases. The awarded strike prices were below, or very close to, prevailing expectations of future power prices, making the projects commercially unattractive and creating the possibility that the generators would be required to make payments to the LCCC under a two-way CfD. One interpretation is that the bids submitted by these projects were too low to support delivery and may have reflected an attempt to improve the probability of winning while expecting the clearing price to be set by higher bids from competing projects[13][u]. A similar case occurred in AR2, where *Redruth* (ACT, 8 MW, £40.00/(MWh)) did not sign its contract after bidding at a level that appears to have been unsustainable[47].

These cases are relevant because they show that strategic withdrawal is not unknown within the CfD framework. However, they differ from the mechanism examined in this study in one important respect: they arise before contract execution and therefore do not engage the termination amount provisions that apply after signature and project progression. Their significance here is mainly contextual, illustrating that very low strike prices can alter project incentives even at the earliest stage of the CfD process.

4.2 Termination before the Milestone Delivery Date

After signature, a CfD may also be terminated if the generator fails to demonstrate satisfactory progress by the Milestone Delivery Date, which is typically set at 12 months after contract signature[60]. If termination occurs at this stage, no payment is payable by either the generator or the LCCC. These are therefore non-delivery cases rather than cases involving a termination amount[v].

A number of such cases have arisen in practice[47,61,62]. In AR1, *Netley Landfill Solar* (solar PV, 12 MW, £79.23/(MWh)) had its contract terminated in March 2016 after failing to meet its development deadline. *Neart na Gaoithe* (offshore wind, 448 MW, £114.39/(MWh)) was terminated in May 2016 following major delays linked to challenges concerning its environmental impacts, although the CfD was later reinstated in March 2017 after a successful appeal. Two ACT projects, *Enviroparks Hirwaun* (11 MW, £119.89/(MWh)) and *BHEG Walsall* (26 MW, £114.39/(MWh)), had their contracts terminated in May 2019. Although the specific reasons were not made public, they may have included difficulties in securing timely and affordable grid connections or wider changes in project viability. Another generator, *Wren Power and Pulp* (energy from waste with CHP, 49.75 MW, £80.00/(MWh)), had its contract terminated in March 2020.

Among AR2 projects, three generators were terminated for failing to meet the relevant requirements by the Milestone Delivery Date: *Station Yard* (ACT, 0.05 MW, £74.75/(MWh)) and *Grangemouth* (biomass with CHP, 85 MW, £74.75/(MWh)) in October 2018, and *Drakelow* (ACT, 15 MW, £74.75/(MWh)) in November 2018.

These non-delivery cases provide useful institutional background, but they differ from the mechanism examined in this study. Because termination before the Milestone Delivery Date does not give rise to a termination amount, it does not create the same enforcement and recoverability issue as post-milestone termination. Their relevance lies mainly in showing that contract termination is an established feature of the CfD framework, even though the financial consequences differ materially from those considered in the present analysis.

4.3 Termination after the Milestone Delivery Date

After the Milestone Delivery Date, termination has different financial consequences. In this case, if the CfD contract is terminated, a termination amount becomes payable by the generator. Under the CfD Standard Terms and Conditions, this amount is calculated as

$$\text{Termination amount} = \max\left[0, \sum_{i=1}^{n}(RP_i - SP)\frac{Gen_i}{(1+d)^{i-1}}\right] \tag{1}$$

where n is the remaining number of periods in the contract, RP_i is the estimated future market electricity price for period i, SP is the strike price at the point of termination, Gen_i is the estimated generation in period i, and d is the social time preference rate or the discount rate[56].[w]

As Eq. (1) shows, the termination amount is defined as the greater of zero and the discounted value of expected future paybacks from the generator to the LCCC. If the expected future market price exceeds the strike price, the generator would have been expected to make payments to the LCCC under continued

[u] As a consequence of these strategic bids and the failure to deliver contracted capacity, the sites of these two projects were treated as excluded sites and were prevented from submitting a new CfD application for 13 months[59].

[v] Similarly, following a non-delivery case, new applications from excluded sites are prohibited for 13 months[59].

[w] For details, see Annex 1, "Calculation of Termination Amount" [56].

contract performance, and the termination amount is therefore positive. By contrast, if the expected future market price is below the strike price, the generator would have been expected to receive payments under the CfD, but the termination amount is set at zero rather than becoming negative.

The economic logic is straightforward. Once the project has passed the Milestone Delivery Date, termination is intended to be financially punitive in states where the generator would otherwise owe future paybacks to the LCCC. In principle, this design discourages opportunistic exit by requiring the generator to internalise the expected value of the remaining payment stream. The stronger the expected wedge between the future market price and the strike price, and the longer the remaining contract term, the larger the termination amount[x].

This feature is central to the present study. It means that post-milestone termination is not merely an administrative event, but a point at which the contractual value of future CfD paybacks is converted into a single claim against the generator. The effectiveness of that deterrent, however, depends not only on the contractual formula, but also on whether the resulting termination amount can be recovered in practice when the generator is financially distressed. That issue is considered in the next subsection.

4.4 Termination as a result of insolvency

A more difficult case arises when termination occurs because the generator becomes insolvent. In this situation, the termination amount may still exist as a contractual claim, but its practical recoverability may be materially weakened.

Figure 1 illustrates the contractual and financial relationships when the CfD remains in force. The LCCC and the developer are linked by the CfD contract. The developer, typically an SPV, is owned by holding companies and financed by creditors through loans, which are often secured against the project's assets. The wind farm and associated assets are owned by the developer, but these assets may also serve as collateral for lenders through fixed and/or floating charges. Under these conditions, the CfD remains binding and the generator continues to make or receive settlement payments in line with the difference between the strike price and the wholesale market price.

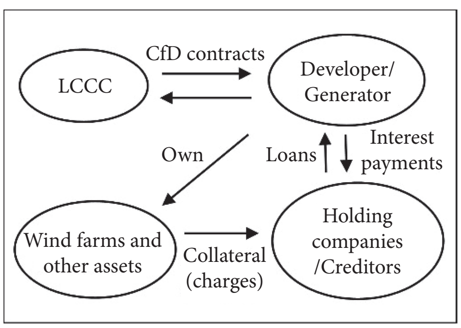

Fig. 1 The relationship between players under the CfD scheme.

By contrast, Figure 2 illustrates the position once the developer becomes insolvent and enters an insolvency process. In that setting, the project's assets may be taken over by secured creditors, enforced against as collateral, or transferred to another entity, including a newly created SPV. Alternatively, the assets may be sold, with the proceeds distributed according to the creditor hierarchy discussed in Section 3.2. In either case, the LCCC's position changes fundamentally. Rather than continuing to receive a stream of CfD paybacks, it is left with a termination claim whose recoverability depends on its ranking relative to other creditors.

