Spacing dependence on wind turbine array boundary layers

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Wind tunnel experiments of a 4 X 3 model wind turbine array are carried out to understand impact on the flow field and turbulence statistics due to the changes in turbine spacing. Stereoparticle Image Velocimetry (SPIV) is used to obtain measurements in dual planes, fore and aft of wind turbine models in the centerline of the array. The mechanical power was also obtained independently via the use of a torque sensor. Variations in turbulence statistics are assessed by altering the streamwise and spanwise spacing. Spacing schemes tested include permutations of streamwise spacing, \( S_x = [3D; 6D] \), and spanwise spacing, \( S_z = [1.5D; 3D] \), where \( D \) is the rotor diameter. The kinetic energy flux, \(<u v>U\) and production of mean kinetic energy are also obtained. Wakes of continued interest in wind energy studies.

Furthermore, the mechanical power is measured for these turbines reflecting the influence of spatial variations. The analysis has consequences on land use versus power output. There is a clear effect of the wake into the preceding turbines from the previous when the spacing is decreased. This corresponds to a decrease in power. The wakes are not fully recovered by three diameters downstream thus this has a profound effects on the power extracted by the turbine. These effects are also found in the kinetic energy flux and production terms, where the largest magnitudes of these quantities occur for cases A and D containing the largest streamwise spacing. It is also found that the spanwise spacing plays a role in affecting all the analyzed quantities but not with the same severity as the streamwise spacing. This analysis allows to observe the direct impact on power production and how this relates to quantities contained in the equations of mean momentum and kinetic energy.