Title: Multidisciplinary optimisation of wind farms through experiments and data-driven modelling

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The generation of power from wind has attracted a lot of interest in the last decades as an alternative to fossil fuels for clean energy production [1]. In fact, clean energy contributes to reaching various sustainability goals as it has a direct positive impact on the environment, as well as on human and animal quality of life. However, several technological and environmental challenges are associated with power generation from multiple turbines (i.e., wind farms). For instance, high power levels can be extracted from large turbines (typically deployed offshore or over desert areas), but at the cost of significant technological, installation, and transportation issues emerging owing to their size and weight (blades in a traditional horizontal-axis turbine can reach a hundred metres) [2]. Moreover, wind turbines in a wind farm interact with each other, since the wake of upwind-located turbines affects the incoming airflow of downwind turbines, lowering the performance of the latter ones [3].

Figure 1: Graphical illustration of the proposed project. (Image generated by means of Microsoft Bing Image Creator and intended to be used for non-commercial purposes).

This project aims at addressing these two issues, by investigating the power-generating performance of a wind farm that can be employed in a variety of environments, including in the proximity of urban areas. A data-driven optimisation will be carried out to find the best turbine layout and features that maximise performance under various atmospheric and working conditions.

This project will allow the PhD candidate to carry out a multidisciplinary work inter-connecting insights from atmospheric fluid dynamics, clean energy generation, and numerical optimisation. The project will tackle a real-world issue with widespread impact from both a numerical and experimental point of view, by exploiting state-of-the-art data-driven modelling techniques and experimental facilities at the EnFlo laboratory of the University of Surrey. In conjunction with training opportunities, this PhD project will allow the candidate to gain a unique set of skills and a strong multi- and interdisciplinary attitude, which are nowadays needed in engineering and physical sciences.

Training opportunities:

Specialised modules on various aspects of atmospheric fluid mechanics and wind power are available at the Universities of Surrey and Reading. Additional modules on data-driven modelling are also available at the University of Surrey. The student will be encouraged to take part in the Summer School "Introduction to Atmospheric Science" offered by the NCAS in Leeds (UK), the "Introduction to Measurement Techniques" Lecture Series at VKI (Belgium), and workshops/seminars at the Alan Turing Institute (London, UK) and the Institute for People-Centred AI at the University of Surrey. Specialist training will be provided for the required numerical and experimental skills.

References

1. GOV UK, Offshore Wind Net Zero Investment Roadmap, March 2023. (https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1167856/offshore-wind-investment-roadmap.pdf)

2. Porté-Agel, F., Bastankhah, M., & Shamsoddin, S. (2020). Wind-turbine and wind-farm flows: A review. Boundary-layer meteorology, 174(1), 1-59. https://doi.org/10.1007/s10546-019-00473-0

3. Placidi, M., Hancock, P. E., & Hayden, P. (2023). Wind turbine wakes: experimental investigation of two-point correlations and the effect of stable thermal stability. Journal of Fluid Mechanics, 970, A30. https://doi.org/10.1017/jfm.2023.631