

Quantifying Distortions Induced by Contracts for Difference in Sequential Electricity Markets

– Evidence from a Simulation-Based Iberian Case Study –

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Strommarkttreffen Köln, 08.05.2026

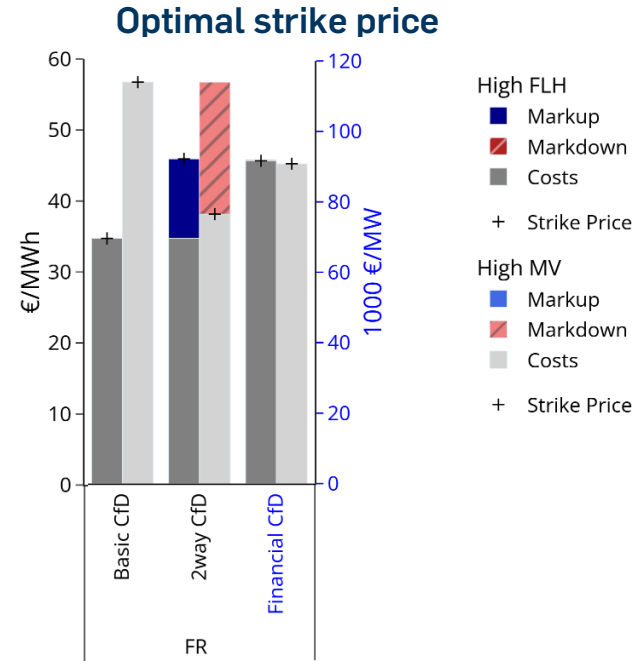


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1. Motivation

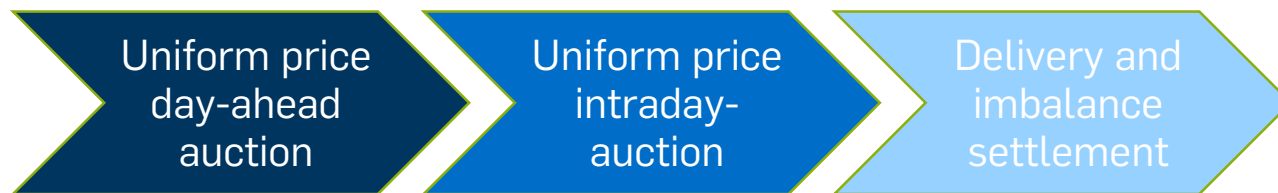
- Capacity-based Contracts for Difference (CfDs), such as financial CfDs, induce no dispatch distortions
- However, they induce adverse investment incentives (power plant with lowest strike prices in €/MW \neq power plant with lowest strike prices in €/MWh)...
- ...and might increase revenue volatility for investors
- Therefore, financial CfDs are not unambiguously favorable
- Distortions by volume-based CfDs should be examined carefully
- Intraday distortions have not been quantified, yet



Source: <https://doi.org/10.48550/arXiv.2512.17508>

2. Theory: Setup

Consider a renewable power plant in a sequential electricity market



Renewable
Forecast:

$$\widehat{Q}_t^{DA}$$

$$\widehat{Q}_t^{ID}$$

$$Q_t$$

Supply
Schedule

Sales

$$q_t^{DA} = S^{DA}(p|p \leq p_t^{DA}) \quad q_t^{ID} = S^{ID}(p|p \leq p_t^{ID})$$

Demand
Schedule

Clearing price

Purchases

$$q_t^{ID} = D^{ID}(p|p > p_t^{ID})$$

$$q_t^{ID} + q_t^{DA} \in [0, Q_t]$$

2. Theory: Day-ahead market strategy







Ex post short-term profit function:

$$\Pi_t = \underbrace{q_t^{DA} \cdot p_t^{DA} + q_t^{ID} \cdot p_t^{ID}}_{\text{Net sales/purchases}} - \underbrace{Q_t \cdot c}_{\text{Generation costs}} + \underbrace{(Q_t - q_t^{DA} - q_t^{ID}) \cdot p_t^{imb}}_{\text{Imbalance settlement costs}} + \underbrace{P^{\text{type}}}_{\text{CfD-payment with Strike price S}}$$

Quantity bid	Price Bid		
	No (volume-based) CfD	Basic CfD (reference price: p_t^{DA})	2way CfD (reference price: v)
\widehat{Q}_t^{DA} Available generation	c marginal costs	p_{min} minimum price ↓	$c - S + v$ marginal costs + CfD payments ↑↓

