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Laser Doppler scanning of a wind turbine wake

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Many wind turbines are today erected in wind farms and, consequently, loads from wakes are becoming more and more important. The mean wake has been studied extensively in the past due to its implications for park energy efficiency. The present study focuses on the dynamics of the wake. We present a new experimental technique for fast measurements of the wake, with the ultimate goal of improving load calculations due to wakes from upstream turbines.

The wind laser Doppler called ZephIR was developed primarily to make vertical profiles of the wind vector. Comparison with several tall, meteorological masts have already proven the instrument to be extremely accurate in this respect. We have now mounted the system on the back of the nacelle of a small wind turbine looking downwind. The telescope head of the instrument is mounted on a tilt-and-pan head to scan the wake, which enable us to study wind speed variation across the wake. One horizontal traverse of the wake takes one to two seconds and the wind speed is measured 110 times per second and under favorable condition up to 300 times per second. The instrument is focused from one to ten rotor diameters downstream making it possible to study the meandering, widening and attenuation of the wake deficit. We have have also made fast vertical scans of the wake by introducing a vibrating prism in from of the laser beam. In this mode a scan can be completed in one quarter of a second. The experimental goal is to make 2D scans of the wake having one complete scan at some fixed downwind distance scan every two seconds.

We use the experiment to test the simple hypothesis that the wake deficit is advected passively by the larger than rotor size eddies in the inflow, and that the wake at the same time widen gradually. The hypothesis is implemented in a model and a comparison is performed.