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THE MODELING AND OBSERVATION OF THE LONG-TERM OFFSHORE VERTICAL WIND PROFILE AND WIND SHEAR

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Introduction

The North Sea is the most promising offshore area for continuing with the development and harvesting of wind energy in Europe and also the region where most of the offshore wind farms are planned to be installed [1]. With the purpose to assess wind resources and validate results from numerical weather prediction models (NWP) over the North Sea, vertical profiles of wind speed and direction have been observed from a network of wind lidars installed at fixed offshore platforms and oil rigs as part of the EU FP7 NORSEWInD project.

Approach

The wind lidars are velocity-azimuth-display scanning units able to observe winds at 10 simultaneous levels in the range between 40 and 300 m above the instrument (a.i.), in the case of the pulsed wind lidars, and at 5 non-simultaneous levels between 20 and 160 m a.i., in the case of the continuous wave wind lidars. This allows us to study the temporal and vertical variation of the wind speed, direction and at some degree of turbulence (the wind lidars measure wind characteristics within a much longer volume compared to that of the cup and sonic anemometers and thus they filter the turbulence). These observations lead to more accurate wind power estimates, since we do not only measure the wind speed at hub height over a long period (the so-called long-term), but also its vertical variation (wind shear) and the vertical variation in wind direction (wind veer) [2]. In this fashion we are able to estimate the long-term wind speed and direction profiles.

Main body of abstract

We find that the wind profile shape, and therefore the wind shear, observed over heights' ranges were large offshore wind turbines operate can vary considerably. This mainly depends on atmospheric stability and on the measuring height among others. From our results it is very clear that the current wind engineering commonly-used wind shear norms and standards seem to be far too optimistic and not very conservative.

Conclusion

We derive the long-term wind profile and wind shear at each specific offshore location. Since we do not have atmospheric stability measures at many of the wind lidar locations, we make use of the advanced weather research and forecast (WRF) NWP model to estimate the surface turbulent fluxes and thus atmospheric stability. WRF, which is proven to estimate well the long-term characteristics of atmospheric stability at the Horns Rev offshore wind farm [3], is used to compute the long-term stability correction of the long-term wind profile based on similarity theory [4]. When the analysis is performed based on the traditional diabatic wind profile models, there is generally an overestimation of the long-term wind resource. Such overestimation is avoided by using wind profile parameterizations, like those in [5], that include the boundary-layer height as a scale parameter.

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