VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Konstantinos Vratsinis**

The public defense will take place on **Tuesday 18th August 2026 at 4pm** in room **D.2.01** (Building D, VUB Main Campus)

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WIND FARM PERFORMANCE ANALYSIS AND INFLOW CHARACTERIZATION WITH THE USE OF LIDAR AND 1-SECOND SCADA DATA

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Abstract of the PhD research

Assessing turbine performance within a large offshore wind farm is more complex than assessing an isolated turbine. As wind moves through an array, upstream turbines alter the conditions experienced by those downstream. Consequently, differences in power output can reflect changing wind conditions and turbine position within the farm, as well as the condition of the turbine itself.

Industry practice typically assesses turbine operation using measurements averaged over ten minutes. This standardized approach is useful, but it can conceal short-term variation in both wind conditions and turbine response. This thesis combines one-second operational data with measurements from a nacelle-mounted laser wind sensor, or lidar. It also develops an uncertainty-aware method for aligning the lidar with the turbine rotor, improving confidence that the measured wind represents the air approaching the turbine.

The results show that the relationship between wind conditions and power output changes from the front to the rear of a large offshore wind farm. Standard correction methods, developed mainly for turbines operating in relatively undisturbed wind, become less effective deeper inside the farm, where wakes from upstream turbines alter the flow.

The study also shows that the pattern of wind-speed fluctuations over time contains useful information that conventional measures of turbulence do not fully capture. Applying the same approach to rotor speed, generator speed, and electrical power helped identify unusual operation, including wind-sensor problems and an imbalanced rotor.

Overall, the thesis shows that accurate wind measurements and one-second operational data can improve the assessment and monitoring of offshore wind turbines. The proposed methods may help operators compare turbine performance more accurately and identify developing problems sooner, using data already recorded by modern turbines.