Novel Power Market & Grid Model to Allow for Endogenous Flow Based Market Coupling Analysis

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Overview

The electricity sector continues to evolve with national and international agreements regarding CO2 emissions and capacity development. Recently the most prominent development is the shift in generation capacity towards decentralized renewable generation. Although grid development is a major part of this process, the transmission system has been given a rather passive role as a mere vehicle to transport market results.

The interdependency of grid and market is only rarely a topic in both economic and technical studies. From an economic point of view, physical congestion in the transmission grid are the cause for price zones and are thus an integral part of the European electricity market. From a technical perspective, line flows and therefore congestion, are a result of the market and only relate to security of supply. Thus congestion management is traditionally performed by transmission service operators (TSOs).

Methods of congestion management differ in their physical and temporal realization. Redispatch, i.e. real-time adjustment of the generation schedules, can be described as manual and short term, while the construction of a new line or investment in transmission capacity in general can be considered systematic and long term.

Those operational methods are generally expensive, untransparent or long-term. Therefore, potential to implement congestion management already on the market side has gained interest in the power-economic community. One of the most promising concepts is the so called Flow-Based Market Coupling (FBMC) which has to-date only been implemented in the CWE Region (Central West Europe). However, an extensive rollout in europe or other power-markets is still up for discussion.

The power market model presented in this paper specializes on the interdependency between grid and market and enables an endogenous representation of FBMC. This allows for efficient further research on this topic and will increase the transparency of potential real-world market implementations of FMBC.

Besides presentation and introduction of our model, the main contribution of this paper is a case-study investigating the impact of a wider rollout of FBMC in the European power market by applying and verifying the model.

Methods

FBMC aims to effectively allocate cross border capacities based on line load and potential additional load from outages. Since FBMC takes a zonal perspective, there has to be an assumption on how the (additional) injections are distributed within the zone. These distribution keys are known as generations shift keys (GSKs). The process of acquiring the respective GSKs is done by TSOs and is not publicly available. There are various possibilities to generate such GSKs endogenously which are presented and discussed in this paper.

To keep the model open source it is written in Python and Julia and formulated as a linear problem (LP). Since the scope for a FMBC analysis is fairly large and nodal resolution is required, the dispatch model is as simple as possible but as complex as needed. Besides the grid constraints the model incorporates CHP and storage generation and provides market clearing both for electricity and heat.

The load flow calculation is based on the well established dc-load-flow approximation, but accounts for true N-1 criterion which is the main driver of FBMC capacity allocation. Data for the case-study is drawn from the Open

Power System Data platform[1] and extended with the needed spatial information. We use current data (2017) and aim to find the impact of FBMC firstly on the current power system and secondly on future transmission system infrastructure.

Results

While the numerical results of this study are yet to be produced and verified, tests on sample data lead to the expectation, that an increased rollout of FBMC allows for a more efficient use of transmission capacities in Europe. It can further be expected that mainly generation with low marginal costs, such as renewable generators, will profit from this.

[1] https://open-power-system-data.org