MSc. Thesis Proposal

Title: Optimization of Vertical Axis Wind Turbines for Urban Energy Production

Supervisors

Tiago Gomes (MSc): CFD Development & Application at blueOASIS
Guilherme Vaz (PhD): R&D manager at blueOASIS
Professor at Instituto Superior Técnico

Introduction

Motivation

Vertical Axis Wind Turbines (VAWT) are a class of wind turbines gaining increasing traction over the last years. While their Horizontal Axis counterparts are still far more popular, VAWTs present themselves as a suitable alternative to bring wind energy to small scale urban productions, as part of an energy democratization process and carbon footprint reduction, due to their simplicity and compactness. It is based on this premise that holistic approaches to their design and simulation are relevant, to optimize their shape based on the consumer's requirements.

Existing work

The CFD simulation of a VAWT is a topic already analyzed in the literature, although more rarely than their HAWT counterparts, usually starting with a predefined turbine geometry. The fidelity of such analysis varies widely, with increasing computational cost:

- **Low-fidelity:** vorticity-based lifting line theory (OpenFAST or QBlade).
- **Mid-fidelity:** CFD RANS simulations using body-force source terms to account for geometry effect (ReFRESCO).
- **High-fidelity:** CFD RANS simulations with fully discretized geometry, using Sliding or Overset Grids to incorporate their motion (ReFRESCO).

The development of optimization tools for VAWT is not a new topic on the literature. For example, in [1] the authors have used QBlade to optimize a VAWT design, taking advantage of the relative low computational cost per design evaluation. On the other side of the spectrum, there have already been attempts at using high-fidelity simulations to optimize a design, such as in [2].

Objectives

The objective of this thesis is:

- To analyze existent design optimization tools for VAWT;
- To identify relevant characteristics of a VAWT for small-scale energy production;
- To develop a VAWT design optimization tool based on first-principles/low-fidelity tools;

The expected tasks are:

- Literature review on VAWT and existing methodologies for their simulation and design optimization;
- Selection of a VAWT type and definition of respective design variables and design space;
- Development of optimization tool based on first-principles/low-fidelity tools, such as OpenFAST or QBlade;
- Application of tool to a real test case, with meteorological data.

Requisites

Applicants must have:

- General knowledge on CAD modelling software.
- General knowledge on Fluid Dynamics and CFD.
- Coding experience with Python or similar.

Good to have:

- Linux experience.
- LaTeX experience.
- Git experience.

Location

blueOASIS (www.blueoasis.pt) Edifício D. Pedro, Quinta da Fonte, R. Malhões, 2770-071 Lisboa or Ericeira Business Factory, R. Prudêncio Franco da Trinitade 4, 2655-344 Ericeira.
The student must be present at the office **at least 4 days per week**. This is mandatory to pursue a thesis with blueOASIS.

Companies Involved

blueOASIS is a young team with more than 65 years of combined knowledge and experience on Aerospace, Mechanical, Naval and Maritime engineering. The multicultural and multidisciplinary team is committed to make our oceans safer and greener, using state of the art numerical and data science tools. BlueOASIS focuses on renewable energies, ocean cleaning, decarbonization, sustainable offshore structures and green ships optimization.

Bibliography

[1] A. I. Altmimi, M. Alaskari, O. I. Abdullah, A. Alhamadani, and J. S. Sherza, “Design and Optimization of Vertical Axis Wind Turbines Using QBlade,” *Appl. Syst. Innov.*, vol. 4, no. 4, Art. no. 4, Dec. 2021, doi: 10.3390/asi4040074.

[2] T. J. Carrigan, B. H. Dennis, Z. X. Han, and B. P. Wang, “Aerodynamic Shape Optimization of a Vertical-Axis Wind Turbine Using Differential Evolution,” *Int. Sch. Res. Not.*, vol. 2012, p. e528418, Jan. 2012, doi: 10.5402/2012/528418.