Evaluating Contracts for Difference as Private Hedging Instruments: A Sensitivity Analysis for Medium-Term Price Protection

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***Abstract*—This paper investigates the role of Contracts for Difference (CfDs) as private hedging instruments in electricity markets, shifting from investment support to market-driven risk management. We analyze the financial impact of basic, one-way, and two-way CfDs using projected 2030 market data, assessing how strike price variations influence compensation payments and profit redistribution. Results show that basic CfDs provide the most balanced risk-sharing mechanism, while one-way CfDs lack provider viability, and two-way CfDs introduce higher financial exposure. These findings emphasize the need for adaptable CfD designs aligned with competitive market conditions.**

***Index Terms*-- Contracts for difference (CfDs), electricity markets, financial risk management, hedging instruments, renewable energy.**

I. INTRODUCTION

Contracts for Difference (CfDs) stipulate payments between two contract parties based on the difference between a strike and a reference price. Traditionally, CfDs served as long-term financial instruments to mitigate price risks for renewable energy investors, stabilize revenues, and lowering capital costs by reducing the levelized cost of energy (LCOE) [1]. Government-backed CfDs are widely used as support schemes, offering an alternative to feed-in tariffs and fixed market premiums [2]. However, their role has mainly been analyzed within the context of long-term investment frameworks, where they influence market participation, investment decisions, and risk allocation over extended periods [3], [4].

In this paper, we propose an alternative perspective: evaluating CfDs as private hedging instruments in electricity markets for medium-term price risk management. Instead of focusing on investment incentives, we consider a scenario where renewable generation assets are already in place. Our goal is to explore how CfDs can be structured and traded in the market to provide financial protection against price fluctuations. Specifically, we examine the role of CfDs as contracts that can be bought and sold between private parties, rather than as governmental instruments [5].

We highlight a key distinction between CfDs and Power Purchase Agreements (PPAs). While PPAs can be structured as physical or financial contracts, they typically involve long-term electricity delivery at a fixed price. In contrast, CfDs function purely as financial instruments, compensating for price differences without requiring physical power transactions. This distinction is crucial in positioning CfDs as more flexible market-based instruments, separate from the traditional structure of long-term power contracts [6].

To analyze the feasibility and implications of this approach, we conduct a sensitivity analysis of different CfDs by varying their strike and reference prices. The study focuses on the MIBEL electricity market and utilizes one year of market data to assess the redistribution of profits between CfD providers and renewable producers. Unlike conventional CfD studies, we do not incorporate investment decisions into our model; instead, we assume that renewable generators are already operational and seek financial stability through these contracts.

The core objective is to determine how profits shift between the CfD provider and the renewable producer under different market conditions. While our initial simulations consider a single buyer and seller, this study lays the groundwork for future research into multi-agent interactions, where multiple market participants engage in CfD trading. By positioning CfDs as private financial instruments, this research expands their potential applications and opens the door to new market-based risk mitigation strategies.

The paper is organized as follows: Section 2 presents the problem formulation, detailing the CfD types and analytical framework. Section 3 describes the case study based on the MIBEL market, including data sources and assumptions. Section 4 discusses the results, examining how different CfD configurations affect profit distribution. Finally, Section 5 concludes with key findings and suggestions for future research directions.

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II. Problem Formulation

Contracts for Difference (CfDs) are financial agreements used in electricity markets to hedge against price risks. They stipulate payments between two parties based on the difference between a strike price and a reference market price. Traditionally, CfDs have supported long-term renewable investments by ensuring stable revenues (Schlecht et al., 2024). However, an emerging perspective is to consider CfDs as private hedging instruments that can be traded in competitive markets to offer medium-term price protection

This study explores CfDs as a market-based tool for renewable producers and private entities to manage electricity price fluctuations. Unlike government-backed schemes, privately traded CfDs allow decentralized risk management. We hypothesize that variations in strike and reference prices influence profit redistribution between investors and CfD providers, shaping incentives for both parties.

Assuming existing renewable assets, we analyze financial interactions between CfD providers and producers over one year. Using future MIBEL market projections, we conduct a sensitivity analysis on how different CfD configurations affect profit distribution and risk exposure. Although risk metrics are not explicitly measured, CfDs inherently shift market volatility between participants. The next subsections present key variables, the evaluation method, and case study rationale.

