## Wind Vane Correction during yaw misalignment

Rott, A., Höning, L., Hulsman, P., Lukassen, L. J., Moldenhauer, C., and Kühn, M.: Wind vane correction during yaw misalignment for horizontal-axis wind turbines, Wind Energ. Sci., 8, 1755–1770, <u>https://doi.org/10.5194/wes-8-1755-2023</u>, 2023.

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## Motivation









## Motivation







# Hypothesis

We assume that this is an inherent problem of measuring the wind direction behind the rotor.

 $arphi_{
m wt}$  $arphi_{
m ref}$ Because of the rotor's thrust, the wind direction gets deflected during a yaw misalignment. The angle between the rotor axis and the inflow get amplified.





# CFD (OpenFoam)



To prove this hypothesis, we conducted high-fidelity flow simulations, with a laminar inflow and a NREL 5MW turbine.





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# CFD (OpenFoam)





The measurements revealed a strong deflection of the flow in yawed situations.



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# **CFD (OpenFoam)**



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## **Comparison: Met Mast vs Wind Vane**

To prove the overestimation of the wind vane, we compared the yaw misalignment of a BARD 5 MW estimated by a close by met mast to the wind vane signal. Here, we compared 60-s averages and calculated the orthogonal distance regression (ODR). The slope of this regression shows an overestimation of the wind vane of 20 %.



A correction factor for the wind vane can be derived by taking the inverse of the slope 1/1.2 = 0.833



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#### **Step response analysis**



To derive the correction factor of the wind vane from wind vane measurements alone (without the need of a met mast), we developed the step response analysis for the yaw angle



For this we evaluate the wind vane measurements before and after yaw manoeuvres. We calculated the average wind vane signal before and after a clock-wise yaw manoeuvre and used the given formula to estimate the correction factor.

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# **Toggle Test**

We implemented the correction factor in the yaw controller of a BARD 5MW turbine. With the corrected wind vane the average wind vane measurement after the yaw manoeuvre is close

to 0°.





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# Summary

**Hypothesis**: The wind vane of HAWT overestimates the yaw misalignment



**CFD** shows a flow deflection behind the rotor



Met Mast comparison: linear wind vane overestimation



Step response analysis: Data driven estimation of correction factor



#### => **Toggle Test**: Significant improvement of yaw behaviour.

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