

10247

C5 Electricity Markets & Regulation
PS1 System Enhancement, Markets and Regulation

**Contracts for Difference (CfDs) as a Future Tool
for Clean Energy Transition in Brazil**

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SUMMARY

Contracts for Difference (CfDs) are financial mechanisms that stabilize revenue for clean energy producers by paying the difference between a fixed strike price and a fluctuating market price. CfDs have evolved from financial hedging tools into key instruments for promoting clean energy and decarbonization. Governments worldwide are using CfDs to incentivize investments in renewable energy, green hydrogen, and carbon capture and storage (CCS). CfDs provide price stability, reducing risks for investors in long-term, uncertain projects by ensuring predictable revenue streams. While they mitigate market volatility risks, they don't eliminate them entirely, encouraging better risk management and market maturity. The "two-sided CfDs" are emerging as the standard for clean energy projects. This study analyzes CfDs as strategic tools for boosting clean energy investments in Brazil, comparing them to other support mechanisms and exploring their potential applications. It also addresses challenges and future opportunities for expanding CfDs across Brazil's economy to accelerate the energy transition and foster sustainability. The goal is to provide insights for policymakers and investors on leveraging CfDs to build a greener future.

KEYWORDS

Clean Energy Investments, Contracts for Difference (CfDs), Hydrogen, Offshore Wind, Brazil.

1 Introduction

Contracts for Difference (CfDs) are financial mechanisms that stabilize revenue for clean energy producers by paying the difference between a fixed strike price and a fluctuating market price. CfDs are emerging as the preferred method for governments around the world to encourage investment in initiatives to reduce carbon emissions and promote the development of new technologies. Previously recognised as purely financial hedging instruments, CfDs have proven effective in accelerating the production of offshore wind energy in the UK and are playing a central role in reforming European electricity markets. Following the successful experience with renewables, it has been recognised that the CfD concept can be suitable for applications beyond electricity generation. Work is underway to develop and scale up CfD-based business models for clean hydrogen and carbon capture and storage (“CCS”). There is also scope for wider use of CfDs for low-carbon solutions as the energy transition progresses [1].

In one of the most recent and widely publicized developments towards decarbonization, the German government launched the first bidding round of its Carbon Contracts for Difference (CCfDs) scheme (Klimaschutzverträge) in March 2024, offering payments over 15 years to industrial players (such as steel and chemical producers) to adopt green hydrogen, CCS or other low-emission production methods. The estimated value of the scheme is estimated to reach €50 billion, and the CCfDs scheme is also expected to indirectly incentivize future investments in green hydrogen infrastructure, such as hydrogen production plants and gas pipelines [2, 3].

The objective of this paper is to present an initial analysis of CfDs as future strategic instruments for promoting investments in clean energy projects in Brazil and their best application. This paper begins, in Section 2, by presenting the conceptual foundations of Contracts for Difference (CfDs), explaining their origin, financial design, and the distinction between one-sided and two-sided models. In Section 3, the paper made a review of international experiences, highlighting how CfDs have been implemented in countries such as the United Kingdom, Germany, and New Zealand, and examining emerging applications in sectors like hydrogen production and carbon capture. Section 4 explores the role of CfDs in managing financial risks, particularly in renewable energy projects, where revenue stability is critical for securing long-term investment. The paper then provides, in Section 5, an overview of Brazil’s evolving regulatory landscape, including recent legal developments in green hydrogen, offshore wind, battery energy storage, and carbon markets. Building on this context, the discussion moves to a forward-looking vision for implementing CfDs in Brazil, in Section 6, proposing tailored mechanisms for hydrogen, storage, and offshore wind, while addressing challenges such as reference price determination and the treatment of negative pricing scenarios. The Conclusion section presents recommendations aimed at policymakers and investors, emphasizing how CfDs can serve as a strategic tool to support Brazil’s clean energy transition.

