A Look at Wind Turbine Performance in Canadian Icing Climate

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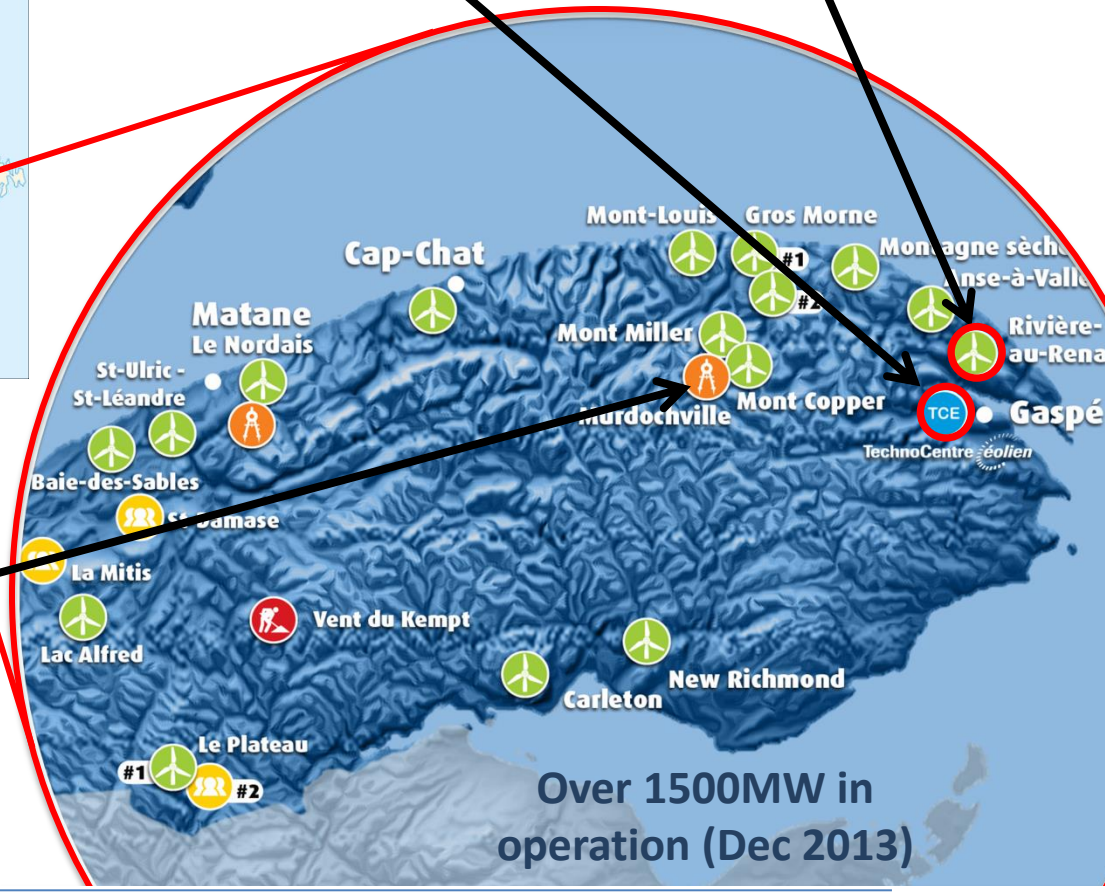
Plan

- What is TCE?
- ARD Research Program – NSERC
- Infra-structure and sensors
- Icing Background (performance, load, ice detection)
- Optimisation strategy with IOM
- Performance loss example cases
  - without IOM
  - with IOM
  - with IOM and deicing
- Load analysis example case
- Ice detection on blades
- Conclusion

TechnoCentre éolien (TCE)



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Wind Energy TechnoCentre

Wind Farm / Test Site

- Two 2.05 MW Senvion MM92 CCV

SENVION
wind energy solutions

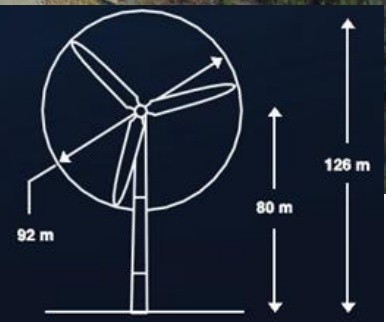
- Commissioned March 2010

Hydro Québec

- Icing (IEA Class 2-3)
- Complex terrain (IEC Class 2)
- R&D, technological transfer, technological validation, performance assessment.

OSIsoft.

Description	Value
Number of wind turbines	2
Model	REpower MM92 CCV
Rated power / Wind turbine	2.05 MW
Frequency	60 Hz
Rotation speed	7.8 – 15 RPM
Start-up speed	3 m/s (10.8 km/h)
Shut-down speed	24 m/s (86.4 km/h)



IEC wind class: 2
Annual average wind speed: 7.9 m/s
Topography: Complex site with high turbulence, near the sea
Temperature: -30°C to +30°C
Ice conditions: Up to 40 mm of ice

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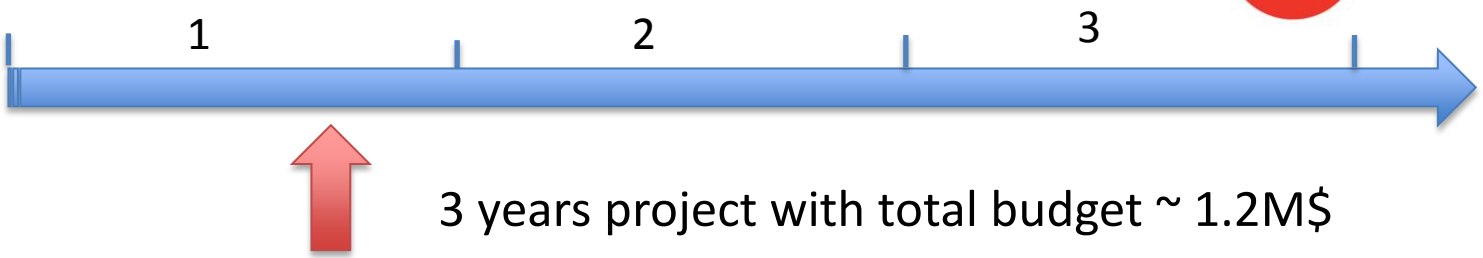
NSERC Research Program

- **Applied Research & Developpement program (ARD)**

CRSNG NSERC



3 years project with total budget ~ 1.2M$

- Project Canada
- R&D Germany
- Student intern
- College teachers
- Project leads
- Research Analyst