A. *Contracts for difference and key variables*

CfDs are financial agreements that stabilize revenue for renewable producers by compensating for price differences between an ex ante agreed strike price S, and a reference market price p^{R} that is determined ex post. These contracts, designed to hedge against market price fluctuations, can be structured in different ways, depending on how the reference price is set and how financial transfers occur [7].

The general profit equation for a renewable producer under a CfD can be expressed as:

$$\Pi_{i,n} = \sum_{t=1}^{T} \left(q_{t,i,n} \cdot p_{t,n} \right) - C_{i,n} + P_{i,n}^{\mathrm{type}} \tag{1}$$

where $q_{t,i,n}$ is the power sold by producer i at time t in bidding zone n; $p_{t,n}$ is the market price at time t in bidding zone n; $C_{i,n}$ represents the producer's costs; and $P_{i,n}^{\mathrm{type}}$ is the net CfD payment, which varies by contract type.

For the CfD provider, their profit equation is simply the negative of the net payments made to the producer:

$$\Pi_{j,n}^{\mathrm{provider}} = -P_{i,n}^{\mathrm{type}} \tag{2}$$

This reflects the core principle of CfDs. When the market price is below the strike price, the provider compensates the producer, and when the market price is above the strike price, the producer compensates the provider.

This study evaluates three CfD structures, each defined by its reference price and payment mechanism. The basic CfD defines payments based on the difference between a fixed strike price $S_{i,n}^{\mathrm{basic}}$ and the market price at each hour. The reference price in this case is simply the hourly market price, $p^{\mathrm{R,basic}} = p_{t,n}$. Thus, the net payment to the producer is:

$$P_{i,n}^{\mathrm{basic}} = \sum_{t=1}^{T} q_{t,i,n} \left(S_{i,n}^{\mathrm{basic}} - p_{t,n} \right) \tag{3}$$

Since the reference price fluctuates hourly, this type of CfD provides direct price stabilization for the producer but exposes the CfD provider to substantial short-term volatility. Conversely, one-way and two-way CfDs use a reference price based on the annual average market value of electricity, v_n:

$$v_n = \frac{\sum_{t=1}^{T} \sum_{i=1}^{I} \left(q_{t,i,n} \cdot p_{t,n} \right)}{\sum_{t=1}^{T} \sum_{i=1}^{I} q_{t,i,n}} \tag{4}$$

By using an annual reference value instead of hourly prices, these CfDs smooth out short-term market fluctuations and reduce exposure to hourly volatility for the provider, while increasing revenue fluctuations for the producer. The one-way and two-way CfD payments are formulated as follows:

$$P_{i,n}^{\mathrm{1way}} = \sum_{t=1}^{T} q_{t,i,n} \left(\max\{0, S_{i,n}^{\mathrm{1way}} - v_n\} \right) \tag{5}$$

$$P_{i,n}^{\mathrm{2way}} = \sum_{t=1}^{T} q_{t,i,n} \left(S_{i,n}^{\mathrm{2way}} - v_n \right) \tag{6}$$

One-way CfDs (i.e., Eq. (5)) ensure that producers receive compensation when the reference price is low but retain the upside when market prices exceed the strike price. Unlike one-way CfDs, two-way CfDs (i.e., Eq. (6)) require producers to compensate the provider when the reference price exceeds the strike price. By including bidirectional payments, this contract reduces the financial exposure of CfD providers while still ensuring that producers benefit from revenue stabilization.

B. *Methodology for Evaluation*

This section outlines the methodology for evaluating the financial impact of different CfD designs, focusing on how compensations and paybacks vary with strike price selection. The analysis considers a renewable energy agent's market and operational data over one year, including hourly electricity prices and power production volumes. By varying strike prices $S_{i,n}^{\mathrm{type}}$, we assess the resulting financial flows between the CfD provider and the producer.

The evaluation examines basic, one-way, and two-way CfDs, simulating financial outcomes under different strike price settings. Specifically, we analyze how CfDs influence the producer's total profits, the provider's gains or losses, and the overall financial balance between both parties.

The analysis operates under the following assumptions: renewable assets are already installed, investment costs are not considered, and the study reflects medium-term price fluctuations over a one-year period. Initially, we model a bilateral agreement between a single CfD provider and one renewable agent, though the framework allows for future extensions to multiple market participants.

The next section presents the case study, the MIBEL market characteristics and their relevance to this analysis.

