REASONS FOR CURTAILMENT OF ELECTRICITY PRODUCTION IN NORTHEASTERN GERMANY – AN EMPIRICAL ANALYSIS

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Overview

Due to the geographical imbalance of production and consumption of electricity in Germany and the time delay in extending and strengthening the electricity network, the grid is congested on a regular basis. To solve the bottlenecks, the transmission system operators interfere in the market and reduce conventional and, more recently, renewable production in northern Germany while increasing reserved capacity production in southern Germany and Austria. In recent years, the curtailed energy amounts and the related costs increased tremendously. In 2016, 6.3 TWh of conventional energy and 3.7 TWh of renewable energy were curtailed, leading to estimated costs of 400 million Euros (BNetzA 2017). A substantial part of the curtailments takes place in northeastern Germany.

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 this question, a wider understanding of the reasons for curtailments is crucial. In a first step, this study identifies the main drivers for curtailments and quantifies their influence. For grid operators and other market actors, such as direct marketers and alternative flexibility providers, knowledge about the reasons for curtailment is necessary in order to prevent or react to grid congestion.

Methods

First, we use an explorative data analysis (visualization, correlation and autocorrelation analysis) to identify and describe possible explanatory variables for the curtailment of conventional and renewable generation. Second, we quantify the influence of the explanatory variables on the curtailments with different regression methods (linear and multiple linear regression with auto correlated error terms).

- Considered time resolution: yearly, monthly, hourly and quarter-hourly data
- Considered data on control area aggregated level: Redispatch, Eisman[1], Wind day-ahead forecast and actual generation (on- and offshore), PV day-ahead forecast and actual generation, conventional generation, load, residual load, vertical load, control area balance, day-ahead and intraday electricity prices
- Considered time period from 2010 to 2016 (update for 2017 to be presented at the conference)

Results

The study gives an overview about the statistical characteristics of congestion management measures (frequencies, durations) and analyses the correlation with possible explanatory variables over different time periods and in different time resolutions. Wind generation, for instance, shows the clearest correlation with the curtailments (see figure 1). Using monthly data, the Pearson correlation coefficient is 0.89 (it ranges between 0.68 in 2010 and 0.95 in 2016). Quarter-hourly data lead to a lower correlation of 0.73. It can be observed that the coefficients change substantially after major grid extensions. Moreover, the empirical probability of curtailment as a function of the wind generation in northeastern Germany is calculated (see figure 2).

Within the study, regression models of different complexities are described to quantify the influence of the variables. For instance, the simplest model of a linear regression for the curtailments with the wind generation as explanatory variable leads to an influence of 0.35 GW of curtailment for an additional 1 GW of Wind feed-in ($R^2 = 0.53$, taking particularities of time series into account). In multiple linear regression, other variables are also significant, but their additional explanatory share is small.

[1] "Eisman", abbreviation for „Einspeisemanagement" which stands for the "Curtailment of RES" in German.

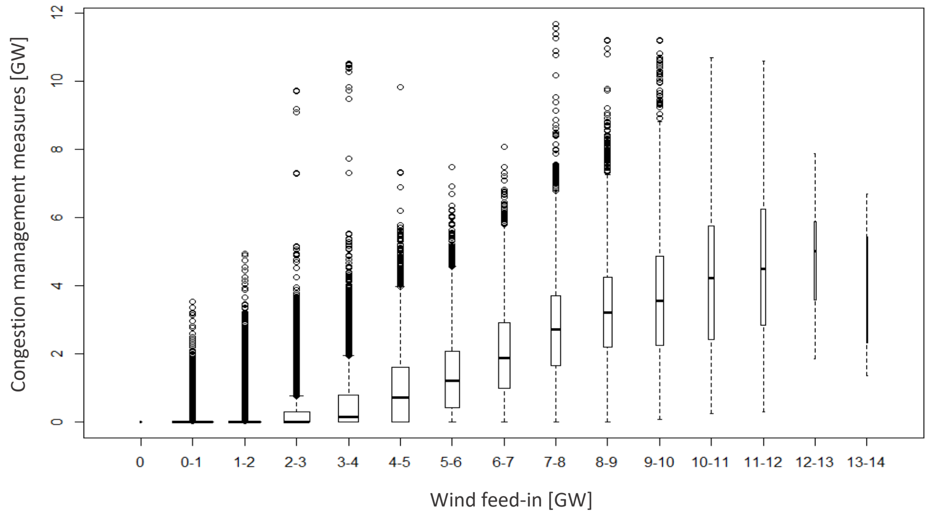

Figure 1: Correlation between congestion management measures and wind feed-in in northeastern Germany (2010 - 2016), Source: own calculation

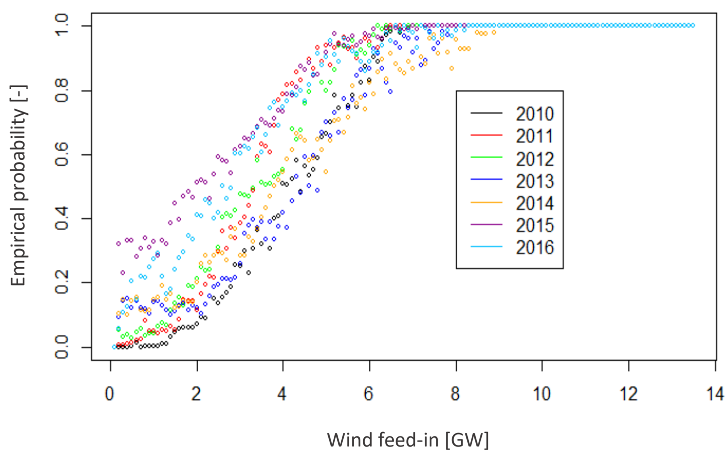

Figure 2: Empirical probability of congestion management measures as a function of the wind feed-in in northeastern Germany, Source: own calculation

Conclusions

The study provides a good understanding of the reasons for curtailment on the control area aggregated level. The results are explainable by technical and energy economical interactions and it is even possible to quantify the influence of some of the explanatory variables. The findings of this study also provide the basis for developing a short-term forecasting method for curtailments, although not all explanatory variables are available ex-ante. It can also be shown that the statistical figures change heavily with technical changes in the electricity network. To develop a deeper understanding, further research on regional congestion management procedures is necessary (compare Schröder et al. 2018).

References

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