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Atmospheric impacts on power curves of Multi-Mega Watt offshore wind turbines

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Europe's Offshore wind capacity is expected to grow up to a total of 130 Gigawatt in the year 2030. Wind farms of several 100 Megawatt per wind farm are planned, most of them concentrated at single locations, mainly in the Southern North Sea. This can pose a threat to the electrical grid as changing atmospheric flow properties result in intense wind power fluctuations.

Multi-Mega-Watt turbines are subject to an unsteady vertical wind profile within the marine atmospheric boundary layer. Fluctuations in these wind profiles can cause a high variability to power curves of wind turbines. Also for the modeling of wind turbine wakes and their loads on subsequent turbines in a wind farm, an enhanced understanding of the atmosphere-turbine interaction in the marine boundary layer is essential.

For these purposes we investigated boundary layer characteristics as shear and turbulence intensity for the offshore research platform FINO1. A main focus was their influence on power curves of wind turbines in the nearby offshore wind farm 'alpha ventus'. For offshore wind turbines the influence of stability on power production has hardly been investigated.

The influence of shear and turbulence intensity was first investigated for wind turbines at the edge of the alpha ventus wind farm for non-wake situations. In a second step the influence of these parameters on the power production of a wind turbine in single and double wakes (AV04, AV05, AV06) of others was studied. The wake - power curves showed a higher dependency on shear and turbulence intensity than in the non-wake case. In the (low-shear) second half of the year 2011 up to 20% difference in power production between stable and unstable stratification for in-wake wind turbines at the same wind speed occurred. During strong shear (stable stratification) less power was produced than during times of low shear. The highest influence on the power curve was found in the 'concave' region before rated power. In the non-wake case, the differences in between stability regimes were lower (up to about 10% between stable and unstable stratification).

Results from this research can lead to a better understanding of available power in different atmospheric conditions as well as to an improved wind turbine control for a better integration in the electrical grid.