SENVION wind energy solutions

Cégep de la Gaspésie et des Îles

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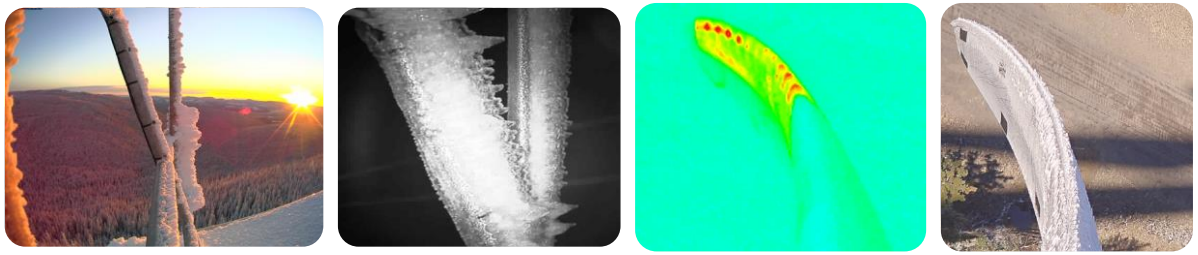
Main Objective → **Optimisation of a Wind Turbine Ice Operation Mode (IOM)**

Infrastructure and Sensors

On TCE test site

- On the 2 MM92 turbine

Camera packages



Blade sensor bench test

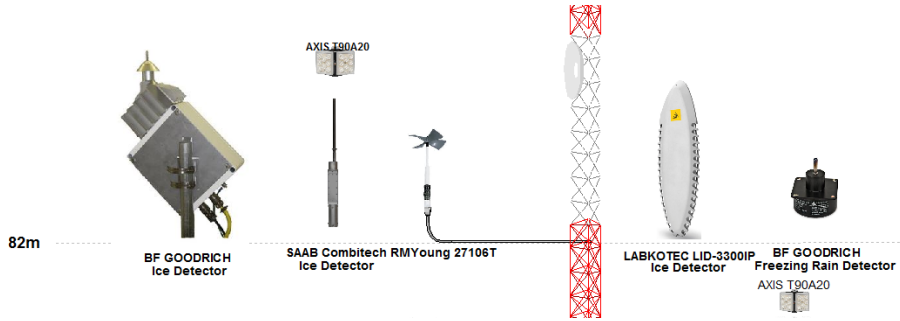
fos4X

eologix sensor technology

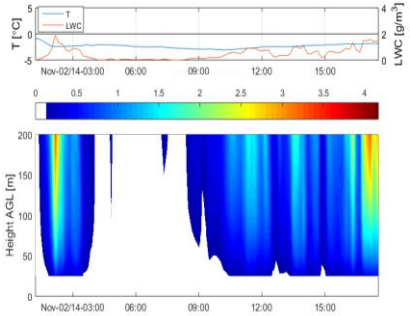
Rexroth Bosch Group

- On MMV1 weather masts

Ice detector bench test



Micro Rain Radar



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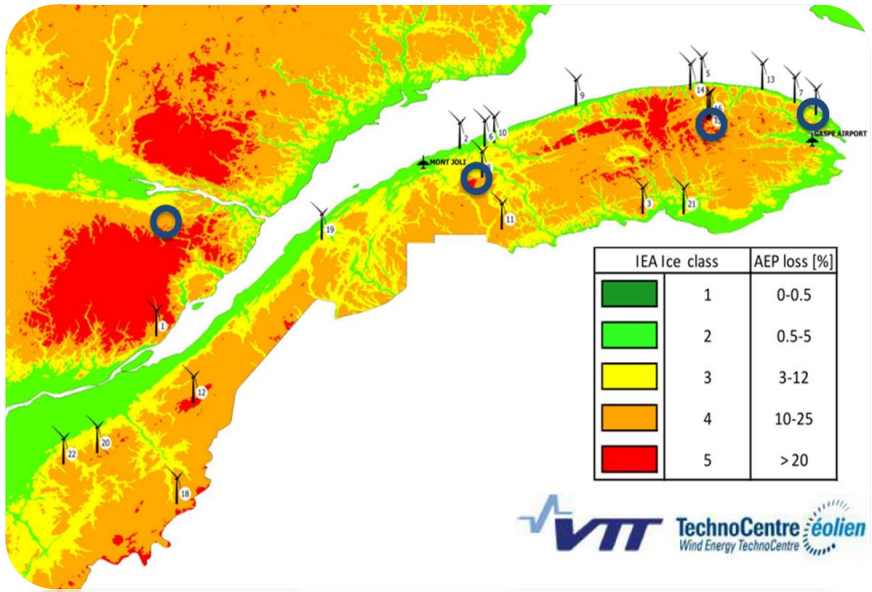
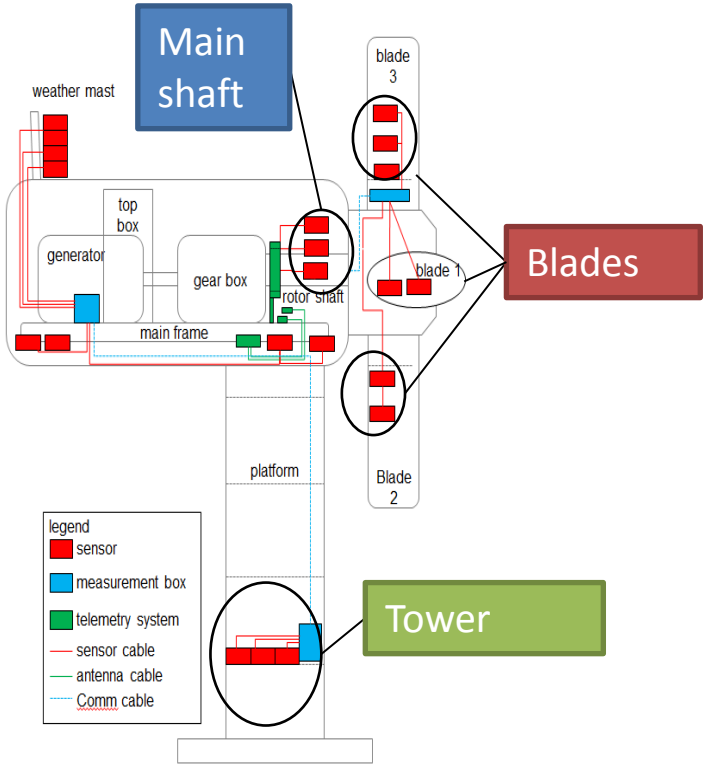
Infrastructure and Sensors

