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Linking meteorological conditions to extreme power system impacts

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There is a global increase in the use of renewable generation to meet carbon reduction targets, with technologies such as wind power and solar power expected to play a key role in future power systems. The intermittent nature of renewable generation makes power systems significantly more difficult to control, and increasingly dependent on meteorological patterns, ranging from the synoptic-climate scale. This study investigates the meteorological conditions associated with three GB power system impacts, and how the conditions associated with these impacts change with increasing amounts of installed wind power generation.

Multi-decadal time series of meteorological re-analysis data are combined with a simplistic representation of the GB power system, of which the weather-dependent components are hourly electricity demand and hourly wind power production. Multiple GB power system scenarios are analysed, including 0GW, 15GW, 30GW, and 45GW of installed wind power generation. A Load duration curve framework is used for analysis, from which Total Annual Energy Requirement (TAER), peak demand and wind power curtailment are calculated. The meteorological conditions associated with extremes in each metric are then assessed.

In a system with no wind power generation years of extreme TAER are associated with anomalously low near-surface temperatures over central and Northern Europe. As the amount of wind power generation is increased, TAER transitions from being dependent on near-surface temperatures to near-surface wind speeds. TAER is also shown to be related to the phase of the NAO. Peak load and wind power curtailment are related to particular synoptic conditions occurring on the timescale of days. The specific conditions are dependent on the amount of wind power capacity installed on the system. This study allows for the improved use of seasonal forecasts of near-surface temperature, wind speed and the NAO within the energy sector.