2 Contracts for Differences

A Contract for Difference (CfD) is a financial instrument designed to stabilize revenue for renewable energy producers, rather than functioning as a Power Purchase Agreement (PPA). Unlike a PPA, the primary purpose of a CfD is not to facilitate the direct sale of energy. Instead, it operates as a financial derivative, similar to Call Options and Put Options, which helps

manage price volatility. When a renewable energy producer enters into a CfD agreement with the government, they retain the flexibility to sell their electricity on the day-ahead market or any other market of their choice.

The CfD ensures that the producer receives a predetermined revenue for their energy, with the government compensating for any shortfall or reclaiming excess revenue if market prices deviate from the agreed-upon strike price.

CfDs are designed to provide some revenue stability and encourage investment, particularly in sectors like clean energy generation. It operates by establishing a fixed "strike price" per unit of energy between the government (or a designated body) and the energy producer. If the market price falls below the strike price, the producer receives a payment to cover the difference. Conversely, if the market price exceeds the strike price, the producer returns the difference. This arrangement reduces financial risks associated with energy price volatility, making clean energy projects with high upfront costs and low operating expenses more attractive to investors.

2.1 CfD: one-sided and two-sided

The most commonly used CfDs schemes in Europe include the one-sided CfD contract in Germany and the Netherlands, and the two-sided CfDs used in the UK and Denmark. Once a renewable producer and the government have entered into a CfD contract, the producer can continue selling their power on the day-ahead market or any other market of their choice. However, the rules regarding excess revenues when the electricity price exceeds the support price differ between the one-sided and two-sided CfDs.

A one-sided CfD contract is a financial agreement (not a PPA) commonly used in Europe to support renewable energy projects. In this scheme, the government or a designated authority guarantees a fixed "strike price" for the electricity generated. If the market price falls below this strike price, the government pays the producer the difference, ensuring stable revenue. However, if the market price exceeds the strike price, the producer keeps the excess revenue, and no payments are made to the government. This one-sided structure incentivizes renewable energy development while minimizing financial risk for producers.

Under the UK two-sided CfD, owners of renewable energy assets are guaranteed a fixed price (£/MWh) for the electricity they generate over a fixed contract period, for example a 15-year contract. The CfD payments are determined through a separate financial settlement, which takes into account the relative levels of the floating reference market price and the fixed strike price. If the reference market price falls below the strike price, the government or CfD party pays the difference to the renewable producer as a payout. Conversely, if the reference market price exceeds the strike price, the renewable producer must pay the difference between the two prices to the government [4].

Table 1 shows the main differences between One-Sided and Two-Sided CfD.

Table 1 - An example of a Contract for Difference (CfD) for an Offshore Wind Generator

Aspect	One-Sided CfD	Two-Sided CfD
Payment when market price < strike price	Counterparty pays the difference.	Counterparty pays the difference.
Payment when market price > strike price	No payment; producer keeps market price.	Producer pays the difference.

Aspect	One-Sided CfD	Two-Sided CfD
Risk for Producer	Protected from low prices; benefits from high prices.	Always receives strike price; no upside from high prices. But must manage the risk between low strike price and high strike price.
Risk for Counterparty	Bears cost when prices are low; no benefit when prices are high.	Bears cost when prices are low; benefits when prices are high.

Table 2 shows an example of a Contract for Difference (CfD) for an offshore wind generator selling electricity in the Day-Ahead (DA) Market. The market reference price for the CfD is \$20/MWh (the market reference price is not the DA Market), and the CfD strike price is \$25/MWh. For each hour, the generator produces a specific amount of energy (MWh) and sells it at the DA market price. Since the market reference price is below the CfD strike price, the counterparty compensates the generator (positive CfD revenue). The total CfD revenue per MWh remains constant at \$5/MWh, showing that CfD ensures a stable income regardless of DA Market fluctuations.

