ping

Intelligent Listening

Winterwind

INTERNATIONAL WIND ENERGY CONFERENCE

29 March 2023

The importance of early-stage ice detection

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Outline

1. Introduction
2. Hypothesis - why early ice detection
3. Proposed method to detect ice build up early
4. Results of measurements
5. Conclusions

We use sound to monitor wind turbine blades and detect changes. Site technicians hear abnormal blade sound. We replicate this with permanent installations.


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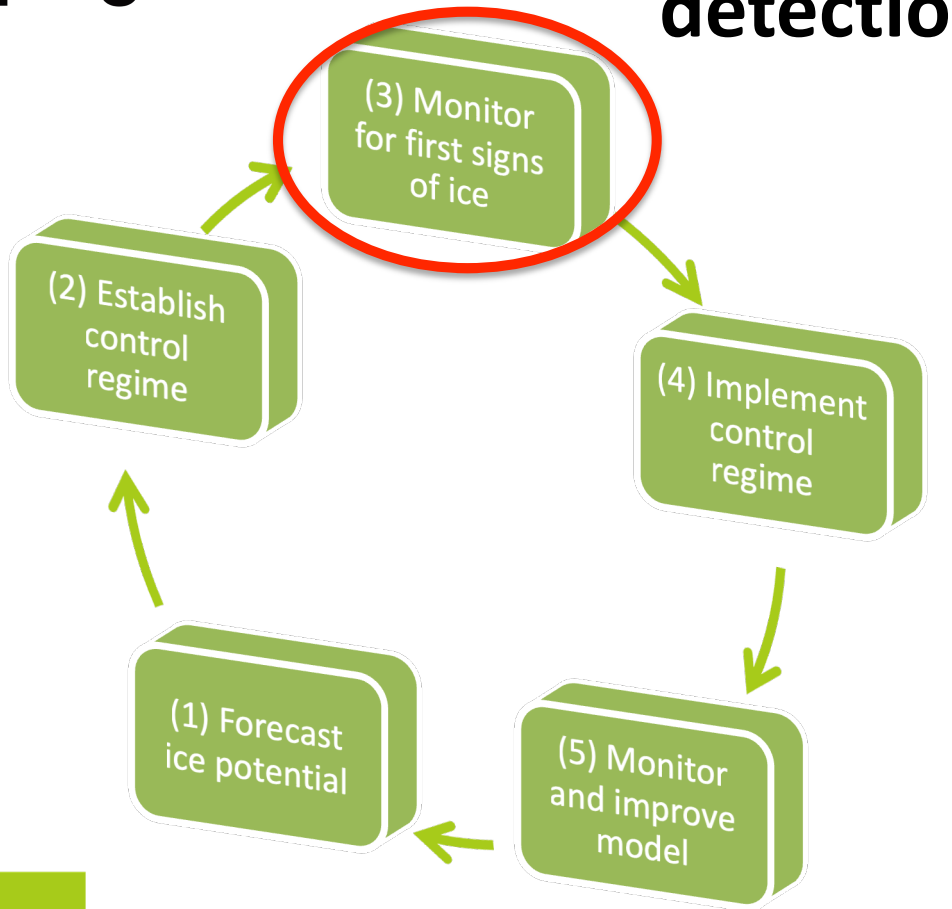
Hypothesis: Why early ice detection



Assumptions:

- No safety shut down / restart (or heating)
- No existing sensor with sufficient accuracy

Reasons to do this:

- Increase power output
- Power curve method is blunt
- Rotor monitoring
- Limited budget

Optimal control of a wind turbine with de-icing system through ice forecasting and observations

