THE COMPETITIVE EFFECTS OF LINKING ELECTRICITY MARKETS ACROSS SPACE

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CEEM POLICY PAPER 2

It is becoming abundantly clear that key aspects of the current electricity market design in the European Union (EU) cause inefficient market outcomes which increase the total costs of supplying electricity to consumers. Extensive renewables policies across the union have significantly increased the cost of making generation schedules that emerge from the day-ahead (spot) market operational in real-time. One of those deficiencies is a bidding zone configuration which fails to account for important constraints in the transmission network. An illustrative example is the domestic north-south congestion inside Germany which is ignored in the determination of spot market prices. The uniform spot price in Germany creates excess supply of electricity in the north and excess demand in the south. Resulting loop flows spill into the neighboring countries both to the west and the east. Extensive redispatch of electricity in the balancing market is required to maintain the physical balance of the system.

The Agency for the Cooperation of Energy Regulators in the EU (ACER) recently suggested to split several member states into multiple bidding zones to solve the problem of internal network congestion. Germany, for instance, could be divided into as many as five bidding zones under this proposal. However, implementation of domestic bidding zone configurations ultimately resides with the individual EU member states and not with ACER. Major barriers to adopting more locational pricing in these countries are fears that granular prices increase consumers' costs of hedging electricity prices and the perceived unfairness of charging different wholesale prices to consumers at different locations in the transmission network. Such arguments received a lot of attention when the Swedish wholesale electricity market was divided into four bidding zones in late 2011. Previously, Sweden had constituted a single bidding zone.

Markets that build on locational marginal pricing (LMP) address liquidity and equity issues to varying degree. Forward contracts often settle against trading-hub prices instead of individual LMPs. A trading-hub price is calculated as the volume-weighted average of the LMPs at all locations that jointly form the trading hub. This construction is thought to increase liquidity in the forward market by reducing the importance of any single locational price in determining the profitability of forward contracting. Regulators and market operators have addressed equity concerns in LMP markets by requiring that all customers within a given geographical area purchase wholesale electricity at a price based on the volume-weighted average of all locational prices in that geographic area.

We show that these regional features of LMP market designs have important consequences for the performance of imperfectly competitive short-term wholesale electricity markets that employ location-based pricing. Our basic insight is that linking local markets through a regional forward market in which contracts have a settlement price equal to the quantity-weighted average of the locational spot prices, increases the equilibrium quantity of forward contracts held by retailers and large consumers beyond what would occur in a design with local forward markets with a settlement price equal to the locational spot

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price in each local market. As is well-known, forward contracts can improve short-term market performance. Producers then have an incentive to increase output in the spot market because the associated reduction in the spot price increases the forward market profit by reducing the settlement price of the forward contract. The increase in the equilibrium quantity of forward contracts reduces short-term prices under the regional forward contract below the level that would exist under local forward contracts.

Requiring all consumers to purchase wholesale electricity at a quantity-weighted average of LMPs increases spot prices compared to the case when consumers pay individual LMP prices for their electricity. Such «equity-based» pricing reduces the incentives for large consumers and retailers to purchase forward contracts because of the spill-over effects of lower spot prices into other local markets. The reduction in forward quantities reduces competition in the spot market thus resulting in higher spot prices.

Current discussion in Europe illustrates the policy relevance of these findings. In a proposal for a reformed electricity market, the European Commission introduces so-called regional virtual hubs for the forward market. Our results suggest that dividing EU member states into multiple bidding zones, while allowing producers and consumers to write forward contracts based on the quantity-weighted average of those zonal prices, would indeed increase liquidity in the forward market and reduce spot prices by improving local competition. However, regional forward contracts would make it difficult for market participants to hedge spatial price risk. The efficient scope of virtual hubs would balance the marginal benefit of improved competition against the marginal cost of increased spatial price risk. A reformed market design could address consumer spatial price risk by introducing complementary regional consumer prices. Charging retail prices based on the quantity-weighted average of zonal spot prices would also address equity concerns across consumers.

More generally, our results argue that introducing an LMP market where all relevant operating constraints are explicitly priced, all generation units are paid their locational marginal price, forward contracts clear against the quantity quantity-weighted average of LMPs, and all loads pay that quantity-weighted average for their consumption, can increase market efficiency relative to an LMP market where all suppliers and loads face their local price. Since the default LMP design with local prices is more efficient than any non-LMP market design, our results show that it is possible to increase market efficiency through locational pricing, while still ensuring liquid forward markets and equity-based consumer prices.

Link to the Working paper