Pricing in Day-Ahead Electricity Markets with Near-Optimal Unit Commitment

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Extended Abstract:

In the US, wholesale electricity markets are run by Independent System Operators (ISOs). The ISO coordinates the market by accepting bids and offers from market participants then solving a unit commitment problem that determines the most cost-efficient production schedule. Wholesale electricity prices are based on the bids and offers that the ISO receives as well as the production schedule that it determines. A well-known drawback to this approach is that prices can change substantially based on which production schedule is selected. That is, the ISO must choose among production schedules that might raise or lower prices significantly despite almost no difference in cost.

This paper revisits some peculiar pricing properties of near-optimal unit commitment solutions. Previous work has found that prices can behave erratically even as unit commitment solutions approach the optimal solution, resulting in potentially large wealth transfers due to suboptimality of the solution. Our analysis considers how recently proposed pricing models affect this behavior. Results show a previously unknown property of one of these pricing models, called approximate Convex Hull Pricing (aCHP), that eliminates erratic price behavior, and therefore limits wealth transfers with respect to the optimal unit commitment solution. The absence of wealth transfers may imply fewer strategic bidding incentives, which would result in increased market efficiency.

These properties of convex hull pricing and near-optimal unit commitment solutions are important for a multitude of reasons. First, it removes the ISO's discretion from affecting prices, which ensures that market participants trust that the market outcome is not biased against them. Second, unscheduled participants are less likely to see that they would have been profitable given the current prices, if only they had been scheduled. This property translates to better market efficiency by reducing incentives for participants to self-schedule, for which we provide a numerical example. Finally, we show that the profits of individual generators are essentially independent of the unit commitment solution, regardless of the size and cost of the generator. Thus, the convex hull pricing mechanism reduces inequities to resources that only provide small or negligible improvements to the unit commitment solution.

This paper is the first to our knowledge to recognize connections between near-optimal unit commitment and convex hull pricing. A simple example in the appendix shows how self-scheduling incentives can arise in the presence of multiple near-optimal solutions. These incentives are reduced when convex hull pricing is adopted, thus providing some theoretical support for the efficiency gains of convex hull pricing. It would be difficult to estimate potential efficiency gains in a realistic test case, but improved computational approaches to do so may be a valuable area for future work.