Analysis of upstream wake induced loads to optimize the design layout of an array of cylinders

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The influence of wakes on adjacent wind turbines has been the subject of extensive research to optimize the design of wind farms. The goal of this optimization is to maximise the farm's overall power output subject to minimising the expected fatigue damage induced by the interaction between the wake phenomena and downstream wind turbines generated by the fluctuating flow velocity in this region[1]. In the present work, we report the influence of the presence of a turbulent wake, generated by a cylinder (A), on a cylinder located downstream (B) at different streamwise spacings as represented in figure 1. A set of experiments is carried out in a water channel, combining simultaneous particle image velocimetry (PIV) measurements, where essentially two fields of view (FOV) are captured (FOV1 and FOV2 - see figure 1); strain measurements using fiber optic distributed strain sensors (FODS) mounted to the cylinder[2], to analyse the fluctuating strain of the cylinder ε'; and load measurements using 6-axis load cells in each cylinder on the array, mounted in a similar manner to[3], to assess the influence of the flow on the fluctuating load F'. The flow is subjected to different "flavours" of background turbulence, produced by a set of turbulence-generating grids located upstream of the cylinder array. The same combination of regular- and space-filling-fractal-grids will be used as [4], designed to explore a broad range of the TI, L parameter space of the freestream turbulence, where TI is the turbulence intensity and L is the integral length scale. Both cylinders, with diameter $\varnothing = 50$ mm, are mounted as cantilever beams supported at one end, having 95% of their bodies submerged and exposed to the respective incoming flow. The position of the downstream cylinder is modified covering $0 < y/\varnothing < 4$ and $2 < x/\varnothing < 8$.

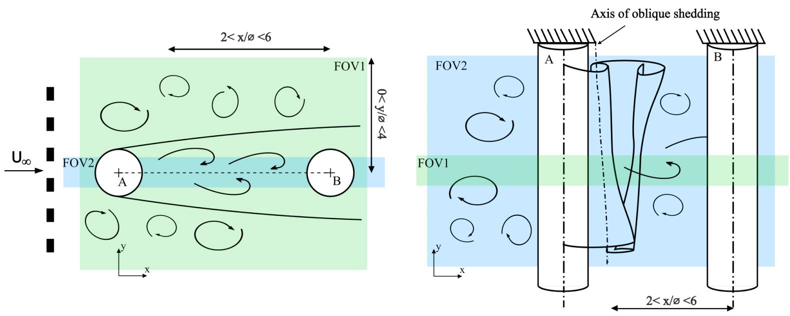

Figure 1: Representation of the two Fields of view to be captured, flow area to be analysed, and some of the flow events of interest such as oblique vortex shedding.

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[1] Moens and Chatelain, *Frontiers in Energy Research*, 10 (2022).

[2] Xu and Khodaei, *Sensors*, **4040**, 20 (2020).

[3] Cicolin et al., *J. Fluid Mech.*, **915**, A33 (2021).

[4] Kankanwadi and Buxton., *J. Fluid Mech.*, **905**, A35 (2020).