Title: Investigation of transient dynamic behaviour of small-scale horizontal axis wind turbines

Abstract:

In this research, we present an experimental and numerical framework for examining the transient dynamics and yaw behavior of horizontal axis small wind turbines (SWTs), with a particular emphasis on the role of tail fins as passive yaw control systems. This study fills a critical gap in renewable energy research by delivering a comprehensive aeroelastic analysis of small-scale wind turbines with tail fins. The analysis is bolstered by extensive experimental benchmarks conducted at Carleton University's Wind-Induced Dynamics Laboratory (WInDLab). Given that the transient performance of SWTs remains underexplored in both theoretical and experimental contexts, we focus on investigating the unsteady aerodynamic loading and interactions between the turbine blades and tail fins, resulting in a detailed and insightful analysis.

The research combines experimental testing and modal analysis techniques to investigate the structural behavior of SWT blades, while also incorporating Ansys Fluent to evaluate and uncover their aerodynamic properties. To further enhance the accuracy of the findings, we use the OpenFAST aeroelastic simulation platform, developed by the National Renewable Energy Laboratory (NREL), to conduct real-time numerical simulations of our wind turbine prototype. This allows us to bridge the gap in existing simulation tools by incorporating experimental data that captures the transient behavior of SWTs operating in varied conditions commonly found in urban environments. This methodology enables a detailed analysis of turbine performance in dynamic settings, where wind speed and direction frequently change.

By integrating these experimental and simulation approaches, we enable more precise modelling of tail fin dynamics for future SWT designs, ultimately contributing to the development of more efficient wind energy systems suitable for urban applications. Our research has already demonstrated significant progress in understanding the dynamic response of SWTs under fluctuating wind conditions, offering valuable insights into their performance in challenging urban settings.

Bio:

Saeid Fadaei Naeini is a PhD candidate (2019-2024) at the Applied Dynamics Laboratories at Carleton University. He holds an undergraduate degree (2013) in mechanical engineering from Isfahan University of Technology and a master’s degree (2016) from Yazd University,

where he focused on the numerical simulation of flutter behavior in floating offshore wind turbine blades. His current research focuses on the transient dynamics and yaw behavior of small wind turbines, with an emphasis on urban applications. Saeid's expertise spans structural dynamics, fluid-structure interaction, and renewable energy systems.