Transmission and generation investment for a core market region within a larger electricity market

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Overview

Market liberalization in the electricity sector has resulted in larger integrated market regions, covering multiple countries. In addition, the development of renewable generation capacity is increasing supra-regional electricity trade. On the other side, national regulation, within its spatial responsibility, sets market rules and decides on investment levels in transmission as well as renewable generation capacity. In the context of the low-carbon transformation and with increasing market integration, national regulation on country level should consider the implications of neighboring market regions on its national decisions.

Representing this limitation in spatial decision power is mathematically more challenging than a system-wide perspective, but allows for better analysis of national decisions on market regulation and infrastructure investments. Building on a three-level model for the European electricity market, we develop a framework to analyze scenarios for the German energy transition in the electricity system until 2035.

Methods

The approach builds upon the three-level optimization model of Grimm et al. (2016) which can be reformulated into a mixed-integer quadratic program (MIQP) with linear contraints. This formulation allows the combined analysis of regulated investment in transmission lines and market-based generation investment, followed by multiple spot market scenarios in a zonal market setting and cost-based redispach by the network operator. We extend this formulation in two dimension. First, we add several zonal neighboring market regions to the intial core region in the spot market and second, the regulator of the core region is allowed to invest in transmission lines and also determines the amount of investment in renewable generation capacity within its region. The implementation of this model formulation requires a tailored approach with decomposition techniques to account for cross-border electricity trade.

Results

As we are in the final stage of the model implementation, quantitative results will be available within the upcoming weeks. The results will provide insights in the interdependency between decisions by a national regulator on spatial placment of renewable generation and on transmission investment with market-based generation investment in a larger market context. Interesting sensitivities are an increased cross-zonal trade capacity to neighboring markets, changes in the renewable generation portfolio of neighboring countries and the reshaping of the spatial definition for bidding zones.

Conclusions

Most research on electricity markets (cf. Grimm et al., 2016) and infrastructure investment (cf. Bertsch et al., 2017) takes the perspective of system optimization for the entire model scope. The reality in electricity markets is somewhat different as the influence of regional or national regulators is constraint to the national or state level while electricity markets cover considerable larger regions and experience increasing interregional electricity trade. The adjusted model formulation will allow to address this context taking into account the influence of larger market regions on changes in market design or on infrastructure investments within the core region.

References

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