At Client Wind Farms

- Load measurement sensors





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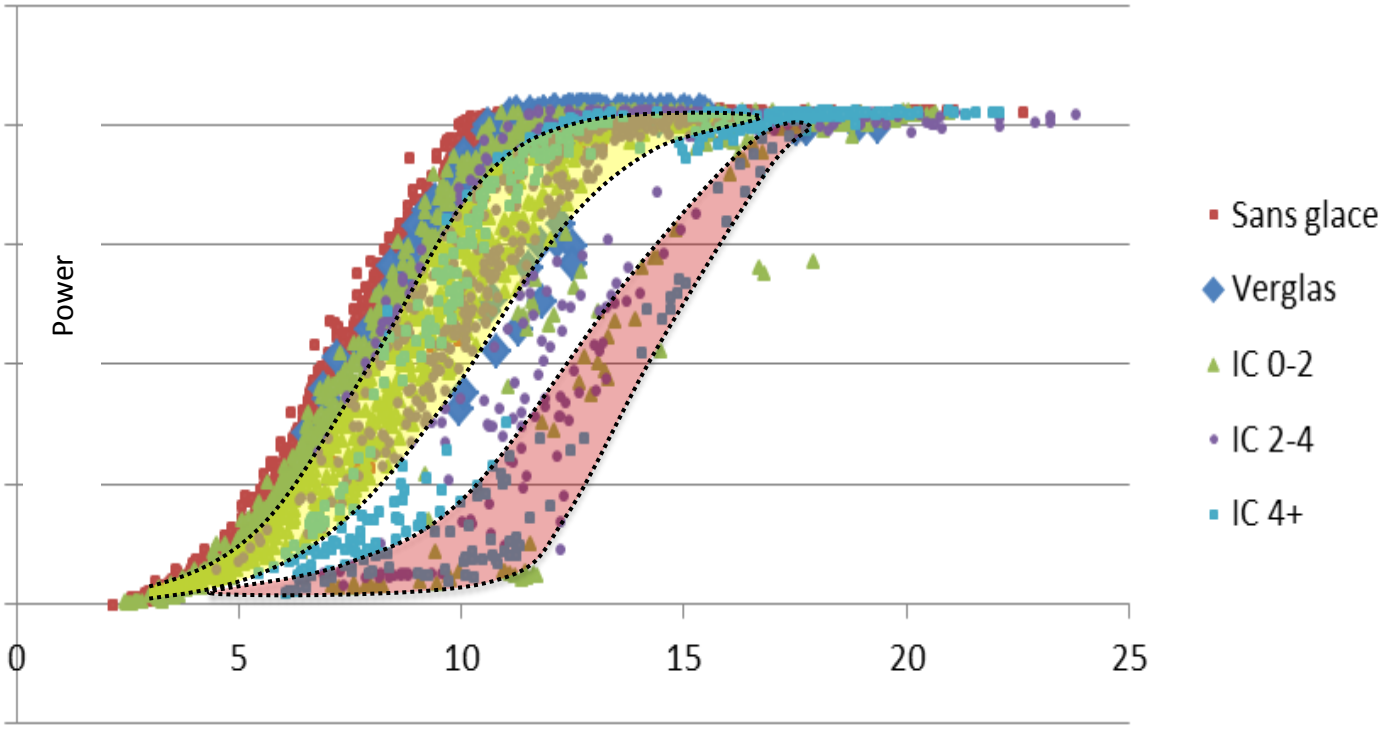
Icing Background

- Wind turbine performance
  - Performance vs icing severity (ISO 12494 Ice Class)
  - Power loss during operation
  - Turbine stall higher probability



Icing Background

Wind turbine load under icing (WW2014)

- Collaboration with:

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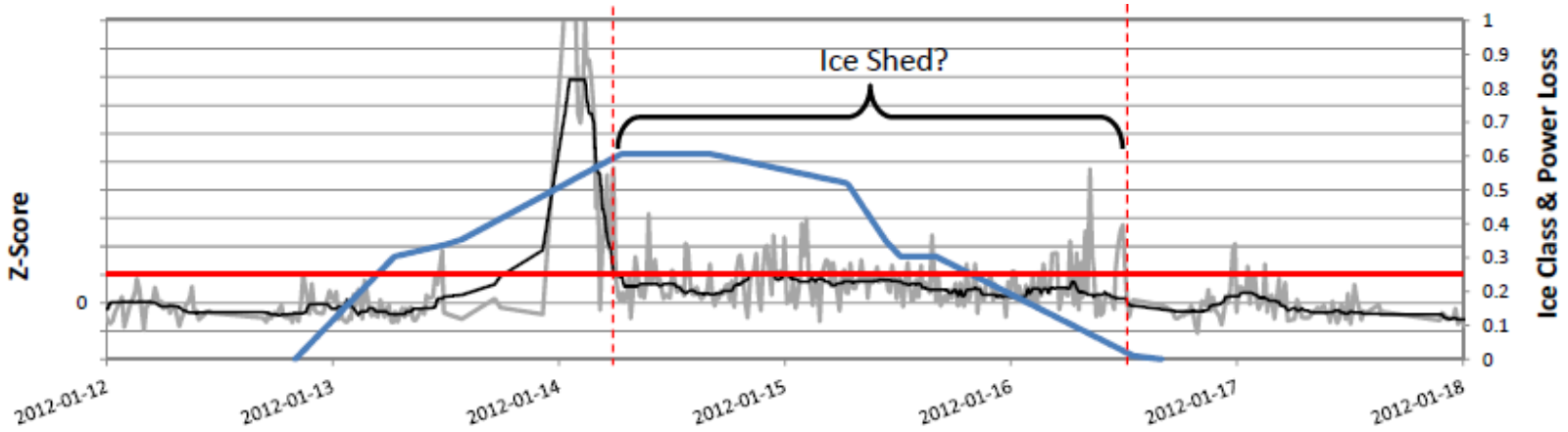
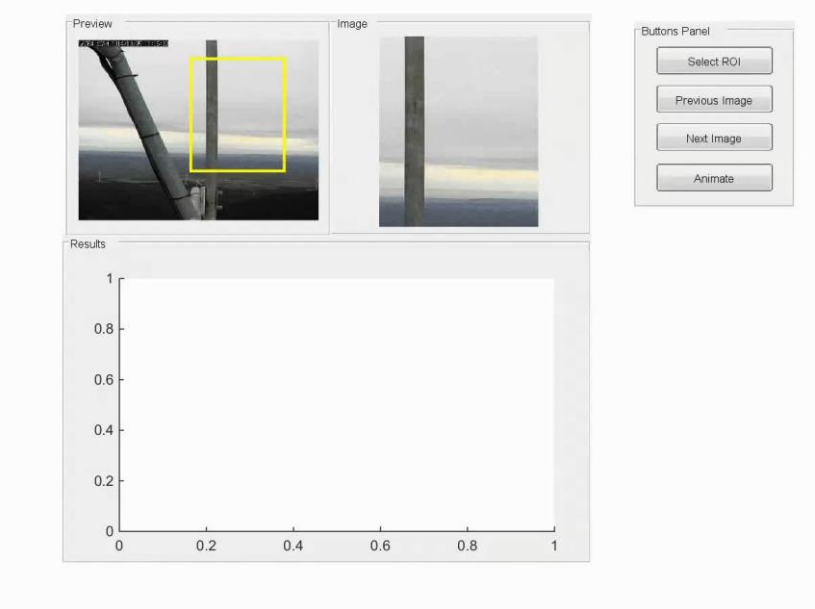
- No significant effect except tower base side-to-side
- Analysis only for 1.5 winter data
- Ice load during ice shedding need more study



