

Predictability Assessment of Photovoltaic Solar Energy Production with Analog Ensemble

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Photovoltaic solar energy production is highly subjective to weather-dependent conditions such as ambient temperature changes and cloud formations. Therefore, predictions of the actual power generation from solar farms and panels can be volatile due to its intermittent nature. Furthermore, aside from the meteorological factors, the anthropogenic climate change and conditions of the power facilities are making the prediction even harder. This is challenging when integrating such a form of renewable energy source to the operation power grid as the power supply is not fully controlled and its high variability increases the operational cost of the power grid.

Ensemble simulations are usually carried out to better understand the predictability of meteorological factors. Run at high resolutions, ensemble simulations provide a range of possible scenarios with increased prediction accuracy but at a higher computational cost. However, the missing linking lies between the modeled global horizontal irradiance and the actual power generation. As mentioned above, other factors such as conditions of the facilities and the setup of the panels can differ greatly from place to place which also impacts the ultimate power generation. To improve the status quo of integrating renewable energy into the operational power grid, the missing link should be made to understand how meteorological and non-meteorological factors, as a whole, affect the predictability of solar power generation.

This interdisciplinary work focuses on assessing the predictability of photovoltaic solar energy production over the continental US. Meteorological forecasts are collected from WRF-NAM and then fed into Analog Ensemble, which is a technique to transform a deterministic model simulation into a simulation ensemble purely based on archived historical forecasts and the corresponding observations. Analog Ensemble does not require extra model simulations, and therefore, it is efficient and highly desired when the weather model is computationally expensive. The photovoltaic energy system is modeled using the System Advisor Model from National Renewable Energy Laboratory. It facilitates a wide range of solar panel setup and decision-making processes. The goal of this work is to gain insights into how predictable different regions in the US are and how to optimize the predictability and the power generation using state-of-the-art technologies.

Keywords: Solar Energy, Ensemble Modelling, Predictability, Renewable Energy, Analog Ensemble