III. CASE STUDY

This case study evaluates the impact of CfDs on the financial outcomes of renewable producers and CfD providers under varying strike price conditions. The analysis is based on a synthetic dataset from the TradeRES project [4], simulating projected MIBEL market prices and trading behaviors for 2030. We assess how a renewable market participant performs with and without CfDs, conducting a sensitivity analysis on strike price variations for basic, one-way, and two-way CfDs to examine profit redistribution dynamics.

A. Dataset and Market Simulation

The study utilizes one year of simulated market data, representing projected MIBEL market conditions for 2030. The dataset includes hourly market clearing prices, bid prices and energy volumes submitted by market participants, as well as market results detailing accepted bids and financial transactions. These projections are derived from the TradeRES project S0 scenario, which models future electricity markets based on evolving policy, economic, and technological conditions (see Annex A in [4]).

Figure 1 presents the projected 2030 clearing prices, sorted in descending order to highlight price distribution and extreme variations. The blue curve represents the day-ahead market (DAM) clearing price, while the orange line denotes the mean market price, which remains exceeded by hourly prices for nearly 5,500 hours out of 8,760 annually, indicating prolonged periods of elevated market prices. The green and red lines correspond to the generation-weighted average market prices, i.e., the market value v_n, from Eq. (4), for wind and solar, both of which fall below the mean. Notably, v_n for solar is lower than for wind, reflecting that solar generators earn lower average market revenues than wind producers.

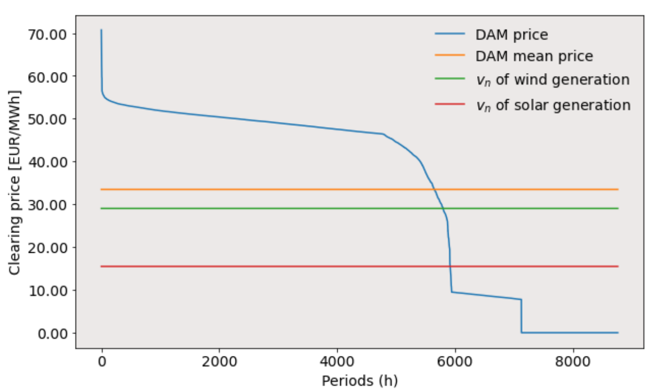

Figure 1. Projected 2030 DAM clearing prices (descending order).

Table I summarizes key aggregated metrics for 2030, including total traded volume, average market price volatility, installed capacity, and market participation. The total trade volume exceeds 718 TWh, with an average price of 33.48 €/MWh and significant fluctuations. Solar and wind technologies together represent a notable share of renewable participation, with solar accounting for 12.3% of total traded energy and wind for 20.7%. Two specific renewable agents were selected for CfD evaluation, one solar and one wind producer, representing nearly half of the total traded energy within their respective technologies (also shown in Table I).

TABLE I. MARKET AGGREGATED METRICS.

	Traded Volume (GWh)	Mean+std Price (€/MWh)	Installed Capacity (GW)	No. of players (RES)
Total	718689.84	33.48 ± 21.32	245.65	1515
Solar	88772.88	28.51 ± 22.30	41.13	79
Solar agent	40186.21	22.83 ± 21.84	19.59	1
Wind	148891.09	33.52 ± 21.33	57.92	33
Wind agent	79622.02	33.57 ± 21.34	30.75	1

B. Analysis Framework

This study evaluates the financial impact of CfDs by analyzing a single renewable energy agent under varying strike prices from two perspectives: (i) the r**enewable agent, e**valuating how CfDs hedge against price volatility and stabilize revenues, and (ii) the CfD provider, assessing profitability financially viable strike price ranges.

A reference scenario for 2030 is first established, where the renewable agent's profits are computed without CfDs, serving as a benchmark. Next, a series of experiments systematically vary the strike prices for basic, one-way, and two-way CfDs to assess their impact on compensation payments and financial transfers between the agent and the provider.

Strike prices are tested relative to the annual average market price, with deviations of ±5% to ±50% analyzed to determine the range of profitable and unprofitable CfD configurations.

IV. RESULTS

This section presents the financial outcomes of the CfD analysis, evaluating how different strike price settings impact profit redistribution between the renewable agent and the CfD provider. The analysis considers both solar and wind agents, as they exhibit different pricing dynamics due to their distinct market revenue structures. For each case in Figures 2-4, total annual profits are computed as a function of the strike price, distinguishing between compensation payments (green bars) and paybacks (red bars). The vertical dashed lines indicate key reference prices, the mean market price (orange) and the generation-weighted market price (v_n) for wind and solar (purple).

