EMPIRICAL ANALYSIS OF REGIONAL CONGESTION AND CURTAILMENT CLUSTERS IN NORTHEASTERN GERMANY

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Overview

Big structural changes in the wake of the German Energiewende have led to geographical shifts of generation capacity and consequently transregional imbalances of generation and consumption of electricity in Germany. The necessary extensions and strengthening measures of the electricity network come with a delay. Grid congestions are therefore a common occurrence. To solve problems of congestion, grid operators interfere with the market result and decrease the generation on the oversupplied side of the bottleneck -typically in Northern Germany- and increase the generation on the other side of the bottleneck -typically in Southern Germany and Austria. In accordance with the prevailing regulations, conventional generation units must be redispatched before curtailing renewable generators.

In recent years the amount of energy and the cost of such curtailment measures have greatly increased to up to 6.3 TWh of conventional energy and 3.7 TWh of renewable energy and costs of 400 Million Euro (BNetzA 2017). The increasing amount of curtailed energy and the costs of congestion management lead us to the question whether it is more efficient to solve bottlenecks by using alternative flexibility options instead of curtailing RES (EnSys et al. 2017). To answer the question, a wider understanding of the reasons for curtailments is crucial. As a first step, the paper by Koch et al. (2018) identifies the main drivers for curtailments and quantifies their influence and provides the basis for developing a forecasting method for curtailments.

Ourresearch explores links of congested grid elements and curtailed renewable generators. It analyses local clusters and patterns of cause of congestions, effect and countermeasures. Furthermore, a map of potentially usable curtailed energy and regioanally specific times series are derived.

Methods

It is our hypotheses that clusters of congested grid elements and curtailed renewable generation units exist: to heal a congestion on a certain grid element, typically the same set of renewable generators will be curtailed. With the intention of exploring these correlations a database with three datasets[1] is assembled:

1) Published TSO measures with information on the causal congested grid element, time of the measures and the curtailed generator directly connected to the transmission system or the subordinate DNO which was delegated to curtail generators connected to his distribution network.

2) DSO measures with information on the origin of the measure -the superordinate TSO or a grid element in the own distribution network-, time of the measure and the curtailed generation unit's assets code.

3) A comprehensive list of all generators with their asstets codes and information on the location.

Timely correspondence and the documented cascade from measures initialised by the TSO through the DSOs' database and the generators' list make it possible to link congested grid elements with the curtailed generation units. This way a list of all curtailed generators linked to each grid element over all congestion occurrences can be put together. Also vice versa all grid elements that caused a curtailment of a single generator can be found.

The analysis of typically congested grid elements also makes it possible to assess the value of structural reinforcements and new construction of additional capacity to avoid local grid congestion as a whole. In order to do so, the development of congestion and necessary curtailment before and after extension or strengthening measures are evaluated.

[1] So far, the available data covers the 50Hertz-control area in northeastern Germany in the years 2015 and 2016. An update with data from 2017 will be available in May.

Results

Congestions can occur in the high-voltage transmission system, operated by the transmission system operator (TSO), subordinate lower voltage distribution networks, operated by the distribution system operators (DSO), or the connecting substations between the two voltage levels. Congestions in the transmission system's power lines can either be healed by curtailing generation units directly connected to the transmission system or by generation units in the subordinate distribution grid. Congestion in a distribution network or an overload of a substation connecting a DSO to the superordinate TSO can only be healed in the underlying distribution network.

The study gives an overview of regional clusters and patterns of grid congestion and renewable curtailment. The analysis shows clear clusters of regionally correlated grid elements and generation units. Congestions on individual grid elements are routinely healed by curtailing the same set of generators. The generation units are often but not always geographically close to the congested elements. It can furthermore be observed that concrete changes in the grid have a clear effect on the curtailment of the connected generation units. Exemplary the high voltage transmission line from Remptendorf (50Hertz control area) to Redwitz (TenneT control area) was frequently congested until July 2016. Typically, when this grid element was congested, an identifiable set of geographically nearby generators was curtailed. With the commissioning of a parallel transmission line -the "Südwest-Kuppelleitung"- congestions on this part of the transmission system was drastically reduced.

Similarly, the analysis of curtailment of individual renewable generators creates an understanding of potential regional energy surpluses for alternative flexibility options. The curtailment of individual renewable generators show a high dependency of very few identifiable congested grid elements.

Conclusions

The study provides a good understanding of how system operators handle congested grid elements and curtail renewable generators. The examined clusters highlight the importance of extensions and strengthening measures of the electricity network to avoid congestion and curtailment.

Furthermore, regionally resolved curtailment time series can be derived from the historic data. The statistical features and dependencies from congestion on individual grid elements of these time series can serve as reference for future alternative flexibility options, such as Power-to-Heat or Power-to-Gas facilities. At the same time, the high dependency of the curtailment of single renewable generators from a very limited amount of grid elements complicates estimates of regional potential for alternative flexibility options, since an extension or strengthening measure in the transmission system obviates the need to curtail the linked renewable generators.

References

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