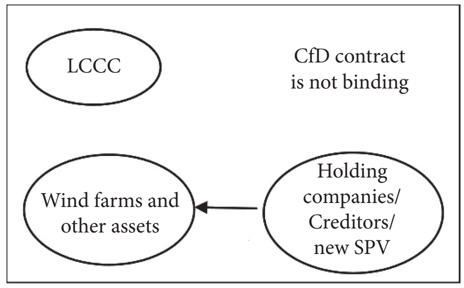

Fig. 2 The relationship between players when the developer becomes insolvent.

This distinction is central to the enforcement gap examined in this study. When expected future market prices exceed the strike price, the termination amount is positive because the generator would otherwise be expected to make future paybacks to the LCCC. In principle, this should deter exit by requiring the generator to compensate the LCCC for the discounted value of those expected paybacks. However, if the generator is insolvent and the LCCC ranks as an unsecured creditor, the contractual size of the termination amount does not guarantee its recovery.

Once the contract is terminated, the CfD settlement mechanism ceases. The generating asset may continue to operate on a merchant basis or under a different offtake arrangement, while the LCCC's position changes from an ongoing contractual counterparty to a creditor with a single termination claim. In sustained high-price states, this is economically important because continued operation under the CfD would have generated a stream of paybacks from the generator to the LCCC. Termination converts that future stream into a one-off claim, but the practical recoverability of that claim may be substantially reduced if it ranks behind secured creditors in insolvency.

The enforcement gap is therefore most relevant when a large termination amount coincides with financial distress. High-price states increase the value of expected future paybacks and therefore increase the termination amount. However, financial distress may arise from adverse operating or financing conditions. As a result, the termination amount may be large in contractual terms, while its practical recoverability remains uncertain if the project company is financially distressed or insolvent.

5 Financial resilience and termination exposure

Section 4 showed that the termination amount is intended to deter exit from a CfD after the Milestone Delivery Date. However, the deterrent effect of this provision depends not only on the contractual size of the claim, but also on whether that claim can be

[x] If the realised future market price exceeds the estimated future price used in the termination calculation, the generator may benefit from terminating the contract. For simplicity, the analysis assumes that estimated future prices provide an accurate representation of future market conditions.

recovered if the generator enters insolvency following financial distress. Building on this point, this section develops a stylised quantitative framework to illustrate a conditional vulnerability within the current CfD structure. The exercise does not attempt to estimate the probability of insolvency for any specific project, nor does it seek to replicate lenders' internal credit models. Instead, its purpose is to show that the termination amount owed to the LCCC may be economically large, but that the practical recovery of this claim may be undermined if a highly leveraged SPV faces financial stress and subsequent insolvency.

The analysis focuses on two dimensions. The first is financial resilience within the project company, measured using the debt service coverage ratio (DSCR). This indicates whether operating cash flow remains sufficient to meet scheduled debt obligations under adverse assumptions relating to output, operating costs, and financing conditions, while the CfD remains in force and revenue per unit is stabilised at the strike price. The second is the termination amount owed to the LCCC, measured as the present value of the remaining CfD payback stream when expected wholesale prices exceed the strike price. The first dimension concerns the project company's capacity to remain solvent. The second concerns the scale of the LCCC's contractual claim if the project exits the CfD before expiry.

The framework is developed for a project financed through a leveraged SPV. The numerical exercise proceeds in two steps. First, it identifies the conditions under which financial stress may arise within the project company. Second, it evaluates the scale of the termination amount under sustained high-price conditions. The analysis then considers how these two dimensions interact and how an enforcement gap may arise if the termination amount is large, but its recoverability is weak when the project company is financially distressed and enters insolvency.

5.1 Debt service coverage ratio (DSCR)

The first dimension of the quantitative analysis concerns the financial resilience of the project company under adverse operating and financing conditions. This is evaluated using the DSCR, which measures whether cash flow available for debt service is sufficient to meet scheduled debt obligations in a given period. In project finance, the DSCR is a standard indicator of repayment capacity because it links operating performance directly to the firm's ability to service debt.

The DSCR in period t is defined as

$$\mathrm{DSCR}_t = \frac{\mathrm{CFADS}_t}{\mathrm{DS}_t} \tag{2}$$

where CFADS_t denotes cash flow available for debt service in period t, and DS_t denotes total debt service due in the same period. A value above one indicates that operating cash flow is sufficient to cover scheduled debt service, whereas a value below one indicates a shortfall and therefore signals financial stress.

Cash flow available for debt service is defined as

$$\mathrm{CFADS}_t = \mathrm{TR}_t - \mathrm{OPEX}_t \tag{3}$$

where TR_t is total revenue after CfD settlement and OPEX_t is operating expenditure.

To make the revenue component explicit, under a standard two-way CfD, the generator sells electricity at the wholesale market price p_t^{w} and then makes or receives a settlement payment based on the difference between the strike price p^{s} and the wholesale price. Total revenue is therefore given by

$$\mathrm{TR}_t = p_t^{\mathrm{w}} Q_t + \left(p^{\mathrm{s}} - p_t^{\mathrm{w}}\right) Q_t = p^{\mathrm{s}} Q_t \tag{4}$$

where Q_t denotes electricity output in period t. This identity captures the stabilisation feature of the CfD, implying that realised revenue per unit of output is anchored to the strike price when the CfD remains in force. Accordingly, within this framework, financial distress is not driven directly by wholesale price fluctuations, but by factors that affect output, costs, or financing conditions.

Operating expenditure is specified as

$$\mathrm{OPEX}_t = c_t Q_t \tag{5}$$

where c_t denotes operation and maintenance cost per unit of output. This formulation allows changes in generation and operating costs to affect cash flow separately.

Total debt service in period t is defined as

$$\mathrm{DS}_t = \mathrm{PR}_t + I_t = \frac{\overline{D}}{N} + I_t \tag{6}$$

where PR_t denotes scheduled principal repayment, $\overline{D}$ denotes total debt at the start, N is the number of repayment periods, and I_t denotes interest payments. For simplicity, principal repayment is assumed to be constant across periods. Let $t = 1, \ldots, N$, so that the outstanding debt before repayment in period t is $D_t = \left(\frac{\overline{D}}{N}\right)(N - t + 1)$. Interest payments are therefore given by

$$I_t = r_t D_t = r_t \left(\frac{\overline{D}}{N}\right)(N - t + 1) \tag{7}$$

where r_t is the effective interest rate.

Taken together, the DSCR can be expressed as

$$\mathrm{DSCR}_t = \frac{\left(p^{\mathrm{s}} - c_t\right) Q_t}{\frac{\overline{D}}{N} + r_t \left(\frac{\overline{D}}{N}\right)(N - t + 1)} \tag{8}$$

Equation (8) shows that the project company's DSCR is affected by variables that change either cash flow available for debt service or scheduled debt-service obligations. On the cash-flow side, the DSCR varies with generation (Q_t) and unit operating costs (c_t), while on the financing side, it varies with scheduled principal repayment, outstanding debt, and the effective interest rate (r_t). By contrast, wholesale price movements do not directly affect the DSCR while the CfD remains in force, because revenue per unit of output is anchored to the strike price (p^{s}).

