CONTRACTS-FOR-DIFFERENCE AND NUCLEAR FLEXIBILITY: A PATH TO COMPLEMENTING RENEWABLES

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Overview

The increasing reliance on solar and wind power highlights the importance of flexibility in electricity markets. Nuclear power plants (NPPs) can enhance system flexibility, but their cycling constraints limit adaptability. Contracts-for-Difference (CfDs) are widely used to promote low-carbon investments while shielding producers from price volatility. However, conventional CfDs may disincentivize flexible operations and distort market efficiency. This study explores how alternative CfD designs influence the dispatch and flexibility of nuclear power. Using a partial equilibrium model of the European electricity market in 2040, solved via a Mathematical Program with Equilibrium Constraints (MPEC), we assess CfD schemes' effectiveness in incentivizing nuclear flexibility while mitigating market inefficiencies.

Methods

We developed a bilevel numerical model focusing on Central Western Europe (CWE) in 2040. The upper level models the profit-maximization behavior of a monopolistic nuclear operator under different CfD schemes, while the lower level represents market-clearing conditions for competitive fringe generators. CfD designs analyzed include: (i) Classical CfD: Fixed strike price with payments based on generation; (ii) CfD with Suspension during Negative Prices: No payments during negative price periods; (iii) Averaged Reference Price CfD: Payments tied to average market prices over a defined period; and (iv) Non-Production-Based CfD: Payments decoupled from actual generation, mimicking long-term contracts. Flexibility constraints specific to NPPs were incorporated, with scenarios calibrated using existing European nuclear fleet operations.

Results

Our results show that CfD designs significantly influence nuclear dispatch patterns and the incentives to fit the competitive benchmark. First, we show some results relative to the interaction of CfDs with renewables no longer hold when applied to dispatchable but relatively unflexible technologies like nuclear. For instance, nuclear operators can still exert market power under a CfD in moments of cease of payments when prices go negative. Consequently, they will not try to maximize availability in moments of energy scarcity but rather try to minimize production in moments of negative prices, leading to inefficient dispatch decisions. Non-production-based CfDs circumvent this problem by incentivizing nuclear operators to slightly overproduce compared to a competitive case, which is critical for a regulator willing to ensure dispatchable means of production are effectively available when the system needs it the most. We quantify the discrepancy for the European case in 2040 and find this can be substantial, with the conventional CfD option lowering total welfare by approximately 5% compared to the case of non-production-based CfD.

Conclusions

Alternative CfD designs can reconcile the need for financial stability with operational efficiency, particularly for dispatchable technologies like nuclear power. Policymakers can foster efficient market integration of low-carbon technologies by integrating clauses that align incentives with market needs, such as excluding payments during negative pricing or using non-production-based designs. Some options are better than others, and conventional CfD designs can lead to lower availability and production from nuclear assets in moments of energy scarcity, which is a critical concern and should be monitored. These findings are relevant for other technologies like electrolyzers, where tailored CfDs could address similar flexibility challenges. Future research should explore broader applications and scalability in real-world settings.

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