Abstract Submitted
for the DFD20 Meeting of
The American Physical Society

Large-Eddy Simulations of a Cross-Flow Turbine with Intracycle Angular Velocity Control[1] MUKUL DAVE, University of Wisconsin-Madison, BENJAMIN STROM, XFlow Energy Company, Seattle, WA, ABIGALE SNORTLAND, OWEN WILLIAMS, BRIAN POLAGYE, University of Washington, JENNIFER FRANCK, University of Wisconsin-Madison — Straight-bladed cross-flow turbines have certain advantages over axial-flow turbines such as no need for yaw control and ease of manufacturing and maintenance. Experiments and Reynolds-averaged Navier-Stokes (RANS) simulations have shown that optimized sinusoidal variation of angular velocity, instead of a constant angular velocity through the turbine rotation, increases the power conversion efficiency by up to 54%. The relative flow velocity and effective angle of attack profile experienced by the blade are modified, hence also controlling the flow separation at the blade. High resolution visualization of flow structures is difficult in experiments, while RANS modeling has limitations in separating flows and at moderate Reynolds numbers. Hence large-eddy simulations (LES) are performed to investigate the effect of intracycle variation of angular velocity on the flow separation and vortex dynamics. The computed flow field is validated with particle image velocimetry (PIV) data from an experiment using a constant angular velocity turbine. The flow field for a sinusoidal angular velocity turbine is analyzed in terms of flow separation at the blade, the blade-vortex interactions, and their effect on turbine performance.

[1]University of Washington researchers were supported by the U.S. Department of Defense Naval Facilities Engineering Command.

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Date submitted: 06 Aug 2020 Electronic form version 1.4