5.2 Termination amount

The second dimension of the analysis concerns the termination amount associated with exit from the CfD scheme. The termination amount is calculated as the discounted value of the remaining expected settlement stream owed by the generator to the LCCC. Under a standard two-way CfD, the generator receives a top-up payment when the wholesale reference price falls below the strike price and makes a payback when the wholesale reference price exceeds the strike price. From the perspective of the LCCC, the settlement cash flow in period t is therefore defined as

$$\mathrm{SCF}_t = \left(p_t^{\mathrm{w}} - p^{\mathrm{s}}\right) Q_t \tag{9}$$

where p_t^{w} is the wholesale market price in period t, p^{s} is the strike price, and Q_t is electricity output. When $p_t^{\mathrm{w}} > p^{\mathrm{s}}$, the settlement cash flow is positive and the LCCC receives a payment from the generator. When $p_t^w < p^s$, the settlement cash flow is negative and the LCCC makes a payment to the generator.

If the contract is terminated in period i, the termination amount is expressed as the present value of expected future settlement cash flows over the remaining contract horizon.

$$\mathrm{TA}_t = \sum_{t=i}^{T} \frac{E(\mathrm{SCF}_t)}{(1+d)^{t-i}} = \sum_{t=i}^{T} \frac{E[(p_t^w - p^s)Q_t]}{(1+d)^{t-i}} \quad (10)$$

where T is the final period of the remaining contract horizon, $E(\mathrm{SCF}_t)$ is the expected future settlement cash flow from the generator to the LCCC in period t, and d is the discount rate. This formulation implies that the termination amount depends on both the size of the expected price wedge and the number of periods remaining under the contract. Equation (10) represents the case in which the present value of expected future settlement cash flows is positive. As indicated by Eq. (1), if this present value is negative, the termination amount is set equal to zero.

5.3 Calibration

The numerical exercise is calibrated using publicly available project information and a set of simplifying assumptions intended to support a stylised quantitative framework rather than project-specific credit replication. The benchmark case is based on the combined Dogger Bank A, B, and C projects, which together provide a representative large-scale offshore wind example within the GB CfD framework. As shown in Table 3, the baseline capacity is set at 3.6 GW, with expected annual generation of 18 TWh.

The CfD strike price is set at £40.63/(MWh) in 2012 prices, corresponding to the average of the AR3 offshore wind strike prices of £39.65/(MWh) for the 2023/24 delivery year and £41.61/(MWh) for 2024/25. Operation and maintenance costs are set at £19.97/(MWh) in 2012 prices. This value is derived from the estimate of £22/(MWh) for projects commissioning in 2025, expressed in 2018 prices, and converted into 2012 prices using the Consumer Price Index published by Ref. [53].

On the financing side, total project financing is assumed to be £8.5 billion, of which £7.3 billion is senior debt. The annual interest rate is set at 2.0 percent, and the repayment period is assumed to be 30 years. For the termination amount calculations, three illustrative price scenarios are considered, in which the wholesale reference price exceeds the strike price by £10/(MWh), £25/(MWh), and £50/(MWh), respectively. The discount rate used in the present-value calculations is 3 percent[y].

Under these assumptions, the implied Year 1 financial metrics are reported in Table 3. Total annual revenue under the CfD strike price is £731.34 million, total annual operating expenditure is

Table 3 Baseline calibration parameters and implied first-year financial metrics for the combined Dogger Bank A, B, and C projects.

Variable	Value	Unit	Note
Calibration			
Total capacity	3.6	GW	Combined installed capacity of Dogger Bank A, B, and C
Annual generation	18	TWh	Baseline expected annual generation for the combined three projects; sensitivity analysis varies output from 80% to 120% of this level
Strike price (in 2012 prices)	40.63	£/(MWh)	Average AR3 offshore wind strike price, based on £39.65/(MWh) for 2023/24 and £41.61/(MWh) for 2024/25
O&M costs (in 2012 prices)	19.97	£/(MWh)	Baseline O&M cost for projects commissioning in 2025; sensitivity analysis varies costs from 80% to 120% of this level
Total financing	8.5	£ billion	Total project financing at financial close for the three projects
Senior debt	7.3	£ billion	Total senior secured debt component of project financing
Interest rate	2	%	Baseline annual interest rate on senior debt; sensitivity analysis varies this from 1% to 6%
Repayment period	30	year	Amortisation period of senior debt
Hypothetical market price 1	50.63	£/(MWh)	Strike price plus £10/(MWh)
Hypothetical market price 2	65.63	£/(MWh)	Strike price plus £25/(MWh)
Hypothetical market price 3	90.63	£/(MWh)	Strike price plus £50/(MWh)
Discount rate	3	%	Real discount rate used to calculate the present value of termination amounts and future cash flows
Implied first-year financial metrics under the baseline calibration			
Total revenue	731.34	£ million	Annual revenue under the CfD strike price, calculated as annual generation × strike price (18 TWh × £40.63/(MWh))
OPEX	359.46	£ million	Total annual operating expenditure, calculated as annual generation × O&M cost (18 TWh × £19.97/(MWh))
Principal repayment	243.33	£ million	Annual scheduled principal repayment, calculated as senior debt ÷ repayment period (£7.3 billion ÷ 30 years)
Interest payment	146	£ million	Interest payment in Year 1, calculated as outstanding senior debt × interest rate (£7.3 billion × 2.0%)
DSCR	0.9552	–	DSCR in Year 1, calculated as (Total revenue – Total OPEX) ÷ (Principal repayment + Year 1 interest payment); used as the core liquidity metric in the sensitivity analysis

[y] For reference, expressed in 2012 prices, annual average wholesale electricity prices were £29.94/(MWh) in 2020, rose to £96.77/(MWh) in 2021 and £156.35/(MWh) in 2022, before declining to £68.81/(MWh) in 2023[53,63].

£359.46 million, annual principal repayment is £243.33 million, and the Year 1 interest payment is £146.00 million. These values imply a Year 1 DSCR of 0.9552.

These calibration values should be interpreted as inputs into a stylised framework rather than as a reconstruction of lenders' internal underwriting assumptions. The purpose of the calibration is to generate transparent comparative statics across operating, financing, and price scenarios using parameters anchored in publicly observable magnitudes. In particular, the baseline DSCR should not be interpreted as evidence regarding the actual covenant structure or financeability of any individual project at financial close. Instead, it serves as a reference point from which the sensitivity of debt-service capacity and the termination amount can be examined under alternative assumptions.

A scenario-based sensitivity-analysis approach is adopted throughout. Sensitivity analysis for output and operating costs is conducted through proportional deviations around their baseline levels. Financing conditions are captured by varying the effective interest rate while holding operating conditions fixed. The termination amount is then evaluated separately by applying the present-value formulation developed in Eq. (10) to the three price scenarios. This approach keeps the channels of transmission analytically distinct. Operating and financing shocks affect the DSCR through cash flow available for debt service and debt-service obligations, whereas price conditions affect the scale of the termination amount through the expected future payback stream to the LCCC.