Figure 2 shows the financial impact of basic CfDs on the solar and wind agents, showing how profit redistribution shifts as the strike price varies. Compensation payments (green bars) increase as the strike price rises, while paybacks (red bars) grow when the strike price is lower, reflecting the core mechanism of CfDs. For the solar agent (Figure 2a), compensation consistently exceeds paybacks, indicating that solar market prices are frequently below the selected strike price, making basic CfDs particularly beneficial for revenue stabilization. In contrast, wind generation (Figure 2b) exhibits a more balanced pattern, with frequent reversals where the producer must return payments to the CfD provider. This suggests that wind market prices are closer to the strike price on average, reducing the net financial benefit compared to solar. These results highlight that basic CfDs provide stronger protection for solar generators, while wind producers experience a more neutral redistribution of profits.

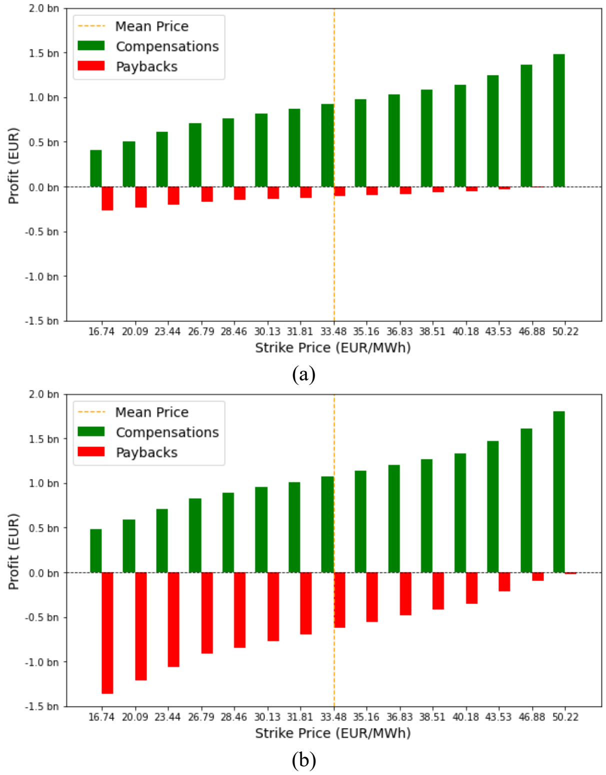

Figure 2. Basic CfD results: a) solar agent, b) wind agent.

Figure 3 illustrates the financial impact of one-way CfDs for the solar and wind agents, where compensation occurs when the strike price exceeds the reference price, given by the annual market value v_n, but no paybacks are required vice versa.

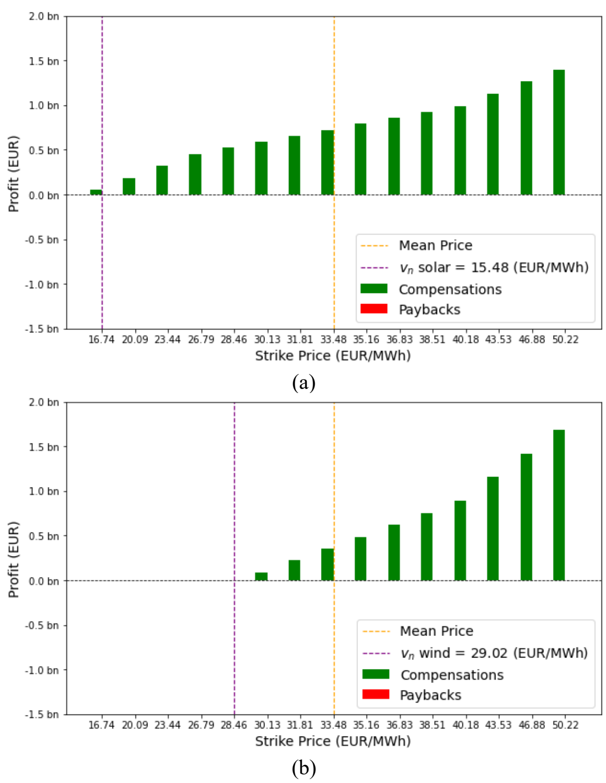

Figure 3. One-way CfD results: a) solar agent, b) wind agent.