Table 2 - An example of a CfD for an Offshore Wind Generator

Hour	Offshore Generation (MWh)	Electricity Price from DA Market (\$/MWh)	CfD Strike Price (\$/MWh)	Revenue from CfD (\$/MWh)	Reference Price (\$/MWh)	Offshore Total Revenue (\$)
i	10.0	29.0	25.00	5.00	20.00	$(10.0 * 29.0) + (10.0 * 5.00)$
i + 1	20.0	28.00	25.00	5.00	20.00	$(20.0 * 28.0) + (20.0 * 5.00)$
i + 2	3.0	7.00	25.00	5.00	20.00	$(3.0 * 7.0) + (3.00 * 5.00)$

While Contracts for Difference (CfDs) are often contrasted with physical Power Purchase Agreements (PPAs), it is important to also consider their similarities and differences with virtual or financial PPAs, futures and forwards, and market-based support schemes such as feed-in tariffs (FiTs) and market premiums. Like virtual PPAs, CfDs are financial hedging instruments that settle the difference between a fixed strike price and a floating market price, without involving physical delivery of electricity.

However, CfDs are typically underwritten by governments or public agencies, which reduces counterparty risk and enhances bankability for capital-intensive clean energy projects. In contrast, virtual PPAs are usually signed between private actors and may involve higher credit risk and more complex settlement mechanisms.

Compared to futures and forward contracts, which are standardized, short- to medium-term financial tools used mainly for trading and risk management, CfDs are long-term and project-specific instruments designed to enable investment in new low-carbon capacity.

Furthermore, two-sided CfDs can be seen as a modern evolution of feed-in tariffs—effectively functioning as financial feed-in mechanisms that preserve market exposure. Unlike traditional FiTs, which offer a fixed payment regardless of market price, CfDs retain efficiency signals by requiring producers to return the difference when market prices exceed the strike price. Market premium schemes, in turn, offer partial exposure to the market, but typically without the symmetric settlement that characterizes CfDs. This makes CfDs a hybrid mechanism that

combines the investment certainty of FiTs with the market integration benefits of competitive pricing.

3 CfDs around the world

Several countries are currently in the process of planning or developing new Contracts for Difference (CfD) schemes. This trend includes nations that have already utilized CfDs in the past, as well as those that are now considering them as a novel form of support mechanism [4, 5]. For example, France, which has a strong track record with renewable energy CfDs since 2016, is reportedly exploring the possibility of extending CfDs to nuclear energy projects. Beyond Europe, CfD schemes are also gaining momentum in other parts of the world. In New Zealand, for instance, CfDs are being actively discussed in consultation documents as part of efforts to create a regulatory framework for offshore renewable energy. Given New Zealand's substantial offshore energy potential and the limited number of potential customers for Power Purchase Agreements (PPAs), CfDs are viewed as a particularly appealing option to provide the necessary commercial stability for such projects [4, 5].

The use of Contracts for Difference (CfDs) is expanding to new markets and technologies, including clean hydrogen and carbon capture and storage (CCS). In the UK, a Hydrogen Production Business Model (HPBM) based on CfDs has been developed to support low-carbon hydrogen production, with similar schemes being explored in the EU and Asia. Additionally, Carbon Contracts for Difference (CCfDs) are emerging as a key tool to support decarbonization in heavy industries, such as steel and chemicals, by bridging the cost gap between high-carbon and low-carbon production methods.

4 Risk Management with CfDs

CfDs are essential for financing renewable energy projects because these projects have high upfront capital costs and operational costs, making them vulnerable to price fluctuations in energy markets. Risk Management with Contracts-for-Difference (CfDs) is a critical aspect for entrepreneurs, especially those involved in renewable energy projects like wind or solar farms [6]. By ensuring predictability of future revenue streams, CfDs mitigate the risks associated with long-term projects with uncertain returns. It is worth noting that while it mitigates the risk associated with market price volatility, CfDs do not eliminate it completely, encouraging entrepreneurs to improve their risk management practices and consequently maturing the market through healthy competition.

Lenders (e.g., banks, institutional investors) of renewable energy projects are often hesitant to finance projects with uncertain revenue streams. Without a guaranteed revenue stream, the risk of default increases, making it harder to secure loans or attract investors. CfDs act as a financial hedge, reducing the risk for lenders by ensuring a predictable revenue stream. This makes it easier for entrepreneurs to secure financing at lower interest rates, as lenders are more confident that the project will generate enough revenue to repay the debt.