5.4 DSCR path over time

This subsection examines how debt-service coverage evolves over time when total debt service changes as a result of declining outstanding debt and associated interest payments, while cash flow available for debt service is held constant. The purpose is to show how the DSCR of a leveraged project company may improve over time even in the absence of any change in operating performance.

Figure 3 reports the resulting path of the DSCR together with annual interest payments over a 15-year horizon. Because the effective interest rate is held constant, annual interest payments decline monotonically as the debt balance amortises. Total debt service therefore falls over time, while cash flow available for debt service remains unchanged. As a result, the DSCR rises steadily.

Numerically, the DSCR increases from 0.9552 in Year 1 to 1.1579 in Year 15, crossing the break-even threshold of one at approximately Year 5. This implies that, within the stylised framework, the early years are the period of greatest financial pressure, because high initial debt balances generate the largest interest payments and the weakest debt-servicing capacity. As debt is repaid and the outstanding balance declines, the project company's financial resilience improves.

This time-path result provides the baseline for the subsequent sensitivity analysis in Sections 5.5 and 5.6. The results that follow should therefore be interpreted relative to the Year 1 debt profile, when the project company is the most vulnerable because debt balances and interest payments are the highest.

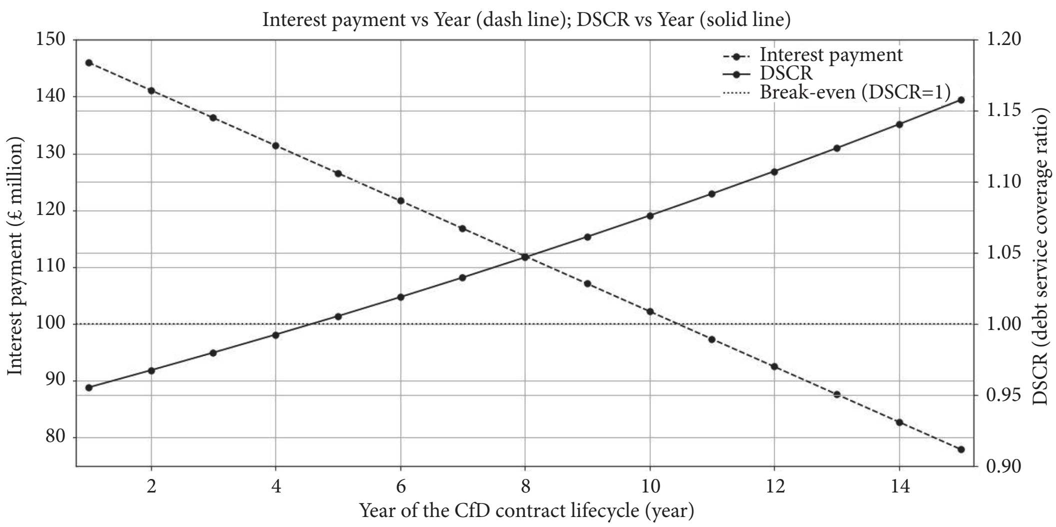

Fig. 3 Evolution of interest payments and DSCR over the 15-year lifecycle.

5.5 Operating conditions: sensitivity to generation and O&M costs

This subsection examines how adverse operating conditions affect debt-servicing capacity by reducing cash flow available for debt service and, in turn, weakening the DSCR. Two sensitivity analyses are conducted. The first varies electricity generation around the baseline level, while the second varies O&M costs.

Figure 4 reports the resulting sensitivities in Year 1. In the first sensitivity analysis, annual output is varied from 80 percent to 120 percent of the baseline 18 TWh. Under the CfD, total revenue depends directly on realised generation, so lower output directly reduces cash flow available for debt service. As shown in Figure 4, the DSCR rises monotonically from 0.7641 at 80 percent of baseline generation to 1.1462 at 120 percent. The break-even threshold is reached at approximately 105 percent of baseline generation, where the DSCR first exceeds one at 1.0029. This result shows that weaker generation performance can reduce debt-servicing capacity within a leveraged project company.

The second sensitivity analysis varies O&M costs from 80 percent to 120 percent of baseline. An increase in O&M costs reduces cash flow available for debt service by raising operating expenditure. Figure 4 shows that the DSCR declines monotonically from 1.1398 at 80 percent of baseline costs to 0.7705 at 120 percent. The break-even point occurs at approximately 95 percent of baseline O&M costs, where the

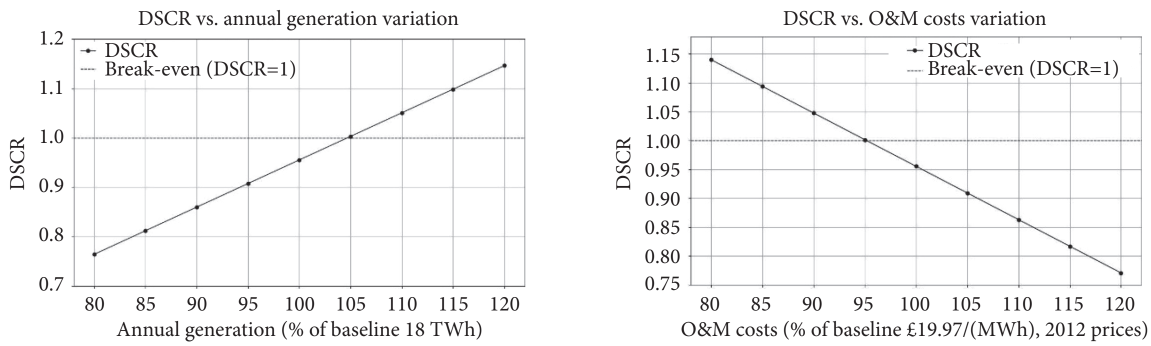

Fig. 4 Sensitivity of the DSCR to changes in generation and O&M costs in Year 1. DSCR represents debt service coverage ratio.

DSCR is 1.0013. This indicates that higher O&M costs can place pressure on debt-servicing capacity.

These results show that both lower generation and higher O&M costs reduce cash flow available for debt service and weaken the DSCR. The implication is that, although the CfD stabilises revenue per unit of output, operational underperformance can still reduce total cash flow and increase debt-servicing pressure.

5.6 Financing conditions: sensitivity to interest rate

This subsection examines how changes in financing conditions affect debt-servicing capacity when operating performance is held constant. The analysis focuses on the sensitivity of the DSCR to changes in interest rates.

Figure 5 reports the resulting sensitivities in Year 1. The sensitivity analysis varies the interest rate from 1 percent to 6 percent. The DSCR falls from 1.1756 at a 1 percent interest rate to 0.5458 at a 6 percent interest rate. The break-even threshold of one is reached at an effective interest rate of approximately 1.8 percent. Beyond this point, cash flow available for debt service is no longer sufficient to cover scheduled principal and interest payments. These results indicate that higher financing costs can materially weaken debt-servicing capacity within a highly leveraged project company.

As the interest rate rises, annual interest payments increase for a given outstanding debt balance, thereby raising total debt service. As a result, while cash flow available for debt service remains unchanged, the DSCR declines as financing costs increase. Therefore, although the CfD stabilises revenue per unit of output, debt-servicing pressure can still arise through higher interest rates and the resulting increase in interest payments, even when operating performance remains unchanged.

