Most certainly certain? The implications of Contracts for Difference design on revenue certainty for investors

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Overview

Due to their ability to mitigate price risks for both consumers and generators, governmental Contracts for Difference (CfDs) gained popularity as support instrument for renewables amidst high electricity prices during the energy crisis in 2022 (Directive 2024/1711) and in the context of uncertainties during the energy transition (Beiter et al., 2023). Governmental CfDs stipulate payments between the government and producers of renewable electricity defined by the difference of an ex post realised reference market price and an ex ante agreed-upon strike price. There exist different possibilities to define a CfD's reference price. While the simplest type of CfD applies the hourly spot market price as a reference price, more sophisticated types of CfDs consider average market prices or market values of specific technologies over longer periods, such as a month or a year. While these CfDs define payments based on volumes produced or sold, other types of CfDs consider payments per capacity (Huntington et al., 2017; Schlecht et al., 2024). Finally, one-way CfDs consider payments to renewable generators only, while two-way CfDs also stipulate payments from the generator to the government, if the reference price is higher than the strike price. Strike prices are typically determined within competitive auctions for CfDs that are awarded to a certain amount of new renewable capacities to be built (Anatolitis et al., 2017). If the auction is perfectly competitive, the strike price bid of an investor reflects the strike price required to set expected profits including CfD payments over the economic lifetime of the investment project to zero. However, expected profits over economic lifetimes of typically 15 or more years are subject to several uncertainties at the time of the auction. Amongst others, these uncertainties contain cost developments, the regulatory framework, electricity production and market prices. Investors are required to form expectations on these profit determinants to calculate their strike price bids for the auction, while CfD payments are settled based on ex post outcomes, i.e., market prices and electricity production. Hence, investor profits are not necessarily zero, if expectations used to determine strike prices deviate from ex post outcomes. This study investigates the volatility of ex post reference revenues of investors in wind power plants under different CfD design options and across different scenarios of a fully decarbonised European power market.

Methods

We start the analysis by deriving a rule for optimal strike price bids for four different types of CfDs that are awarded to wind power plants within a competitive auction. We consider two two-way CfDs with volume-based payments based on different reference prices, a volume-based one-way CfD and the newly proposed financial CfD (Schlecht et al., 2024), which we interpret to be capacity-based (cf. Table 1).

Table 1: Types of CfD considered

CfD type	Unit of payment	Reference price	Allowed direction of payment
Basic	€/MWh	Hourly spot market price by bidding zone	Both
1way	€/MWh	Average wind market value by bidding zone	To generator only
2way	€/MWh	Average wind market value by bidding zone	Both
Financial	€/MW	Average wind revenues per capacity by bidding zone	Both

Optimal strike prices are determined by setting ex ante expected profits, $E(\Pi_{i,n})$, of a power plant $i \in \{1, 2, \dots, I\}$ in bidding zone $n \in \{1, 2, \dots, N\}$, over its economic lifetime to 0. Ex ante expected profits under a CfD of type ∈ {basic,1way,2way,fin} are given by

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

They are composed by the sum of expected spot market revenues, i.e. expected power sold $E(q_{t,i,n})$ for expected market price $E(p_{t,n})$, over each hour $t \in \{1, 2, \dots T\}$; lifetime costs as described by the cost function $C_{i,n}(\,)$ of power plant *i* in *n* that depends on expected power sold; and expected CfD payments, $E(P_{i,n}^{\text{type}})$. The latter are generally defined by the difference of a power-plant-individual strike price, $S_{i,n}^{\text{type}}$ and a reference market price, $p_n^{\text{R,type}}$, which is uniform in each bidding zone n. With type = 2way, for instance, we define the reference price

to be determined as the ex post realised average market value of wind power plants in bidding zone n, i.e., $p_n^{\mathrm{R,2way}} = v_n \equiv \frac{\sum_{t=1}^{T}\sum_{i=1}^{I} q_{t,i,n}\, p_{t,n}}{\sum_{t=1}^{T}\sum_{i=1}^{I} q_{t,i,n}}$.

Hence, ex post payments under the 2way CfD are given by $P_{i,n}^{\mathrm{2way}} = \sum_{t=1}^{T} q_{t,i,n}\left(S_{i,n}^{\mathrm{2way}} - v_n\right)$. Setting ex ante expected profits under this type of CfD yields the optimal strike price, $S_{i,n}^{\mathrm{2way}*}$:

$$E(\Pi_{i,n}) = \sum_{t=1}^{T}\left(E(q_{t,i,n})E(p_{t,n}) + E(q_{t,i,n})\left(S_{i,n}^{\mathrm{2way}} - E(v_n)\right) - C_{i,n}(E(q_{t,i,n}))\right) = 0$$

$$\Leftrightarrow S_{i,n}^{\mathrm{2way}*} = \frac{\sum_{t=1}^{T} C_{i,n}(E(q_{t,i,n}))}{\sum_{t=1}^{T} E(q_{t,i,n})} + E(v_n) - \frac{\sum_{t=1}^{T} E(q_{t,i,n})E(p_{t,n})}{\sum_{t=1}^{T} E(q_{t,i,n})}$$

