



Nordex Group

Turbine Performance during Icing Events

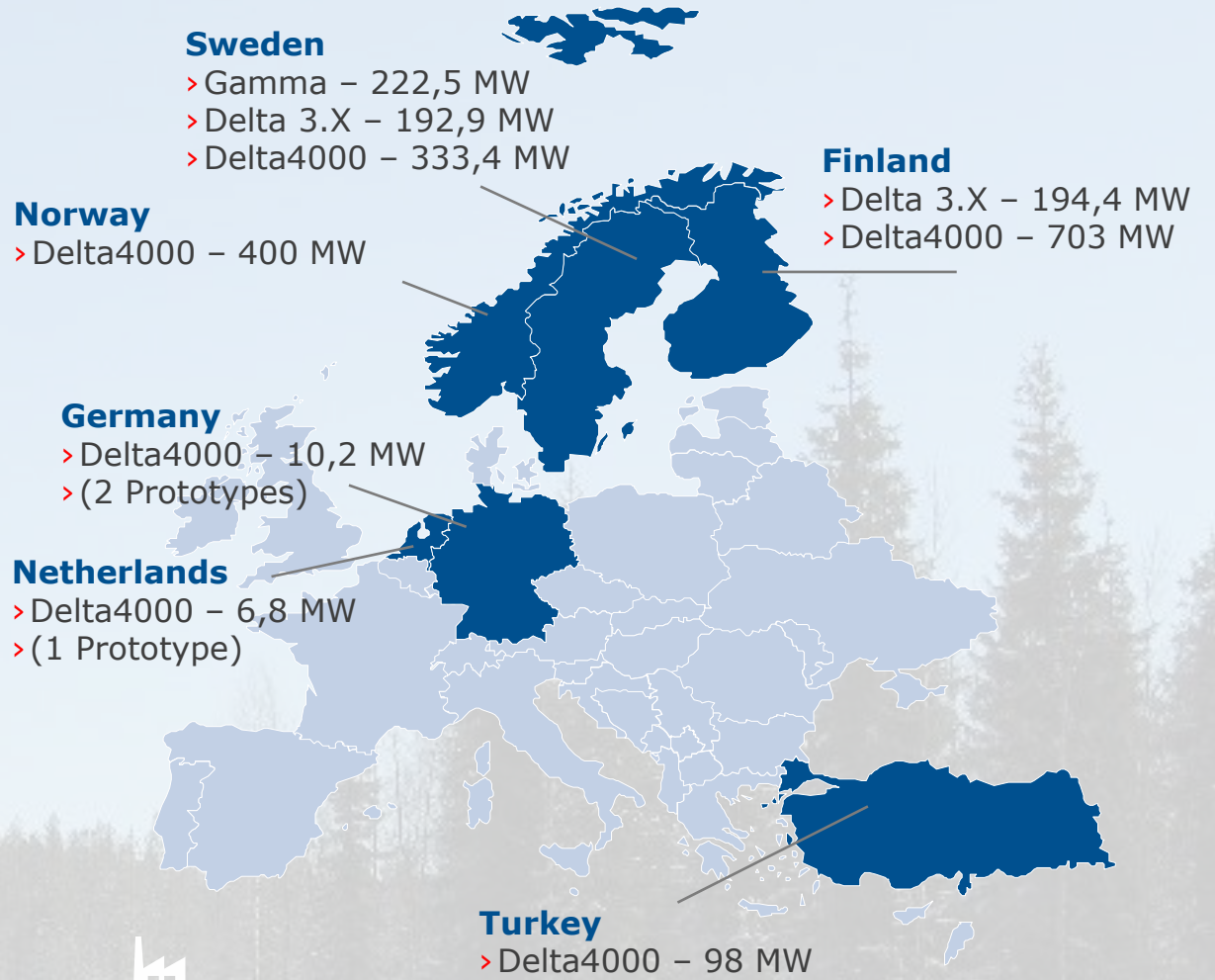
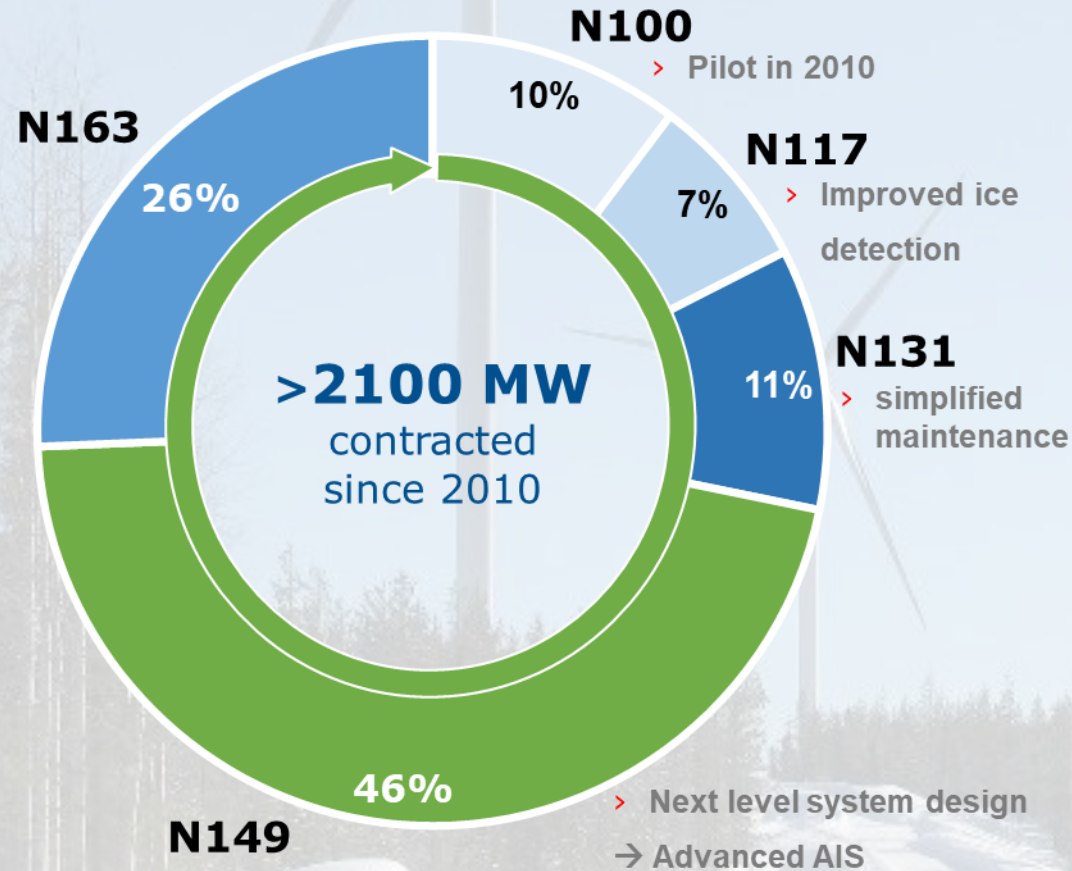
Åre, March 2023

