The importance of Climate Variability for a weather-dependent GB power system.

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The increased use of weather-dependent renewable generation in the power system of Great Britain (GB) is resulting in the system becoming more weather sensitive. The impact of weather, on power supply is an area which must be well understood if renewable generation is to be used to meet ambitious carbon targets. Here we investigate the impact of inter-annual climate variability on the GB power system and the meteorological drivers which can be associated with this. Further details can be found in [1].

Methodology

Meteorological reanalysis data is used to create an hourly artificial record of GB-aggregated demand and wind power from 1980-2015, based on the methods of [2] and [3]. Four wind-power capacity scenarios are considered: 0GW, 15GW (approximately current), 30GW and 45GW (based on 2025 and 2035 respectively from National Grid's Gone Green scenarios).

36 demand-net-wind time series are created by subtracting each years wind power from its demand. The resulting time series are interpreted through a load duration curve (LDC) framework. A LDC can be thought of a cumulative frequency distribution, showing the percentage of the year that a given load threshold is required (see example in **Figure 1**).

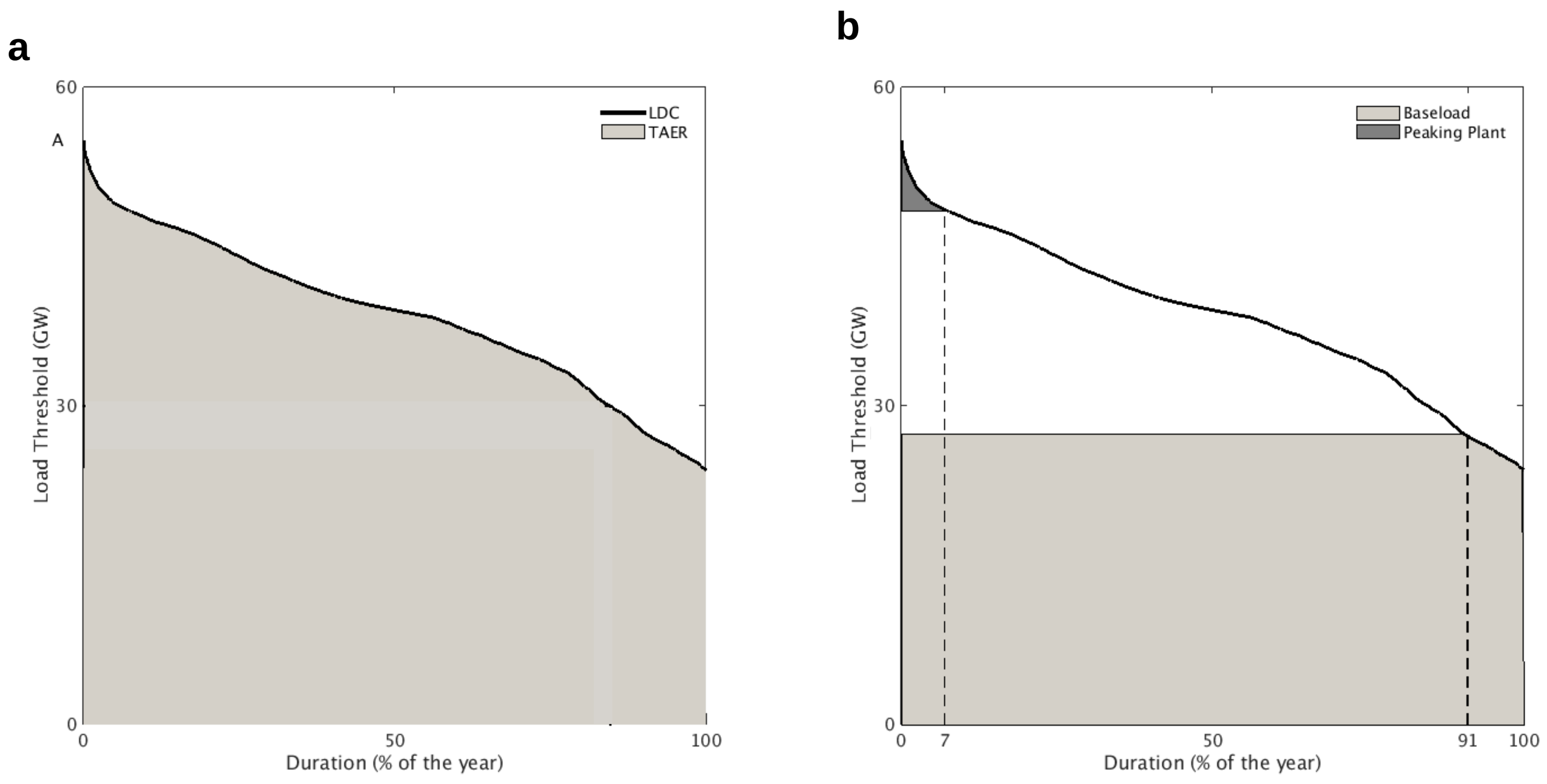

Figure 1. Power system metrics. In each curve, the solid black line is a single years LDC. Metrics illustrated are: (a) Total annual energy requirement (shading) with point A marking peak load. (b) peaking-plant and baseload plant total energy requirements (dark and light shading respectively).