With $\frac{\sum_{t=1}^{T} C_{i,n}(E(q_{t,i,n}))}{\sum_{t=1}^{T} E(q_{t,i,n})} := E\left(lcoe_{i,n}\right)$, i.e., expected levelised costs of electricity (LCOE), and $\frac{\sum_{t=1}^{T} E(q_{t,i,n})E(p_{t,n})}{\sum_{t=1}^{T} E(q_{t,i,n})}$ $:= E\left(v_{i,n}\right)$, i.e., the individual market value of power plant *i* in *n*, the optimal strike price is given by:

$$S_{i,n}^{\mathrm{2way}*} = E\left(lcoe_{i,n}\right) + E(v_n) - E\left(v_{i,n}\right)$$

To calculate $S_{i,n}^{\mathrm{2way}*}$, investors must form expectations on uncertain market outcomes. $E\left(p_{t,n}\right)$ and $E\left(q_{t,i,n}\right)\ \forall\ i \in \{1, 2, \ldots I\}, \forall\ t \in \{1, 2, \ldots T\}$ and $\forall\ n \in \{1, 2, \ldots N\}$. We asume them to be given by $E\left(p_{t,n}\right) = \frac{1}{w_s}\sum_{s=1}^{S} p_{t,n,s}$ and $E\left(q_{t,i,n}\right) = \frac{1}{w_s}\sum_{s=1}^{S} q_{t,i,n,s}$, where $p_{t,n,s}$ and $q_{t,i,n,s}$ denote realisations of spot prices and electricity sold in a market scenario $s \in \{1,2, \ldots S\}$ with weight w_s. We determine these possible realisations by optimising several scenarios of future, fully decarbonised electricity markets in a European, sector-coupled power system model developed by Johanndeiter et al. (2024). After determining $S_{i,n}^{\mathrm{2way}}$ based on expected values, we assess ex post resulting profits in each scenario $s \in \{1,2, \ldots S\}$. Particularly, we calculate ex post profit of power plant *i* in *n* as

$$\Pi_{i,n,s} = \sum_{t=1}^{T}\left(q_{t,i,n,s}p_{t,n,s} + q_{t,i,n,s}\left(S_{i,n}^{\mathrm{2way}*} - v_{n,s}\right) - C_{i,n}(E(q_{t,i,n,s}))\right)\ \forall\ s \in \{1,2, \ldots S\}.$$

We then assess the volatility of $\Pi_{i,n,s}$ across scenarios and for different types of CfDs to derive conclusions on revenue certainty of a type of CfD.

Results & Conclusions

A preceding study on CfDs demonstrated disparities between ex ante expected and ex post realised cost recovery rates, when the strike price is determined based on the outcomes of a single target scenario, while ex post market outcomes change due to incentives set by different types of CfDs (Johanndeiter et al., 2024a; Johanndeiter & Schmidt, 2024). For five exemplified bidding zones and a particular target scenario, Figure 1 illustrates that the basic CfD provides the most stable rate of cost recovery, while the financial CfD yields the largest disparities. This study aims at elaborating the insights on revenue certainty by type of CfD based on strike prices that are determined based on weighted outcomes of multiple market scenarios.

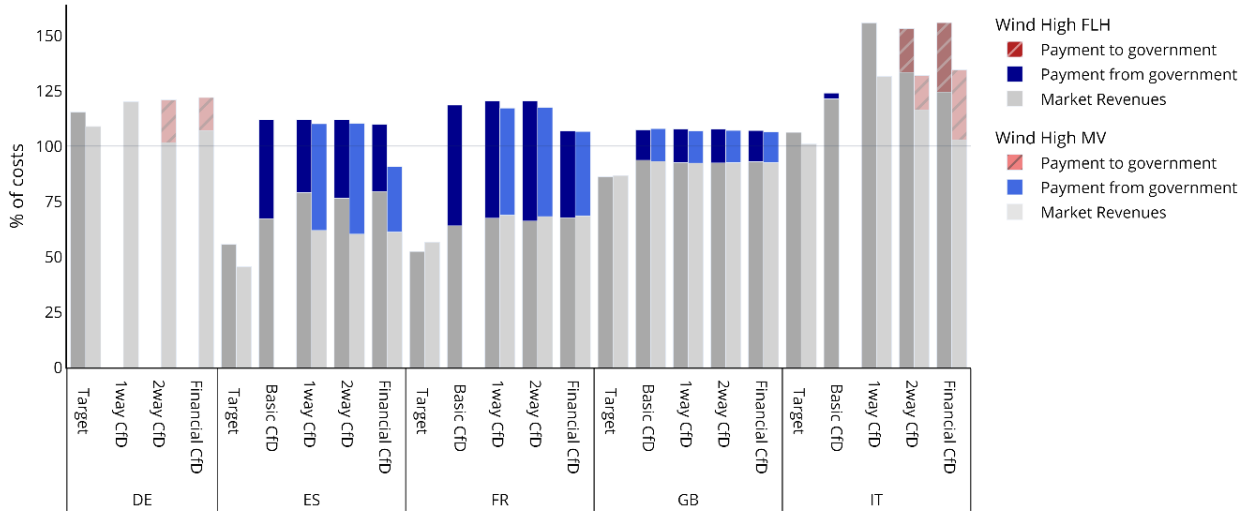

Figure 1: Ex post cost-recovery of two types of wind onshore power plants (Wind High FLH and Wind High MV) decomposed by market revenues and CfD payments in a target scenario and under three types of CfDs at the example of five bidding zones (Germany, Spain, France, Great Britain and Italy).

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