

# ***DAY-AHEAD PHOTOVOLTAIC POWER FORECASTING: A STATISTICAL APPROACH***

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## **Overview**

In several European countries, solar photovoltaic (PV) electricity generation represents one of the pillars of the energy transition and has constantly increasing share in the energy mix. In Germany, one of the leaders in renewable energy, photovoltaic systems have undergone a tremendous growth in the past 15 years: from 1.1 GW in 2004 to 45.9 GW in 2018. Depending on the time of day and weather conditions, electricity is produced during the sunshine hours and fed into the transmission grid whereas consumers cannot necessarily always directly accept the renewable power generated. Because of the variability and excess availability of this renewable energy source (RES), accurate PV forecasts are essential for their enhanced integration into the system and for lower system costs. In the face of growing power generation from renewable sources, the aim of the paper is to obtain more precise predictions of the day-ahead PV feed-in.

## **Methods**

The forecasting model involves a dynamic linear combination of different single forecasts. The model also allows to penalize for especially large deviations of the model coefficients and for unnecessary explanatory variables. The structure of the model is such that it can be applied for predicting energy from different renewable sources. The data is obtained in cooperation with one of the German transmission grid operators and covers the years 2012-2018. In this one regional zone in Germany approximately one quarter of the total installed PV capacity is located. The data is gathered in quarter-hourly intervals, totaling 245,472 observations of actual PV feed-in. In the first stage, the data undergoes several checks for consistency and reliability, as well as detailed analyses of the individual forecasting errors of the six different forecasts. After this stage, the forecasts are used in a combination model (with dynamic estimation of the model coefficients) and final improved day-ahead forecasts for photovoltaic feed-in are obtained.

## **Results**

The precision and bias of the forecasts are evaluated using several measures like the mean squared error (MSE), the relative mean squared error (RMSE), the mean error (ME), the mean absolute error (MAE) and a skill score (SS) relative to three benchmarks. The new forecasts have a smaller monthly and yearly forecasting errors (especially in terms of RMSE and MSE) for extended periods in comparison to other combination models like a dynamic linear regression (OLS) or arithmetic average of individual forecasts. The combined forecast also performs better than each of the individual forecasts. The monthly forecasting errors are largest during April, May and June under all three methods, which might be explained by increased availability and variability of solar irradiance during these months in Europe.

## **Conclusions**

Combining the forecasts from different commercial forecasting institutions with a dynamic method leads to reduced forecast errors and enhances the precision of the 24-hours ahead PV forecasts for German data. The combined forecast performs better than the benchmarks in terms of forecasting errors and as measured by the skill score and also brings improvements relative to each of the individual forecasts. The results will be useful in order to increase the integration of renewable energy into the energy system and reduce the system balancing costs and the model can have wider application also for other types of RES in Germany as well as other European countries.