> Anti-Icing System at work

Nordex Anti-Icing System



➤ 13 years EXPERIENCE in operating Anti-Icing Systems with different rotor sizes in severe icing conditions



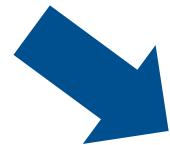
Status as of January 2023

CONTINUOUS IMPROVEMENT based on more than 13 years operational experience

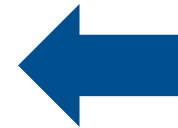
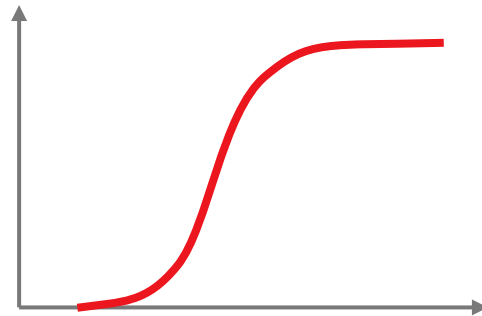
> Influence on Turbine Performance

Hardware of the Turbine

- Rotor diameter
- Hub height
- Generator
- ...



Power Curve



Weather Conditions

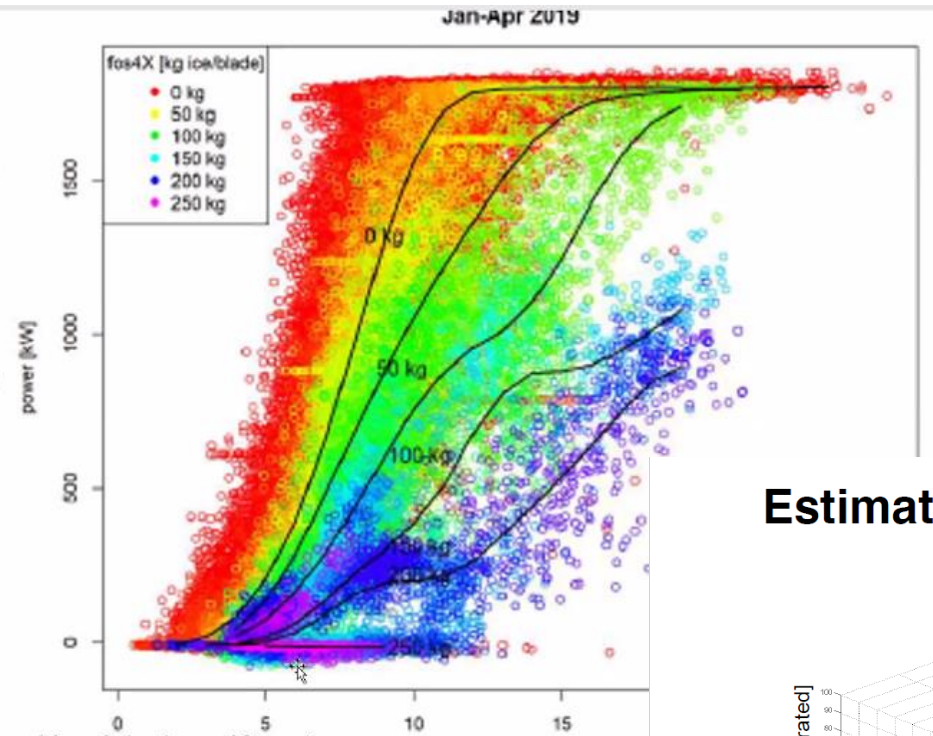
- Wind Speed
- Wind Density
- Shear
- Turbulence Intensity
- ...

Software of the Turbine

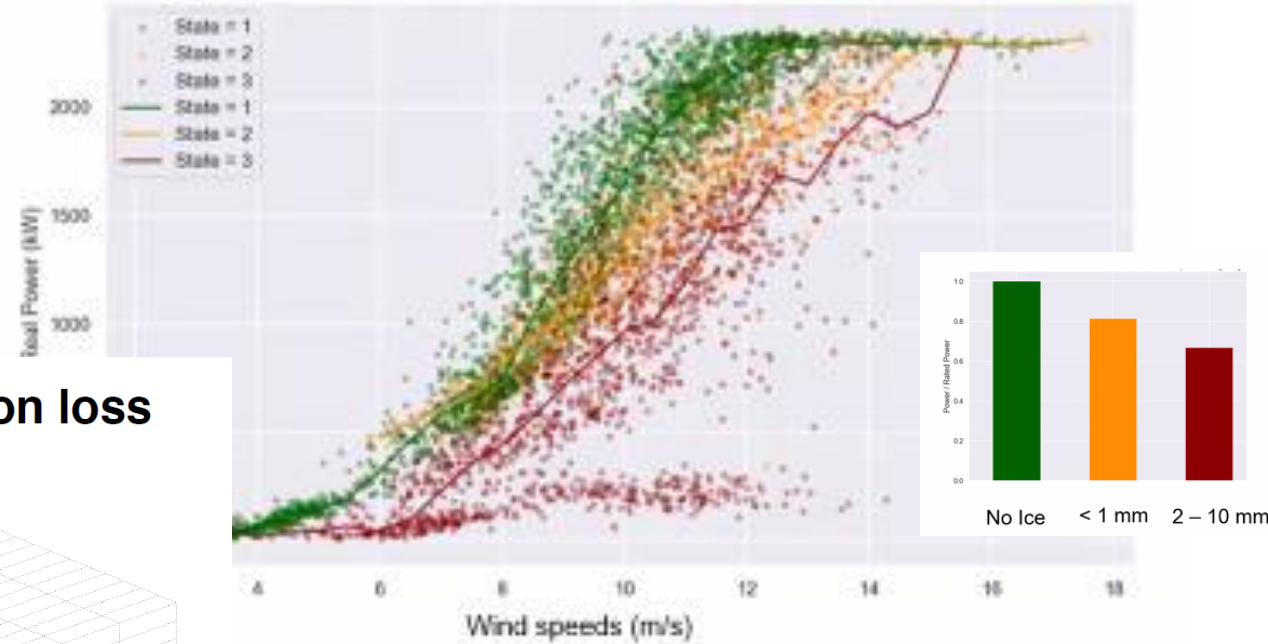
- Rotating speed
- Pitch angle
- Control algorithm
- ...



