MSc. Thesis Proposal

Title: High-fidelity acoustic characterization of floating offshore wind turbines

Supervisors

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Guilherme Vaz (Dr., inv. Prof): R&D manager at blueOASIS

Introduction

Motivation

With the increasing popularity of floating offshore wind turbines (FOWT), and planned projects for farms worldwide, it is critical to assess the underwater acoustic footprint of these systems, not only as part of environmental impact studies but also for developers to try to find ways to minimize it. Yet, the information in the literature about this topic is very scarce.

As part of the EU project FLOATFARM, blueOASIS is leading the development of engineering models to characterize the underwater acoustic signature of these systems, through the usage of high-fidelity Computational Fluid Dynamics (CFD) and Finite Element Analysis (FEA) in combination with Artificial Intelligence (AI) for surrogate models. In turn, these models are intended to be used with blueOASIS's underwater noise propagation tool, RAINDROP, to generate noise maps where these parks are installed and couple the data with trophic models.

The underwater noise emission of a FOWT can have several origins: aerodynamic, from the interaction the blades and tower with the air; hydrodynamic, due to the floater and moorings; and mechanical caused by the generator/gearbox assembly and the moorings. Not only that, but these noise sources can propagate through different media until they reach the water. Therefore, this problem requires a holistic approach, using different tools and methodologies.

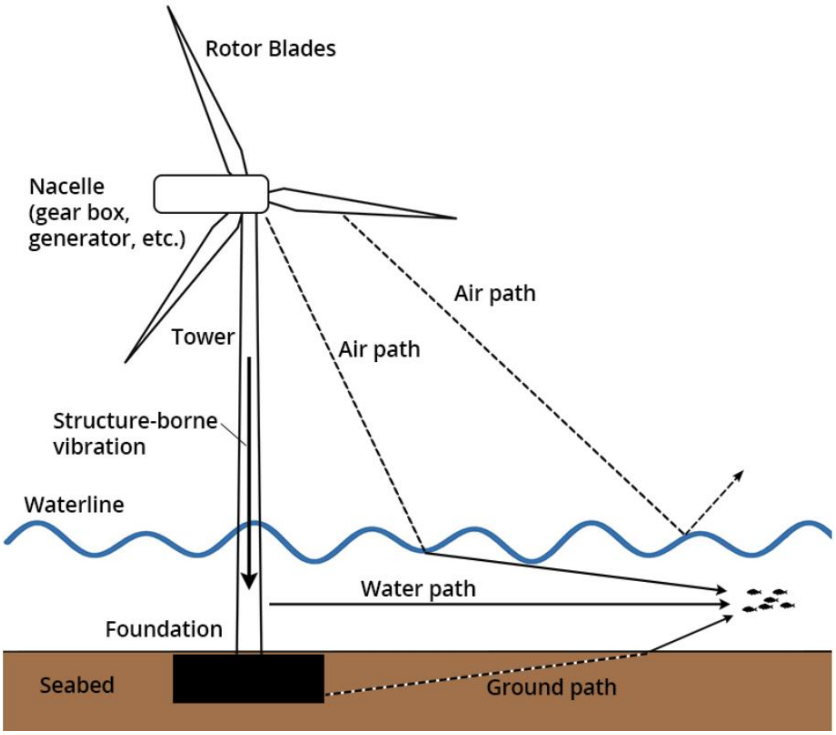

Figure 1 - Acoustic propagation paths in a fixed offshore wind turbine [1].

Existing work

As it was already stated, specific literature on the acoustic signature of FOWT is very scarce. In fact, most of what can be found is related to onshore wind turbines and aeroacoustics, such as in [2]

blueOASIS is currently assessing the aerodynamic noise produced by turbines using high-fidelity CFD and acoustic analogies, based on its previous work with RANS and other scale-resolved turbulence models [3]. Similarly, the experience of the team with the numerical modelling of floating platforms [4] and even the acoustic analysis of a cavitating propeller [5] is also very relevant.

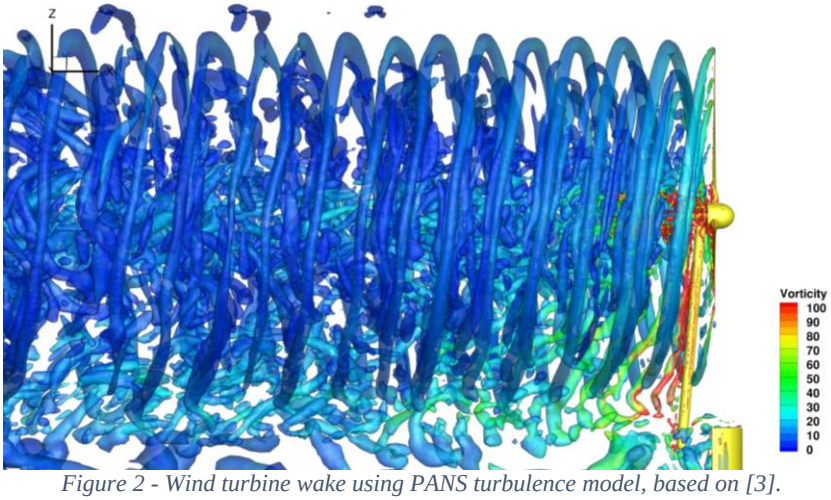

Figure 2 - Wind turbine wake using PANS turbulence model, based on [3].

