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Increase-Decrease Game under Imperfect Competition in Two-stage Zonal Power Markets - Part II: Solution Algorithm

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Electricity markets around the world use different methods to manage transmission congestion. The US uses nodal pricing while Europe has favoured zonal pricing. Nodal pricing explicitly considers the transmission constraints and all accepted bids are paid with the local price in the node where the participant is located. In Europe, the zonal market is settled in two stages. The first stage is the day-ahead market. This stage considers transmission constraints between zones, but neglects transmission constraints within zones. The second stage is the real-time market, where all transmission constraints are considered.

A problem with zonal pricing is that different representations of the transmission constraints in the two stages yield different prices. This gives producers an arbitrage opportunity. A producer located in an export-constrained node can increase its profit by overselling in the day-ahead market and then repurchasing the electricity at a lower price in the real-time market. This type of arbitrage strategy is referred to as the increase-decrease (inc-dec) game. The game increases the turn-over in the real-time market. Hence, more production decisions have to be taken in the last minute. This increases production costs and it also makes it more difficult to keep the system in balance. In the long-run, the arbitrage profits lead to inefficient investments.

This paper is a continuation of Part I of this paper. The contribution of Part II is to develop solution algorithms that make it possible to compute the inc-dec game for large power systems, with more than hundred nodes. For this purpose, we outline a

constraint-reduction technique and a decomposition technique, which makes it possible to use parallel processing when computing the inc-dec game in large power systems. We show that the outlined algorithm can find a solution quicker and for larger systems compared to commercial optimization software.
Large-scale power systems often have many market equilibria. It is normally too time-consuming to compute all equilibria. We outline an algorithm that can compute representative equilibria in parallel.

As in the first part of the paper, we use a discrete approximation, such that the problem can be reformulated as Mixed-Integer-Linear Program (MILP). In the second part, we develop a grid-refinement technique that can iteratively improve the accuracy of the computed market equilibria.

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