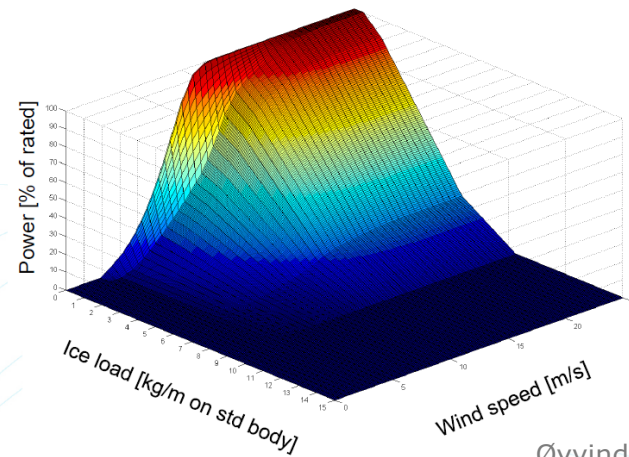
Power Output under Icing Conditions



Nils Lesmann: „Ensuring safe heating system operation“, VGB Webinar "Operation of Wind Power Plants in Cold Climate", 2021



Estimating production loss



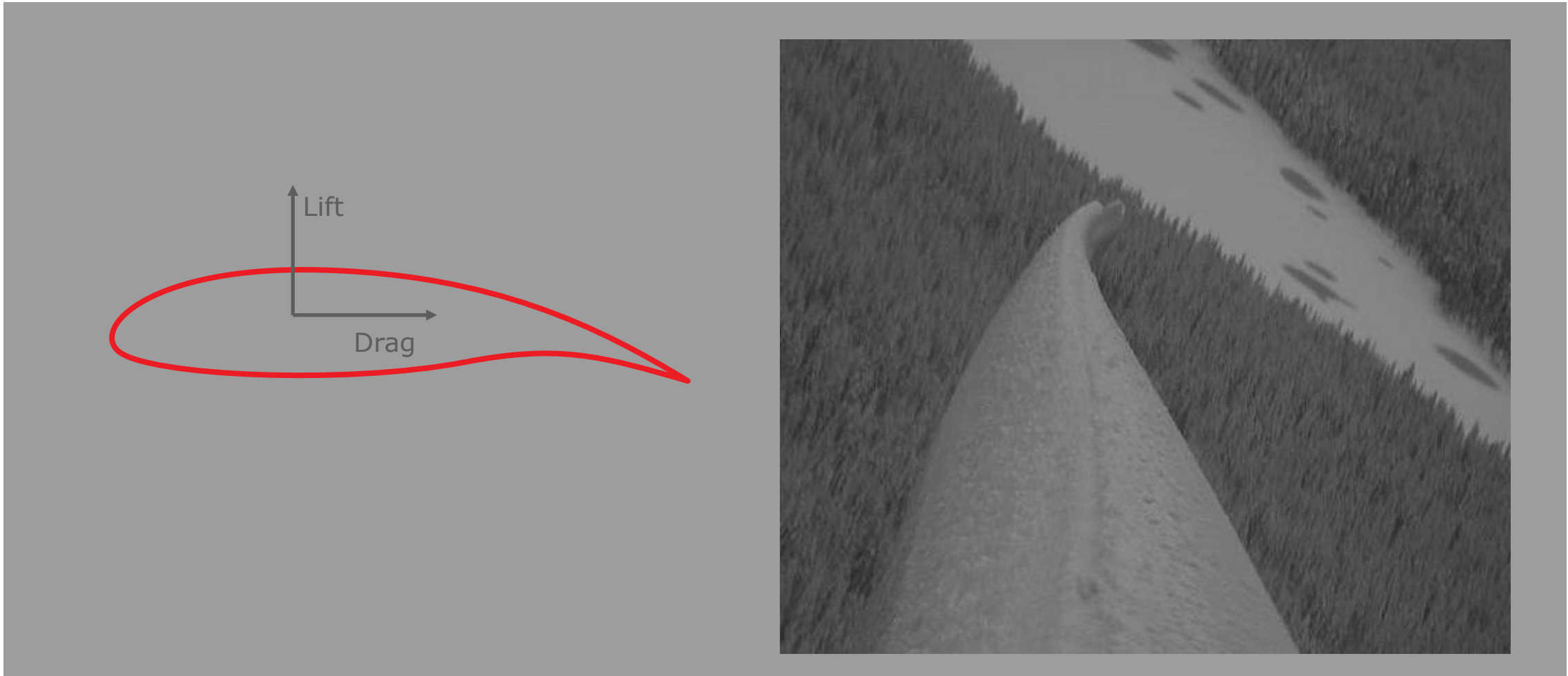
Paul Froidevaux, Franziska Gerber: „Comparison of blade-based ice detection systems – Results and outlook“, VGB Webinar "Operation of Wind Power Plants in Cold Climate", 2021

