PhD offer 2022-2025

Study of the performance of wind and tidal turbines as a function of operating conditions by high-fidelity numerical simulation

Context

In the context of the development of renewable energies, wind power has become a mature technology after several decades of development. Today, the share of wind power in the energy mix is constantly increasing and offshore wind turbines are increasingly being implemented because the wind resource is more important and more stable [PPE 2020]. At the same time, other technologies such as tidal turbines are being developed. The latter still suffers from reliability and performance problems. However, several farms of 3 or 4 prototypes are being tested around the world [MeyGen 2021, EnFait 2021].

Wind and tidal power are two similar technologies: they seek to extract kinetic energy from the fluid in which they are immersed (air or water) using a rotating machine. The energy source of these rotors being intermittent by definition, their production depends directly on the operating conditions. In addition to the intermittence, i.e. variation in amplitude, the upstream flow can vary on other characteristics: turbulence rate, anisotropy, characteristic lengths, boundary layer... These properties can lead to variations in turbine performance and mechanical loads [Slama 2021]. The cost of energy and the life of the machines are then affected [Walker 2021].

In order to reduce installation and maintenance costs, offshore wind and tidal turbines are grouped in farms that can have up to 50 machines. In this configuration, turbine-to-turbine wake interaction phenomena appear, again impacting performance and loads [Gaurier 2020].

A detailed understanding of the physical phenomena involved in the flows around wind and tidal turbines, and more specifically the aerodynamics around the blades and in the wake, is therefore essential to optimize them, reduce costs and extend their lifetime.

Objectives

The objective of this thesis is to **better characterize the performance, loads and impact on the wake of offshore wind and tidal turbines** as a function of operating conditions and to **deepen the knowledge on the machine-to-machine interactions in the farms**. This work will be performed using high-fidelity numerical simulations with the **YALES2 platform**.

YALES2 aims at solving unsteady, multi-physics and multi-scale flows efficiently on supercomputers [Moureau 2011]. It is based on an Eulerian approach of the flow and is able to handle complex geometries using unstructured meshes of several billion elements, making possible the direct numerical simulation of laboratory or even semi-industrial configurations. The Actuator Line method has been implemented to model wind rotors [Benard2018] and has recently been coupled with a servo-elastic library [Gremmo 2021].

The thesis work will consist of 2 main tasks:

- Study of the performances, loads and wakes of wind and tidal turbines in several configurations: amplitude and direction of the upstream flow, turbulence rate, anisotropy, characteristic lengths, boundary layer... The goal is to generate a database of numerical calculation results with different numbers of turbines and under different conditions. This database will then be post-processed and analyzed.

- Comparison of two advanced numerical methods: simulations performed with YALES2 will be compared to those performed with the Dorothy code (code developed at the LOMC laboratory, in collaboration with IFREMER and CNRS) [Pinon 2012]. Although both codes are dedicated to unsteady turbulent flows, they use fundamentally different numerical methods. The codes will therefore be compared on some aspects such as the quality of the results, the restitution time or the parallel performances. The idea is to identify the advantages/disadvantages of each approach on a given range of spatial/temporal scales and/or a given configuration (single turbine, multi-turbine, whole farm).

General informations

- 3-years PhD thesis at CORIA laboratory, Rouen
- Salary: roughly 1600€ net/month
- Starting date: preferentialy 1st october 2022
- Funding: Labex EMC3, WILIAM project in collaboration with LOMC laboratory
- Contact: Pierre BENARD (pierre.benard@coria.fr)

Candidate profile

- Master degree in Mechanical or Energetic engineering (Fluid mechanics, Aerodynamics, Scientific computing, CFD).
- High level of communication skills, both oral and written (French or English required) to be able to present at conferences and write articles in scientific publications.
- Application process:
    - Send CV, cover letter and grades of Master 1 and 2 or equivalent engineering level to pierre.benard@coria.fr
    - The closing date for sending applications is June 1st, 2022.

References

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