A Large-Scale Spatial Optimization Model of the European Electricity Market

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In this paper, we present a large-scale spatial model of the European electricity market including both generation and the physical transmission network (DC Load Flow approach). The model was developed to analyze various questions on market design, congestion management, and investment decisions, with a focus on Germany and Continental Europe. It is a bottom-up model combining electrical engineering and economics: its objective function is welfare maximization, subject to line flow, energy balance, and generation constraints. The model provides simulations on an hourly basis, taking into account variable demand, wind input, unit commitment, start-up costs, pump storage, and other details. Various forms of spatial price discrimination can be implemented, such as locational marginal pricing (”nodal pricing”), or zonal pricing. With over 2,000 nodes and over 3,000 lines, this is one of the largest models developed to date, and allows a highly differentiated spatial analysis. We report modeling results regarding efficient congestion management for Germany and Europe, optimal network expansion under the aspect of increased wind energy production, and the impact of network constraints on location decisions of generation investments.

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