Entrepreneurs need to plan for long-term costs and revenues, but volatile energy prices make it difficult to forecast cash flows accurately. This uncertainty can deter investment and complicate project planning. Renewable energy projects are often price-takers in energy markets, meaning they have little control over the price they receive for their energy. This makes them vulnerable

to market distortions and price fluctuations caused by factors like oversupply or changes in energy policy. Then CfDs can reduce market risk by decoupling the revenue of renewable energy projects from short-term market fluctuations. This allows entrepreneurs to focus on optimizing production and reducing operational costs, rather than worrying about unpredictable market conditions.

Besides market risks, the entrepreneurs can face counterparty risks in energy markets. This arises when the agent involved in a PPA fails to meet its obligations. But with a CfD, they typically involve reputable counterparties (government body) with a lower likelihood of default. Additionally, their long-term nature provides a degree of stability, reducing the chances of abrupt contractual changes.

5 Regulatory Frameworks in Brazil

Brazil is making significant strides in shaping its energy policies to align with sustainable development goals, balancing economic growth with environmental care. A well-defined regulatory framework is critical to attracting investment and fostering innovation in the energy sector. Recent legislative measures in Brazil aim to enhance market efficiency and promote clean energy solutions. Below is an overview of key regulations introduced in the country.

Hydrogen Regulation in Brazil

The Hydrogen Regulatory Framework, established under Law No. 14,948 on August 2, 2024, introduces three classifications for hydrogen production: Low Carbon Emission Hydrogen (LCEH), Renewable Hydrogen, and Green Hydrogen. LCEH is defined as hydrogen with greenhouse gas emissions not exceeding 7 kgCO₂e/kgH₂, based on lifecycle analysis. This threshold is notably higher than the 3 kgCO₂e/kgH₂ standard set by European regulations, reflecting Brazil's intent to accommodate hydrogen production from natural gas, influenced by domestic lobbying efforts.

Renewable Hydrogen, a subset of LCEH, includes hydrogen derived from biomass, ethanol, and other biofuels, as well as electrolytic hydrogen produced using renewable energy sources such as solar, wind, and hydropower. Green Hydrogen specifically refers to hydrogen generated through water electrolysis powered exclusively by renewable energy.

The law also created the Brazilian Hydrogen Certification System (SBCH₂), overseen by the National Agency of Petroleum, Natural Gas, and Biofuels (ANP). This system ensures alignment with international certification standards and addresses the recognition of imported hydrogen derivatives. Notably, Brazilian hydrogen producers cannot claim carbon neutrality by purchasing credits from the domestic regulated market under European rules.

Additionally, the law introduced the Special Regime of Incentives for Low Carbon Emission Hydrogen (Rehidro), offering tax suspensions and other benefits for five years starting January 1, 2025. Eligible entities include not only LCEH producers but also companies involved in packaging, storage, transport, and distribution, as well as renewable energy and biofuel producers.

Another pivotal measure, Law No. 14,990 of September 27, 2024, established the Low Carbon Hydrogen Program (PHBC), which grants tax credits for the production and consumption of low-carbon hydrogen (≤ 7 kgCO₂e/kgH₂) and its derivatives. The allocation of credits will be

determined through a competitive process, prioritizing projects with lower emissions and stronger contributions to the national value chain. The total budget for tax credits from 2028 to 2032 is R\$ 18.3 billion, with annual limits specified.

Brazil's Regulated Carbon Market

Law No. 15,042, enacted on December 11, 2024, established Brazil's Regulated Carbon Market, a cap-and-trade system targeting companies emitting over 25,000 tonnes of CO₂e annually (excluding agribusiness). The system will be implemented in phases from 2025 to 2029, beginning with regulatory development, followed by the creation of a management body, emission monitoring, allowance allocation, and full market operation.

The initial phase in 2025 will focus on sub-legal regulation, followed by the development of measurement mechanisms for emissions reporting. The government will then define sector-specific emission caps through the National Allocation Plan.

Offshore Wind Energy Development

Brazil's regulatory framework for offshore wind energy was formalized through Law No. 15,097 on January 10, 2025. This law enables the exploitation of wind resources in territorial waters using fixed or floating platforms. Two primary mechanisms govern the allocation of maritime areas: a permanent offer system, where interested parties can request areas for direct authorization, and a planned offer system, involving competitive bidding for government-designated zones.

