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Leveraging Passive Shape Morphing for Wind Energy Conversion

Short Abstract: Aerodynamic systems are designed to optimally operate at a given set of conditions, sometimes called the design point. When conditions stray from this point, system efficiency can suffer, making off-design operation a significant area of concern for engineers. This fact has given rise to adaptable geometries which use rigid body motion to increase performance and/or provide enhanced maneuvering abilities. A few examples of this include hinged flaps and ailerons for aircraft, and pitch control mechanisms for wind turbines.

However, any casual observer watching birds in flight, or dolphins in motion, will notice an absence of controlled rigid body movement. These organisms exhibit something different: continuous deformation of the fluid-solid interface which can allow for better management of flow fields, reducing drag and mitigating losses associated with vortex formation. Propulsive efficiencies of many swimming organism remain far superior to artificial means, suggesting that passive, large-deformation flexibility could be incorporated *into* the design process to increase aerodynamic efficiency.

This presentation addresses the use of the passive shape morphing to increase wind turbine performance. Flexible-bladed wind turbine simulations and experiments are discussed for both horizontal and vertical-axis configurations, with special emphasis on open-source, finite-volume fluid-structure interaction algorithms developed for this study. Future work in this facet and other related research thrusts are also discussed.

Bio: Dr. David W. MacPhee is an Assistant Professor of Mechanical Engineering at the University of Alabama. He received his PhD in Engineering Sciences from the University of California, San Diego in 2014. He is the Assistant Director for the Alabama Industrial Assessment Center and Director of the Alabama Rural Energy Program. His research focuses on energy efficiency and sustainability in the industrial, agricultural and renewable energy fields using computational means (see http://acelab.ua.edu). He has been awarded 10 external research contracts (8 as principal investigator) from the US Department of Energy, National Science Foundation, and the US Department of Agriculture. He was awarded the 2018 DOE IAC Junior Faculty Research Award, is published in 40 peer-reviewed journal and conference articles and holds two patents. He was born and raised in the Ottawa Valley, attending Queen's University and UOIT for his BSc and MSc degrees, respectively. He is also very possibly the sole Ottawa Senators fan in the entire state of Alabama.