MSc. Thesis Proposal

Title: CFD Analysis of Vertical Axis Wind Turbines for Urban Energy Production

Supervisors

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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. The fidelity of such analysis varies widely, with increasing computational cost:

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

Some relevant examples include the work of Rezaeiha et al. [1], in which the authors performed a series of parametric CFD studies with ANSYS Fluent of a 2-blade H-type VAWT, having validated them against wind tunnel data. Another example is the work by Alaimo et al. [2], in which ANSYS Fluent was also use to simulate an helical and straight blade VAWT.

Objectives

The objective of this thesis is:

- To analyze existent VAWT designs for urban energy production;
- To study the impact of turbulence models, transition models and grid refinement in high-fidelity CFD simulations;
- To compile a list of best-practices when using CFD to simulate VAWT.

The expected tasks are:

- Literature review on VAWT and best-practices for their simulation;
- Selection of an existent VAWT design, with respective mesh generation using Hexpress/Fidelity;
- Simulation of VAWT using the high-fidelity solver ReFRESCO;
- Assessment of the impact of different RANS turbulence models, transition models and grid refinements. Possibility of performing Validation studies if experimental data is available.

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. Rezaeiha, I. Kalkman, and B. Blocken, “CFD simulation of a vertical axis wind turbine operating at a moderate tip speed ratio: Guidelines for minimum domain size and azimuthal increment,” *Renew. Energy*, vol. 107, pp. 373–385, Jul. 2017, doi: 10.1016/j.renene.2017.02.006.

[2] A. Alaimo, A. Esposito, A. Messineo, C. Orlando, and D. Tumino, “3D CFD Analysis of a Vertical Axis Wind Turbine,” *Energies*, vol. 8, no. 4, Art. no. 4, Apr. 2015, doi: 10.3390/en8043013.