HOW PRICE ZONE CONFIGURATIONS IMPACT SYSTEM COSTS IN THE EUROPEAN POWER SYSTEM

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Overview

By interlinking power systems, significant welfare gains can be achieved. With increasing amounts of fluctuating energy from renewables sources, these welfare gains grow further and the congestion management for electricity grids becomes more important. When coupling electricity markets, different ways of taking grid connections into account have been considered and established. We focus mainly on Central Western Europe which is operated by a zonal market system where price zones (ususally) align with national borders and thus congestion is not necessarily reflected by market prices. As redispatch amounts and cost rise significantly (especially in Germany [1]), the question of alternative market designs is controversial. Many authors see nodal pricing as applied in parts of North America, as the optimal solution, but also optimized zonal configurations, where borders of price zones rather align with congested transmission lines than with national borders, could improve the current system [2,3,4].

For an extended Central Western Europe (CWE+) area, containing France, Belgium, Luxembourg, the Netherlands, Germay, Switzerland and Austria, we compare five configurations with an increasing number of price zones (up to a near nodal setup) to the current setup. The zonal configurations are determined using a hierarchical clustering algorithm that minimizes price variations within a zone so that congestions are mainly restricted to the borders between zones [5]. For each configuration, we model intraday system costs (after market closure) as well as re-dispatch quantities and costs by running separate cost-minimizing market and grid simulations. Thereby, we assess the benefits of optimized price zone configurations and (quasi-)nodal pricing in a large scale model of the European power system.

Methods

For modeling the electricity market, we use the WILMAR Joint Market Model [6], a detailed scheduling model performing a central optimization of the whole European market based on the assumption of a competitive market and inelastic demand. Flow-based market coupling (FBMC) as applied in reality since 2015 [7] is utilized inside CWE+. Flow reliability margins (FRMs) are varied for sensitivity analyses. Other necessary FBMC-parameters are calculated based on a preceding DC-OPF grid simulation with the open-source software matpower [8] taking over 2200 nodes of the 220- and 380-kV grid into account. The same accounts for the cluster algorithm, determining the bidding zone configurations.

The resulting dispatch of the market simulation is fed into the grid model again for each configurations, where overload situations are identified and thereby re-dispatch costs are calculated.

Much effort has been spent creating input data for grid and market simulations. Hourly load time series are calculated in a top-down approach, splitting national time series into time series for different sectors (industry, service sector and households) and distributing these to regions based on their share of sector-specific gross value added or population respectively. Regional PV and wind time series are calculated in a bottom-up approach by scaling regional characteristic infeed profiles based on measured data and wind with the expected regional installed capacity. A CHP model determines the hourly heat generation of the CHP plants, which translates to minimum and maximum generations constraints. For market simulations with new bidding zones, all input data has to be reaggregated according to the new zones.

Results

We find that new zonal configurations have a significant influence on overall system costs. A zonal configuration with 5 zones determined with our clustering algorithm shows a noteworthy decrease of overall system costs (sum of intraday market and redispatch) compared to the currently implemented configuration. For configurations with an increasing number of bidding zones, redispatch costs tend towards zero. System costs are also dependent on the exact realization of the flow-base market-coupling algorithm, particularly on the chosen values of FRMs.

Conclusions

Nodal pricing is seen as the theoretically first-best-solution to include congestion of the physical grid in electricity markets. Yet, a detailed model-based assessment of the power system in Central Western Europe shows that many of the positive effects can already be achieved by altered zonal configurations, whose borders are adjusted along the actual congestions. Alongside the incentives that prices set to invest at the “right side” of the congestion, also the sum of market costs and redispatch costs can already be decreased to a low level for a small number of bidding zones.

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