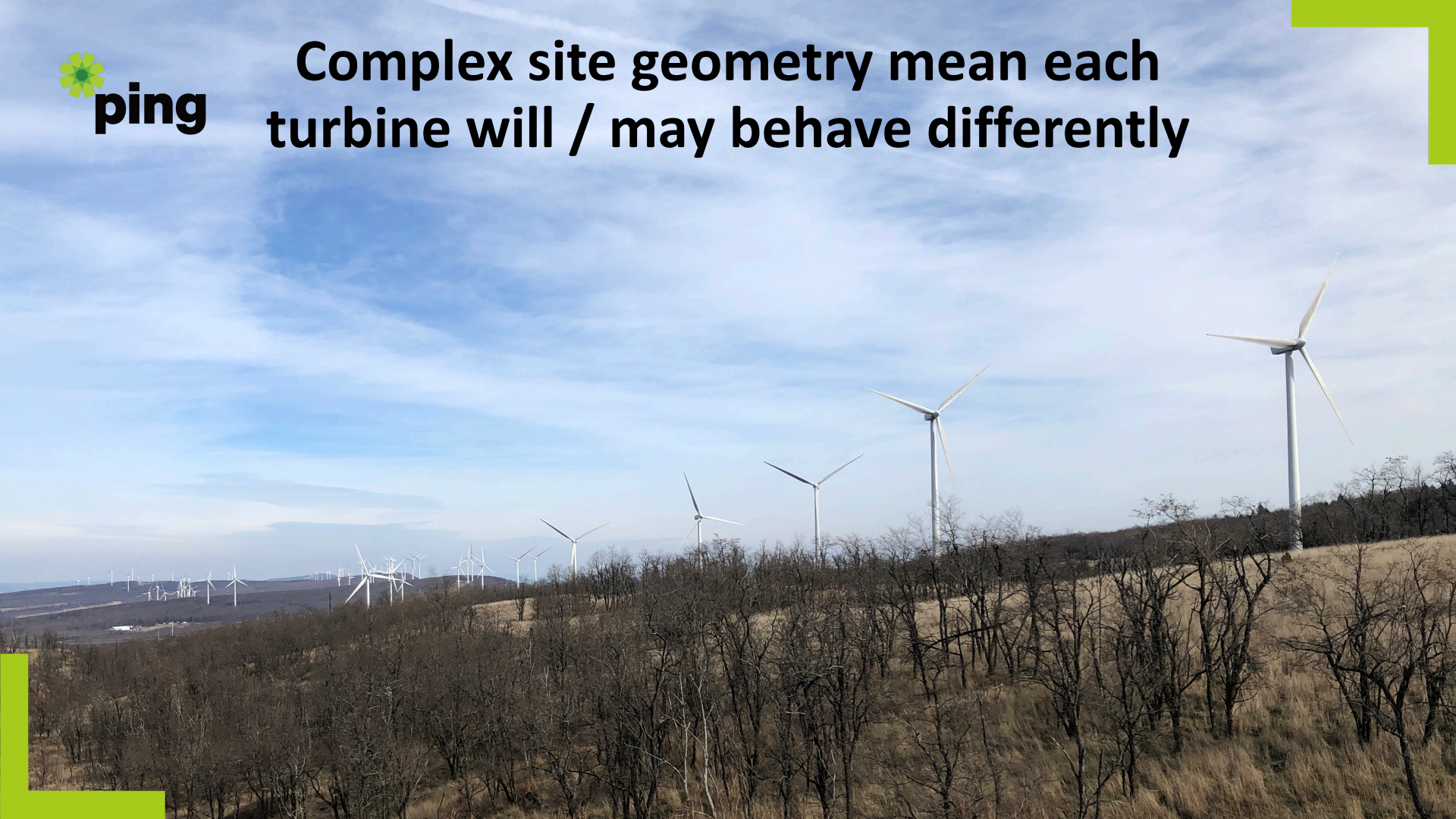
WIND POWER

Partners: Capstone Infrastructure Corporation

Period of realization: December 2018 – March 2023

This project is made possible thanks to the financial participation of the Government of Quebec, via InnovÉÉ and of the Government of Canada, via the Natural Sciences and Engineering Research Council