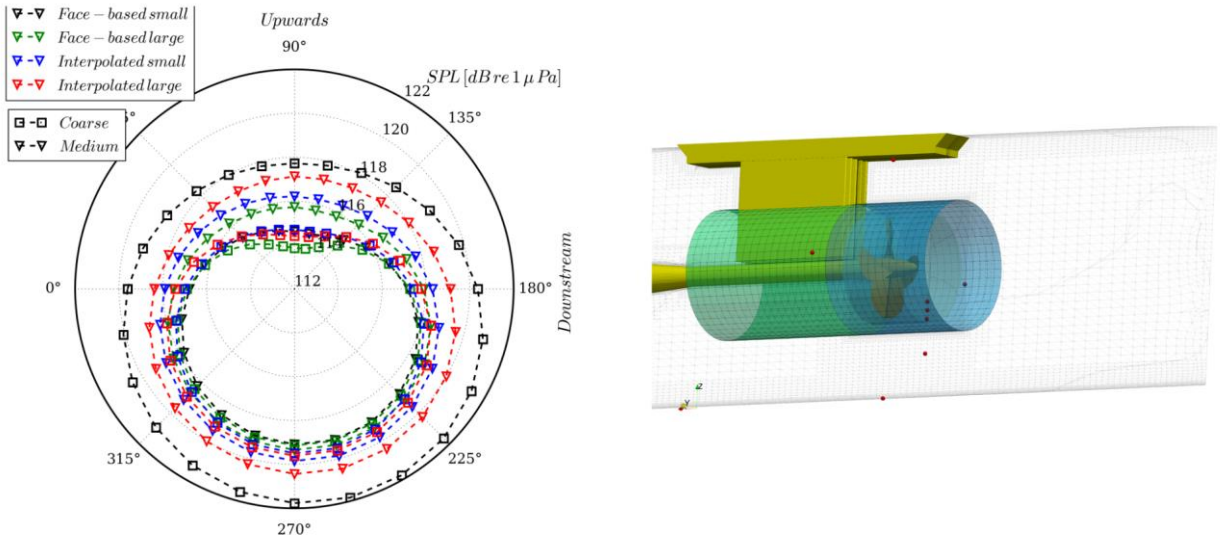

Figure 3 - Acoustic simulation of a propeller using CFD + Ffowcs Williams-Hawkings acoustic analogy [5].

Objectives

Option 1 – Aerodynamic Noise Modelling (CFD)

The goal is to develop engineering models that characterize the aerodynamic noise of a FOWT, and its propagation underwater, based on high-fidelity CFD data. The student is expected to:

- Carry out a thorough literature review on the topics of aeroacoustics of turbines, engineering models for aeroacoustics (e.g. airfoils, wings, cylinders, etc.) and air-water noise transmission;

- Prepare and perform CFD simulations of a FOWT under several operating conditions;
- Analyze and compare the aeroacoustic footprint with real-life microphone measurements;
- Develop engineering models to predict aeroacoustic noise footprint, and transmission to underwater.

Option 2 – Mechanical/Structural Noise Modelling (FEM)

The goal is to develop engineering models that characterize the structural noise of a FOWT generated by its mechanical components (e.g. transmission box, generator), and its propagation to underwater through mechanical vibrations based on FEM simulations. The student is expected to:

- Carry out a thorough literature review on the topics of structural acoustics / vibrations of wind turbines, engineering models for structural acoustics / vibrations (e.g. gearboxes, propagation over cylinders) and transmission across media;
- Prepare and perform FEM simulations of an idealized FOWT under several operating conditions;
- Analyze and compare the underwater acoustic footprint with real-life hydrophone measurements;
- Develop engineering models to predict structural noise footprint, and transmission to underwater.

Requisites

Applicants must have:

- General knowledge of CFD or FEA.
- Coding experience with Python or similar.

Good to have:

- Linux experience.
- Latex experience.
- Git experience.

Added value to have:

- Knowledge of acoustics.

Location

The student must be present at the office at least 4 days per week. This is mandatory to pursue a thesis with blueOASIS.
blueOASIS (www.blueoasis.pt) offices at Ericeira, Faial or Utrecht, Netherlands

Companies Involved

blueOASIS is a young team with more than 60 years of combined knowledge and experience in Aerospace, Mechanical, Naval and Maritime engineering. The multicultural and multidisciplinary team is committed to making our oceans safer, greener and quiet, using state of the art numerical and data science tools. BlueOASIS focuses on renewable energies, underwater acoustics, decarbonization, sustainable offshore structures and green ships optimization.

References:

[1] R. Kikuchi, "Risk formulation for the sonic effects of offshore wind farms on fish in the EU region," *Marine Pollution Bulletin*, vol. 60, no. 2, pp. 172–177, Feb. 2010, doi: 10.1016/j.marpolbul.2009.09.023.
[2] R. Z. Szasz and L. Fuchs, "Wind turbine acoustics," in *WIT Transactions on State of the Art in Science and Engineering*, 1st ed., vol. 1, WIT Press, 2010, pp. 153–183. doi: 10.2495/978-1-84564-205-1/05.
[3] L. Sileo, T. Gomes, V. Krasilnikov, and A. Maximiano, "Towards the CFD Validation and Analysis of Aerodynamic Loads Acting on the Rotor of a Floating Wind Turbine Subject to Forced Motions," in *Numerical Towing Tank Symposium (NuTTS2023)*, Ericeira, Portugal, Oct. 2023.

[4] A. Maximiano, T. Gomes, and G. Vaz, "Comprehensive High-Fidelity Hydrodynamic Analysis of Floating Offshore Wind Turbine Platforms," presented at the 24th Numerical Towing Tank Symposium (NuTTS2022), Zagreb, Croatia, 2022.
[5] A. K. Lidtke, T. Lloyd, and G. Vaz, "Acoustic modelling of a propeller subject to non-uniform inflow," presented at the Sixth International Symposium on Marine Propulsors smp'19, Rome, Italy, May 2019.