A simulation framework for uneconomic virtual bidding in day-ahead electricity markets*

[Short talk]

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ABSTRACT

About two thirds of electricity consumers in the United States are served by Regional Transmission Organizations (RTOs) and Independent System Operators (ISOs). One of their primary responsibilities is the operation of organized auctions for purchasing and selling electricity that have a two-settlement structure with coordinated day-ahead (DA) and real-time (RT) energy markets. The DA market takes place on the day before the actual power dispatch, and creates a financial obligation to deliver and withdraw power from the transmission grid. In contrast, the RT energy market is a physical market where predicted and actual supply and demand of electricity are balanced on the delivery day. Purely financial transactions, known as virtual bids, were introduced in wholesale electricity markets to allow participants (including energy traders that do not control generation assets or serve load) to exploit arbitrage opportunities arising from expected price differences between day-ahead and real-time energy markets and to enhance convergence between DA and RT prices. More specifically, virtual demand (supply) bids are financial positions for the purchase (sale) of energy in the DA market, which are settled with a countervailing offer to sell (buy) at the RT price without the bidder taking title to physical electricity. Virtual demand bids are typically referred to as DECs, while virtual supply bids are known as INCs. Virtual bids clear with generation and load bids in the DA market, and may set the DA market-clearing price.

Virtual bids have strong interactions with other elements of the electricity market design. For instance, Financial Transmission Rights (FTRs) are financial contracts to hedge transmission congestion between two nodes in the transmission network (a source and a sink defined in the contract), and entitle their holders the right to collect a payment when day-ahead congestion arises between the source and the sink [1]. Since FTRs settle at the day-ahead prices, virtual bids could be placed in the day-ahead energy market in order to affect day-ahead electricity prices in a direction that enhances the value of the FTRs.

In our study, we consider a model of the DA electricity market at any node in the network. Market participants include power generators and loads submitting physical bids, and financial players placing virtual bids. Virtual bids affect the DA market clearing prices, but we assume that they have no impact on RT prices. Theoretical results on interior Nash equilibria are given, assuming that virtual bidders can perfectly predict RT prices and hold no FTRs [2] sinking at the node. We then adopt a hypergame framework [3] to model the DA market, assuming imperfect prediction of RT prices by different virtual bidders. When no market participant holds FTRs, virtual bidders help achieve convergence between DA and RT nodal prices, as expected [4]. In this setting, we also allow one virtual bidder to hold a FTR position sinking at the node. Our numerical results show that, with FTR as another source of revenue, the larger the FTR position, the greater the incentive for the FTR holder to place uneconomic virtual bids at the FTR sink to enhance the value of her financial position, in line with [5, 6]. We also show that the manipulation causes not only losses for other virtual bidders, but also the divergence between DA and RT prices. Methods for detecting such uneconomic bidding are also investigated. Our technical report is available at `http://www.cse.psu.edu/research/publications/tech-reports/2016/CSE-16-003.pdf`.

1. REFERENCES

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