Note: Details on CfD definition may be found here: DOI: [10.1016/j.reseneeco.2025.101495](https://doi.org/10.1016/j.reseneeco.2025.101495)

2. Theory: Intraday market

Quantity bid	Price Bid		
	No (volume-based) CfD	Basic CfD (reference price: p_t^{DA})	2way CfD (reference price: v)
$\widehat{Q}_t^{ID} - q_t^{DA}$ Excess generation if $\widehat{Q}_t^{ID} \geq q_t^{DA}$	c marginal costs	$c - S + p_t^{DA}$ distorted by CfD payments 	$c - S + v$ distorted by CfD payments 
$\widehat{Q}_t^{ID} - q_t^{DA}$ Missing generation if $\widehat{Q}_t^{ID} < q_t^{DA}$	p_t^{imb} imbalance price	p_t^{imb}  imbalance price	p_t^{imb}  imbalance price
$-q_t^{DA}$ Day-ahead buy-back	c marginal costs	$c - S + p_t^{DA}$ distorted by CfD payments 	$c - S + v$ distorted by CfD payments 

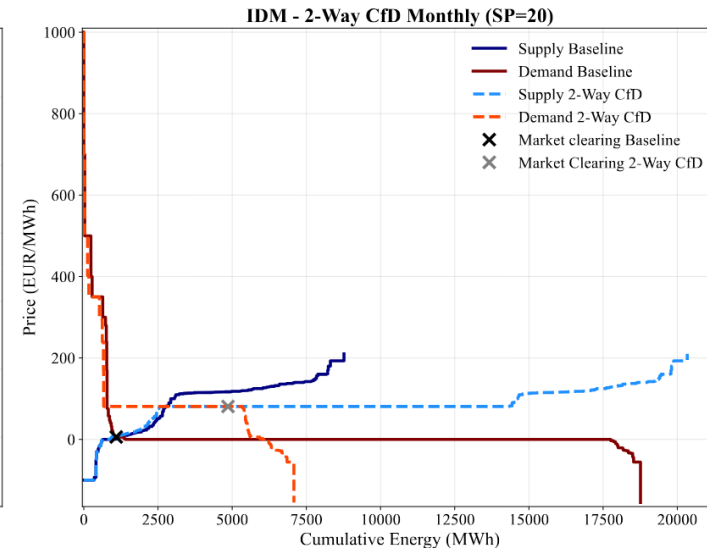
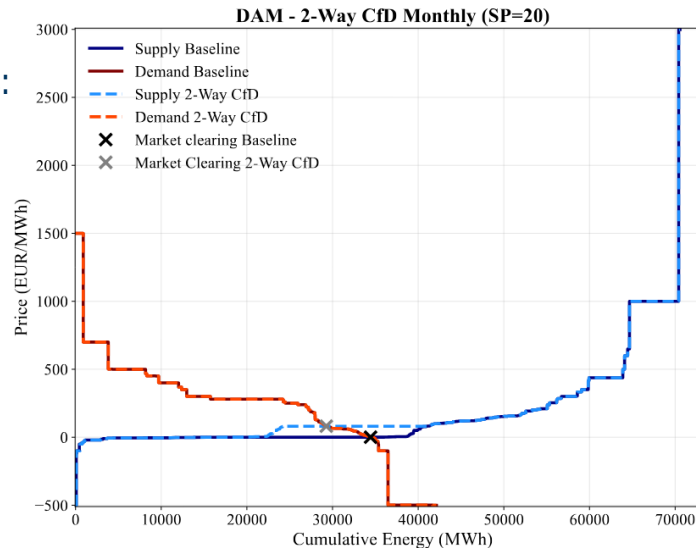
3. Method: Simulation model

Reconstruction of hourly day-ahead (DAM) and intraday market (IDM) demand and supply curves from historic bidding data in ES/PT

1) Manipulation of observed wind bids:

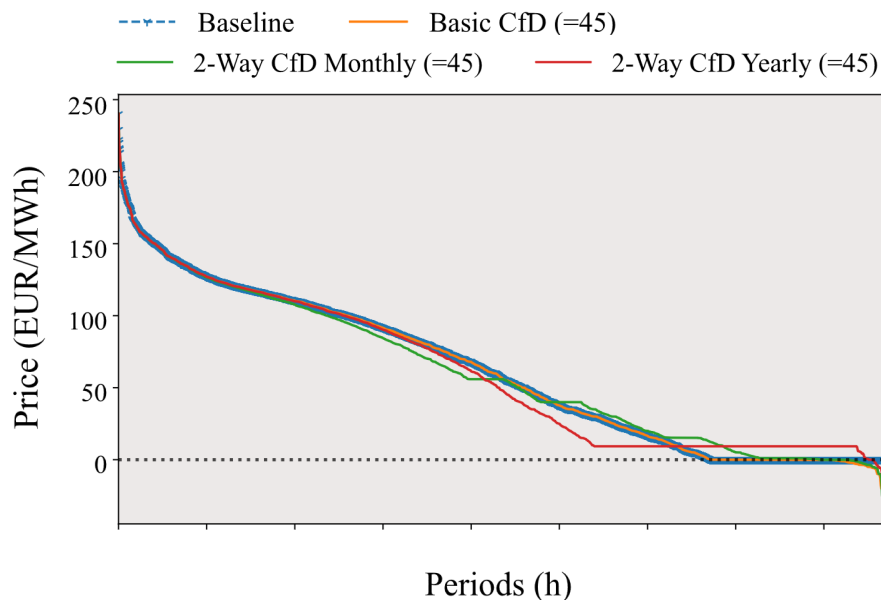
- Quantity: forecast changes
- Prices: Based on derived rules

2) Market clearing by maximizing social welfare (=area below curves)



Note: Monthly average wind market value as reference price and 20€/MWh as strike price

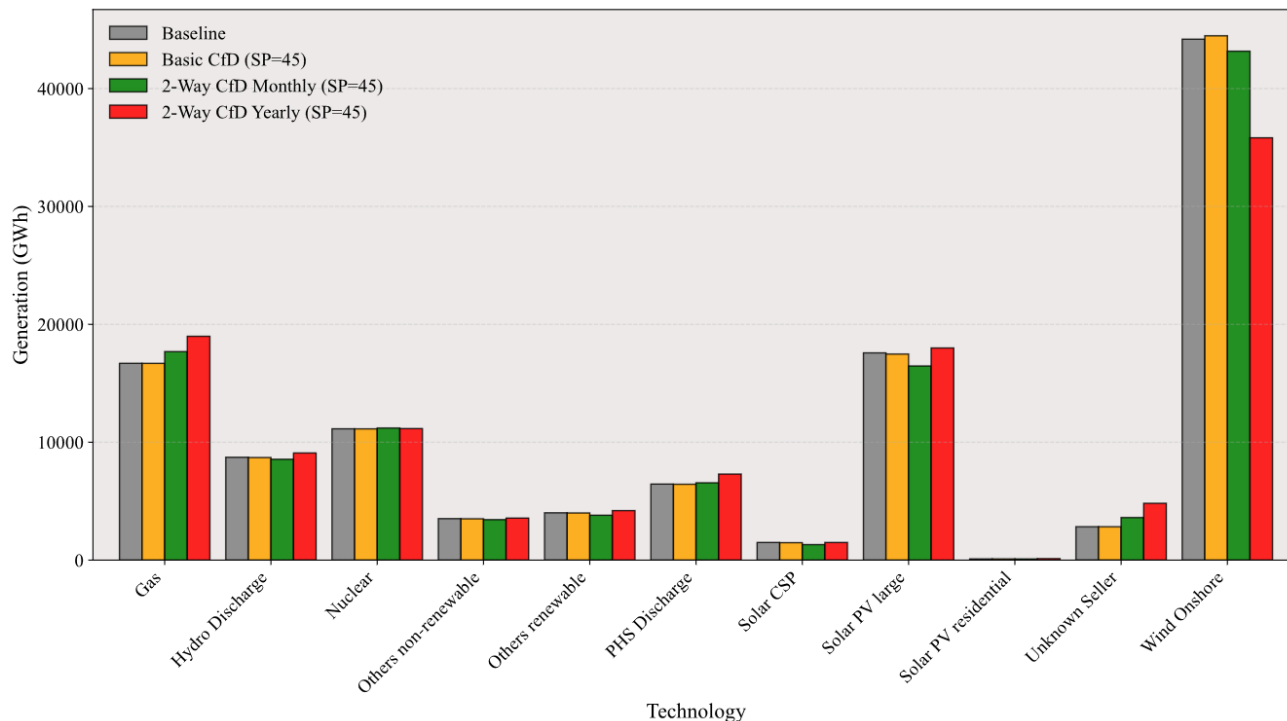
4. Preliminary Results: Effect on intraday prices