Øyvind Byrkjedal: "The benefits of forecasting icing on wind energy production", Winterwind 2012

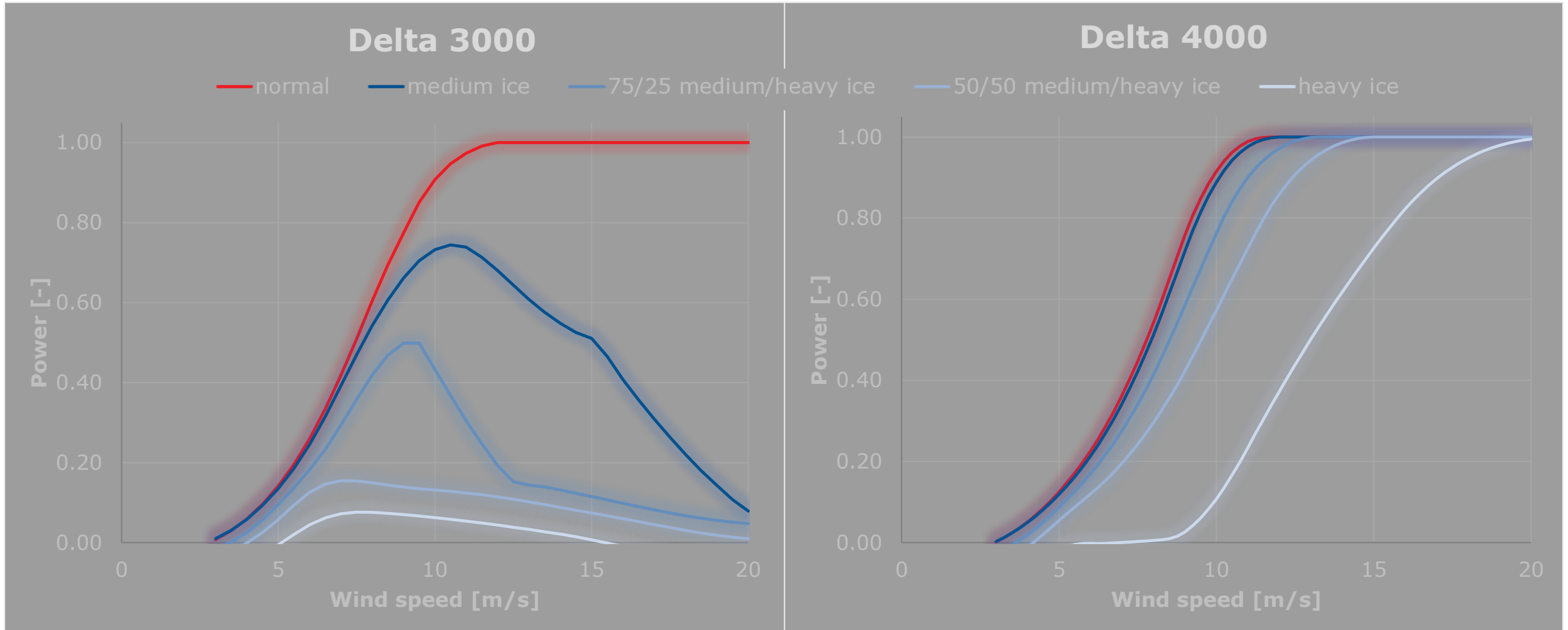


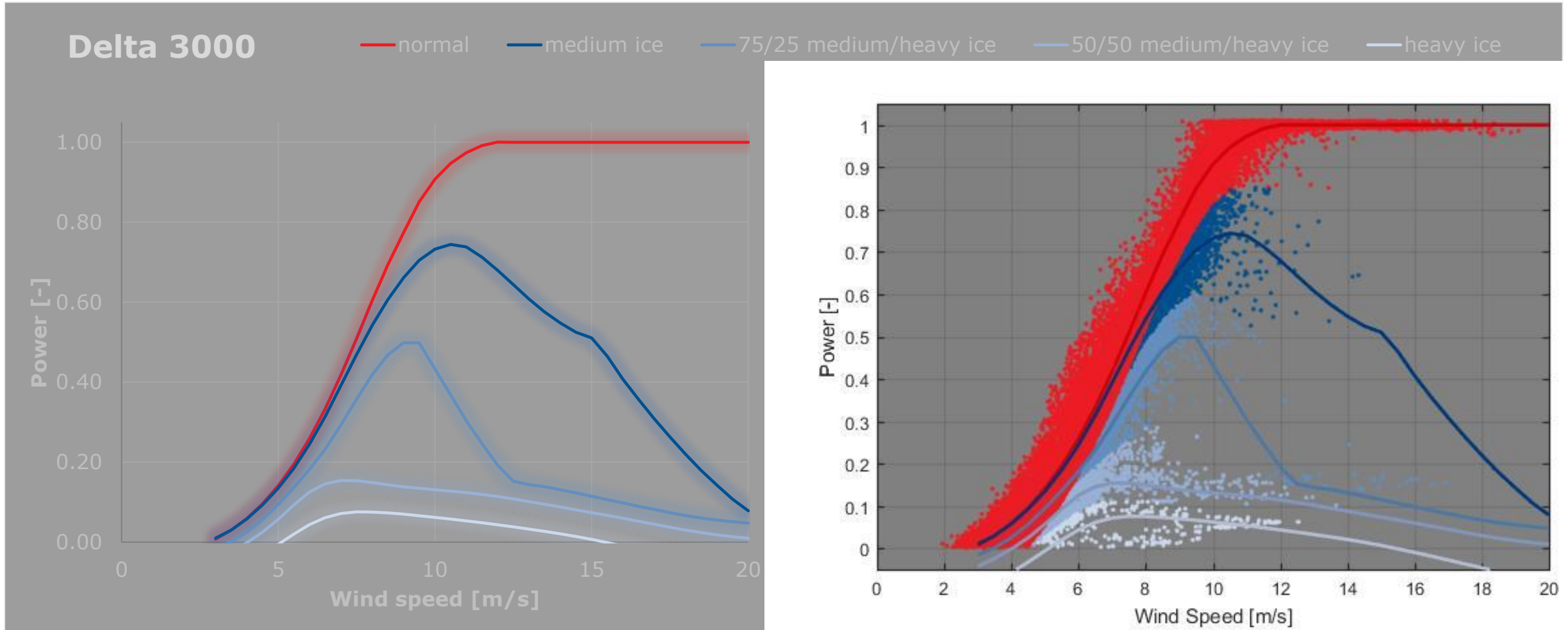
