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Photovoltaic-battery systems as irradiance sensors: first results of a prototype study

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In view of the rapid growth of solar power installations worldwide, accurate forecasts of photovoltaic (PV) power generation are becoming increasingly indispensable for the overall stability of the electricity grid. In the context of household energy storage systems, PV power forecasts contribute towards intelligent energy management and control of PV-battery systems, in particular so that self-sufficiency and battery lifetime are maximised. Typical battery control algorithms require day-ahead forecasts of PV power generation, and in most cases a combination of statistical methods and numerical weather prediction (NWP) models are employed. The latter are however often inaccurate, both due to deficiencies in model physics as well as an insufficient description of irradiance variability.

A promising approach to improving irradiance forecasts is to use the measured PV data themselves. In this work a novel algorithm was employed in order to infer global horizontal irradiance from measured PV data of household energy storage systems, with the goal of better characterising global horizontal irradiance (GHI) and ultimately improving irradiance and power forecasts. The inversion methods developed as part of the BMWi-funded MetPVNet project were applied to five PV-battery systems in different locations across Germany, in a pilot project sponsored by the local government of North Rhine-Westphalia (MWIDE NRW). High resolution measurements of PV power and current were used together with two different PV models in order to extract the plane-of-array irradiance. These data were then used together with both the DISORT and MYSTIC radiative transfer codes (Emde et al., 2016) to infer aerosol optical depth, cloud optical depth and irradiance under all sky conditions. The transposition of tilted to horizontal irradiance was performed with a new lookup table based on 3D radiative transfer simulations in MYSTIC.

The PV-battery systems were all equipped with irradiance sensors to provide independent measurements of both global tilted irradiance (GTI) and GHI, in order to validate the proposed inversion and transposition methods. Comparisons were also made with the irradiance predictions of the ICON-D2 weather model, the irradiance and cloud optical properties from satellite retrievals and the aerosol optical depth from the relevant AERONET stations. This work can provide the basis for future investigations using a larger number of PV-battery systems to evaluate the improvements to irradiance forecasts by the assimilation of inferred irradiance into a NWP model. In addition, the results could be used to improve the intelligent control of the storage systems in the field.

References

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