PhD Position

The role of the turbulence cascade in wind energy applications

Project summary

Over the last years, wind energy research has experienced an exponential growth worldwide. In particular, the study of the flow downstream one or several turbines has captured the attention of the turbulence community. Despite this growing interest, many recent advances in the modelling of turbulent flows have not yet been adapted to such studies. They concern the understanding of the inner structure of turbulence: the energy cascade, that models how energy is transferred among large to small scales and how ultimately the energy of the flow is dissipated. The energy cascade has been found to set important properties of turbulent wakes, such as their velocity deficit and how they spread in the streamwise direction. Furthermore, while theoretical models usually consider laminar incoming flows, all applications involve turbulent backgrounds, that are characterised by strong inhomogeneities and instationarities. Very few is known about the effect of background turbulence in the wake's downstream development nor about the energy cascade within it.

This PhD project proposes an experimental study on the energy cascade of the turbulent wakes, and on their coupling to different background turbulent flows, shedding light on the relevance of this process in wind energy applications. The project is part of an international collaboration between UGA and Oldenburg University. The PhD candidate will work at LEGI lab from UGA and at Oldenburg University, in the wind tunnels available at both institutions. His/her tasks can be summarised as:

- A systematic study on the energy cascade in the turbulent wake generated by different generators (regular and irregular bluff bodies and scaled wind turbines).
- By means of an active grid, he/she will control the background flow, by generating different bespoke turbulent flows.
- Once the properties of single generators and their interaction with the background flow are studied and documented, the PhD student will set different arrays of generators (with and without background turbulence), and study the interaction between wakes, mimicking realistic conditions like the ones found in wind farms.

The PhD student will spend 50% of his/her time in LEGI lab at Grenoble (first 18 months) and other 50% at Oldenburg University (final 18 months). He/she will be in charge of the planning, setting up and data acquisition for experiments and the subsequent data analysis. In LEGI he/she will focus of the study of a single wake under laminar and steady/unsteady turbulent background flow. He/she will then work in the interaction of multiple generators (including wind turbines) at Oldenburg University.

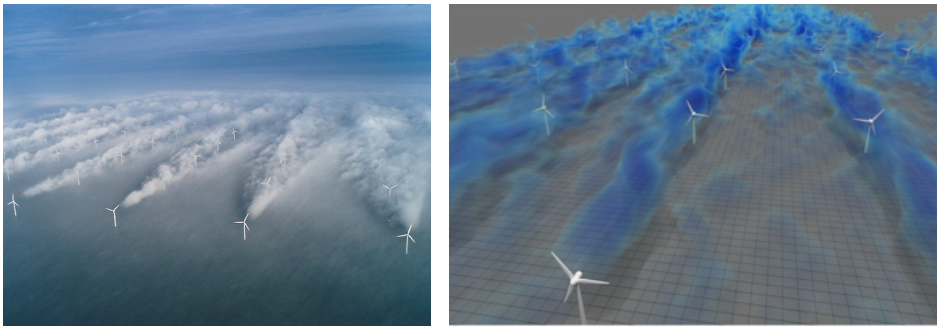

Figure: interaction between wakes in a wind farm (left, image from wind Action website, http://www.windaction.org). LES performed by Stevens et. al. (2016) (right).

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References

1. Dairay, Thibault, Obligado, Martin, and John Christos Vassilicos. "Non-equilibrium scaling laws in axisymmetric turbulent wakes." Journal of Fluid Mechanics 781 (2015): 166-195.
2. George, William K. "The self-preservation of turbulent flows and its relation to initial conditions and coherent structures." Advances in turbulence 3973 (1989).
3. Knebel, Pascal, Kittel, Achim and Peinke, Joachim. "Atmospheric wind field conditions generated by active grids." Experiments in fluids 51, no. 2 (2011): 471-481.
4. Mora, D. O., E. Muñiz Pladellorens, P. Riera Turró, M. Lagauzere, and Obligado, Martin. "Energy cascades in active-grid-generated turbulent flows.", Physical Review Fluids 4 (2020): 104601
5. Neunaber, Ingrid, Hölling, Michael, Stevens, Richard JAM, Schepers, Gerard and Peinke, Joachim. "Distinct turbulent regions in the wake of a wind turbine and their inflow-dependent locations: the creation of a wake map". Energies 13, no. 20 (2020): 5392.
6. Stevens, Richard JAM, Dennice F. Gayme, and Charles Meneveau. "Effects of turbine spacing on the power output of extended wind-farms." Wind Energy 19, no. 2 (2016): 359-370.

Location and practical aspects

3 years PhD fellowship offer, starting 2020. The gross salary will be 1787 euros/month, equivalent to a net salary of 1414 euros/month.

The successful applicant will be hosted by the laboratory **LEGI** (located at Grenoble, http://www.legi.grenoble-inp.fr/) in the EDT team and by the TIWST group (Turbulence, Wind Energy and Stochastics) from the Institut für Physik at the Carl-von-Ossietzky University of Oldenburg, Germany (https://uol.de/en/physics/twist).

The student will work under the supervision of Dr Obligado and Dr Barre from laboratory LEGI and Dr Hölling and Pr Peinke from University of Oldenburg.

This project is part of an international collaboration sponsored by TEC 21 (https://www.tec21.fr), and includes funds assigned to the PhD student for conferences, consumables and small equipment.

Qualifications of the applicant

Engineering or physics background with strong formation in fluid mechanics. Interest in experimentation measuring techniques and modelling. Experience using Matlab/Python is recommended.

Applications

Interested candidates should send their CV and cover letter to Martin Obligado (Martin.Obligado@univ-grenoble-alpes.fr) and/or Michael Hölling (michael.hoelling@uni-oldenburg.de).

Deadline for the application: 18/07/2021.

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