Roughness Effects on Wind-Turbine Wake Dynamics in a Boundary-Layer Wind Tunnel - DTU Orbit (08/11/2017)

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Increasing demand in wind energy has resulted in increasingly clustered wind farms, and raised the interest in wake research dramatically in the last couple of years. To this end, the present work employs an experimental approach with scaled three-bladed wind-turbine models in a large boundary-layer windtunnel. Time-resolved measurements are carried out with a three-component hot-wire anemometer in the mid-vertical plane of the wake up to a downstream distance of eleven turbine diameters. The major issue addressed is the wake dynamics i.e. the flow and turbulence characteristics as well as spectral content under two different neutral boundary-layer inflow conditions. The wind tunnel is arranged with and without roughened surfaces in order to mimic moderately rough and smooth conditions. The inflow characterization is carried out by using all three velocity components, while the rest of the study is focused on the streamwise component's evolution. The results show an earlier wake recovery, i.e. the velocity deficit due to the turbine is less persistent for the rough case due to higher incoming turbulence levels. This paves the way for enhanced mixing from higher momentum regions of the boundary layer towards the centre of the wake. The investigation on the turbulent shear stresses is in line with this observation as well. Moreover, common as well as distinguishing features of the turbulent-scales evolution are detected for rough and smooth inflow boundary-layer conditions. Wake meandering disappears for rough inflow conditions but persists for smooth case with a Strouhal number similar to that of a solid disk wake.

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