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Distribution Strategies for Solar and Wind Renewables in NW Europe

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Whilst the UNFCCC Paris Agreement Climate change was ratified in November, 2016 saw the highest global temperature anomaly on record at 1.2°C above pre-industrial levels. As such there is urgent need to reduce CO_2 emissions by a move away from fossil fuels and towards renewable electricity energy technologies. As the principal renewable technologies of solar PV and wind turbines contribute an increasing fraction to the electricity grid, questions of cumulative intermittency and the large-scale geographic distribution of each technology need to be addressed.

In this study our initial emphasis is on a calculation of a relatively high spatial resolution (0.1° × 0.1°) daily gridded dataset of solar irradiance data, over a 10 year period (2006-2015). This is achieved by coupling established sources of satellite data (MODIS SSF level2 instantaneous footprint data) to a well-validated radiative transfer model, here LibRadTran. We utilise both a morning and afternoon field for two cloud layers (optical depth and cloud fraction) interpolated to hourly grids, together with aerosol optical depth, topographic height and solar zenith angle. These input parameters are passed to a 5-D LUT of LibRadTran results to construct hourly estimates of the solar irradiance field, which is then integrated to a daily total. For the daily wind resource we rely on the 6 hourly height-adjusted ECMWF ERA-Interim reanalysis wind fields, but separated into onshore, offshore and deep water components.

From these datasets of the solar and wind resources we construct 22 different distribution strategies for solar PV and wind turbines based on the long-term availability of each resource. Combining these distributions with the original daily gridded datasets enables each distribution strategy to be then assessed in terms of the day-to-day variability, the installed capacity required to maintain a baseline supply, and the relative proportions of each technology.

Notably for the NW European area considered we find that distribution strategies that only deploy renewables in regions with the highest annual mean irradiance or wind resource, also minimise the total required installed capacity and typically exhibit the smallest output range. Further in the majority of strategies we find that the onshore and offshore wind resource fractions fall to zero with the wind contribution being fully composed of deep water installations. Only as the strategy is to increasingly concentrate each technology in areas with the highest annual mean resource do firstly offshore, and then onshore wind, contribute.