THE BENEFIT OF COORDINATING CONGESTION MANAGEMENT IN GERMANY

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1 Overview

The German Energiewende is characterized by the phase-out of nuclear plants and an increasing share of renewable generation. As the high voltage transmission grid, however, had not been constructed to serve such needs, congestion is an issue in an increasing number of hours. A short-run curative relief consists in the redispatch of conventional generating units to re-establish network feasibility — a method that is employed by the transmission system operators (TSOs). As the operation of the German network is spatially divided into four control zones, each of which run by one TSO, the question arises whether coordinating redispatch measures among them can be beneficial.

2 Methods

To address this question, we formulate a generalized Nash model in the fashion of Oggioni et al. (2012), and Oggioni and Smeers (2012): in a first step, the spot market is cleared by equalizing supply and residual demand in a cost-minimizing fashion, without taking the power network into account. The dispatched quantities of conventional plants then become data for the actual model, in which the high voltage grid comes into play: the objective function consists in the cost-minimal redispatch of conventional power plants in order to re-establish network feasibility. By lowering and increasing generation at certain nodes, power flows — captured with help of a PTDF-matrix that also takes lines in adjacent countries into account — are changed such that line overflows can be eliminated. In our approach, we consider three distinct cases of coordination among the TSOs: as a benchmark, we model one single unrestricted TSO responsible for the entire German system (Case (i)). In the other two cases, the TSOs are restricted in such a way that for each zone there is one TSO solely eligible to access plants. At the same time, each TSO is either responsible for removing congestion on each line in the system (Case (ii)), or only for lines in its own zone (Case (iii)). In both cases, however, its actions alter the set of feasible choices for the other TSOs as loop flows influence the constraints on network feasibility for all lines in the entire system. TSOs thus interact over shared constraints. Setting up the model formulation as mixed complementarity problem, a mathematically underidentified system of equations emerges, which is a typical feature of generalized Nash problems: as multiple players face the same shared constraints, and at the same time attach endogenously different multipliers to them, there are more distinct variables than equations. Oggioni et al. (2012) and Oggioni and Smeers (2012) approach this problem with an additive decomposition of the Lagrange multipliers following Nabetani, Tseng, and Fukushima (2011). As a solution, however, we propose a multiplicative decomposition of the Lagrange multipliers into an endogenous part for each line and an exogenous valuation parameter. For each TSO-line pair, this parameter takes on either the value one — such that the TSO respects the congestion constraint for that line — or zero such that the TSO does not take into account at all the respective constraint in its optimization task. The resulting system is just identified and can be solved while at the same time different degrees of coordination can be represented in a simple and concise manner.

Moreover, we confront the model with a detailed representation of the German electricity system, comprising the high voltage grid, generation portfolio, and hourly demand and renewables generation data. Simulations of the three cases for all 8760 hours of the year 2011 are carried out in GAMS.

3 Results

Our results on network congestion deliver a by and large similar spatial pattern as reported for actual real world 2011 data. Concerning the effect of different degrees of coordination in the redispatch model, the results are intuitive: total redispatching costs increase substantially as the level of coordination decreases. They are lowest in case there is one TSO across all zones (30 million Euro for Case (i)), intermediate if each TSO has access to resources solely located in its own zone but takes into account congestion on all lines in the system (124 million Euro for Case (ii)). Costs are highest for the case each TSO has access only to own resources and only takes care of congestion within its own zone (180 million Euro for Case (iii)). The main driver of results consists in the finding that more expensive resources have to be called when there is less coordination. While in the unrestricted Case (i) average redispatching costs per MWh amount to 4 Euro, they rise to 11 Euro in the restricted but coordinated Case (ii), and add up to 21 Euro in the restricted and uncoordinated Case (iii).

4 Conclusions

Due to a high voltage grid not constructed to serve the needs of the changing German electricity generation portfolio, congestion management through redispatching of power plants plays an important role as short-run curative method. We show that coordinating redispatch measures among TSOs can be beneficial as a higher degree of coordination lowers total redispatch costs by utilizing less expensive resources. Political implications thus consist in enhancing coordination: this may be achieved for example through information sharing or a common market for redispatching resources.

References

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