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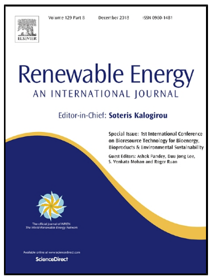

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Short-term and regionalized photovoltaic power forecasting, enhanced by reference systems, on the example of Luxembourg

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Abstract

The authors developed a forecasting model for Luxembourg, able to predict the expected regional PV power up to 72 hours ahead. The model works with solar irradiance forecasts, based on numerical weather predictions in hourly resolution. Using a set of physical equations, the algorithm is able to predict the expected hourly power production for PV systems in Luxembourg, as well as for a set of 23 chosen PV-systems which are used as reference systems. Comparing the calculated forecasts for the 23 reference systems to their measured power over a period of 2 years, revealed a comparably high accuracy of the forecast. The mean deviation (bias) of the forecast was 1.1% of the nominal power – a relatively low bias indicating low systemic error. The root mean square error (RMSE), lies around 7.4% - a low value for single site forecasts. Two approaches were tested in order to adapt the short-term forecast, based on the present forecast deviations for the reference systems. Thereby, it was possible to improve the very short term forecast on the time horizon of 1-3 hours ahead, specifically for the remaining bias, but also systemic deviations can be identified and partially corrected (e.g. snow cover).

Keywords

Photovoltaic forecasting, forecasting performance, rmse, photovoltaic integration, solar forecasting, solar energy integration

1. Introduction

The share of decentralized and fluctuating energy sources, such as wind power and photovoltaic (PV), is constantly increasing and will represent a major part of the future energy mix. The reliable management of our electricity supply and grids as well as the containment of increasing price volatility on the electricity market, will depend on the ability to handle these fluctuating renewable sources. The forecasting of the dynamics of PV power production is therefore crucial for the integration of high shares of photovoltaic into our energy system and market.

The different stakeholders involved in the electricity supply and operation of the grids, have their specific needs for load and production forecasting and these needs are changing with the rising shares of fluctuating, distributed generation. Electricity retailers require accurate day-ahead forecasts of PV systems (hourly resolution; updated once or twice a day) for their energy procurement and sales forecast. Since many small scale PV system feed in behind the meter of their customers, they reduce their demand and need to be considered in load forecasting. But also the utility scale PV systems have increased their share in the production portfolios and force the providers to account for them accurately in their production forecasts. The inaccuracies in day-ahead forecasts for production and demand need to be balanced out on the intra-day level, by procurement, respectively sales on the spot market. Hence, forecasting on intra-day (down to 5 minutes resolution and hourly updates) and day-ahead level is of high economic importance for energy retailers. [1] [2]

A second stakeholder is the transmission system operator (TSO), who establishes forecasts one or two days ahead (hourly resolution, daily updates) with the objective to keep demand and supply balanced and to meet the technical constrains of the grid. In order to avoid congestions, TSOs can mobilize reserves, curtail production or set other regulating measures, mainly short-term on the intra-day level. Hence, day-ahead and intra-day (5 min.; hourly updates) are also important forecast horizons for the TSOs. But, in order to run power flow simulations and identify potential congestions, the spatial variation of the PV power forecast is another aspect for the TSOs, although this can be at coarse resolution. [1] [2]

The distribution system operators (DSO), responsible for the electricity transport from the transmission grid to the final customer in mid- or low-voltage grid level, had a much more passive role in the past, as compared to the TSOs. But with the shift to distributed, fluctuating generation in our low-voltage grids, such as PV, their role is changing. Smart distribution grids, decentralized storage and demand response concepts are innovative technologies with the potential to increase the hosting capacity of the distribution grids for decentralized production [3]. But their operation and predictive control will also require accurate PV forecasting in the near future, but at a relatively detailed spatial resolution (e.g. street level).

In the light of above explained developments, the objective of this work was to develop a forecasting approach reaching a high accuracy for regional PV power forecasts on day-ahead, as well as intra-day level, meeting the requirements of the stakeholders and reflecting the availability of the necessary data. Further, the approach should allow for a high spatial differentiation of the regional forecasted PV power. The effort, in terms of necessary computational power or the set up and operation of measurement devices should remain on a manageable level for the concerned stakeholders.

The following paragraphs will give a brief overview on existing methods and how they relate to above described requirements. Existing methods for PV power or solar irradiance forecasting do exist and can be differentiated by several characteristics. It will be explained to which groups our approach belongs to and how it differs from existing methods.

Literature documents direct and indirect methods, where direct methods try to predict directly the expected PV power (mainly for single sites), while indirect methods forecast the solar irradiance and derive the PV power from this most important influence factor [1]. Direct