Metrics for GB power system analysis

Total annual energy requirement (TAER): The total energy required by the power system each year (TWh) this is calculated as the area under each LDC.
Curtailment: The number of hours where wind power generation is greater than demand.

Peak load: The maximum value of demand-net-wind for each year, calculated as the maximum of each annual LDC.

Peaking plant requirement: The amount energy (GWh) required from plant operating up to 7% of the year. This is represented by the dark shaded area in Figure 1b.

Baseload plant requirement: The amount of energy (GWh) required from plants that operate for over 91% of the year. This is represented by the light shaded area in Figure 1b.

Figure 2 shows that inter-annual variability causes large impacts on the GB power system. For example in the 0GW scenario a 6.2TWh range of TAER is seen. The magnitude of the impact increases in a system with high levels of wind power, with the range in TAER increasing 7-fold to 45.7TWh when there is 45GW of installed wind power.

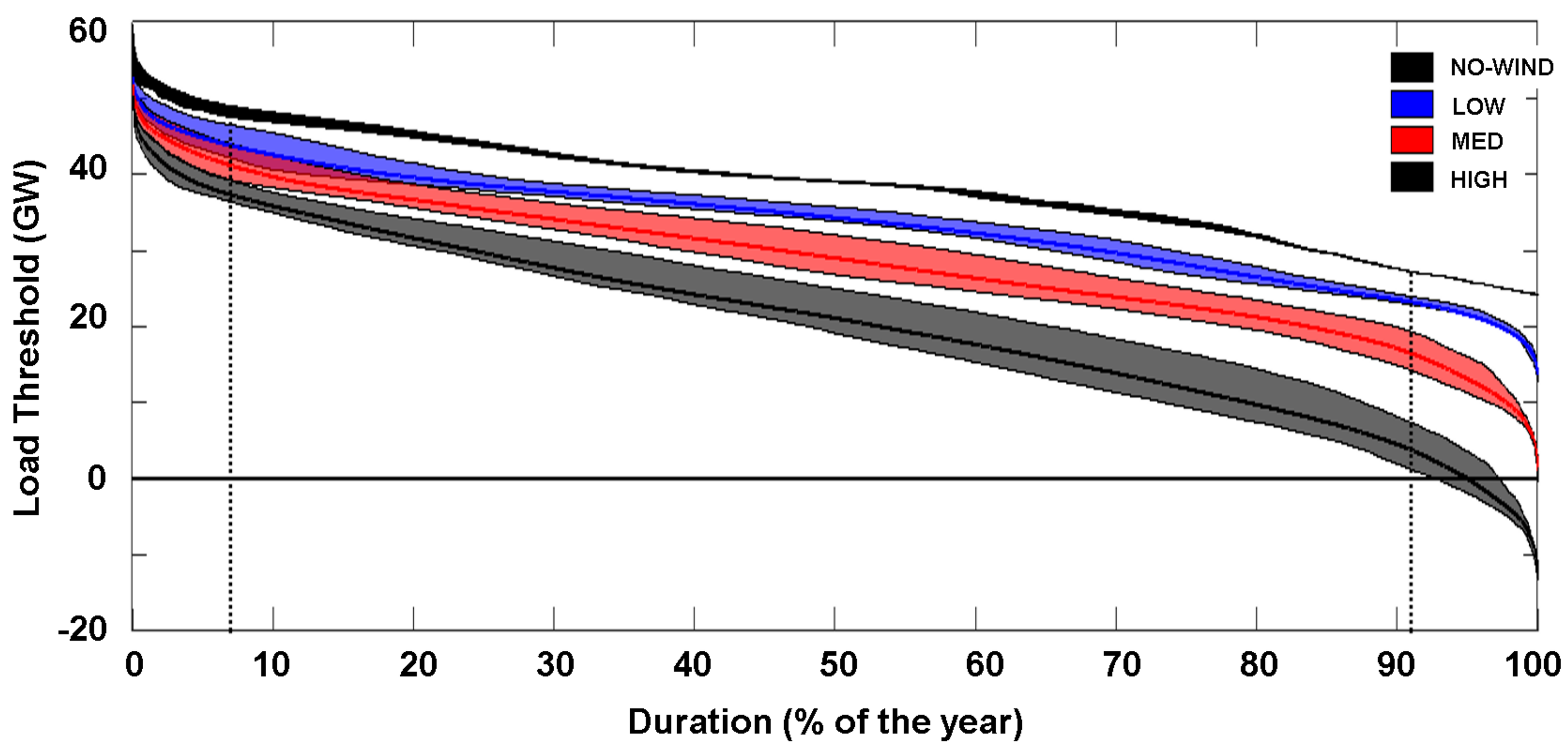

Figure 2: LDC's assuming 0GW, 15GW, 30GW, and 45GW of installed wind power capacity in black, blue red and grey respectively. Thick lines mark the mean LDC from each scenario with the shading showing the bounds of the two most extreme years. Vertical dashed lines show the threshold for peaking plant operation (7%) and baseload plant operation (91%).