Complex site geometry mean each turbine will / may behave differently

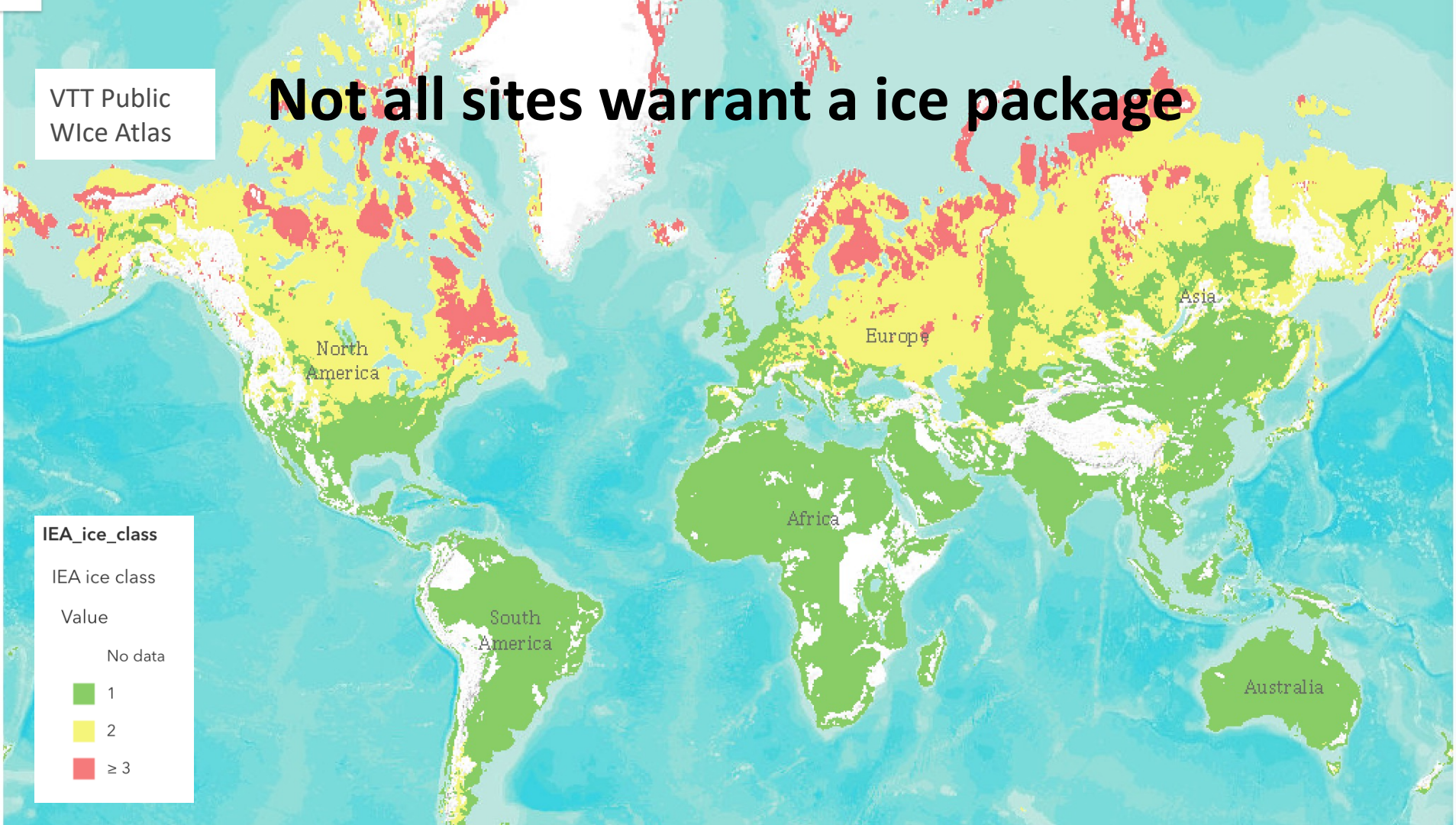


“Grey zone” where ice package not always installed

IEA Ice class	Meteorological icing	Instrumental icing	Production loss
	% of year	% of year	% of annual production
5	>10	>20	> 20
4	5-10	10-30	10-25
3	3-5	6-15	3-12
2	0.5-3	1-9	0.5-5
1	0-0.5	<1.5	0 - 0.5

VTT Public
WIce Atlas

Not all sites warrant a ice package



Location	Icing type	Icing detection signal	Measuring principle [Company]
Wind Turbine Nacelle or Met mas	Meteorological icing	Discrete (True or false)	• Infrared reflection + heating [HoloOptics] • Atmospheric conditions (T, RH, Visibility, etc.) [N/A] • Vibrating wire or probe +heating [Labkotec]
		Continuous intensity (in mm/h, kg/h or kg/m·h)	• Load cell attached to a rotating cylinder [Saab Combitech] • IP cameras coupled with image analysis [Nergica] • Heat transfer rate on a probe [Icetek] • Change of impedance + heating [Goodrich Campbell Scientific]
	Instrumental icing	Discrete (True or false)	• Double anemometry [N/A] • Infrared reflection [HoloOptics]
		Continuous severity (in mm, kg or kg/m)	• Load cell attached to a rotating cylinder [Saab Combitech] • IP cameras coupled with image analysis [Nergica] • Heat transfer rate on a probe [Icetek] • Change of impedance [Sommer]
Wind Turbine Rotor	Meteorological icing	Discrete (True/false or categories)	• IP cameras coupled with image analysis [Nergica, Meteotest] •
		Continuous intensity (in mm/h, kg/h or kg/m·h)	• Change of impedance [eologix] • Change in blade eigenfrequencies [Fos4x, Wolfel, Weidmuller]
	Rotor icing	Discrete (True/false or categories)	• Power curve + Pitch curve [All OEMs, IEA Task 19] • IP cameras coupled with image analysis [Nergica, Meteotest] • Sound emissions from wind turbine blades [Ping Services]
		Continuous severity (in kg or kg/m)	• Change of impedance [eologix] • Change in blade eigenfrequencies [Fos4x, Wolfel, Weidmuller]

