Assessing Improved Price Zones in Central Western Europe under the Regime of Flow-Based Market Coupling

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With increasing amounts of fluctuating energy, congestion management for electricity grids becomes more important. Different approaches of taking grid connections into account have been implemented when coupling electricity markets. We focus on Central Western Europe where a zonal market system is operative with price zones aligning with national borders. In our model region, so called flow-based market coupling (FBMC) is used to model cross-border trade capacities based on grid constraints. The question of an alternative market design is controversial. Nodal pricing, where for each node of the (electrical) grid an own market exists, is commonly seen as the theoretically optimal solution. Still, optimized price zone configurations (PZCs), where borders of price zones rather align with congested transmission lines than with national borders, are seen as a possible improvement compared to the current system.

For an area containing France, Belgium, Luxembourg, the Netherlands, Germany, Switzerland and Austria (called CWE+ from here on), we compare five configurations differing in the number of price zones (up to a near nodal setup) to the current setup. The zonal configurations are determined using a hierarchical clustering algorithm minimizing price variations within a zone so that congestions are mainly restricted to the borders between zones. For each configuration, we model intraday system costs as well as redispatch 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, utilizing FBMC in CWE+ as applied in reality.

For modeling the electricity market, we use a detailed scheduling model performing a central optimization of the whole European market, assuming a competitive market and inelastic demand. FBMC-parameters are calculated based on a preceding DC-OPF grid simulation with the open- source software matpower taking over 2200 nodes of the 220- and 380-kV grid into account. The resulting dispatch of the market simulation is used as input for a second grid model run for each configuration, where overload situations are identified and thereby re-dispatch costs are calculated. Effort is spent creating input data for both grid and market simulations. A CHP model determines minimum and maximum generation constraints of CHP plants based on their hourly heat generation. Hourly load, PV and wind time series are calculated on a regional level based on historical time series, weather data and socio-economic figures. For market simulations with new bidding zones, all input is reaggregated according to the new PZCs.

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 substantial decrease of overall system costs (sum of intraday market and redispatch) compared to the configuration currently implemented. For configurations with an increasing number of bidding zones, redispatch costs tend towards zero. In the best price zone configuration, overall welfare can be increased by around 1 billion € (1.8% of the total system costs), redispatch amounts can be reduced by over

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90%. By calculating consumer, producer and congestion rents, we demonstrate that welfare gains are not equally distributed to market participants, which is likely to cause political frictions in the process of implementing improved PZCs.

Due to inefficiencies in the flow-based algorithm, which we point out in detail, system costs are not monotonically decreasing with an increasing number of market zones. In several sensitivity analyses, the dependency of system costs on the exact realization of the flow-base market-coupling algorithm is investigated. These properties of FBMC should be considered in the process of PZC determination.