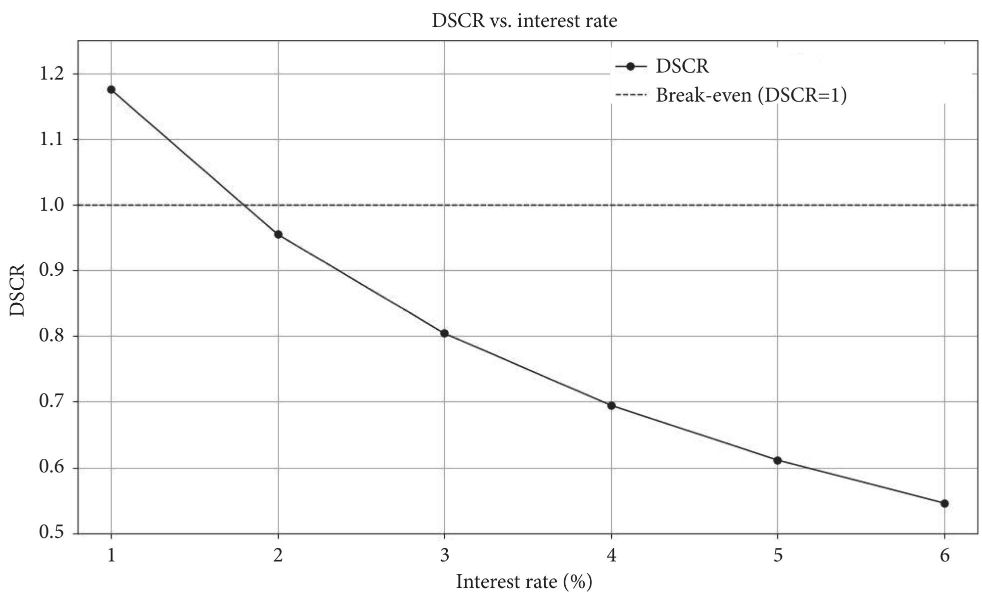

Fig. 5 Sensitivity of the DSCR to changes in interest rate in Year 1. DSCR represents debt service coverage ratio.

5.7 Termination amount under alternative price scenarios

This subsection turns from debt-servicing capacity to the scale of the termination amount if a CfD-supported project exits the contract in sustained high-price states. Applying the present-value formulation in Eq. (10), the termination amount is calculated under three illustrative price scenarios in which the expected wholesale reference price exceeds the strike price by £10/(MWh), £25/(MWh), and £50/(MWh), respectively. These scenarios are intended to show how the termination amount increases as the expected future price wedge widens over the remaining life of the contract.

Figure 6 shows that the termination amount can become economically substantial when the expected future price wedge remains positive over a long contract horizon. For a representative 3.6 GW project with annual output of 18 TWh and a remaining contract term of 15 years, the estimated termination amount rises from approximately £2.21 billion in the strike-price-plus-£10/(MWh) scenario to £5.53 billion in the strike-price-plus-£25/(MWh) scenario and £11.07 billion in the strike-price-plus-£50/(MWh) scenario.

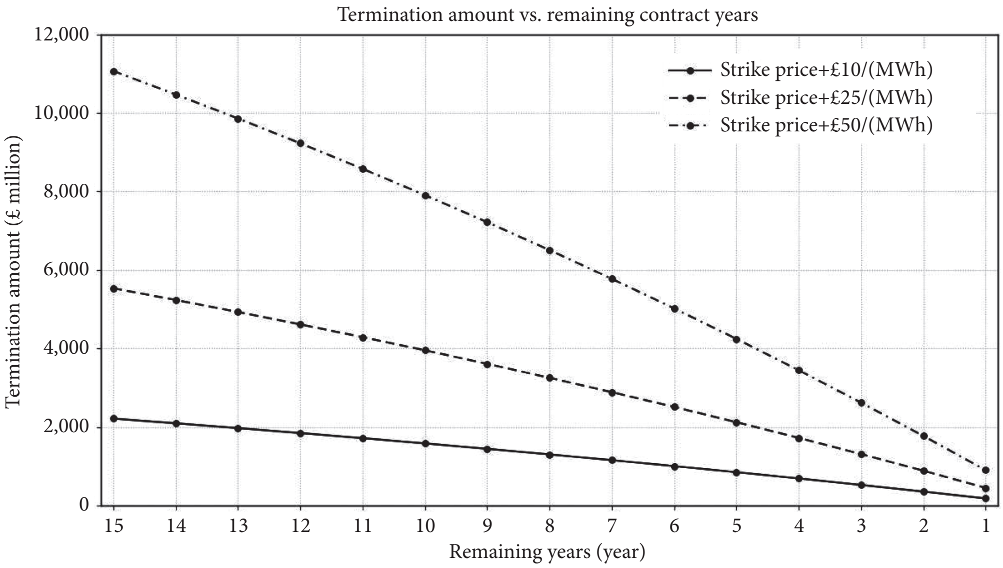

Fig. 6 Estimated termination amount under alternative high-price scenarios.

These values indicate that the contractual claim associated with exit from the CfD scheme may be large relative to the project company's balance sheet when high wholesale prices are expected to persist. This point is important in the context of the CfD scheme. The CfD is designed not only to stabilise revenue per unit of output for low-carbon generators, but also to protect value for money by requiring paybacks to the LCCC when wholesale prices exceed the strike price. In such states, the termination amount is intended to deter exit from the scheme and preserve the expected stream of paybacks that would otherwise accrue to the LCCC. The significance of these estimates therefore lies not only in their magnitude, but also in the fact that they represent the value of future paybacks that the LCCC will seek to recover if the contract is terminated before expiry.

5.8 Possible links between financial resilience and termination amount

The preceding analysis separates two dimensions related to the CfD scheme: the project company's financial resilience, measured by the DSCR, and the scale of the termination amount owed to the LCCC under sustained high-price conditions. These two dimensions are analytically distinct. The DSCR captures the ability of the project company to meet scheduled debt-service obligations while the CfD remains in force. By contrast, the termination amount captures the present value of expected future paybacks that would otherwise accrue to the LCCC if the contract continued. However, these two dimensions may still be connected through volume and price channels.

The volume channel arises because both debt-servicing capacity and the termination amount depend on the volume of eligible generation. Under the CfD, revenue per unit of eligible output is stabilised at the strike price. Therefore, lower generation reduces total revenue and cash flow available for debt service, thereby weakening the DSCR, as shown in Eq. (8). At the same time, when expected wholesale prices exceed the strike price, lower expected future output reduces the expected payback stream from the generator to the LCCC, which lowers the termination amount, as shown in Eq. (10)[z]. This means that reductions in eligible generation, arising for example from lower wind availability, technical outages, or an increasing frequency of negative-price events, may weaken the project company's financial resilience and reduce the size of the termination amount.

