Comparison of congestion management techniques: Nodal, zonal and discriminatory pricing

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Storage possibilities are negligible in most electric power networks, so demand and supply must be instantly balanced. The consequence is that transmission constraints and the way they are managed can have a large influence on market prices. The European Union's regulation 1228/2003 (amended in 2006) sets out guidelines for how congestion should be managed in Europe. System operators should coordinate their decisions and choose designs that are secure, efficient, transparent and market based.

In this paper, we compare the efficiency of three market designs that are in operation in wholesale electricity markets: nodal, zonal and discriminatory pricing. In the nodal pricing design, every node of the network is a local market with a local market price. This allows production in import-constrained nodes to sell at a higher price than production in export constrained nodes. This design is mainly used in U.S., but also in Russia and New Zealand. Discriminatory (pay-as-bid) pricing is used for example in the real-time market in the UK, where all accepted offers from producers are paid as bid rather than a local market price. The zonal design, which dominates in Europe, has one market price in a large region, often a country or state. The zonal market is special in that it has two stages. After the zones of the real-time market have been cleared the system operator often needs to order redispatches,

where supply is increased in import constrained nodes and decreased in export constrained nodes, so that intra-zonal congestion can be relaxed. Market based redispatches (countertrading) use pay-as-bid pricing in the second stage. Characteristics of the three designs are summarized in Table 1.

Table 1: Summary of the three congestion management techniques.

Congestion management technique	Considered transmission constraints	Auction format	
		Uniform-price	Pay-as-bid
Nodal	All	X	
Discriminatory	All		X
Zonal –stage 1	Inter-zonal	X	
Redispatch – stage 2	Intra-zonal		X

We show that in competitive markets without uncertainties, the three designs result in the same efficient dispatch. However, zonal pricing with counter-trading results in additional payments to producers in export-constrained nodes, as they can make an arbitrage profit from price differences between the zonal market and the redispatch stage. This strategy is often referred to as the *increase-decrease* (inc-dec) game. Our paper is first to prove these results for general networks with general production costs.

Although, zonal pricing is efficient in the very short-run, distorted price-signals lead to inefficiencies in the longer run, for example regarding production decisions for inflexible plants with long ramp-rate and location of new production plants. Imperfect prediction of consumption and production also leads to inefficiencies in markets with zonal and discriminatory pricing. This is less of a problem in markets with nodal pricing; an important advantage in markets with a significant share of intermittent renewable production.