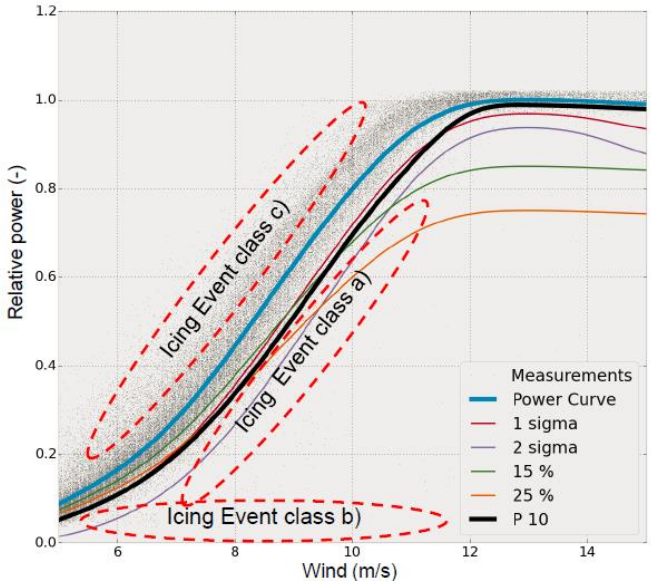
Icing Background

Ice detection

- From image analysis

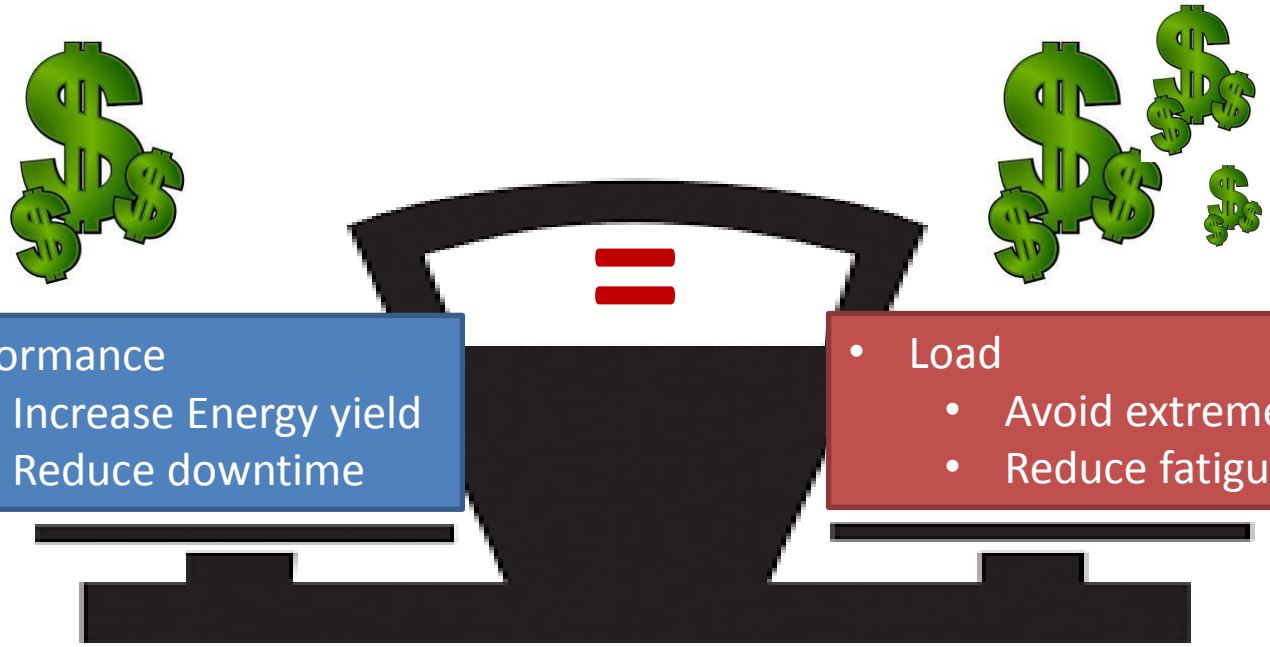


- From power curve (IEA Task 19)



- Blade icing ≠ Nacelle icing
- Detection of ice during stand still
- Uses of multiple methods

