Oversizing solar heating plants in industry: A cost-effective solution to increase solar fractions

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Abstract

Numerous studies have demonstrated the significant impact of the resolution of solar irradiation data on the outcomes of hourly production models. Accurate integration of photovoltaic (PV) systems sometimes demands a high-resolution global horizontal irradiance (GHI) time series to capture the rapid fluctuations in PV power output induced by swift irradiance changes. Most of the available databases provide data at hourly resolution, leading to a lack of accuracy in PV simulations. Those existing hourly averages of global horizontal irradiance in open sources fail to represent this volatility adequately, especially when PV systems are coupled with fast ramp rate technologies. In the present work, an easy-to-use algorithm is implemented to synthesize high-resolution GHI time series from hourly averaged and clear sky irradiance datasets. By employing Linear interpolation, a technique that helps to achieve the desired time resolution and afterward computing critical factors, the algorithm identifies periods characterized by short-term weather phenomena, thus creating a high-resolution time series that accurately represents these dynamics. Avoiding the probabilistic components and machine learning techniques conserves computational power and reduces calculation time, but this comes at the cost of reduced fidelity in reproducing the results. Improving accuracy in PV simulations is not always directly related to reproducing real phenomena, but enhancing the amount of information contained in the data is sufficient. This study's approach enhances user-friendliness and facilitates seamless integration into existing energy modeling frameworks, aiming for representation with sub-hourly time steps. The algorithm's effectiveness is demonstrated by applying the model to hourly averaged data to revert them to a one-minute time step, and finally comparing the synthetically produced one-minute GHI data to the original measured data. The comparative analysis between synthesized and measured data demonstrated a strong agreement, with normalized mean bias error (MBE) values ranging between 1.8% and 9.6% and normalized root mean square error (NRMSE) values between 2.7% and 16.1%, depending on weather conditions. Additionally, the coefficient of determination (R) consistently remained above 0.64. Successful algorithm validation makes our algorithm suitable for use in meteorological datasets and locations, with similar climatic characteristics.

Keywords: Global horizontal irradiance, Solar integration, Downscaling synthesis, Minute time resolution, Data validation, Solar-to-hydrogen coupling

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