Classification of commercially available ice detection methods – adapted from IEA Wind Task19 - © IEA Task19 2021. Nergica 2021.

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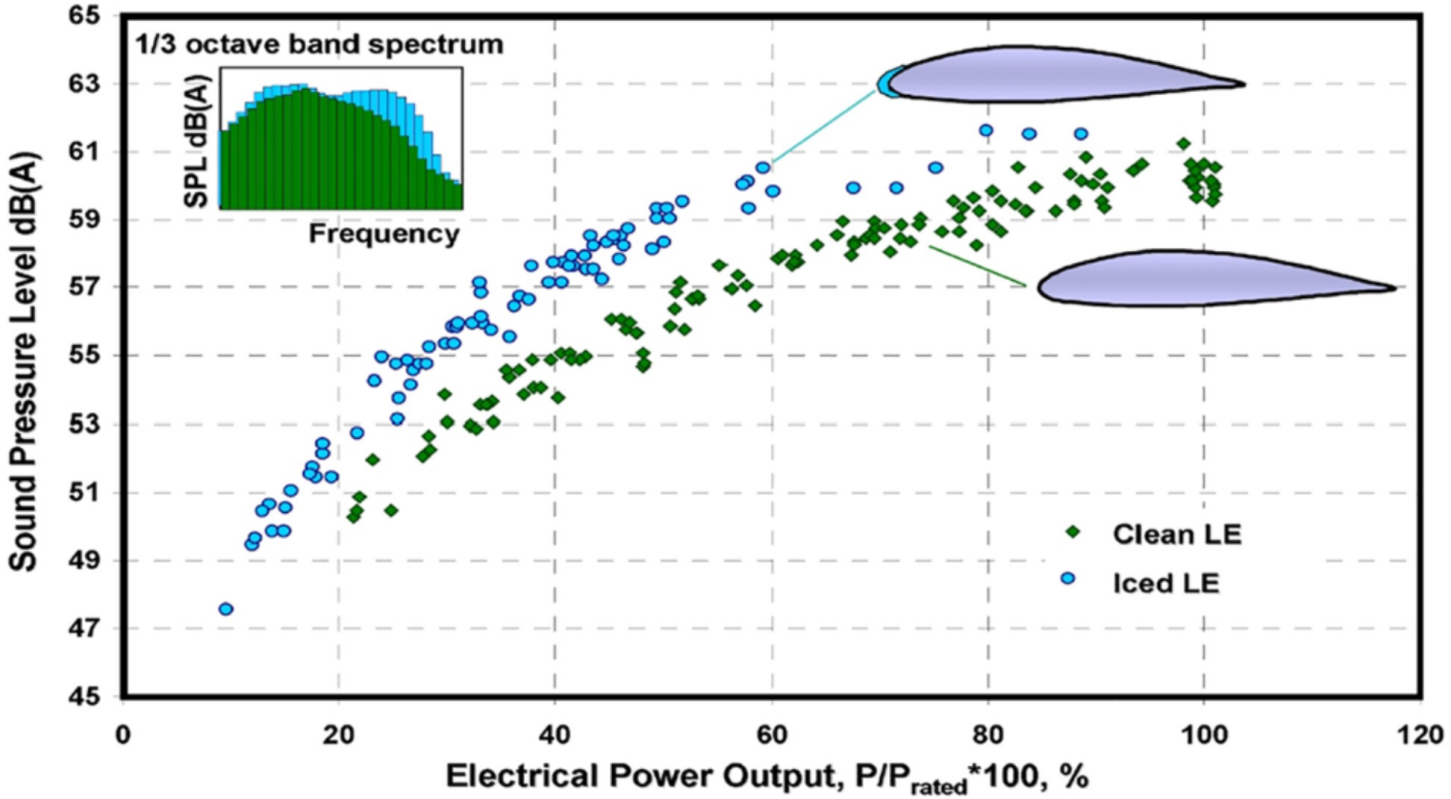
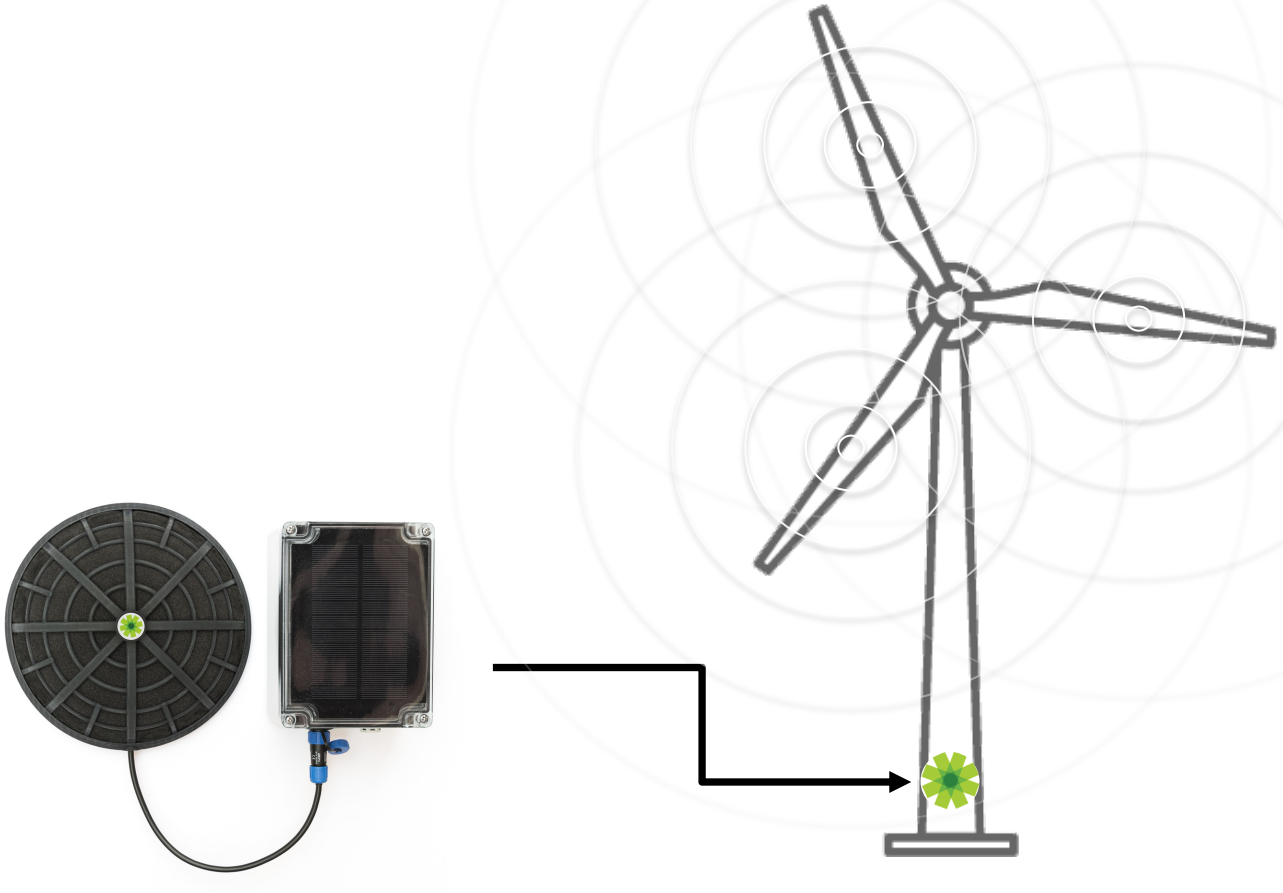
Iced vs clean blade sound



A review on ice detection technology and ice elimination technology for wind turbine
Kexiang Wei, Yue Yang, Hongyan Zuo, Dingqing Zhong
First published: 23 December 2019 https://doi.org/10.1002/we.2427

