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Production efficiency of nodal and zonal pricing in imperfectly competitive electricity markets

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Mahir Sarfati, Mohammad Reza Hesamzadeh, and Pär Holmberg

European electricity markets use zonal pricing. This means that some transmission-lines are neglected when clearing the spot market (day-ahead market). To mitigate this problem, several European countries have changed to flow-based zonal pricing. This paper shows that such a change can lead to more efficient electricity production.

Each EU country is divided into one or more zones. The spot market has a single price per zone. For traditional zonal pricing, intra-zonal congestion is neglected in the spot market. An advantage with this method is that spot and intra-day trading can be simplified. But in real time, when electricity is to be delivered, all transmission lines have to be considered, including intra-zonal lines. Hence, zonal pricing sometimes means that a substantial real-time redispatch is needed to avoid that intra-zonal lines are overloaded. A late, unplanned adjustment in the production is inefficient, and it leads to higher production costs.

The inefficiencies are further exacerbated by arbitrage trading. The difference in how congestion is managed in the spot and real-time market means that there will be predictable price differences between the two markets. Producers at export-constrained locations can make an arbitrage profit by increasing its sales in the spot market where the zonal price is high and decrease it in the real-time market where the local price is low. This trading strategy is often called the inc-dec game. One problem with this type of arbitrage trade is that the turn-over increases in real-time, which means that additional costly last-minute production adjustments will be needed. In the long-run, arbitrage profits also lead to inefficient investments. The inc-dec was prevalent during the electricity crisis in California and has also been observed in the UK.

To mitigate the problems associated with zonal pricing, the Scandinavian countries have divided each country into two or more zones. Central Western Europe (CWE), including Germany, France and Benelux, has chosen another strategy. In 2015, CWE introduced flow-based zonal pricing, which means that the most critical intra-zonal lines will be considered also in the spot market.

In this paper, we simulate the inc-dec game in an oligopoly electricity market with flow-based zonal pricing. In our model, each producer uses its market power and all arbitrage opportunities. We compute a Nash equilibrium, where each producer maximizes its profit given actions of its competitors. In our stylized examples, the introduction of flow-based zonal pricing can reduce the total production costs by 8-15% compared to traditional zonal pricing. However, the difference between flow-based and traditional zonal pricing becomes much lower, around 1%, if it is assumed that a late decision does not influence the production costs in a plant. This is approximately the situation in the hydro-dominated Nordic countries. Late production decisions are expected to be more costly in Continental Europe, where a larger fraction of the production is fuel based.

Contact sarfati@kth.se ; mrhesamzadeh@ee.kth.se ; par.holmberg@ifn.se

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