THE IMPACT OF DIFFERENT DISTRIBUTION OF RENEWABLE ENERGY SOURCES AND LOAD ON FLOW-BASED MARKET COUPLING

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Overview

The consideration of Power Grids becomes more and more relevant in Energy System Modelling. One reason for this is the structural change due to liberalization and intended decarbonization of the energy system which lead to a changed distribution of generation (and consumption) that is not necessarily in line with what the power grid was originallly designed for. This has lead to a growing number of interventions from grid operators to ensure secure grid operation and relieve the power grid from congestions. Furthermore, the direction of AC power flows can only be controlled to a limited degree in highly meshed power grids, leading to cross-border flows being induced even without any underlying cross-border trade.

To account for these grid constraints the target model in the EU for cross-border congestion managment is flow-based market coupling. While this model accounts for physical flows over interconnectors the uncertainty of underlying assumptions (load and generation) are hard to manage. In an operational system the grid operator has a good knowledge of actual or near future generation and load on a nodal level, a level of detail which is not availble to market participants and not available at all in the long run.

Thus we aim at understanding the influence and impact of different assumptions concerning the distribution of load and decentralized renewable energy sources on cross-boder flows which might change the capacity available for trade between market zones and thus affect wholesale electricity prices and welfare distribution.

Methods

We use a transmission grid representation of Germany and Poland based on publicly available data on which we conduct an AC optimal power flow using matpower [1]. The grid model is coupled with an existing electricity wholesale market model to simulate conventional power generation - as well as generation from renewable energy sources (RES) and load on an aggregated country level. We then use a scenario-based approach to examine different regionalized distributions of these power sources and sinks. In one scenario, future RES are placed at existing locations according to a base case distribution. The effect are compared to a scenario where RES are situated at locations which provide optimal yield and a “flattened” distribution where RES are distributed more equal among the grid nodes.

Results

Using the input from the market model, AC Optimal Power Flow resolves congestions in the power grid and reach a feasible dispatch solution. From this state of the power system, the line loadings of cross-border interconnectors are derived which determine the pre-market coupling loading and determine the remaining available margin for market coupling on these interconnecting lines. The specific regionalized distributions produce different loading situations in the grid which are then validated with historical exchange flows to quantify the impact of the regionalization scheme on tradable capacities.

Conclusions

Especially for long term studies the distribution of load and decentralized generation resources are only predictable with a certain uncertainty. While for the operational range the players possess sufficient information to predict flow outcome, for long term studies or even simulations by market participants who possess insufficient knowledge concerning load or RES distribution, modellers need to keep in mind the possible distorting effect induced by this uncertainty.

References

[1] R. D. Zimmerman, C. E. Murillo-Sánchez, and R. J. Thomas, "MATPOWER: Steady-State Operations, Planning and Analysis Tools for Power Systems Research and Education," Power Systems, IEEE Transactions on, vol. 26, no. 1, pp. 12-19, Feb. 2011.