Title: Investigation of large offshore wind turbine power performance in varying incident wind conditions, such as turbulence and shear.

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Background:

Wind turbine output is predicted in yield assessments using site wind speed data and the specified power curve(s) of the wind turbines proposed. However, it is known that other characteristics of the wind, particularly the vertical wind shear profile and the turbulence level, can cause deviations from the expected power output. These variations due to incident conditions are typically addressed through the application of a site-specific power curve (SSPC) factor. The current basis for such factors is currently rather limited and largely based on experiences and published findings from smaller scale onshore turbines in short term tests. The dynamic response of large-scale offshore wind turbines to incident wind conditions is important to understand and quantify better in energy predictions going forward. The expanding deployment of nacelle mounted LiDAR wind measurements for power performance studies in recently constructed projects offers a real opportunity. It is possible to begin to compile targeted relevant results from investigations using these new data to better inform future predictions.

Objectives:

This master's thesis project will require access to RWE's wind farm power performance test data from the most recent and relevant constructed projects. It will include use of nacelle mounted LiDAR wind data and wind turbine operational SCADA data. The student will work to interrogate these data for power performance under different incident shear and turbulence conditions whilst correcting for other influential parameters (e.g., density). The aim will be to create power performance matrices that can be tailored to variable power curve validity ranges and can potentially be used in the future prediction of performance losses in energy yield assessments. The work should consider the continued growth and aggregation of these input data from future suitable projects. There should be some assessment of the variability and uncertainties involved and the minimum volume of input data required for robustness. The effects should be compared and contrasted to existing published findings. The student will receive first-hand experience of working in the wind energy industry with the latest data from large-scale operational projects.

More background:

The Power Curve Working Group (PCWG) (PCWG > Power Curve Working Group) has done quite some work to assess the sensitivity of wind turbine power curves to the wind conditions and surroundings. The PCWG had the benefit of a large number of datasets but was limited by the parameters available to study from the turbine SCADA data of typically smaller scale onshore turbines and typically of short duration (power curve tests). The idea in this project is to dig deeper into to a much smaller number of detailed and good length measurements from large scale offshore relevant turbine types. This should allow deeper understanding of the differences caused by the geometric scale, control behaviour and specific power compared to the PCWG results. It will be possible to look in more detail at seasonal influences and study shear and turbulence intensity separately (rather than together as done by the PCWG). It may be possible to include directional veer. It is acknowledged that the reliance on a limited number (possibly 2-5) turbine types will limit the general applicability of the findings but should give useful insights regarding how different larger scale turbine results are compared to the PCWG findings, the key sensitivities, and methods to use to best parameterise the different effects on performance.

Figure 1: Galloper Offshore Wind Farm where the data are collected [1].

References:

[1] Rwe. (0001, January 01). RWE. Retrieved from https://uk.rwe.com/locations/galloper-offshore-wind-farm