On the effects of environmental conditions on wind turbine performance – an offshore case study

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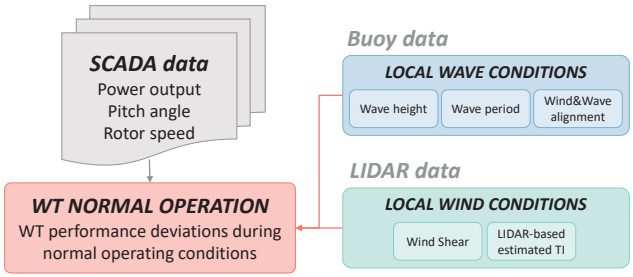
Introduction

- Monitoring **WT performance** offers a means of identifying abnormal operation, but only if artefacts of operating regime change can be excluded.
  - ⇨ Need to more clearly differentiate between changes in SCADA data due to environmental/operational conditions and faulty behaviour.
  - ⇨ This work aims at understanding and quantifying changes in SCADA data and WT performance due to different environmental conditions during normal operation.

These results could contribute to build more reliable WT performance monitoring tools.

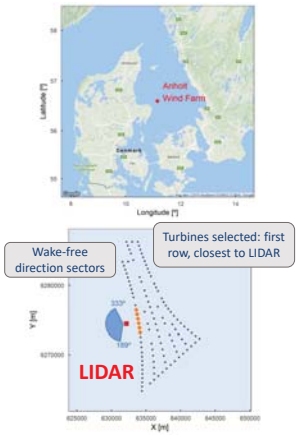
Methodology



Data Description

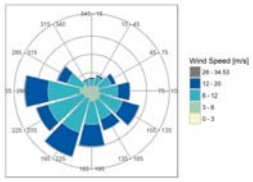
Anholt Wind Farm

- 2 years of operational SCADA data

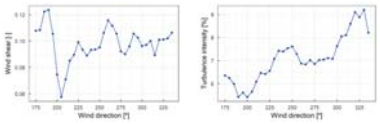


Local Wind Conditions

- Measurements at 9 heights
  - ⇨ **Wind Shear:** power law 65-105 m
  - ⇨ **TI:** LIDAR-based estimated TI



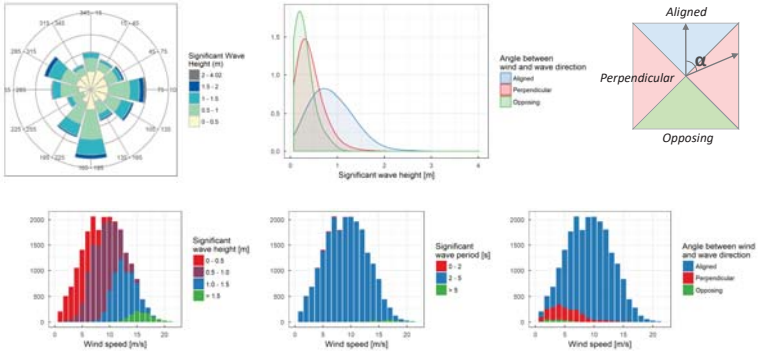
Strongly affected by fetch length



Local Wave Conditions

- ⇨ **Significant wave height**
- ⇨ **Significant wave period**
- ⇨ **Alignment between wind & wave direction**

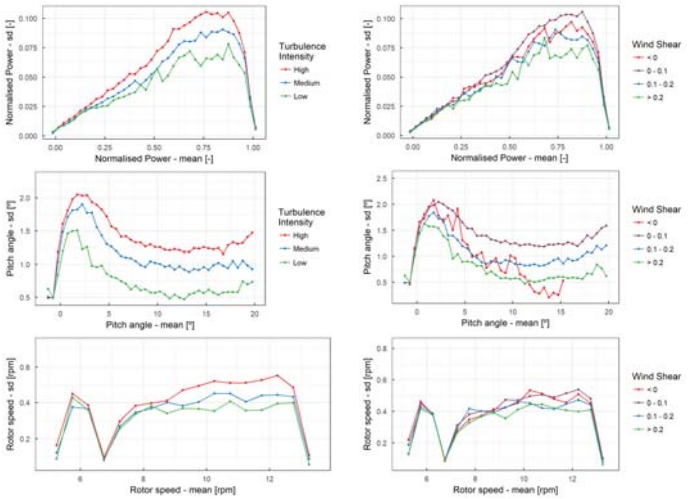
- Low significant wave heights
- Small surface waves
- Lack of observations for categorised analysis



Results & Discussion

Performance variability according to different wind conditions

- Scaling relation between standard deviation and average of 10-min aggregated SCADA data



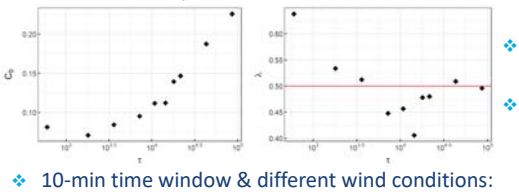
The three operational parameters (power, pitch angle & rotor speed) exhibit a higher degree of variability during lower wind shear and higher turbulence intensity conditions.

Taylor Law for Power Output Data

- The Taylor law, or temporal fluctuation scaling, is a scaling relationship of the form:

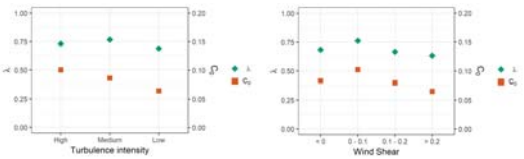
$$\alpha_\tau = C_0 \langle x \rangle^{\lambda_\tau}$$ -> τ: time window (or aggregating period)

- λ_τ gives an information on the mechanism governing the fluctuations involved in the process

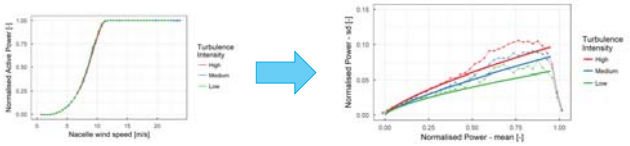


- **λ ≈ ½** - internal factors drive dynamics
- **λ ≈ 1** - external factors drive the dynamics

- 10-min time window & different wind conditions:



- Quantification of WT performance variability



Conclusion

- WT performance variability is highly influenced by environmental conditions, being higher during high turbulence intensity and low wind shear conditions.
- The Taylor law, with small time windows, is suitable, to some extent, to describe WT power output fluctuations.
- The heteroskedastic nature of the power deviations negatively affects fitting possibilities.

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http://awesome-h2020.eu/

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