> Aerodynamic

> LIFT AND DRAG COEFFICIENT FOR HEAVY ICING

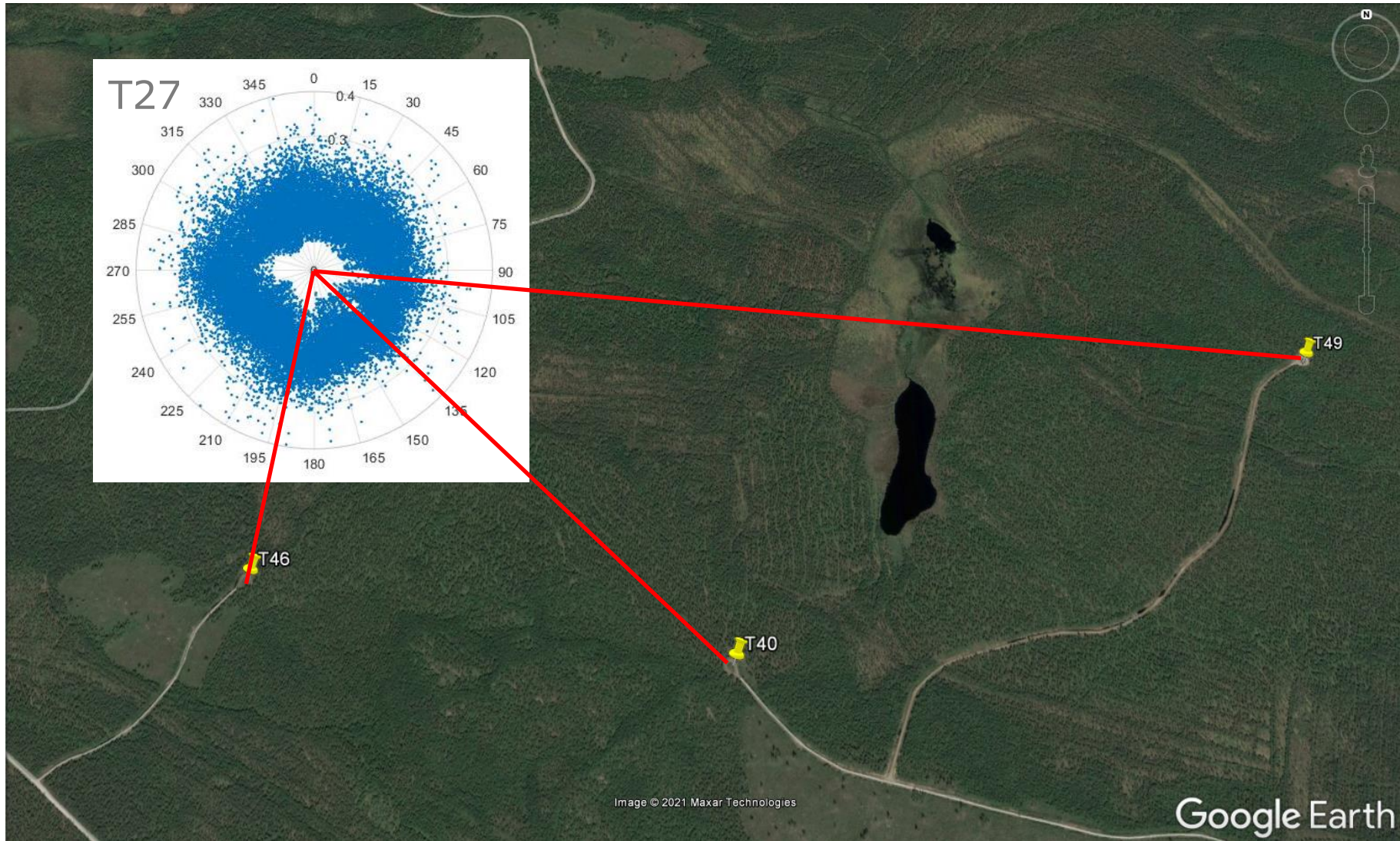


Power Curve with Ice



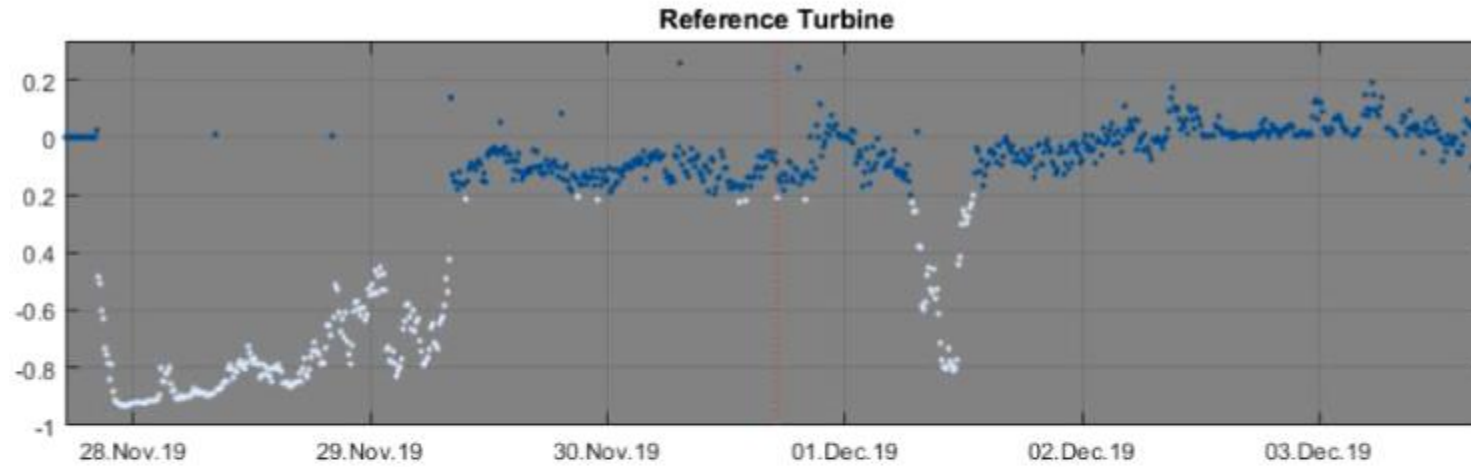


