An experimental study on the influence of gusts and suspended particles on the wake flow characteristics of wind turbines

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The operational efficiency of wind turbines is highly dependent on environmental conditions. Impacting particles such as hail, dust, rain, and other debris that may be suspended in the air, such as during a strong wind gust, can significantly impact the wind turbines and the overall performance of wind farms over the short and long term. As a result, studying the characteristics of the flow during such intense events is essential to identify mitigation strategies.

In this experimental study, we attempt to simulate gust events that are sufficiently strong to suspend particles that subsequently impact a small-scale wind turbine model. A porous disk (Ø 3cm) is placed in a water tank where rotating impellers generate the background turbulence field. A strong gust is intermittently introduced by the deformation of the flow field resulting from the motion of a rapidly moving plate. The fluid is seeded with inertial particles (size Ø≈10μ) that settle on the bottom of the turbulent flow field but are resuspended due to the gust event. Particle Image Velocimetry and Lagrangian Particle Tracking are used to analyze the flow field in the near wake behind the porous disk and characterize the unsteady wake structure that develops.

The characteristics of the results are put in context to natural phenomena, with particular attention to ash and particle sediments and their resuspension prevailing in prospective wind farms in harsh environments.

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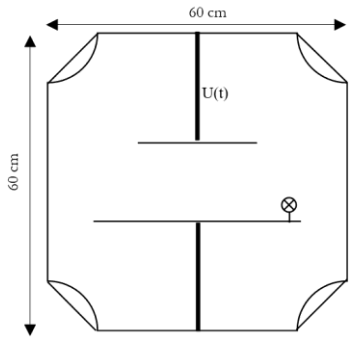

Figure 1 Schematic presentation of the experimental setup. The top piston's movement creates intense deformation that causes periodic gusts. The corners of the tank are equipped with impellers that create background turbulence.