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Wind power, weather and climate: understanding the meteorology of peak demand and the affects of low-frequency atmospheric variability

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Securing a reliable supply of electricity that is sufficient to meet demand is a vital concern for modern economies. With the growing reliance on renewable energy generation systems (particularly wind), it is important to understand the impact of weather on the statistical properties of both the supply of and demand for electricity. Furthermore, this meteorological impact on energy systems must be understood at timescales ranging from "weather" (variations on daily timescales or less) through to "climate" (monthly, seasonal or longer).

At the day-to-day level, much of the discussion in the UK has focussed on the question of peak demand, i.e. what contribution can wind-power make during very high demand periods? Previous studies making direct use of recent demand data have reached very different conclusions in addressing this question (c.f., Sinden 2007 and Oswald et al 2008), and the meteorological situation corresponding to these UK peak-demand events therefore remains rather unclear. This paper presents results from a new study using European weather-classification tools to understand the meteorological context for peak demand, identifying the most relevant weather-types for wind statistics under peak-demand. It is shown that the prevailing view of an anti-cyclonic "low-wind cold-snap" (Gross et al 2006) does not adequately describe peak-demand conditions.

At longer timescales (monthly, seasonal and decadal), wind speeds over Europe and the UK are strongly influenced by large-scale low-frequency climate variations, such as the North Atlantic Oscillation (NAO). These large-scale variations are demonstrated to be capable of yielding a difference in mean wind-power generation of up to 10% in the UK, and affect the probability of experiencing low-wind events at timescales ranging from hours to seasons (e.g., the low-winds and cold-temperatures in Northern Europe during winter 2009/10 were associated with a strongly negative phase of the NAO). It is demonstrated that these slow variations must be taken into account when assessing the statistics of wind-resource both in terms of long-term expectation of power output, but also when assessing the likelihood of experiencing short-term very low-wind conditions. A simple method for exploiting low-frequency atmospheric variability to produce enhanced forecasts of mean wind-power output at month-ahead lead times is demonstrated.