For the solar agent (Figure 3a), compensation payments steadily increase as the strike price rises. Since the generation-weighted market price v_n for solar is 15.48 €/MWh (significantly lower than the mean market price of 28.51 €/MWh), a wide range of strike prices exceeds the reference price v_n, leading to frequent compensation. This indicates that solar producers benefit strongly from one-way CfDs, as they receive payments without any risk of returning funds. For the wind agent (Figure 3b), compensation also grows as the strike price increases, but their magnitude is lower compared to solar. This is because v_n for wind is much higher (29.02 €/MWh), meaning that only strike prices above this threshold trigger compensation. As a result, wind producers receive fewer total payments than solar under this contract.

Figure 4 shows the financial impact of two-way CfDs, where compensation occurs when the strike price exceeds v_n, and paybacks are required when it falls below. For the solar agent (Figure 4a), the results appear identical to the one-way CfD case, as only compensation is observed while payback remains absent. This occurs because solar market revenues are consistently lower than v_n (15.48 €/MWh), meaning that even when a two-way CfD is applied, market prices do not exceed the strike price often enough to trigger paybacks. Thus, two-way CfDs behave similarly to one-way CfDs for solar. For the wind agent (Figure 4b), however, two-way CfDs introduce paybacks (red bars) when the strike price drops below v_n (29.02 €/MWh), requiring the producer to return payments to the CfD provider. This creates a more balanced financial exchange but also exposes wind producers to both upward and downward adjustments, reducing the net benefit compared to one-way CfDs.

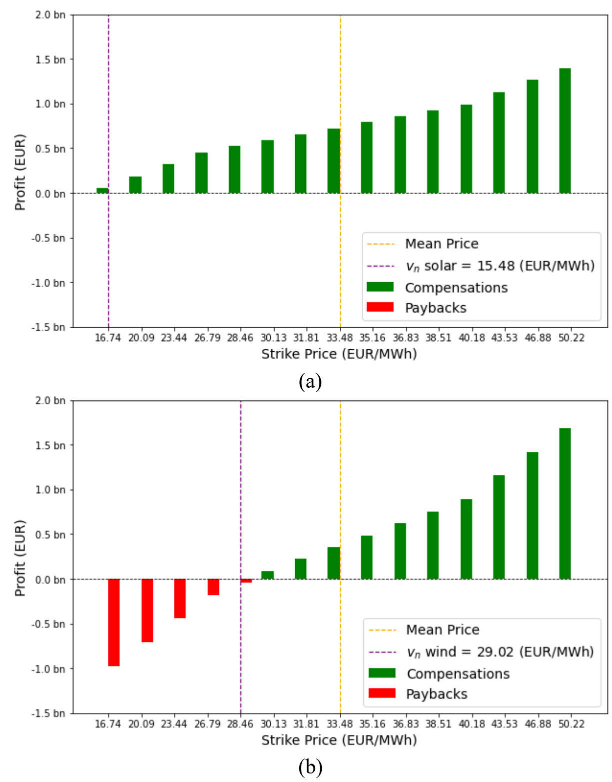

Figure 4. Two-way CfD results: a) solar agent, b) wind agent.

A. Discussion on the Suitability of CfD Structures

Basic CfD seems to be the least risky option for private market applications, as it ensures that compensation and paybacks are shared between the two contracting parties. Unlike the other CfD types, Basic CfDs maintain a more balanced risk distribution, where the CfD provider and the producer benefit or incur costs, depending on the strike price selection. This makes it a viable candidate for implementation in a market-driven setting, where CfD providers seek financial viability rather than acting purely as a support mechanism. However, the key challenge when applying Basic CfDs is the selection of an appropriate strike price. ex post compensation is entirely determined by the level of the strike price times the volume produced, it requires the producer to viably forecast its generation and cost over the contract period. The one-way CfD does not appear to be a viable option for private market applications, as it offers no financial incentive for CfD providers to participate. Since this structure guarantees compensation to the producer but never requires paybacks, it behaves more like a government-backed subsidy rather than a financial contract. For this reason, one-way CfDs are more suited for regulatory support mechanisms aimed at de-risking investments in renewable energy, rather than private hedging solutions. The two-way CfD remains a possible option, but it introduces a higher level of risk for the contracting parties. Unlike the basic CfDs, where financial exchanges occur dynamically throughout the year, the two-way CfD shifts all the risk to one side, meaning that either the producer or the CfD provider will be the net financial winner at the end of the contract period. Hence, it is an appropriate instrument for risk-loving parties that aim at earning market upsides compared to the reference price. While this structure can be implemented in a private market setting, it requires greater strategic analysis and risk tolerance from market participants. Particularly, in addition to forecasting cost and generation, the two-way CfD requires the contract parties to project market outcomes that determine the reference price.