The volume channel is particularly relevant when the treatment of negative prices is considered[64]. For generators awarded CfDs in Allocation Rounds 2 and 3, no CfD payment is made when the day-ahead price is negative for six or more consecutive hours. For Allocation Round 4 and later rounds, CfD payments are suspended for any hour in which the day-ahead price is below zero. These rules imply that some generation may not receive CfD support during negative-price periods. As a result, eligible generation and CfD-supported revenue may be lower, thereby weakening the DSCR. At the same time, the termination amount may also be reduced if the expected future settlement stream excludes these unsupported volumes. Therefore, through the volume channel, lower eligible generation may reduce both debt-servicing capacity and the termination amount. This channel may become increasingly important as renewable penetration rises, because surplus generation events and associated very low or negative price periods are expected to become more frequent, increasing the incidence of output-related revenue disruptions under current CfD payment rules[64].

The price channel operates differently. A higher wholesale reference price increases the expected payback from the generator to the LCCC when the market price exceeds the strike price. As a

[z] When expected wholesale prices are below the strike price, the termination amount is zero by design and therefore does not vary with generation.

result, sustained high wholesale prices raise the termination amount because the present value of the remaining expected payback stream becomes larger. However, while the CfD remains in force, higher wholesale prices do not directly improve the DSCR, because the generator's revenue per unit of eligible output remains anchored to the strike price after CfD settlement. This creates an asymmetry: the LCCC's contractual claim increases with expected wholesale prices above the strike price, while the project company's financial resilience remains driven by generation, operating costs, and the effective interest rate. Therefore, if the project company is exposed to adverse operating or financing conditions, its DSCR may fall and financial distress may emerge. In such a case, the LCCC's contractual claim may be large in principle, but its practical recoverability may depend on the creditor hierarchy, the residual value of the SPV, and the treatment of the CfD claim in any restructuring or insolvency process.

This does not imply that insolvency is likely, nor does it suggest that project sponsors would strategically seek insolvency to avoid CfD payback obligations. Rather, the analysis identifies a conditional vulnerability in the current contractual structure. Under sustained high-price scenarios, the value of future paybacks protected by the termination amount can be substantial. However, if termination occurs when the project company is financially distressed due to operating or financing pressures, the recoverability of that claim may be weakened by limited recoverable assets within the SPV. The implication is that the deterrent effect of the termination amount depends not only on its contractual size, but also on the financial resilience of the project company and the practical recoverability of the claim. This creates a potential enforcement gap within the CfD framework: the stronger the expected future payback stream, the larger the termination claim, but the value of that claim may be most uncertain when financial distress makes recovery most difficult.

6 Conclusion and policy implications

This section summarises the main findings of the study and discusses their implications for the governance of the CfD scheme. The analysis has shown that the deterrent effect of the termination amount depends not only on its contractual size, but also on its practical recoverability if the project company enters financial distress or insolvency. This issue is particularly relevant for offshore wind projects financed through highly leveraged SPVs, where secured lenders may hold priority claims over project assets and cash flows. The central policy challenge is therefore to strengthen the credibility of termination provisions while preserving project bankability and avoiding unnecessary increases in financing costs.

6.1 Main findings and interpretation

This study examines how CfD termination provisions interact with the project-finance structures commonly used in UK offshore wind investment. Its key finding is that the termination amount can deter exit only to the extent that the LCCC is able to recover the resulting claim from the project company. Where the project is financed through a highly leveraged SPV, the practical recoverability of this claim may be weakened if the LCCC ranks behind secured creditors in insolvency.

Under standard CfD operation, revenue per unit of eligible output is stabilised at the strike price. When wholesale prices fall below the strike price, the LCCC makes top-up payments to the generator. When wholesale prices exceed the strike price, the generator makes payback payments to the LCCC. In sustained high-price states, the expected future payback stream can become substantial, especially for projects awarded low strike prices through competitive auctions. If the project exits the CfD before expiry, this expected stream is converted into a termination amount owed to the LCCC.

The study identifies a potential enforcement gap in this setting. The termination amount may be large in contractual terms, but its practical recoverability may be uncertain if the project company is financially distressed or insolvent. This creates a divergence between contractual liability and expected recovery. The issue does not lie primarily in the settlement formula itself, but in the interaction between CfD termination provisions, SPV-based project finance, secured debt, and creditor priority.

The stylised quantitative analysis illustrates this mechanism by separating two dimensions. The first is financial resilience within the project company, measured by the DSCR under operating and financing stress. The second is the termination amount, measured as the present value of expected future paybacks owed to the LCCC under sustained high-price scenarios. The results show that lower output, higher O&M costs, and higher financing costs can weaken the DSCR, while higher expected wholesale prices increase the termination amount without directly improving the DSCR while the CfD remains in force. The enforcement gap becomes most relevant when these two conditions coincide: a large termination amount exists in contractual terms, but the project company's financial resilience is weak.

Importantly, the analysis does not imply that generator insolvency or strategic exit has occurred under the CfD regime to date. Nor does it suggest that project sponsors would deliberately seek insolvency to avoid payback obligations. In practice, insolvency and contract termination are expected to remain relatively rare, because parent firms and project sponsors have strong commercial and reputational incentives to preserve project value, maintain lender relationships, and avoid disruption to operational assets. In addition, financial distress can often be addressed through approaches such as refinancing, restructuring, or equity injections before formal insolvency occurs. Rather, the study identifies a conditional vulnerability that may become relevant under sustained high-price and financial-stress conditions. The contribution is therefore to show that the credibility of the termination amount depends not only on the size of the contractual penalty, but also on the financial position of the project SPV and the recoverability of the LCCC's claim in distress.

6.2 Policy implications

The findings have implications for CfD design and governance. If termination provisions are intended to protect the value of future paybacks to the LCCC, policy attention should not focus only on how the termination amount is calculated. It should also consider whether the resulting claim can be recovered in practice, particularly when the project company is financially distressed. The policy challenge is therefore to improve the practical recoverability of termination claims without undermining project bankability or unnecessarily increasing financing costs.

The first policy implication is that the priority of the LCCC's termination claim may need to be strengthened. This could involve granting the LCCC a form of security over defined project assets or cash flows. Such protection could improve recoverability if the project company enters distress. However, it would also affect the position of senior lenders. If lenders perceive that their security package has been weakened, they may increase the cost of financing or reduce debt capacity.

The second implication is the need for stronger risk-based monitoring and conditional credit support. The LCCC or relevant public authority could monitor indicators such as leverage, DSCR, refinancing exposure, and interest-rate risk. If specified thresholds are breached, the project company could be required to provide additional protection, such as a letter of credit, reserve account, or parent-company support where available. This approach would be more targeted than a universal security requirement, because additional protection would be activated only when risk indicators deteriorate. However, it would also increase monitoring requirements and could create additional financing frictions if the triggers are set too tightly.

The third implication is that a ring-fenced reserve could be used to support the recoverability of payback obligations and the termination amount. Such a reserve could be funded through a small share of project revenues when wholesale prices exceed the strike price and held separately from the project company's general assets. This could improve the LCCC's recoverability without fully subordinating senior lenders or changing the basic non-recourse structure of project finance. However, it may still affect financing terms if lenders view the reserve as reducing cash available for debt service.

