

OPTIMIZATION OF WIND TURBINES USING LOW COST FBG SHAPE SENSING TECHNOLOGY

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INTRODUCTION

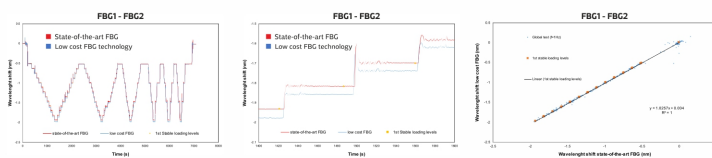
Wind is one of the most efficient ways to generate renewable clean energy. However, last year alone, more than 7B€ were spent in unscheduled maintenance activities and there is potential to improve performance between 5% and 11%. Wind is also very complex, and the industry still measures it in a single point. Therefore, optimization of these assets requires a better understanding of the behavior of these ever-bigger structures during real life operation. For wind to remain competitive in feed-in tariff free market conditions, the pressure to reduce costs and increase revenues is paramount for the industry future.

METHODOLOGY AND RESULTS

Low cost FBG technology accuracy check



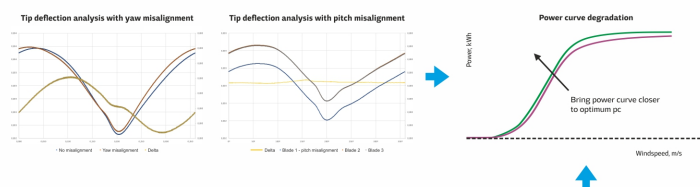
Wavelength shift response comparison between state-of-the-art FBG (blue) and Fibersail low cost FBG technology (red)



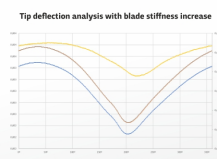
Performance increase and erroneous operational mode detection algorithm



Impact of blade and yaw misalignment at blade tip (no misalignment behavior in orange and grey and misalignment behavior in blue)



Impact of blade stiffness change at blade tip with normal stiffness (orange and grey) and higher stiffness (blue)

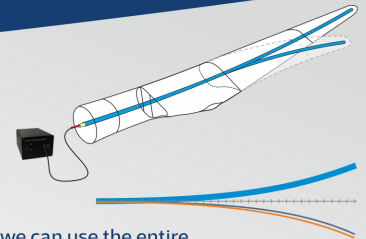


CONCLUSION

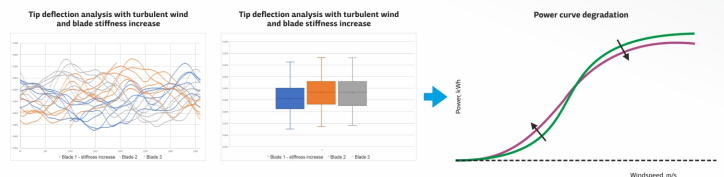
- Low cost FBG offers accuracy level comparable with state-of-the-art technology and a scalable solution at an adequate price tag for spread deployment in the industry.
- Shape sensor technology can accurately deliver value through assets optimization.
- Further developments are possible if real time shape sensing is used in combination with other methodologies and using a higher sampling rate.

SHAPE SENSOR

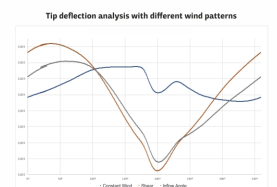
By measuring the shape of the blades, we can use the entire rotor as a giant anemometer, creating a rotor digital twin. Using a lightweight and robust full-length fiberglass beam with fiber optic sensors embedded, Fibersail shape sensor measures flapwise, edgewise and torsion with fiber optic resolution along the blade, without the pain points of current fiber optic technology. It measures the total length without feeling the strains from the blade and is temperature compensated. The new approach offers a retrofit ready plug-and-play sensor that allows a low-cost solution for the industry.



Impact of turbulence intensity with stiffness difference at blade tip with various cycles (left) and box and whisker evaluation (right)



Impact of constant wind conditions at blade tip (blue) compared to increased inflow angle and shear (orange and grey)



Lifetime optimization capabilities



Used in combination with wind turbine numerical models, the full blade length shape measurements provide unprecedented level of detail to calculate loads at component level. Combining these with historical turbine operation, real-time remaining lifetime calculation can be achieved, thus allowing a lifetime optimization of the asset.

Reduce O&M costs potential



Used in combination with ML technics, the shape sensor provides unique insights to calculate component damage level and change from preventive to predictive maintenance, thus helping reduce the LCOE.

REFERENCES

- [1] Ferreira P, Caetano E, Ramos L, Pinto P (2017) Shape Sensing Monitoring System Based on Fiber-Optics Strain Measurements. Exp Tech (2017) 41:407-420. DOI 10.1007/s40799-017-0187-0
- [2] IEC 61400-1 Ed. 3: Wind Turbine – Part 1: Design Requirements, IEC 61400-1, The Netherlands, 2005
- [3] NPR 8400 – 2016: Principles and technical guidance for continued operation of onshore wind turbines. Netherlands Normalisatie-Instituut.
- [4] DNVGL-ST-0262: Lifetime extension of wind turbines, March 2016.