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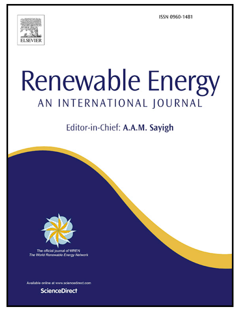

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Experimental investigation of vertical-axis wind-turbine wakes in boundary layer flow

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Abstract

In this experiment, a small scale vertical-axis wind-turbine (VAWT) is immersed in a boundary-layer in a wind tunnel and stereo particle image velocimetry is employed to quantify the 3D characteristics of the wake. The measurements show that the wake is strongest behind the sector of the rotor which turns into the wind. Two counter-rotating vortex pairs in the wake induce crosswind motion which reintroduces streamwise momentum into the wake. Terms of the mean kinetic energy budget are computed and demonstrate that this crosswind flow has a significant influence on the redistribution of momentum in the wake. A similar analysis of the turbulence kinetic energy budget identifies shearing at the boundary of the wake as the primary contributor to the production of turbulence. An analytical model is developed in order to obtain a theoretical basis from which to understand how the aerodynamic behavior of VAWTs induces crosswind motion consistent with the production of counter-rotating vortex pairs.

Keywords: Atmospheric boundary layer, Vertical-axis wind-turbine, Wind-turbine wakes, Stereo-PIV, Wind tunnel

1. Introduction

Carbon emissions produced by the consumption of fossil fuels are a major contributor to climate change, and dependence on oil combined with the volatility of oil prices is a growing source of geopolitical tension. As a result, renewable energy has become an important field of study due to its demonstrated potential as a sustainable, emission-free alternative to fossil fuels. Wind power is one of the fastest growing and most cost-efficient of the different means of producing renewable energy available today. The largest horizontal-axis wind-turbines (HAWTs) are able to generate 6MW of power and are able to extract close to the theoretically maximum energy available from the wind, making them

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