B. Annual Profit Analysis Under CfD Application

Figure 5 shows the annual profits for both the solar and wind agents under different CfD structures, compared to No-CfD case. The results highlight how profit distributions vary depending on the CfD and strike price selection. For the solar agent in Figure 5a, all CfD structures increase overall profits, as the generation-weighted average price for solar (v_n =15.48 €/MWh) is significantly lower than the market average. The basic and two-way CfDs yield comparable profit distributions, while the one-way CfD guarantees the highest returns due to its lack of paybacks. For the wind agent (Figure 5b), the three CfD types show distinct outcomes. When the strike price is low (=below v_n=29.02 €/MWh), both the basic (blue bars) and two-way (yellow bars) CfDs yield lower profits than the no-CfD baseline case (horizontal dotted line), exposing the producer to paybacks. As the strike price increases, all configurations improve, but the basic CfD offers the most consistent gains. The one-way CfD (purple bars) always results in profits equal or above the baseline, as it offers compensation without requiring returns. However, this unidirectional structure makes it financially unattractive for CfD providers, limiting its applicability in private market settings. The high risk exposure of two-way CfDs reinforce the suitability of basic CfDs, which offer more balanced risk-sharing for both parties.

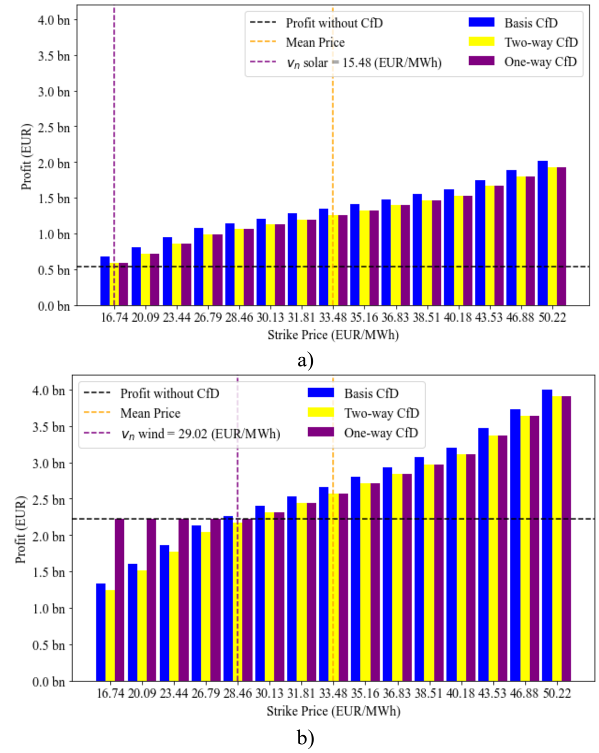

Figure 5. Annual profits: a) solar agent and b) wind agent.

V. CONCLUSIONS

In this article, we explored the potential of Contracts for Difference (CfDs) as private hedging instruments in electricity markets, shifting their traditional role from government-backed investment support to market-driven risk management tools. Through a sensitivity analysis of basic, one-way, and two-way CfDs, we assessed how profits are redistributed between renewable producers and CfD providers under different strike price scenarios. The results indicate that basic CfDs offer the most balanced financial structure, allowing compensation and paybacks to be shared, making them the least risky option for a private CfD market. In contrast, one-way CfDs do not provide financial viability for CfD providers, as they offer no mechanism for recovering losses, while two-way CfDs introduce higher risk, as they shift all financial responsibility to one party depending on price conditions. Future research should focus on expanding the range of CfD designs, including hybrid mechanisms that might provide greater flexibility and risk-adjusted returns. Additionally, agent-based modeling approaches could simulate a fully functional CfD market where strategic interactions between multiple participants influence market outcomes. Further studies could also assess the long-term implications of CfD trading, integrating investment decisions, portfolio diversification, and dynamic strike price adjustments to enhance the practical feasibility of these instruments in competitive electricity markets. Moreover, the potential of CfDs should be explored in local energy markets, where structured risk management instruments could improve financial stability for renewable producers and energy buyers [8], [9].

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