Environmental impact studies and community consultations are mandatory for offshore projects. Companies must also pay fees, including a subscription bonus, annual occupation charges, and a share of energy-generated revenue, which will fund research and sustainable development. The law includes provisions for decommissioning to restore sites post-project.

The Brazilian Institute of Environment and Renewable Natural Resources (IBAMA) has standardized environmental impact assessments for offshore wind projects, emphasizing marine biodiversity protection and stakeholder transparency. Over 250 GW of offshore wind projects are currently under environmental review.

Battery Energy Storage Systems (BESS)

Brazil is in the process of developing regulations for BESS, with the National Electric Energy Agency (ANEEL) leading public consultations to integrate energy storage into the regulatory framework. Key focus areas include grid stability, renewable energy integration, and addressing fiscal challenges like battery taxation. Planned auctions in 2025 aim to stimulate investment, though regulatory hurdles remain.

In summary, Brazil's energy policies reflect a commitment to sustainability, with ongoing efforts to refine regulations and incentivize clean energy adoption.

6 CfDs in Brazil: a future vision

This section explores the potential application of Contracts for Difference (CfDs) in Brazil, focusing on green hydrogen, battery energy storage systems (BESS), and offshore wind energy. The discussion excludes carbon credit-related projects within the regulated carbon market to maintain simplicity.

A significant obstacle to adopting CfDs in Brazil is the lack of clear regulations and standards for these three sectors. While onshore wind and solar PV currently do not require CfDs, offshore wind and hydrogen projects could benefit from such mechanisms. Brazil's substantial curtailment of onshore wind and solar generation presents an opportunity to leverage CfDs for BESS applications, enhancing grid stability and efficiency.

Green Hydrogen and CfDs

For green hydrogen, CfDs could be tailored to benefit consumers rather than producers. A one-sided strike price could be structured to rise annually over a decade, with a predefined trajectory established during auctions. This approach would encourage participation from hydrogen traders and consumers, fostering market liquidity and innovation in production, transportation, and consumption. If a consumer opts for self-production, they could use the hydrogen internally under the CfD agreement and sell any surplus to other buyers.

Brazil faces challenges in implementing hydrogen CfDs, including the risk of market manipulation by dominant producers, which could distort benchmark prices. To mitigate this, an independent pricing benchmark could be established using international hydrogen or LNG prices. Limiting individual market shares and enforcing transparency through mandatory reporting and audits would further ensure fair competition.

The cost burden of CfDs for green hydrogen could be placed on fossil fuel producers and consumers, such as Petrobras and fossil-fired power plants, as well as end-users of gasoline or LNG. This strategy could also promote the adoption of electric and hydrogen-powered vehicles. Export opportunities for cost-competitive renewable hydrogen should also be explored. Financial incentives, such as tax breaks or subsidies, could accelerate adoption in sectors like steel and heavy-duty transport.

Battery Energy Storage Systems (BESS) and CfDs

Renewables are expected to dominate global electricity generation by 2030, with solar PV surpassing wind and hydropower. However, the rapid growth of wind and solar has led to increased curtailment due to insufficient grid flexibility. Brazil, like other countries, faces this issue as grid investments lag behind renewable deployment.

Introducing CfDs for grid-forming BESS could address this challenge. Distribution companies and renewable generators could receive CfDs tied to hourly spot prices (PLD), while BESS units provide ancillary services like synthetic inertia and frequency regulation. This would enhance grid reliability as Brazil integrates more variable renewables.

While Brazil has not yet experienced widespread negative pricing events, the growing share of inflexible renewable generation and weak grid integration in regions like the Northeast, could make such occurrences more frequent. Two-sided CfDs in Brazil explicitly allow for negative reference prices, consistent with recent European practices. In such cases, producers would still receive the agreed strike price, but the CfD payment mechanism must be adapted to cap government exposure and avoid perverse incentives. Mechanisms such as floor prices (minimum strike price) or zero-bound rules can be included in contract design to protect both producers and public funding.