The broader policy lesson is that CfD governance should treat termination provisions as both contractual and financial instruments. A large termination amount can deter exit only if the resulting claim is credible and recoverable in distress. As lower-strike-price offshore wind projects enter operation and wholesale price volatility remains significant, the practical recoverability of future payback obligations becomes increasingly relevant to the scheme's value-for-money objectives. Strengthening this aspect of the CfD framework would help ensure that the scheme continues to support low-carbon investment while protecting the public value of future paybacks owed to the LCCC.

Appendix

JEL Codes:

- D4 Market Structure, Pricing, and Design
- H23 Environmental Taxes and Subsidies
- L94 Electric Utilities
- Q48 Government Policy

Abbreviations: CfD, Contracts for Difference; LCCC, Low Carbon Contracts Company; SPV, Special Purpose Vehicle; FIT, Feed-in Tariff; FIP, Feed-in Premium; DECC, Department of Energy & Climate Change; BEIS, Department for Business, Energy & Industrial Strategy; PPP, Public–Private Partnership; RO, Renewables Obligation; AR, Allocation Round; DSCR, Debt Service Coverage Ratio; OPEX, Operating Expenditure; CFADS, Cash Flow Available for Debt Service.

Acknowledgements

The authors gratefully acknowledge the editor and the anonymous reviewers for their valuable and constructive comments and suggestions. We acknowledge support from the Soft Science Research Project of Henan Province (CN, Project No. 262400410054).

Author contribution statement

Huanhuan Chen: Methodology, conceptualization, formal analysis, writing – original draft, funding acquisition. Jinke Li: Methodology, conceptualization, formal analysis, writing – original draft, writing – review and editing. Guy Liu: Supervision, writing – review and editing. Jing Shao: Methodology, validation, supervision, writing – review and editing.

Data availability

The data are available from the corresponding author upon reasonable request.

Use of AI statement

None.

Declaration of competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

References

[1] Bunn, D., Yusupov, T. (2015). The progressive inefficiency of replacing renewable obligation certificates with contracts-for-differences in the UK electricity market. *Energy Policy*, 82: 298–309.

[2] Li, J. K., Liu, G., Shao, J. (2020). Understanding the ROC transfer payment in the renewable obligation with the recycling mechanism in the United Kingdom. *Energy Economics*, 87: 104701.

[3] Shao, J., Li, J. K., Liu, G. (2021). Vertical integration, recycling mechanism, and disadvantaged independent suppliers in the renewable obligation in the UK. *Energy Economics*, 94: 105093.

[4] Wang, Y. F., Li, J. K., O'Leary, N., Shao, J. (2024). Banding: a game changer in the renewables obligation scheme in the United Kingdom. *Energy Economics*, 130: 107331.

[5] Wang, Y. F., Li, J. K., O'Leary, N., Shao, J. (2024). Excess demand or excess supply? A comparison of renewable energy certificate markets in the United Kingdom and Australia. *Utilities Policy*, 86: 101705.

[6] Winter, S., Schlesewsky, L. (2019). The German feed-in tariff revisited - an empirical investigation on its distributional effects. *Energy Policy*, 132: 344–356.

[7] Böhringer, C., Cuntz, A., Harhoff, D., Asane-Otoo, E. (2017). The impact of the German feed-in tariff scheme on innovation: evidence based on patent filings in renewable energy technologies. *Energy Economics*, 67: 545–553.

[8] Lee, B., Li, J. K., Shao, J. (2025). The intertemporal unfairness of the feed-in tariff scheme in the United Kingdom: catching up across regions. *Utilities Policy*, 97: 102044.

[9] Schallenberg-Rodriguez, J. (2017). Renewable electricity support systems: are feed-in systems taking the lead. *Renewable and Sustainable Energy Reviews*, 76: 1422–1439.

[10] Pyrgou, A., Kylili, A., Fokaides, P. A. (2016). The future of the Feed-in Tariff (FiT) scheme in Europe: the case of photovoltaics. *Energy Policy*, 95: 94–102.

[11] Marckhoff, J., Wimschulte, J. (2009). Locational price spreads and the pricing of contracts for difference: evidence from the Nordic market. *Energy Economics*, 31(2): 257–268.

[12] Kristiansen, T. (2004). Pricing of contracts for difference in the Nordic market. *Energy Policy*, 32(9): 1075–1085.

[13] DECC. (2015). Independent evaluation of the Electricity Market Reform. https://assets.publishing.service.gov.uk/media/5a8071b2ed915d74e33fa765/Independent_evaluation_of_Electricity_Market_Reform_-_Final_report_-_14_....pdf.

[14] Welisch, M., Poudineh, R. (2020). Auctions for allocation of offshore wind contracts for difference in the UK. *Renewable Energy*, 147: 1266–1274.

[15] Kreiss, J., Ehrhart, K. M., Haufe, M. C. (2017). Appropriate design of auctions for renewable energy support – Prequalifications and penalties. *Energy Policy*, 101: 512–520.

[16] Del Río, P., Linares, P. (2014). Back to the future? Rethinking auctions for renewable electricity support. *Renewable and Sustainable Energy Reviews*, 35: 42–56.

[17] BEIS. (2020). Electricity generation cost 2020. https://assets.publishing.service.gov.uk/media/5f450b9be90e07529c25a9c5/electricity-generation-cost-report-2020.pdf.

[18] Grubb, M., Newbery, D. (2018). UK electricity market reform and the energy transition: emerging lessons. *The Energy Journal*, 39(6): 1–26.

[19] Yescombe, E. R. (2002). Principles of Project Finance. Boston: Academic Press.

[20] Gatti, S. (2013). Project Finance in Theory and Practice: Designing, Structuring, and Financing Private and Public Projects, 2nd edn. Boston: Academic Press.

[21] Esty, B. C. (2004). Why study large projects? An introduction to research on project finance. *European Financial Management*, 10(2): 213–224.

[22] Steffen, B. (2018). The importance of project finance for renewable energy projects. *Energy Economics*, 69: 280–294.

[23] Benavides-Franco, J., Gómez, J. M., Pérez-Uribe, M. A. (2023). Determinants of Project Finance success for renewable energy. *Renewable Energy*, 211: 188–201.

[24] Tirole, J. (1999). Incomplete contracts: where do we stand. *Econometrica*, 67(4): 741–781.

[25] Grossman, S. J., Hart, O. D. (1986). The costs and benefits of ownership: a theory of vertical and lateral integration. *Journal of Political Economy*, 94(4): 691–719.

[26] Hart, O., Moore, J. (1999). Foundations of incomplete contracts. *The Review of Economic Studies*, 66(1): 115–138.

[27] Hart, O., Moore, J. (1990). Property rights and the nature of the firm. *Journal of Political Economy*, 98(6): 1119–1158.

[28] Bajari, P., Tadelis, S. (2001). Incentives versus transaction costs: a theory of procurement contracts. *The RAND Journal of Economics*, 32(3): 387–407.