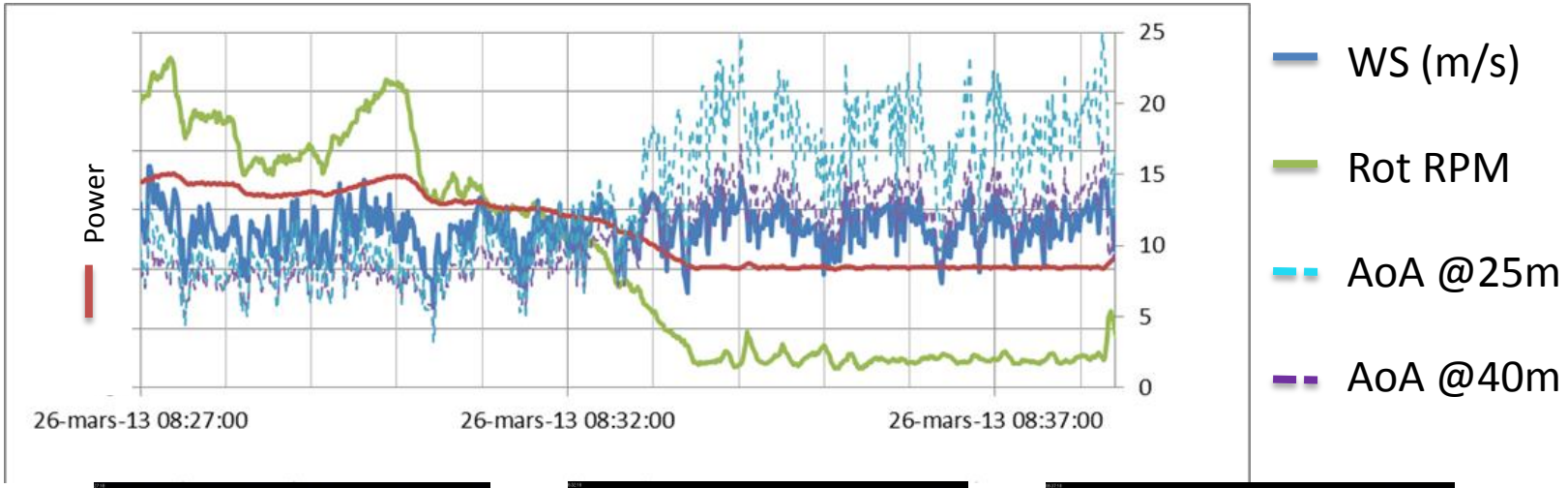
Ice Operation Mode Strategy



- Performance
  - Increase Energy yield
  - Reduce downtime
- Load
  - Avoid extreme loads
  - Reduce fatigue loads
- Ice detection
  - Detect at early stage
  - Assess ice removal