Ping Continuous Listening Technology



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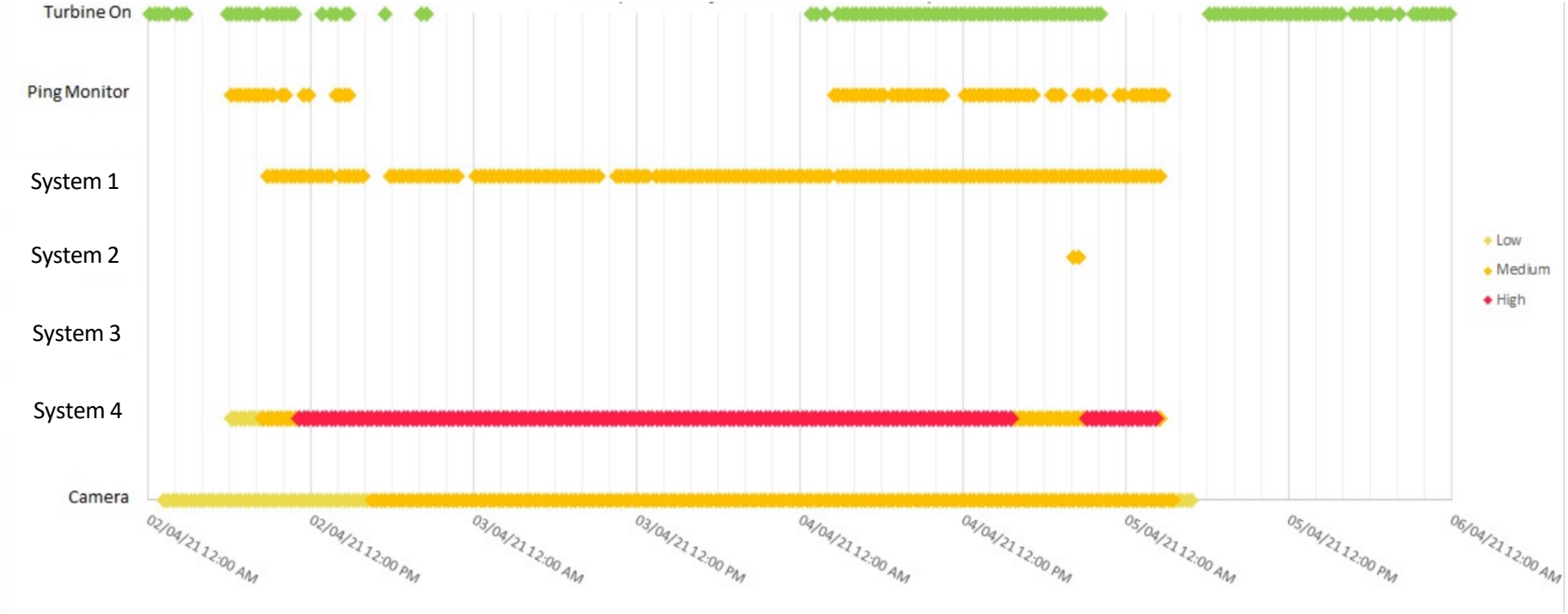
Infrastructures

Nergica owns and operates a full-scale research site that comprises wind turbines, a solar array, met masts, lidars, a wind/solar/diesel microgrid, storage technologies and a real-time simulation platform.

Installed in Rivière-au-Renard (Quebec, Canada) at an elevation of 330 m, these cutting-edge infrastructures constitute a research site that offers real-world conditions and allows for a multitude of research, development and technology transfer projects to be carried out in cold climate conditions and complex terrain.

