Application of hydrological droughts pooling procedures on low wind power generation events in the UK

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Given the growing proportion of wind energy in the UK energy mix, prolonged periods of low wind power generation have come to be recognized as one of the biggest challenges in fully de-carbonising the country's electricity system. Their significance has attracted a growing body of research investigating the frequency and duration of these events by using Runs Analysis [Cannon et al. 2015, Patlakas et al. 2017], a technique that is commonly used in thequantification of hydrological droughts. However, such a technique has major drawbacks, most notably its inadequacy in dealing with excess events i.e., short periods of high wind power which divide low periods of wind power into several mutually dependent events, leading to anunderestimation of the impacts and duration of low wind power events on the electricity system. Therefore, using insights from the characterisationof hydrological droughts, we propose the application of Pooling Procedures to improve the quantification of low wind power events in the UK.

In this study, the ERA5 reanalysis wind speed dataset from 1950 to 2021 was used to simulate an hourly time series of nationally aggregated wind capacity factor in the UK based on the 2022 distribution of wind farms, assumed to be constant through the analysis. Theresultant modelled time series was found to be well-correlated with actual wind power output data from National Grid ESO. This 72-yeartime series was then used to quantify low wind power events by: first applying Runs Analysis, using a number of capacity factor thresholds; and second, applying commonly used Pooling Procedures namely, the Inter-event Time method, the Moving Average method, and the Sequent Peak Algorithm method [Fleig et al. 2006] to the capacity factor time series. Furthermore, to address the limitations of these procedures, modifications were also made to the Inter-event Time method, whereby percentage values were used as the pooling parameter, and to the Sequent Peak Algorithm method, whereby short drought events following a major drought event were taken into account.

Applying these Pooling Procedures on the UK wind capacity factor time series yielded a number of novel insights, the most important of which is that the pooling of mutually dependent low wind power events led to a significant decrease in the annual frequency of low wind power events and a significant increase in the mean and maximum length of events. This was largely due to the identification of mutually dependent events that are longer than 24 hours as a result of pooling. For example, the longest low wind power event according to a capacity factor threshold of 0.1 extended beyond 25 days after pooling as opposed to the 8 days before pooling. This suggests that previously reported frequency and duration of low wind power events may significantly understate the severity of such events and hence, these findings have important implications on the time-series-based assessment of energy storage requirements in an increasingly renewable electricity system.