

# ***RENEWABLE GENERATION AND FORWARD CONTRACTING***

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## **Overview**

Utilizing renewable resources in a large scale is hindered by the fact that they are intermittent and cannot be controlled or accurately predicted. Their integration to the electricity system presents various challenges not only on the technical level, but also in respects of market design. Due to near zero marginal costs, renewable generation comes with a ‘merit order effect’ of displacing conventional generators and lowering wholesale prices. Furthermore, as their penetration increases and the net demand that needs to be met by dispatchable generation is characterized by higher uncertainty, long term investment planning becomes more difficult. To guarantee efficient allocation of resources both in the short- and long-term, market mechanisms should coevolve with the changing mix of electricity generation. Policy makers need to adapt existing policy instruments and create new ones that will facilitate renewable generation while ensuring stable electricity supply. To this end, I examine whether and how the role of forward contracting both as a mechanism to mitigate market power, as well as a tool for participants to hedge risk, changes with the increasing penetration of renewables. First, I present an economic framework in which strategic sellers and buyers trade in a sequence of two markets, approximating thus forward contracting. Based on this model, I study how the introduction of a forward market changes the strategic and hedging incentives of the participants and what are the efficiency gains to the overall market. Then, the model is run for an increasing percentage of power coming from intermittent renewables, which translates to a lower net demand that needs to be met from dispatchable generators. I examine both the strategic and hedging incentives for market participants to trade forward and find that that under increased uncertainty, participants are willing to commit to a higher hedge ratio, reinforcing the role of a forward market.

## **Methods**

To answer the aforementioned questions, I present an economic framework which combines two new modeling approaches. First, a model that accounts not only for market power on the supply side, but also on the demand side. Second, a model that allows participants to trade in a sequence of two markets. The two modules are then integrated into a single model, a two-settlement bilateral oligopoly. Decisions on the optimal allocation of trading quantities in the two sequential markets both from sellers and buyers are based on optimizing expected outcomes and are endogenous to the market process.

## **Results**

Given the higher volatility of the demand, the hedging incentives of risk averse participants lead them to higher forward commitments. The spot price in a single market falls due to the merit order effect, since dispatchable generators now serve a lower expected load. The forward market also falls, since the overall demand to be served is lower, but does so at a lower rate than the price in a single spot market, because participants are willing to accept a price premium to reduce some of the increased spot volatility. Finally, the spot price within a two-settlement market decreases even further, because in addition to the merit order effect, there is the competition enhancement effect from having committed a higher ratio of their output forward. When only strategic incentives are examined the two effects are going in different directions and one can overpower the other depending on the intermittency of renewable generation in a given scenario, but when hedging incentives are also accounted for, the two effects are in the same direction. The risk management rationale is the one driving the results for the forward market and, thus, the competition enhancement effect.

## **Conclusions**

Results reinforce the significance of forward trading in reaching more efficient equilibria under scenarios with increased variability, indicating that the survival of forward markets is a crucial part of achieving long term efficiency goals. In an even more volatile spot market, forward hedging becomes more valuable. Spot prices fall due to the merit order effect. Forward prices fall since the spot price anticipated is lower, but do so at a lower rate than the spot ones. This is because participants are willing to accept a larger premium.