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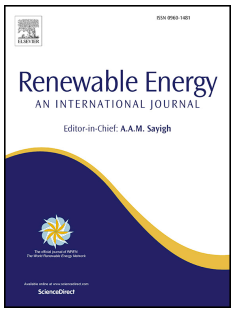

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Development of coherent motion in the wake of a model wind turbine

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Abstract

An experimental investigation of the first five diameters of the wake behind a 0.9m diameter model wind turbine with three blades has been undertaken. The measurements were performed at the turbine design condition, at which the tip speed ratio $\lambda_R = 6$ and the tip-chord Reynolds number $Re_c \approx 10^5$. The turbine uses the NREL S826 profile along the full length of the blades and was tested in a uniform flow with 0.24% turbulence intensity.

Measurements were taken using a hot-wire probe with four wires which is able to resolve all three components of the velocity vector. In addition to the velocity vector, the rotor position was measured simultaneously. This allowed for conditional averaging of the acquired data, which enabled the periodic and turbulent structures in the flow to be separated.

The analysis shows the development from a near wake with strong periodic coherent structures to the region where turbulent motions dominate and where a significant inertial subrange in the spectrum is identified. This transition is shown to be initiated by the mutual induction between the vortices which causes them to leapfrog within 1.75 diameters downstream of the rotor and merge into a single structure by 3 diameters.

Keywords: Model wind turbine wake, Experiment, Tip vortex

1. Background

Understanding the development of the wake behind a wind turbine is perhaps the most important key to successful wind park planning. The evolution of the wake downstream determines the location of the next turbine and inaccuracy in the predictions of the process may have severe consequences