	Basic CfD	2way CfD (monthly)	2way CfD (yearly)
Change in average price (€/MWh)	-0.33	-0.86	-1.48
hours with price decrease	8.4%	31.4%	34.5%
hours with price increase	0	36.2%	44.7%

Note: All CfDs with a strike price of 45 €/MWh

4. Preliminary Results: Effect on generation mix



Note:

- Effect mainly comes from day-ahead distortions
- Sum of all intraday market results under all CfDs slightly increase wind generation

5. Summary & Preliminary Conclusion

Effect on intraday prices:

- 2way CfD, particularly with yearly reference price, affects intraday prices more frequently than Basic CfD
- Basic CfD almost always decreases price; for direction of price change under 2way CfD is ambiguous

Effect on wind curtailment:

- Wind curtailment is highest for 2way CfD with yearly reference price and substituted mainly by gas
- Curtailment is mainly driven by day-ahead market distortions, while net effect of intraday distortions decreases curtailment under our assumptions

→ **Intraday distortions have a minor effect compared to day-ahead distortions**

→ **Overall, a volume-based 2way CfD with monthly reference price might strike a good balance**

Thanks 😊

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Appendix

Method: Experimental setup

Parameter	Symbol	Value / Justification
Simulation horizon	-	Jan 1 – Jun 30, 2025 (OMIE H1 Dataset, 4,344 hours)
Wind strike prices	S	Low: 20, Base: 45, High: 70 EUR/MWh (Auction Scenarios)
Reference value (2-way)	v_m	Monthly generation-weighted average DA price
Forecast deviation	ϵ	± 5 % (Uniform Stochastic Distribution)
Expected imbalance penalty	p^{imb}	500 EUR/MWh (Risk-averse threshold to enforce sequential hedging)

Results: Overview of preliminary results

Table 4: Summary results.

Run	0	1	2	3	4	5	6	7	8	9	10
Cfd	Historical	Baseline	Basic	Basic	Basic	2Way	2Way	2Way	2Way	2Way	2Way
Strike Price	-	-	20	45	70	20	45	70	20	45	70
Reference Price	-	-	-	-	-	Monthly	Monthly	Monthly	Yearly	Yearly	Yearly
DAM average (EUR/MWh)	37,24	36,93	36,93	36,93	36,93	50,57	42,09	37,73	52,79	40,56	35,8
DAM std (EUR/MWh)	43	43,07	43,07	43,07	43,07	40,16	41,99	43,23	31,78	40,12	44,14
IDM average (EUR/MWh)	61,2	61,63	61,33	61,3	61,3	62,94	60,77	60,17	64,81	60,15	62,11
IDM std (EUR/MWh)	53,34	52,9	53,29	53,32	53,32	48,77	51,01	52,58	47,03	52,48	52,53
IDM Total Volume Traded (TWh)	15,51	14,49	11,81	11,79	11,79	17,51	15,51	13,43	17,54	17,14	11,57
Wind Total Curtailment (TWh)	3,59	5,58	5,29	5,29	5,29	13,66	6,6	1,67	21,83	13,95	0,08
Unsold capacity (TWh)	3,92	6,38	6,38	6,38	6,38	14,28	7,42	2,78	21,41	14,19	0,75
IDM Marginal Impact (TWh)	-0,33	-0,8	-1,08	-1,09	-1,09	-0,62	-0,82	-1,11	0,42	-0,24	-0,67

Table 5: Hours conts diff.

Run	2	3	4	5	6	7	8	9	10
Cfd	Basic	Basic	Basic	2Way	2Way	2Way	2Way	2Way	2Way
Strike Price	20	45	70	20	45	70	20	45	70
Reference Price	-	-	-	Monthly	Monthly	Monthly	Yearly	Yearly	Yearly
DAM eq	4343	4343	4343	2240	2650	3063	1756	2383	3507
DAM lo	0	0	0	532	533	783	0	1	835
DAM up	0	0	0	1571	1160	497	2587	1959	1
IDM eq	3999	4007	4007	2135	2591	2944	1820	2423	3342
IDM lo	336	336	336	1206	814	737	1015	836	342
IDM up	8	0	0	1002	938	662	1508	1084	659