Meteorological Drivers of LDC variability

The meteorological drivers of the behaviour of all of the metrics have been investigated. **Figure 3** demonstrates the results for TAER.
Here we see the large temperature anomaly (difference between the temperatures in the lowest and highest six years of TAER) in the system with 0GW of wind power which is reduced when 30GW of wind power is present on the system. The opposite is seen for 10m wind speed.

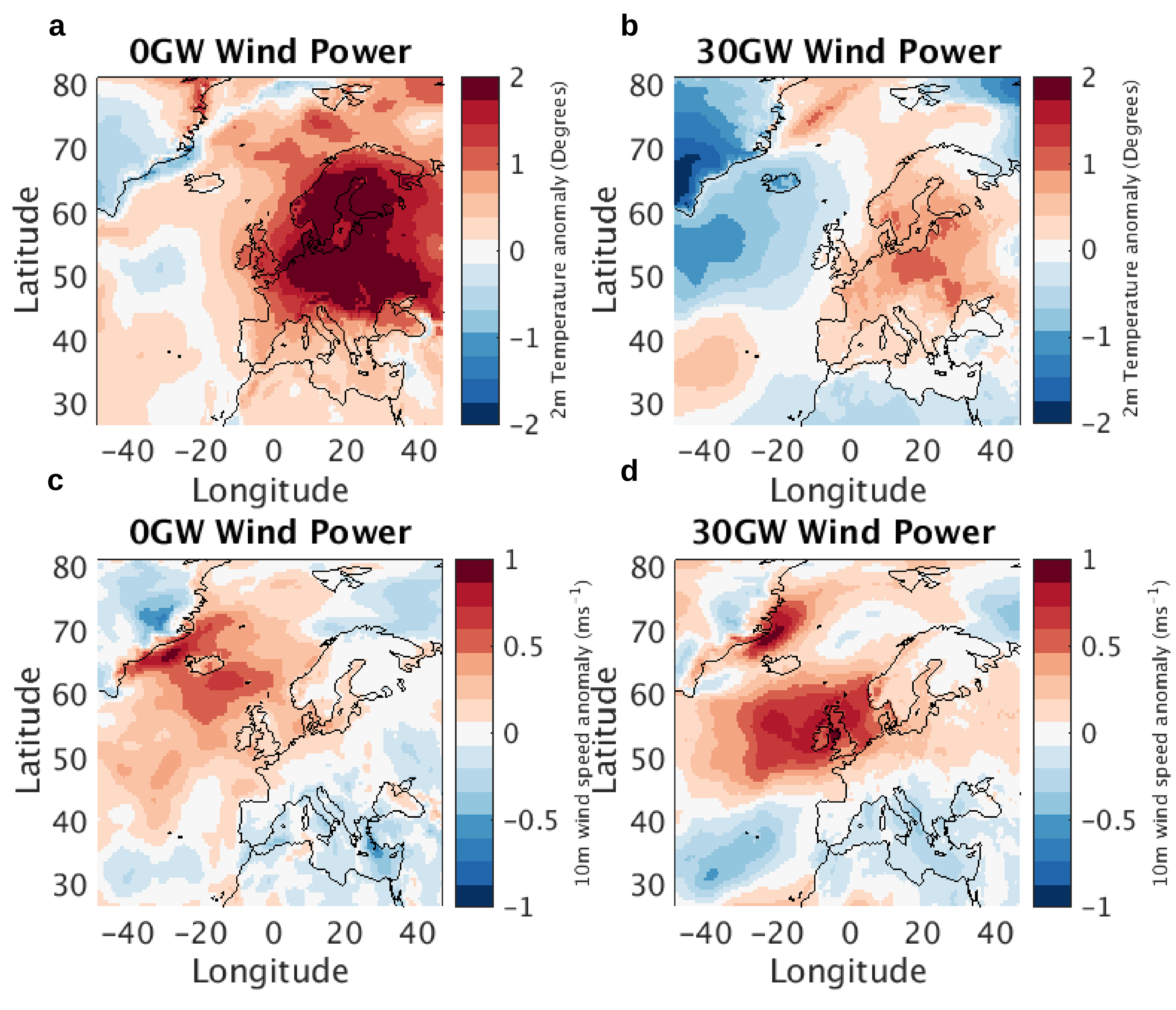

Figure 3: Composites of annual meteorological fields for the six lowest TAER years – six highest TAER years for (a) 2m temperature anomaly in a system with 0GW of wind (b) 2m temperature anomaly in a system with 30GW of wind power. (c) 10m wind speed anomaly in a system with 0GW of wind (d) 10m wind speed anomaly in a system with 30GW of wind power.

Conclusions

Using a LDC approach it has been shown that the GB power system is strongly impacted by inter-annual climate variability. The influence of variability becomes more evident when more renewable energy is present on the system.

The observed variability of the chosen power system metrics can be explained by meteorological drivers.

References

1. Bloomfield et al., (2016) Nature Energy (in review)
2. Cannon et al., (2015) Renewable Energy 75(1) 767-778
3. Taylor and Buizza (2003) International Journal of Forecasting, 19 (1), 57-70.