> Local Influence

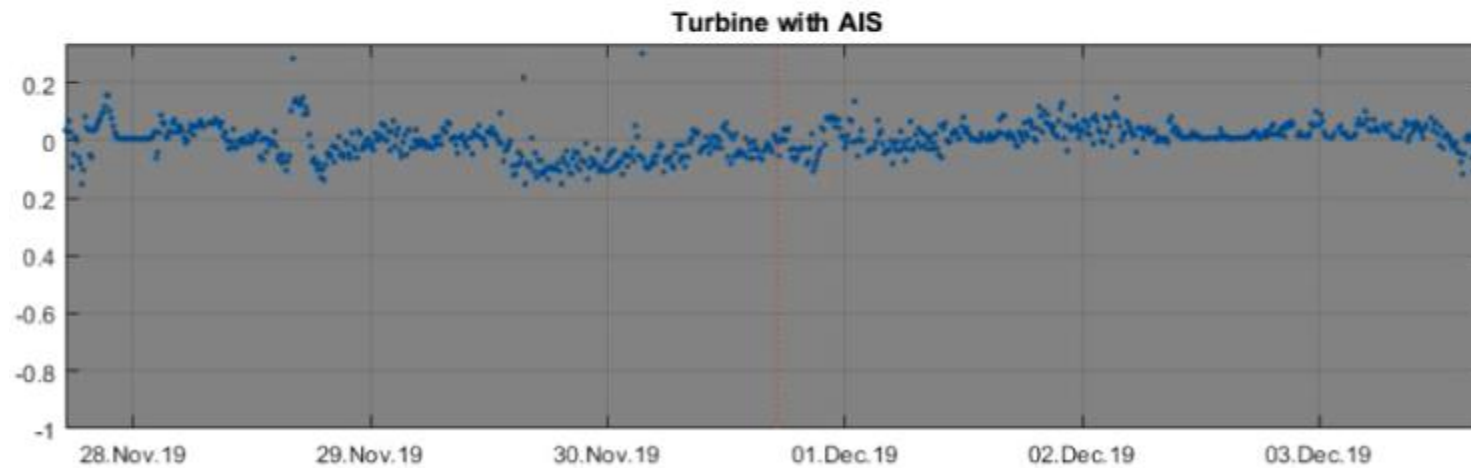



➤ Comparison of Reference Turbine and Turbine with Anti-Icing


$$\frac{P_{\text{produced}} - P_{\text{expeced}}}{P_{\text{max}}}$$



$$\frac{P_{\text{produced}} - P_{\text{expeced}}}{P_{\text{max}}}$$





 Thank you for
your attention

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