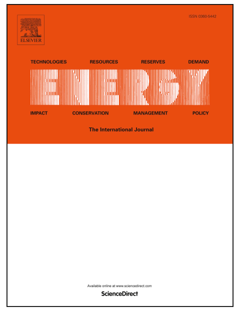

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Large Eddy Simulation of an H-Darrieus rotor

Rohit Patil[a], László Daróczy[a], Gábor Janiga[a,*], Dominique Thévenin[a]

[a]*Lab. of Fluid Dynamics and Technical Flows, University of Magdeburg "Otto von Guericke", Universitätsplatz 2, Magdeburg, D-39106, Germany*

[*]Corresponding author

Email addresses: rohit.patil@ovgu.de (Rohit Patil), daroczylaszlo@gmail.com (László Daróczy), janiga@ovgu.de (Gábor Janiga), thevenin@ovgu.de (Dominique Thévenin)

Abstract

This study primarily aims to examine the flow field around an H-Darrieus wind turbine using Large Eddy Simulation (LES). The corresponding experimental data for the validation is provided by TU Delft. As in the experiments, the turbine operates at a tip speed ratio (TSR) of 2 and a chord-based Reynolds number (Re) of 8×10^4. A dedicated block-structured mesh has been generated to perform 3D LES simulation by using the WALE subgrid model. The low TSR results in a high angle of attack and causes the turbine to experience dynamic stall, leading to particularly challenging aerodynamic conditions. Normal and tangential forces obtained by LES are compared with experimental results, leading overall to a good agreement. The quality of the LES computation is further confirmed by analyzing turbulent spectra at several locations in the simulations. Finally, vortex shedding from a single turbine blade is studied, revealing that six distinct leading-edge and trailing-edge vortex pairs form and detach during one rotation.

Keywords: wind energy, Darrieus, CFD, H-rotor, LES

Nomenclature

$F_{D/L}$	drag/lift/normal/resultant/tangential/horizontal/vertical force (N)
I	turbulence intensity
M	mach number
R	rotor radius (m)
Re	Reynolds number
u_∞	free-stream velocity (m/s)
u_v	relative velocity (m/s)
v_{tip}	blade tip velocity (m/s)
Greek symboly	
α	theoretical angle of attack ($^\circ$)
λ or TSR	tip speed ratio
μ	dynamic viscosity (Pa.s)
ρ	density (kg/m^3)
ϕ	azimuth angle ($^\circ$)
ω	angular velocity (rad/s)

1. Introduction

Over the past decades, energy consumption has dramatically increased worldwide due to continuous population growth, causing greenhouse gas emissions to climb annually. Fossil fuels currently drive