Fluid-structure interaction simulations of a wind turbine blades

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During operation, wind turbines are subject to complex flows that interact with their structure. By consequence, fluid-induced forces deform the blades (exactly as in the case of airplane wings). As the maximum tip deflection of modern wind turbines can be of about 10 m, blades deformation could modify significantly the turbines wake. Therefore, given that the design of modern wind farms relies more and more on numerical simulations, modelling and understanding the effect of blades deformation is crucial for a further optimised design.

At the beginning of this project, along with the supervisors, the student will be guided to improve the already present wind turbine model to take into account for fluid-structure interaction that leads to blades deformation. Then, the focus will be devoted to the fluid dynamics effects: how is the turbines *wake recovery* affected? What are the effects on the *wake instability*? Is the wind farm *power produced* lower/greater? Student's personal insights and propositions will also be welcome.

The study will be conducted using state-of-the art Large Eddy Simulations (LES), using an in-house research code that has been extensively used in our group to simulate the interaction between wind farms and the atmosphere.

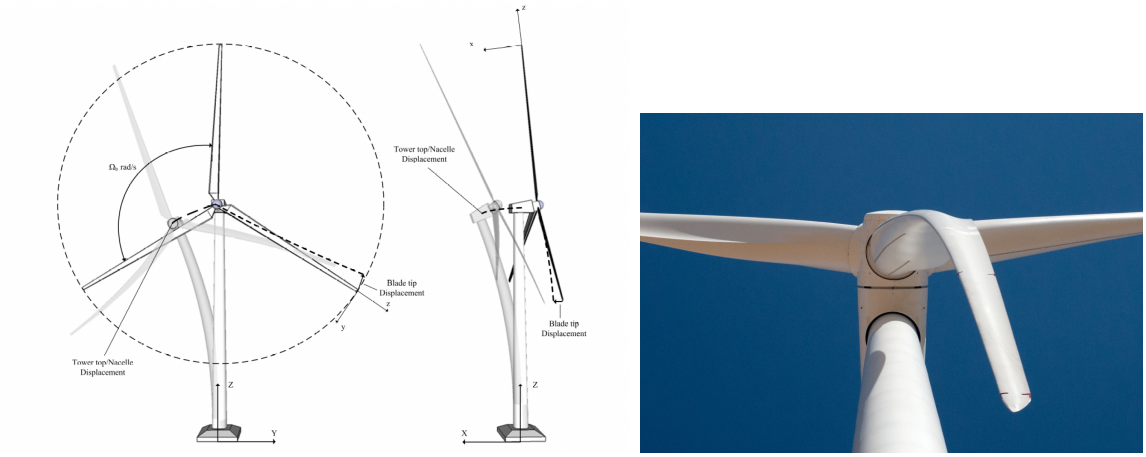

Figure 1: Fitzgerald et al., IJSMSS (2020) (left); Siemens Wind Power A/S (right).

Useful readings: Hsu and Bazilevs (2012); Sun et al. (2020); Leng et al. (2023) (fluid-structure interaction), Stevens et al. (2014) (Large Eddy Simulations).

References

Ming-Chen Hsu and Yuri Bazilevs. Fluid–structure interaction modeling of wind turbines: simulating the full machine. *Computational Mechanics*, 50(6):821–833, 2012. ISSN 0178-7675 1432-0924. doi: 10.1007/s00466-012-0772-0.

Jun Leng, Zhiteng Gao, Michael C. H. Wu, Tao Guo, and Ye Li. A fluid–structure interaction model for large wind turbines based on flexible multibody dynamics and actuator line method. *Journal of Fluids and Structures*, 118, 2023. ISSN 08899746. doi: 10.1016/j.jfluidstructs.2023.103857.

Richard J A M Stevens, Michael Wilczek, and Charles Meneveau. Large-eddy simulation study of the logarithmic law for second- and higher-order moments in turbulent wall-bounded flow. *Journal of Fluid Mechanics*, 757:888–907, 2014. doi: 10.1017/jfm.2014.510.

Zhenye Sun, Wei Jun Zhu, Wen Zhong Shen, Wei Zhong, Jiufa Cao, and Qiuhan Tao. Aerodynamic analysis of coning effects on the dtu 10 mw wind turbine rotor. *Energies*, 13(21), 2020. ISSN 1996-1073. doi: 10.3390/en13215753.