Wake development and interactions within an array of large wind turbines

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Abstract

The investigation of wake development and wake interactions within an array of large wind turbines is a key objective in the EnFlo Wind tunnel laboratory contribution to the **SUPERGEN V - Wind Energy Technologies** project. Extracting energy from the wind, the turbine wake is generally characterised by reduced wind speeds and increased levels of turbulence. Within a wind farm array, the effects of several wakes interact. Thus, the turbines produce less energy and stand greater structural loads than single turbines placed in the free stream (see e.g. Burton et al. (2002); Vermeer et al. (2003)). Current prediction models need improving for these large machines.

Two primary mechanisms determine the decrease of momentum deficit in the wake of a wind turbine: mechanical turbulence generated by the turbine itself, which is controlled by the turbine design and performance and usually is of a relatively high frequency and small scale, and the turbulence level in the ambient atmospheric boundary layer (ABL) flow. With the latter being controlled by terrain roughness, topography, stratification, etc., the characteristic length scales as well as spectral characteristics of these two interacting mechanisms are quite different. Moreover, the quantitative effect of the interactions change as rotor size increases.

Wake characteristics, development and interactions will be studied in the large EnFlo wind tunnel ($L \times W \times H$: $20 \times 3.5 \times 1.5$ m) for two different machine sizes: 5 MW with a rotor diameter of 126 m and a hub height of 90 m and 2 MW with a rotor diameter of 75 m and a hub height of 65 m. At a model scale of 1:300 up to five 5 MW model turbines (eight 2 MW machines respectively) will be arranged successively in the test section as shown in Figure 1. The planned case studies comprise off-shore ABLs for neutral and non-neutral conditions as well as a rural neutrally stratified ABL over different terrain (from flat to steep). The wake measurements will be made using LDA, including phase-locked measurements to separate ordered motion from genuine turbulence.

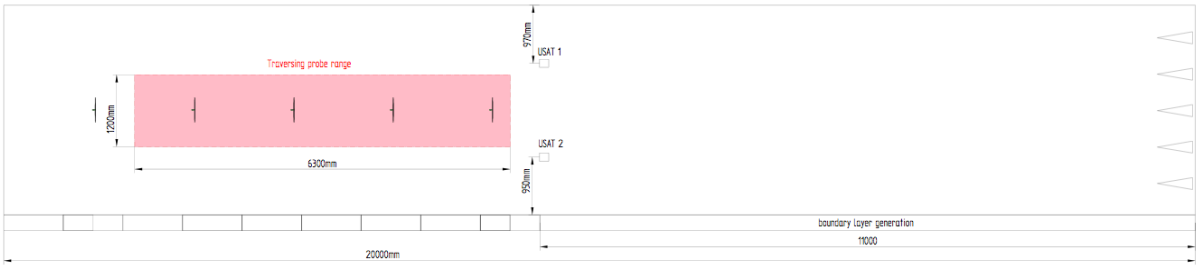

Figure 1: Model set-up for the 5 MW turbine array (topview). Flow from right to left, shaded area indicates the probe traversing range.

References

Burton, T., D. Sharpe, N. Jenkins, und E. Bossanyi, 2002: *Wind Energy Handbook*. John Wiley & Sons, Ltd.

Vermeer, L., J. Sorensen, und A. Crespo, 2003: Wind turbine wake aerodynamics. *Progress in Aerospace Sciences*, **39**, 467–510.