Performance example cases

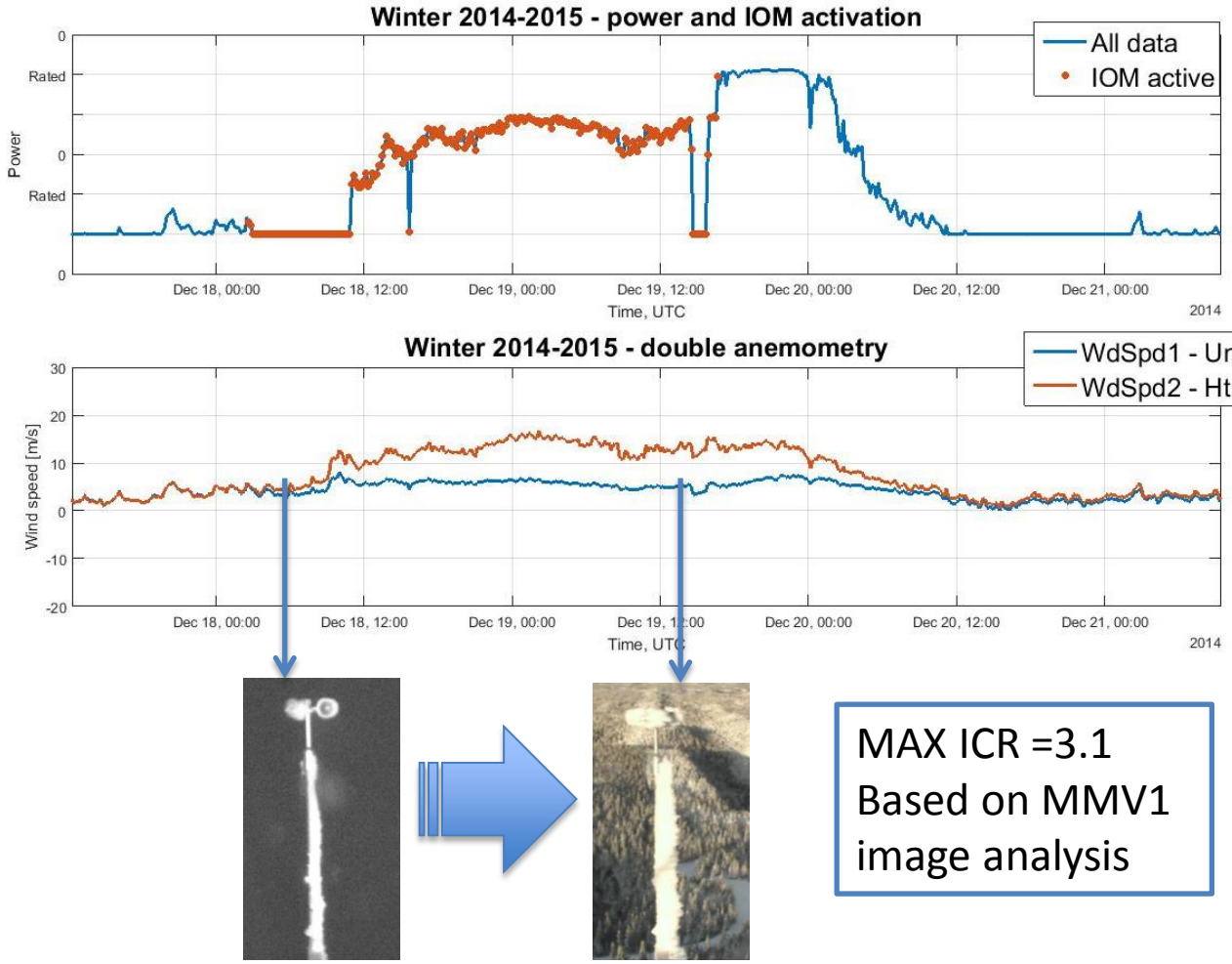
Without IOM (2013) – mixed accretion



8:27	8:32	8:37

Performance example cases

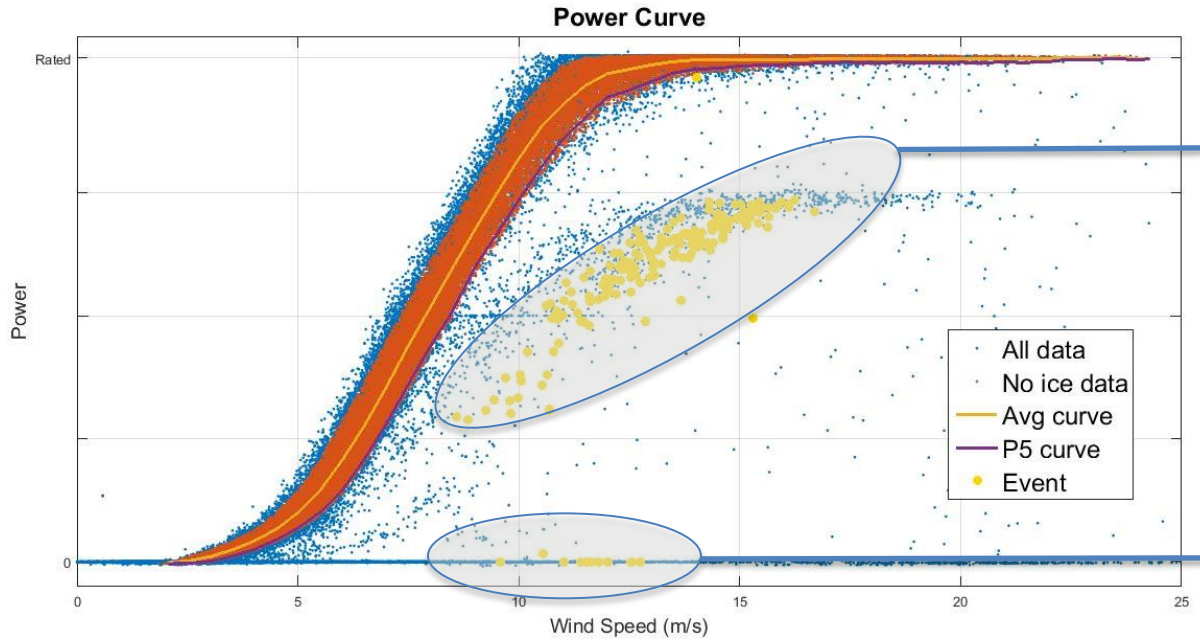
With IOM



MAX ICR =3.1
Based on MMV1 image analysis

Performance example cases

With IOM



Stall prevented

Manual Stop

IOM pitch setting:

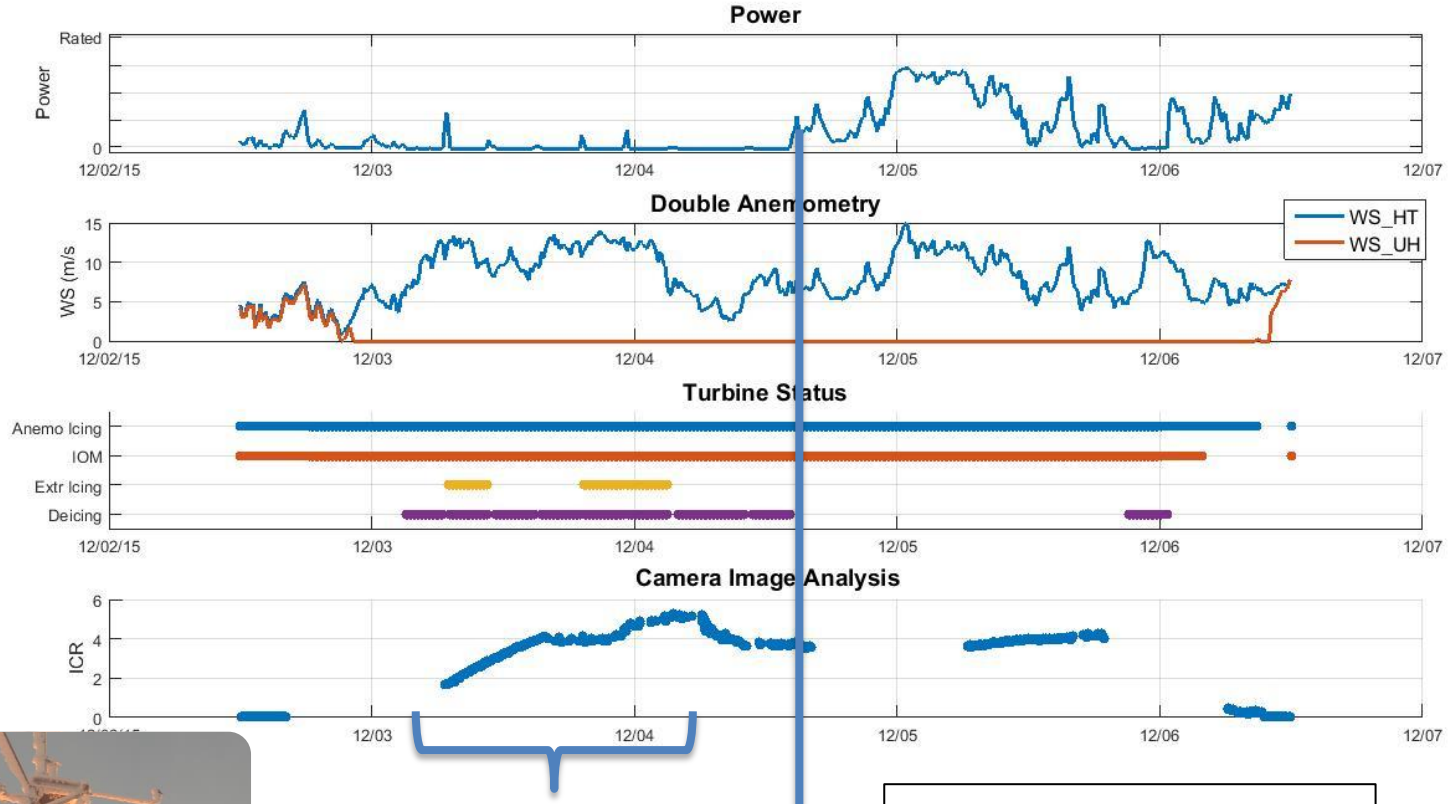
- Prevent stall in light to moderate icing

Turbine derating:

- Reduce turbine loads by reducing rotational speed

Performance example cases

With IOM and de-icing



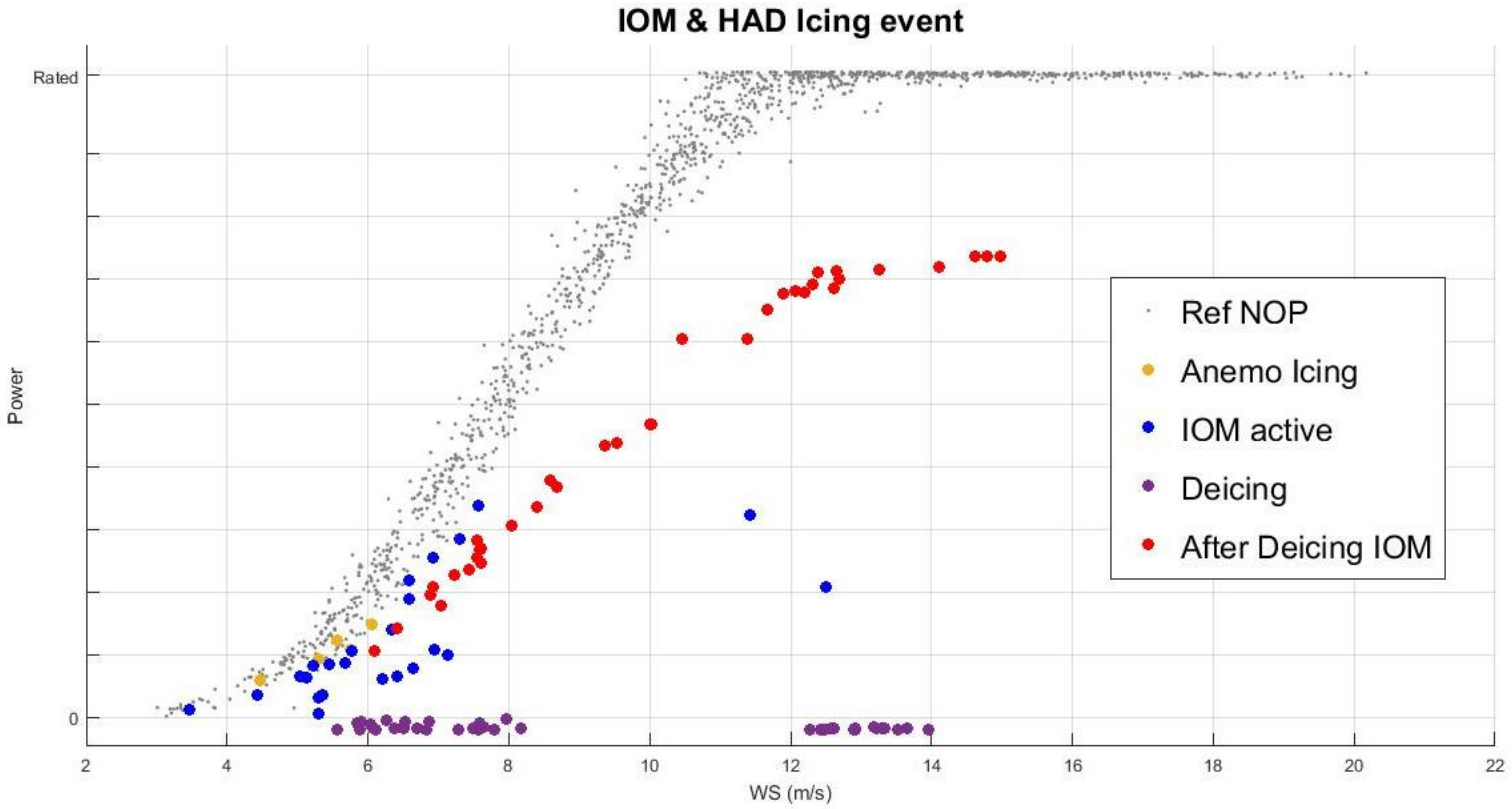
Around 24hrs of active icing **ICR~5**

Resumption of power
Around 48hrs of stand still saved

Performance example cases

With IOM and de-icing

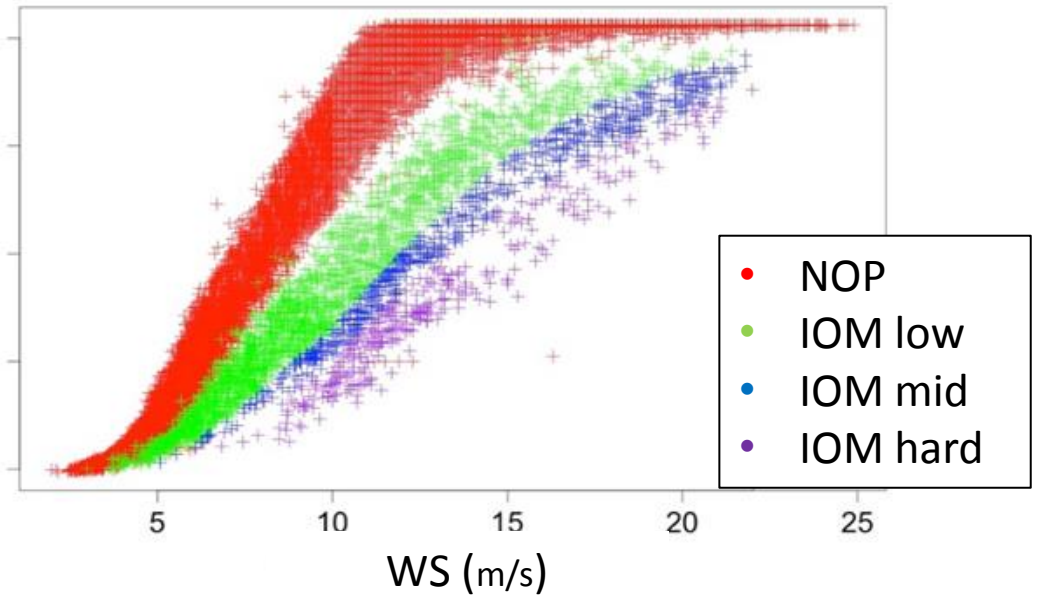
- Power curves during the same event



Load measurement analysis

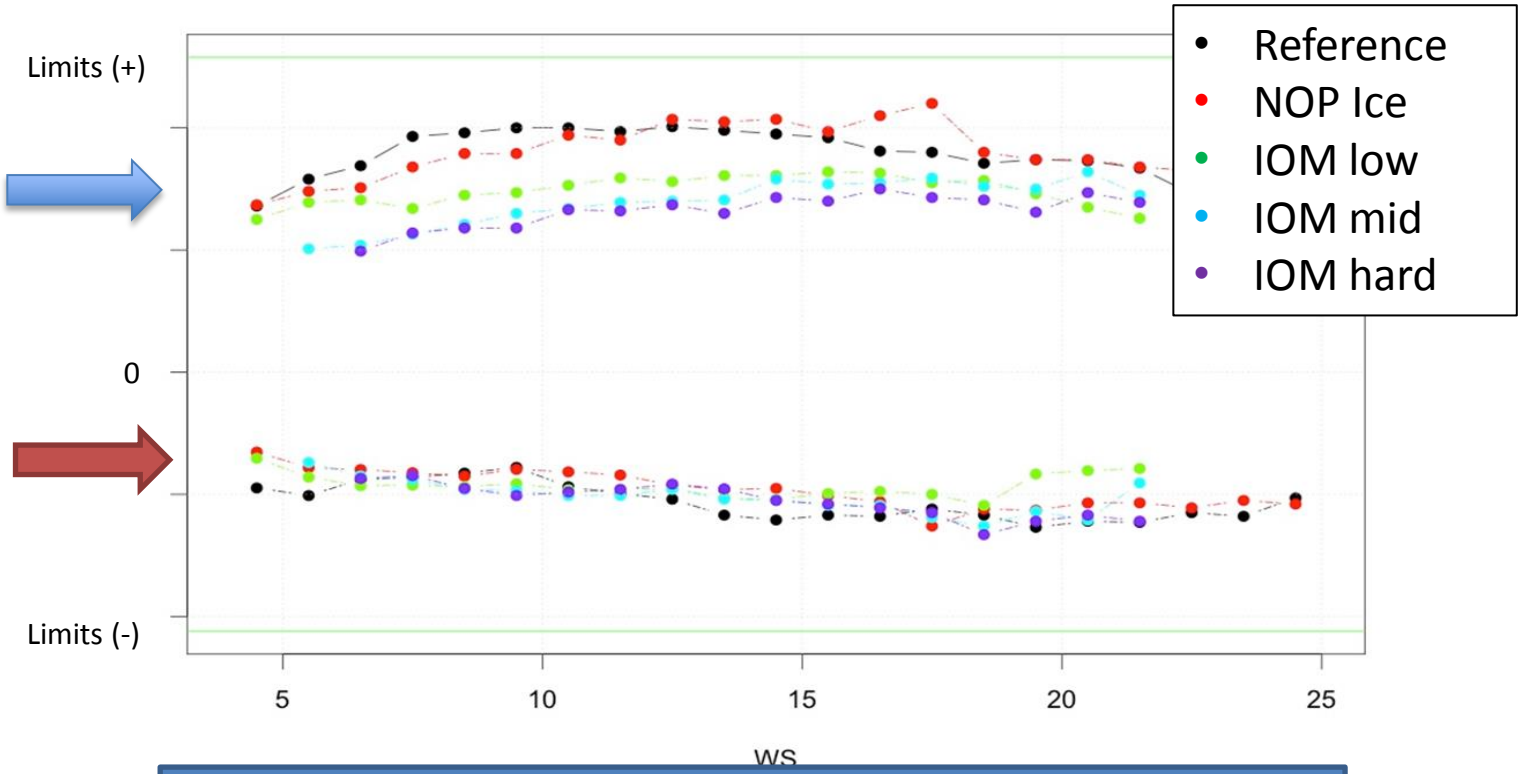
Categorization by Ice Class

- Light icing during Normal Operation with ice
  - ➢ double anemometry
- Medium – Severe Icing during IOM
  - ➢ Base on power curve
  - ➢ 3 levels on IOM ice class



Load measurement analysis (Edgewise)

Edgewise loads grouped by Ice Class

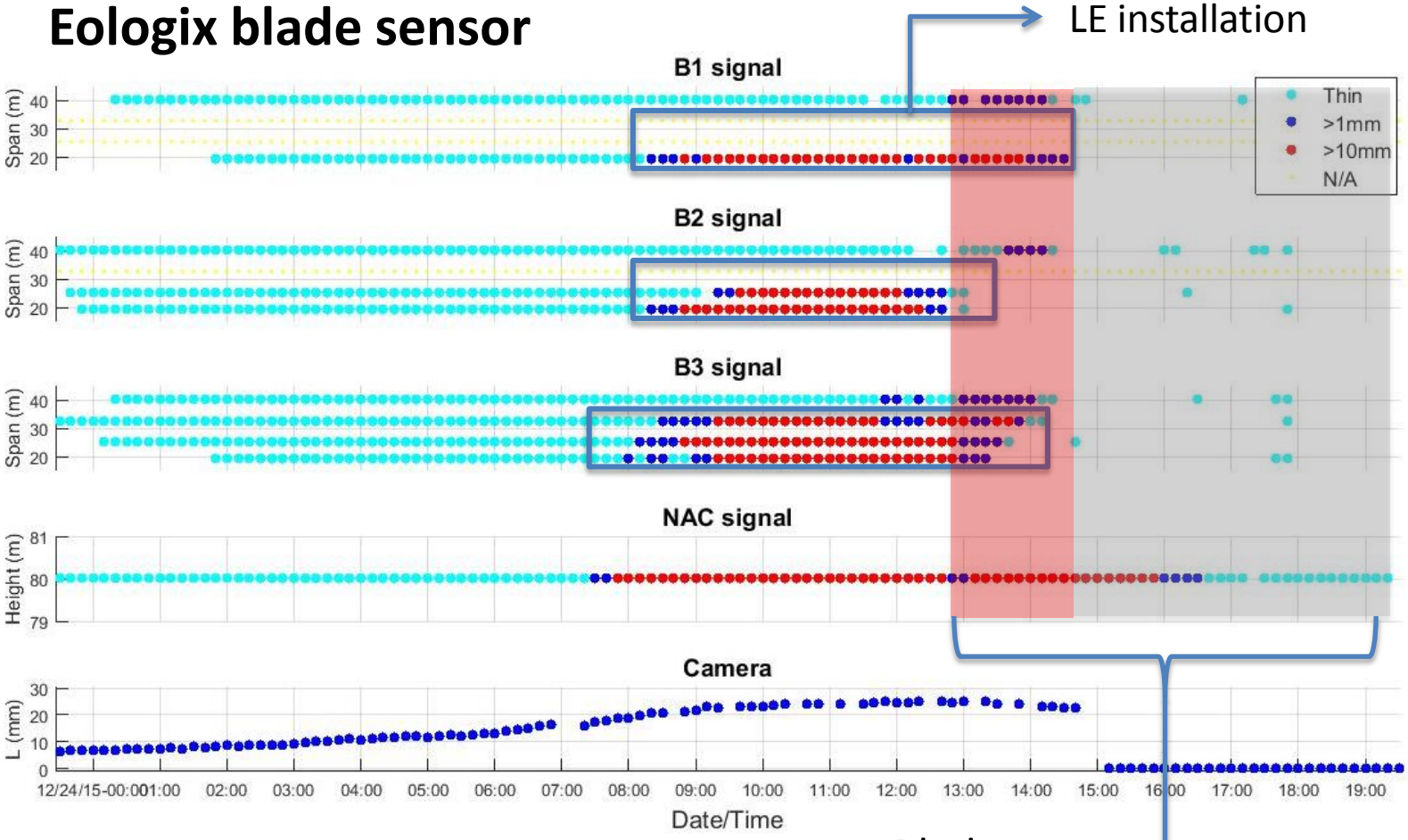


Load reduction on the tension side with IOM

Comparable load on the compression side with IOM

Ice detection importance

Eologix blade sensor



Ice shed timing:

- Blade
- Nacelle

Conclusion

Highlights

- 1st year of IOM optimization program over 3 years
- IOM alone can prevent stall and reduce down time in light to moderate site
- IOM with HAD can reduce considerably down time in severe site
- IOM reduce extreme loads on blade
- Rotor sensors are an added value for ice detection

More to come

- Next iterations of IOM parameters
- Loads analysis on other major components
- Bench test of the blade sensor technologies

Thank you !

Any questions?

Nos principaux partenaires / Our principal partners

Développement économique Canada pour les régions du Québec

Canada Economic Development for Quebec Regions

Canada

Québec

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