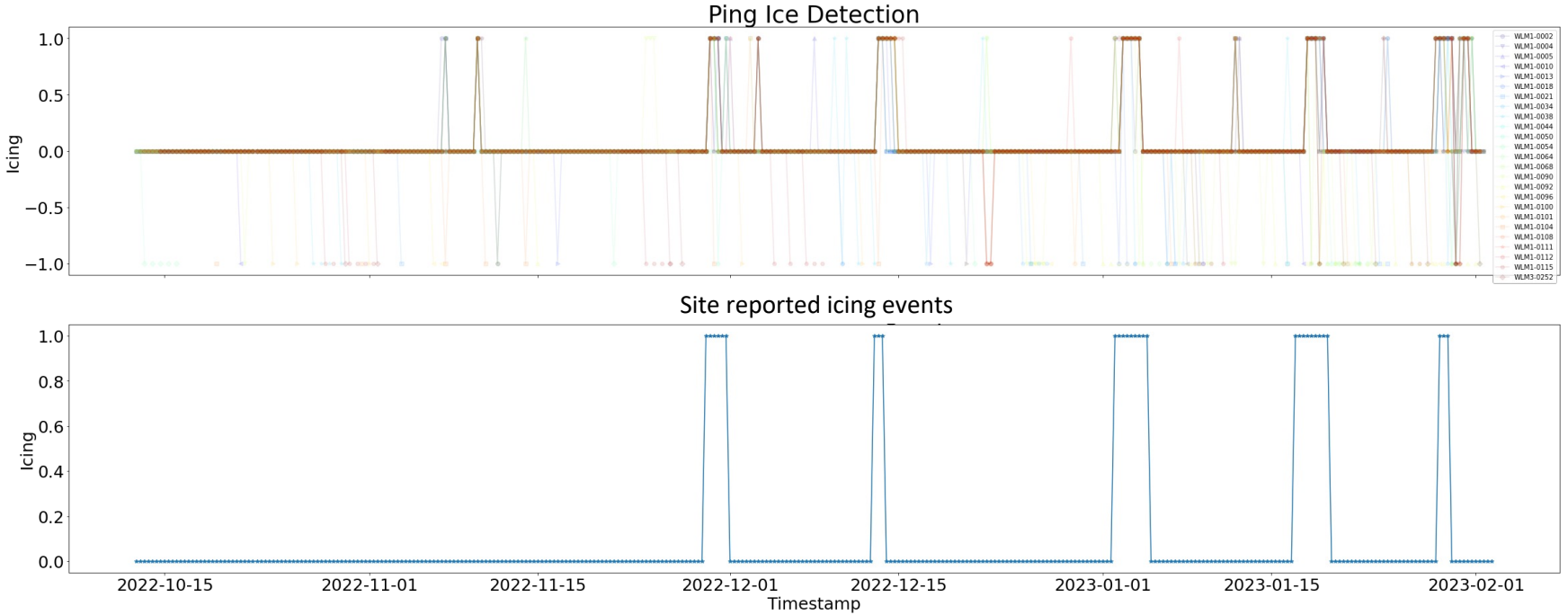
Take advantage of a unique research site in North America!

Case study: acoustic ice detection vs alternative methods



Study conducted at NERGICA (data processing by Ping)

Case study: acoustic ice detection vs site records



1: Ice, 0: No Ice, -1: Low Quality or Turbines Stopped

Monitoring system as currently implemented

Ping Support
Organisation Name

SITE LIST

Site Name

DAMAGE INDICATORS | ICING INDICATORS | TURBINES | SITE MAP | ALERTS

Sort by: Icing Level

EXPORT

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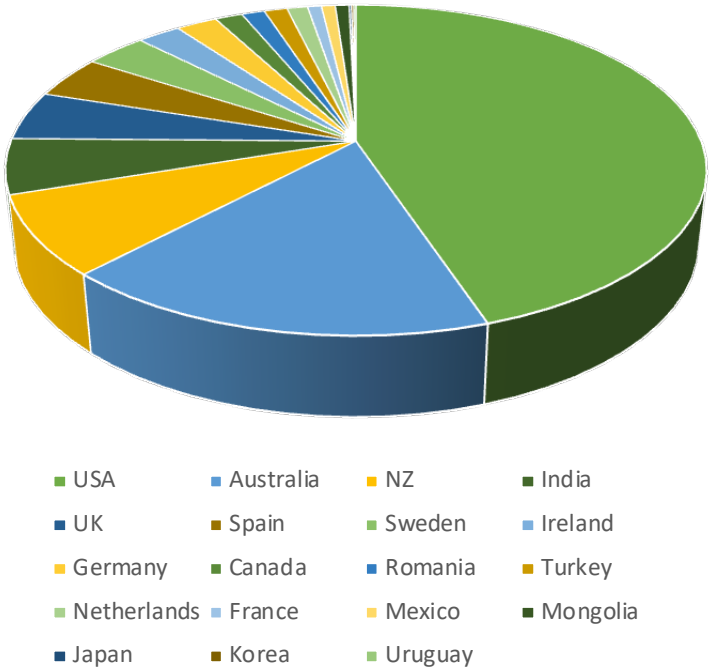
Status of Ping Monitor installations



- 1115 systems*
- >700 in areas with icing potential
- 19 countries
- 47 customers
- Now detecting ice on blades as a software upgrade
- Logging temperature, wind speed (via rotational speed) and ice as a result of a change in acoustic signature.

*Installed or committed to be installed.

