A statistical contemplation of Balancing Energy in Austria: Released quantities of secondary and tertiary control reserves in the context of econometrics and time series analysis

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Overview

In order for an electricity grid to be able to operate properly, generation of electricity has to equal consumption at all times, however, electricity grids cannot store energy. Balancing energy is responsible for maintaining the equilibrium between supply and demand in an electricity grid.

Although in theory it is well understood what can cause disturbances in an electricity grid, sources are often only observed jointly and the demand for balancing energy is notoriously hard to predict. Outages of electricity generating units as well as generation from volatile sources such as wind and photovoltaic energy are some of the possible driving forces behind balancing energy. This paper seeks to identify the most influential factors on balancing energy as well as to provide and evaluate intraday-forecasts for the Austrian control area.

In the beginning, a brief introduction to balancing energy is presented. Afterwards, alternative modelling approaches are introduced in the context of a state of the art. This is followed by a statistical analysis of quarter-hourly time series data of released quantities of secondary and tertiary control reserves in Austria. First the time series itself is investigated. Here the empirical autocorrelations are interpreted, deterministic seasonal components are identified and tests for unit roots are applied to the time series under consideration. In addition a brief discussion of the stationarity of the data-generating process is presented.

Subsequently econometric models are used for modelling the dependencies between balancing energy and other variables of the electricity market. One the one hand, the most influential factors from the available variables of the electricity market are determined through a procedure, which avoids the assumption of stationarity of the variables under consideration. Furthermore intraday-forecasts of released quantities of balancing energy are generated and evaluated.

Methods

Quantifying the influence of variables of the market for electricity in the context of Linear Regression, Tobit model and weighted k-Nearest Neighbour Regression through cross-validation. Creating and evaluating intraday-forecasts of balancing energy in the context of Linear Regression, Tobit model, SARIMA and weighted k-Nearest Neighbour Regression through cross-validation.

Results

The most influential variables are the same among all considered models: electricity generation from wind energy and the associated forecast error as well as unintentional electricity deviations between the Austrian control area and other control areas. An interesting fact is, that unintentional deviation also includes frequency containment reserves. Therefore the activation of frequency containment reserves could have some power in explaining the released quantities of other types of balancing energy.

Comparing the results from the intraday-forecasts of balancing energy shows that the linear regression model and the Tobit model produce the most precise results. Although the quality of the predictions diminishes with the forecast-horizon, the results help with quantifying the difficulties in forecasting the demand for balancing energy. Tobit models explicity consider the non-negative characteristic of the time series, therefore especially predictions of zero-entries are more precise.

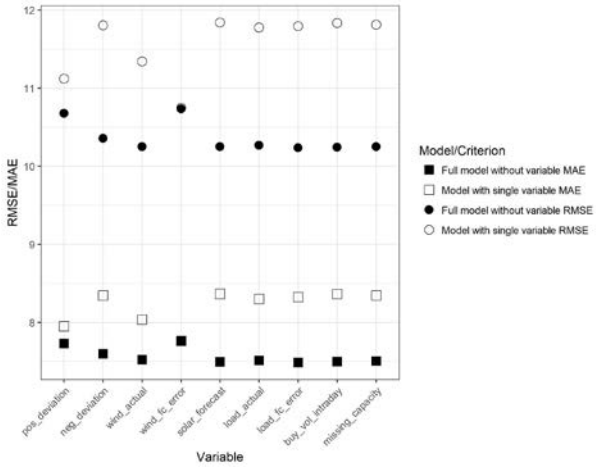

Figure 1 Comparison of the influence of variables

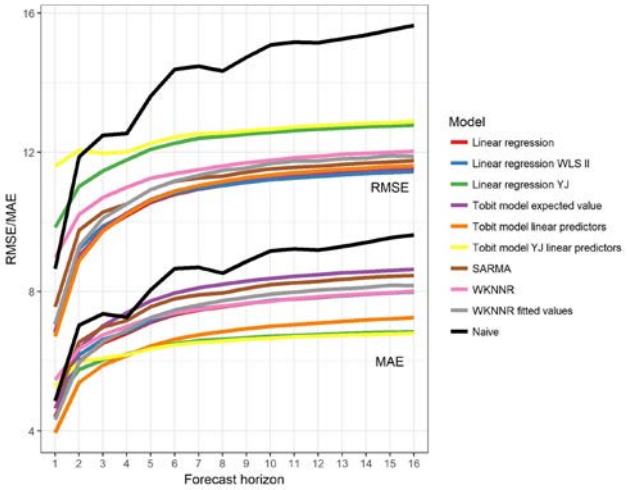

Figure 2 Comparison of forecasts

Conclusions

From the provided analysis one can conclude that unintentional electricity deviation between the Austrian control area and other control areas as well as the forecast error from wind feed–in have the biggest explanatory power in regards to balancing energy in Austria. This information should be incorporated in further modelling processes. The presented results of the forecasts can help with quantifying the uncertainty associated with balancing energy.

There are several possibilities for further investigation: For one, in order to improve point-forecasts of the time series under consideration, one could use more sophisticated modelling techniques respectively additional variables or more immediate forecasts of important variables such as the feed-in from wind energy. Incorporating more data using big data techniques could be a viable option as well. Alternatively, forecasting the distribution of balancing energy and thereby estimating safety levels for the associated distributions could enable short-term dynamic dimensioning of balancing energy.

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