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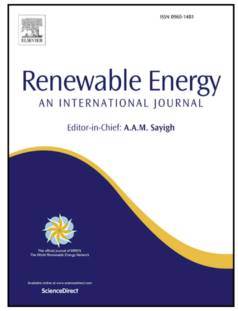

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Local wind speed estimation, with application to wake impingement detection

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Abstract

Wind condition awareness is an important factor to maximize power extraction, reduce fatigue loading and increase the power quality of wind turbines and wind power plants. This paper presents a new method for wind speed estimation based on blade load measurements. Starting from the definition of a cone coefficient, which captures the collective zeroth-harmonic of the out-of-plane blade bending moment, a rotor-effective wind speed estimator is introduced. The proposed observer exhibits a performance similar to the well known torque balance estimator. However, while the latter only measures the average wind speed over the whole rotor disk, the proposed approach can also be applied locally, resulting in estimates of the wind speed in different regions of the rotor disk. In the present work, the proposed method is used to estimate the average wind speed over four rotor quadrants. The top and bottom quadrants are used for estimating the vertical shear profile, while the two lateral ones for detecting the presence of a wake shed by an upstream wind turbine. The resulting wake detector can find applicability in wind farm control, by indicating on which side of the rotor the upstream wake is impinging. The new approach is demonstrated with the help of field test data, as well as simulations performed with high-fidelity aeroservoelastic models.

Keywords: Rotor-effective wind speed, wind speed estimation, wakes, wake detection, wind farm control

Notation

A	Rotor disk area
A_{B}	Planform area of the rotor blade
A_{S}	Area of a rotor sector
B	Number of blades
C_{m_0}	Cone coefficient
C_{P}	Power coefficient
D	Rotor diameter
$E(\cdot)$	Expected value
J	Rotor inertia

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