Experimental study of the flow of a Vertical Axis Wind Turbine

Wind Farm for Atmospheric Boundary Layer Control

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Background: The use of wind energy has become more significant as a viable substitute for conventional fossil fuels, primarily owing to its sustainable nature. The growing demand for renewable energy necessitates the need to optimise the efficiency and productivity of wind energy installations. The 3 bladed horizontal axis wind turbine (HAWT) has often been scaled up in recent years (Shields et al. 2021). While up-scaling has its advantages, there are significant drawbacks as well. Larger wind turbines have higher costs, and are difficult to manufacture. They also impose challenges on transportation, especially for regions with limited accessibility (Veers et al. 2023). Considering such reasons, alternative technologies are being considered. One such technology being considered is the Vertical Axis Wind Turbine (VAWT).

Problem Statement: Ming studied the possibility of vertical movement of wake in H rotor VAWTs, based on blade pitching (Huang 2023). However, the study was conducted on the interaction of the wake of a single wind turbine on another. In real world conditions the wake of all surrounding upwind turbines would influence the downwind turbines. This negative effect needs to be controlled for maximum energy extraction from downstream turbines, and determine the optimal layout of the wind farm.

Objective: The thesis aims to study the flow of a wind farm of nine H-rotor Vertical Axis Wind Turbines, using Particle Tracking Velocimetry in the Open Jet Facility (OJF) tunnel. The research objective is to experimentally test the hypothesis of vertical entrainment of low momentum energy from VAWTs and its hypothetical implementation for atmospheric boundary layer control.

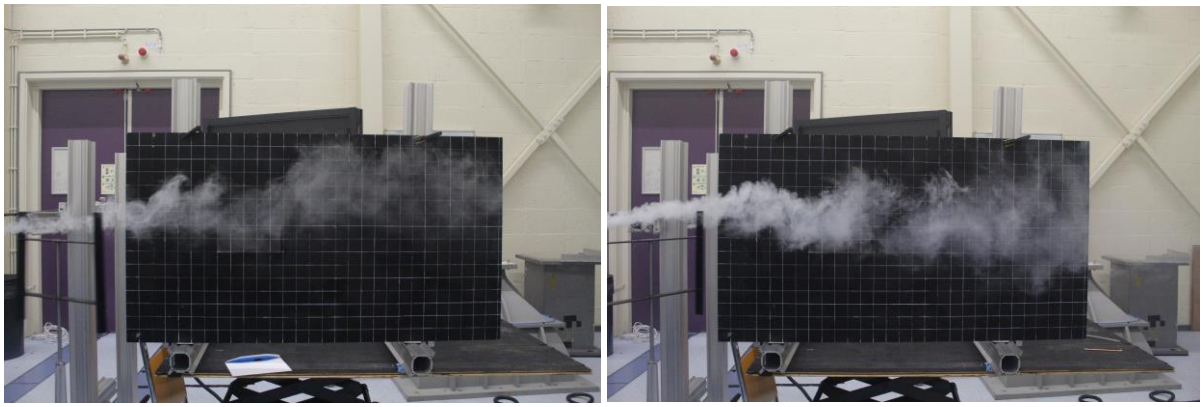

Figure a: -10 ° pitch *Figure b: +10 ° pitch*

Figure 1: Smoke visualization of pitched H-VAWT wake

Matt Shields et al. “Impacts of Turbine and Plant Upsizing on the Levelized Cost of Energy for Offshore Wind”. In: *Applied Energy* 298 (Sept. 2021), p. 117189. ISSN: 03062619. DOI: 10.1 016/j.apenergy.2021.117189

P. Veers et al. “Grand challenges in the design, manufacture, and operation of future wind turbine systems”. In: *Wind Energy Science* 8.7 (2023), pp. 1071–1131. DOI: 10.5194/wes-8-1071-2023.

Huang, M. (2023). Wake and wind farm aerodynamics of vertical axis wind turbines. https://doi.org/10.4233/uuid:14619578-e44f-45bb-a213-a9d179a54264