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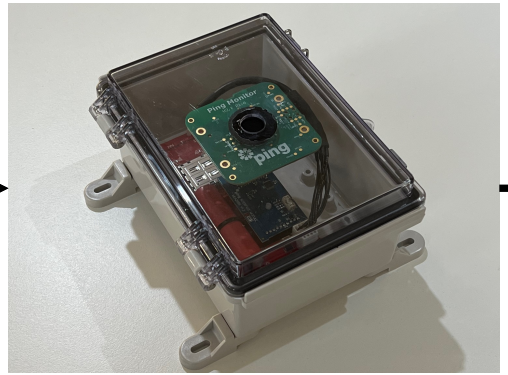
Internal

Root zone structural damage

Lightning option

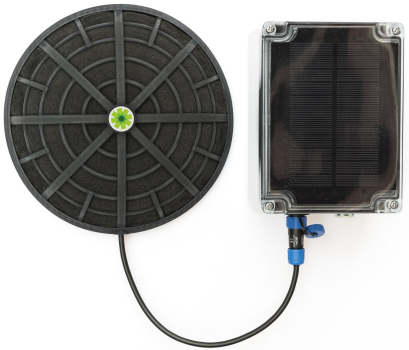


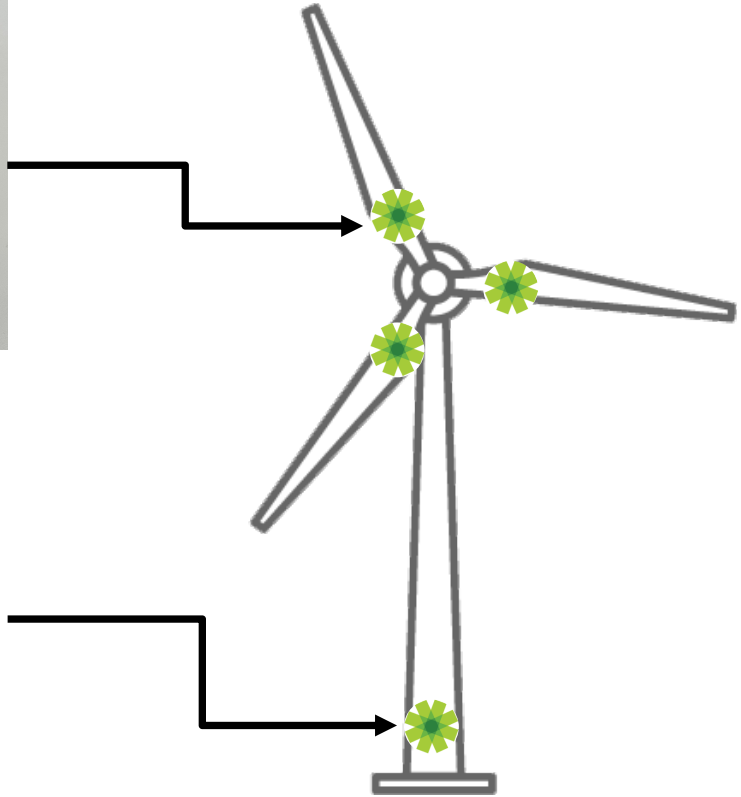
External

Surface blade damage

Ice detection option

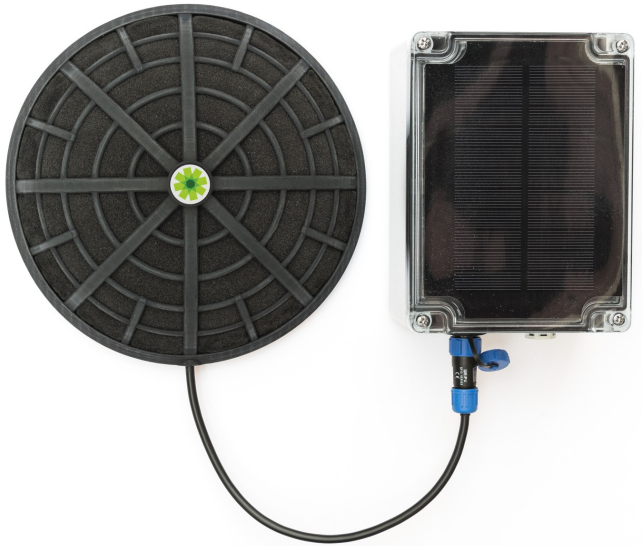
Lightning option





Conclusion

1. Acoustic based ice detection system
2. Next steps is to build in forecasting and operational controls (with partners)
3. Opportunity for generating large data sets to improve prediction models
4. Looking for feedback on integration with forecasting model(s) and partners



Questions?

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