A phased approach is recommended for BESS CfD implementation:

- a) Regulatory Foundation (6–12 months): Align policies between ANEEL, ONS, and CCEE, updating the Grid Code to include BESS requirements. Define CfD eligibility, pricing models, and funding sources.
- b) Pilot Deployment (12–24 months): Launch pilot projects in high grid instability regions like the Northeast. Conduct the first CfD auction and expand BESS participation in ancillary services, by defining remuneration models or a competitive market for essential functions such as fast frequency response, synthetic inertia, and voltage support.
- c) Full-Scale Integration (24–48 months): Refine regulations based on pilot results, expand CfD auctions, and transition BESS revenue models to market-driven mechanisms.

Strong political and regulatory support is essential for this roadmap to succeed, alongside sustainable cost allocation and investor confidence. Furthermore, technical performance must be rigorously assessed to confirm that grid-forming BESS solutions effectively enhance system resilience.

Offshore Wind and CfDs

Brazil's offshore wind potential is vast, but grid integration costs vary by region. CfDs could use hourly PLD as a reference price, with regional strike prices offering higher incentives in areas with weaker grids, such as the North and Northeast. This would encourage development in high-potential but underdeveloped regions.

CfDs could also support hybrid projects combining offshore wind with green hydrogen production. A declining strike price over time could incentivize cost reductions in electrolysis. Floating offshore wind, suited to Brazil's deep waters, could receive additional incentives to accelerate innovation. Bonuses for projects integrating storage or grid services would further enhance viability.

As Brazil develops licensing and auction frameworks for offshore wind, CfDs should align with regulatory progress to provide investor certainty. Offshore wind could play a key role in green hydrogen production for export and domestic industries like steel and ammonia.

Implementing CfDs in Brazil for green hydrogen, BESS, and offshore wind requires tailored approaches to address regulatory gaps and market challenges. Strategic government policies, phased deployment, and independent pricing benchmarks are critical to fostering sustainable energy transitions. By leveraging CfDs, Brazil can enhance grid stability, accelerate renewable integration, and support its long-term energy goals.

In the Brazilian context, a potential benchmark for the reference price in electricity CfDs could be the PLD horário (Preço de Liquidação das Diferenças), the hourly settlement price used in the short-term market administered by CCEE. The PLD is a transparent, centralized, and well-established price signal reflecting marginal system costs. However, as Brazil moves toward greater market liberalization, alternative or composite reference prices—such as weighted averages from free market contracts or hub-based indexes—could also be considered to better reflect regional or locational pricing. For green hydrogen and BESS-related CfDs, we propose the use of international hydrogen benchmarks (e.g., EU or Japan hydrogen indices) or LNG import prices, adjusted for currency and transport, to ensure transparency and reduce the risk of market manipulation in nascent markets.

7 Conclusions

Brazil's path toward a cleaner energy future can be significantly accelerated through the careful adaptation of Contracts for Difference (CfDs), especially in areas such as offshore wind, green hydrogen, and battery-integrated renewable systems. Given Brazil's hydro-heavy electricity matrix and regional transmission challenges, CfDs must be tailored to local conditions. Implementing region-specific strike prices could drive offshore wind investments in the North and Northeast, where wind resources are abundant, but grid infrastructure remains underdeveloped. Combining CfDs with hydrogen production or storage solutions could reduce investment risks and enhance renewable integration. Such contracts might cover both electricity and hydrogen output, encouraging broader decarbonization in hard-to-abate sectors. Floating offshore wind, well-suited to Brazil's deep coastal waters, stands to gain from this support. In the hydrogen market, consumer-oriented CfDs with gradually falling reference prices could foster innovation and market growth. To prevent market distortions, clear pricing benchmarks and robust governance are needed—possibly through an independent body modeled on the UK's Low Carbon Contracts Company. Battery storage systems could also benefit from CfDs indexed to hourly market prices, particularly in areas facing increasing renewable curtailment. With well-structured policies and collaborative efforts, CfDs can mobilize investment, strengthen the grid, and help Brazil transition to a low-carbon economy.

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