DYNAMIC FORECAST COMBINATION USING THE KALMAN FILTER

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Overview

All over the world, we observe an increasing generation of intermittent renewable energy sources (RES) such as wind and photovoltaics. As a result, electricity systems face growing challenges with respect to grid stability and balancing of supply and demand. It can be expected that this development will continue or even accelerate.
A reliable operation of the electrical system is considerably more difficult if the system is influenced by the uncertain energy production of RES. Therefore, both balancing group operators and transmission grid operators profit from accurate forecasts for the electricity generation of fluctuating electricity sources.
This paper will focus on forecasting the variable electricity production from wind energy in Germany. Based on data from a German transmission grid operator, we analyse different wind energy forecasts (from different commercial forecasting institutions) in a quarter-hourly resolution for a period of three years. On this basis, we developed and tested several forecasting methods based on combinations of individual forecasts.

Methods

We apply a Kalman filter to a dynamic linear combination of N different individual forecasts which try to predict at time t_0 of day d the wind energy production of the following day $d+1$ in a quarter-hourly resolution. In this paper we consider the time depending, unrestricted combination coefficients (including an intercept) as a $(N+1)-$dimensional unobservable state vector according to the Kalman theory. We analyse the choice of parameter matrices and compare the resulting forecast performance [measured by the mean error (ME), the mean absolute error (MAE) and the root of mean squared error (RMSE)] to several common static and dynamic methods for the determination the combination coefficients.

Results

Our findings show that wind energy forecast combinations improve the prediction accuracy significantly, especially compared to the performance of individual forecasts. A high prediction quality can be reached by using dynamic methods for the determination of the combination coefficients. Our Kalman filter combination is superior to each of the considered benchmark methods, as long as the filter is well parameterized. The second best method, a dynamic linear regression based on a rolling window with optimized width, leads to results which are relatively close to the Kalman filter approach. However, despite this result there are also significant differences between these two approaches. For the best performance the regression based model needs a long historical data frame. That leads to a comparatively smooth time evolution of the combination coefficients. Instead, the Kalman approach needs only a short time frame for the determination of the combination coefficients and especially for the calculation of the model- and the measurement uncertainty. The latter results in a strong variability of the coefficients over time.

Conclusions

We present forecasting models combining RES-infeed forecasts from different commercial forecasting institutions. We show empirically that forecasting models combining individual wind energy forecasts are superior to each individual forecast. The analysed Kalman filter method yields the highest forecast performance of all models under consideration and has the potential for further improvements by an optimization of the filter parameter. Our results can help to integrate wind energy into electricity systems worldwide. Furthermore, because of the general structure of the methodology, they can potentially improve the forecasting accuracy of other RES-technologies such as e. g. photovoltaics or solar heat.