[29] Engel, E., Fischer, R., Galetovic, A. (2013). The basic public finance of public–private partnerships. *Journal of the European Economic Association*, 11(1): 83–111.

[30] Guasch, J. L., Laffont, J. J., Straub, S. (2007). Concessions of infrastructure in Latin America: government-led renegotiation. *Journal of Applied Econometrics*, 22(7): 1267–1294.

[31] Spiller, P. T., Tommasi, M. (2008). The institutions of regulation: an application to public utilities. In: Handbook of New Institutional Economics. Ménard, C., Shirley, M. M., Eds. Berlin, Heidelberg: Springer, 515–543.

[32] Henisz, W. J. (2000). The institutional environment for economic growth. *Economics & Politics*, 12(1): 1–31.

[33] Jensen, M. C., Meckling, W. H. (1976). Theory of the firm: managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*, 3(4): 305–360.

[34] Iossa, E., Martimort, D. (2015). The simple microeconomics of public-private partnerships. *Journal of Public Economic Theory*, 17(1): 4–48.

[35] Hart, O., Moore, J. (1994). A theory of debt based on the inalienability of human capital. *The Quarterly Journal of Economics*, 109(4): 841–879.

[36] Holmstrom, B., Tirole, J. (1997). Financial intermediation, loanable funds, and the real sector. *The Quarterly Journal of Economics*, 112(3): 663–691.

[37] del Río González, P. (2008). Ten years of renewable electricity policies in Spain: an analysis of successive feed-in tariff reforms. *Energy Policy*, 36(8): 2917–2929.

[38] Hobér, K. (2010). Investment arbitration and the energy charter treaty. *Journal of International Dispute Settlement*, 1(1): 153–190.

[39] Guasch, J. L. (2004). Granting and renegotiating infrastructure concessions: doing it right. The World Bank Group. https://documents.worldbank.org/en/publication/documents-reports/documentdetail/678041468765605224.

[40] Guasch, J. L., Laffont, J. J., Straub, S. (2008). Renegotiation of concession contracts in Latin America: evidence from the water and transport sectors. *International Journal of Industrial Organization*, 26(2): 421–442.

[41] Sarmento, J. M., Renneboog, L. (2021). Renegotiating public-private partnerships. *Journal of Multinational Financial Management*, 59: 100661.

[42] Gifford, J. L., Bolaños, L. A., Daito, N., Casady, C. B. (2024). What triggers public-private partnership (PPP) renegotiations in the United States. *Public Management Review*, 26(6): 1583–1609.

[43] Yescombe, E. R., Farquharson, E. (2018). Lenders' cash-flow controls, security and enforcement. In: Public-Private Partnerships for Infrastructure, 2nd edn. Yescombe, E. R., Farquharson, E., Eds. Oxford: Butterworth-Heinemann, 403–419.

[44] Jennings, T., Tipper, H. A., Daglish, J., Grubb, M., Drummond, P. (2020). Policy, innovation and cost reduction in UK offshore wind. https://discovery.ucl.ac.uk/id/eprint/10118565/.

[45] DECC. (2013). Electricity market reform: contract for difference - allocation methodology for renewable generation. https://assets.publishing.service.gov.uk/media/5a7c27a540f0b61a825d6cc9/Allocation_Methodology_-_MASTER_-_6_Aug_v_FINAL.pdf.

[46] DECC. (2014). Contract for Difference: allocation process high level summary. https://assets.publishing.service.gov.uk/media/5a7edec7e5274a2e8ab48b97/cfd_allocation_process_high_level_summary.pdf.

[47] Woodman, B., Fitch-Roy, O. (2019). Auctions for the support of renewable energy in the UK: updated results and lessons learnt. Report No. AURES II D2.1.

[48] BEIS. (2020). Evaluation of the contracts for difference scheme: phase 2: allocation round 3. https://assets.publishing.service.gov.uk/media/627cd7a6e90e0721b6f172f2/cfd-executive-summary.pdf.

[49] BEIS. (2019). Evaluation of the contracts for difference scheme: phase 1: allocation rounds 1 & 2. https://assets.publishing.service.gov.uk/media/627e3c4be90e0721b3675f3d/CfD_evaluation_phase_1_final_report.pdf.

[50] National Audit Office. (2014). Early contracts for renewable electricity. https://www.nao.org.uk/wp-content/uploads/2014/06/Early-contracts-for-renewable-electricity1.pdf.

[51] National Audit Office. (2018). Investigation into the 2017 auction for low-carbon electricity generation contracts. https://www.nao.org.uk/reports/the-2017-auction-for-low-carbon-electricity-generation-contracts/.

[52] Jansen, M., Beiter, P., Riepin, I., Müsgens, F., Guajardo-Fajardo, V. J., Staffell, I., Bulder, B., Kitzing, L. (2022). Policy choices and outcomes for offshore wind auctions globally. *Energy Policy*, 167: 113000.

[53] Office for National Statistics. (2025). Inflation and price indices. https://www.ons.gov.uk/economy/inflationandpriceindices.

[54] Dogger Bank Wind Farm. (2020). Dogger Bank Wind Farm A and B reaches financial close. https://doggerbank.com/press-releases/dogger-bank-wind-farm-a-and-b-reaches-financial-close/.
[55] Dogger Bank Wind Farm. (2021). Dogger Bank C reaches financial close. https://doggerbank.com/construction/dogger-bank-c-reaches-financial-close/.
[56] BEIS. (2017). Contracts for Difference: standard terms and conditions, version 2. https://www.gov.uk/government/publications/contracts-for-difference-standard-terms-and-conditions-version-2-march-2017.
[57] Ofgem. (2010). Renewables obligation: annual report 2008-2009. https://www.uregni.gov.uk/files/uregni/media-files/Annual_Report_2008-09_2.pdf.
[58] Ofgem. (2019). Renewables obligation annual report 2017-18. https://www.ofgem.gov.uk/sites/default/files/docs/2019/03/ro_annual_report_2017-18_final_v1_1.pdf.
[59] DECC. (2015). Non-delivery disincentive for contracts for difference. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/398825/NDD_Policy_Update_DECC_Update.pdf.
[60] LCCC. (2017). Milestone requirement guidance.
[61] BEIS. (2017). Contracts for difference and capacity market scheme update 2017. https://assets.publishing.service.gov.uk/media/5a82ca5bed915d74e340395b/hc537-contracts-for-difference-and-capacity-market-scheme-update-2017.pdf.
[62] BEIS. (2016). Contracts for difference and capacity market scheme update 2016. https://assets.publishing.service.gov.uk/media/5a80b5cce5274a2e8ab51b93/58054_EMR_report_Web_Accessible.pdf.
[63] Elexon. (2025). Market index prices. https://bmrs.elexon.co.uk/market-index-prices.
[64] Brown, C., Maximov, S., Price, J., Grubb, M. (2024). Generating surplus: the challenges and opportunities of large-scale renewables deployment. Working Paper No 6, Electricity Market Series.