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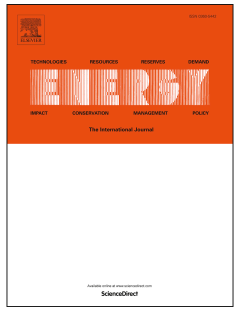

A numerical model for wind turbine wakes based on the vortex filament method

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A numerical model for wind turbine wakes based on the vortex filament method

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Abstract

A numerical wake model based on the vortex filament method is proposed to predict the velocity deficit in the wake of a horizontal axis wind turbine (HAWT). By solving the evolution of the vortex system behind the wind turbine, the model calculates the distribution of the downstream velocity indirectly with very low computational cost. Instead of the usual scheme of the vortex method, the more efficient and mature blade element momentum (BEM) theory is used for the blade aerodynamics and to initialize the calculation of the vortex system evolution. The model is tested by a published wind tunnel experiment of a miniature wind turbine. The numerical results agree well with the experimental data. It is found that the core growth of the vortex filaments due to turbulence mainly dominate the velocity deficit along the downstream distance in the wake. In addition, the generalization of the model to full-scale wind turbines is discussed and within the framework of the present model, a reasonable conclusion can be obtained: wakes of wind turbines with different scales are similar.

Keywords: HAWT, Wake model, Velocity deficit, Vortex theory, BEM

1. Introduction

Due to the growth in the size of wind farms, more and more wind turbines are working in the wakes of others. The incoming flows of them are substantially modified by velocity deficits and additional turbulence compared to the undisturbed flows, causing decreased total power output and increased fatigue loads[1]. It is estimated that the power loss due to the wake effects is between 5% and 20% of the total power output of a large wind farm[2, 3]. Thus wake effects play an important

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