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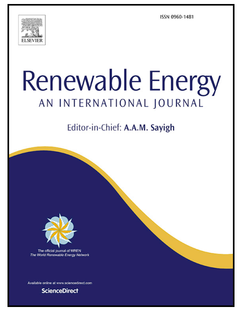

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Atmospheric stability and topography effects on wind turbine performance and wake properties in complex terrain

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Abstract

This paper evaluates the influence of atmospheric stability and topography on wind turbine performance and wake properties in complex terrain. To assess atmospheric stability effects on wind turbine performance, an equivalent wind speed calculated with the power output and the manufacture power curve is proposed and calibrated with the mast hub-height wind speed. After estimating the thrust coefficient and turbulence dissipation, this paper examines wind turbine performance curves and wake profiles segregated by atmospheric stability. Results show that the equivalent wind speed at a given mast wind speed can increase by 2% under stable conditions and decrease by 5% under unstable conditions as compared with that under neutral conditions, yielding about 16% reductions of power output and thrust coefficient from stable conditions to unstable conditions. Due to the lower thrust coefficient and the enhanced turbulence, the wind turbine wakes are found to recover faster under unstable conditions than under other stability conditions. Differences in wind turbine performance and asymmetric wake profiles due to topographic effects are also observed. Results suggest that atmospheric stability and topography have significant influences on wind turbine performance and wake properties. Considering effects of atmospheric stability and topography will benefit the wind resource assessment in complex terrain.

Keywords: atmospheric stability, wind turbine performance, thrust measurements, wind turbine wakes, complex terrain

Nomenclature

A_{wt}	sweeping area of a rotor
B	blade number
C_T	thrust coefficient
D	rotor diameter
E	Youngs modulus
f	frequency
F_T	thrust
g	acceleration due to gravity ($9.8\mathrm{m}\cdot\mathrm{s}^{-2}$)
I	second moment of area
I_u	turbulence intensity
K	transfer coefficient from strain to thrust
L	Obukhov length
M_T	bending moment at tower bottom
P	power