TransAlta's Experience With Blade Icing

Winterwind 2014, Jeff Nelson – Manager, Wind Engineer

TransAlta™

About TransAlta

- 100+ years of generation experience
- 2,600 employees
- 70+ facilities
- Expertise in 5 fuel types: coal, gas, hydro, wind and geothermal
- Fleet Availability of 90% (2012)
- 9,000+ MW of net capacity in operation
- 3 key geographies: Canada, the United States and Australia

Net Capacity Owned by Fuel Type
(In Operation & Development)

Coal	54%
Gas	21%
Wind*	13%
Hydro*	10%
Geothermal	2%

*Renewables

Net Capacity Owned By Geography
(In Operation & Development)

Canada	73%
United States	22%
Australia	5%

Agenda

- Kent Hills Wind Facility
- Our Experience
- Effects of Icing
- Technology
- Detection
- Key Learnings
- Recommendations
- Ongoing Work
- Questions

Kent Hills Wind Facility

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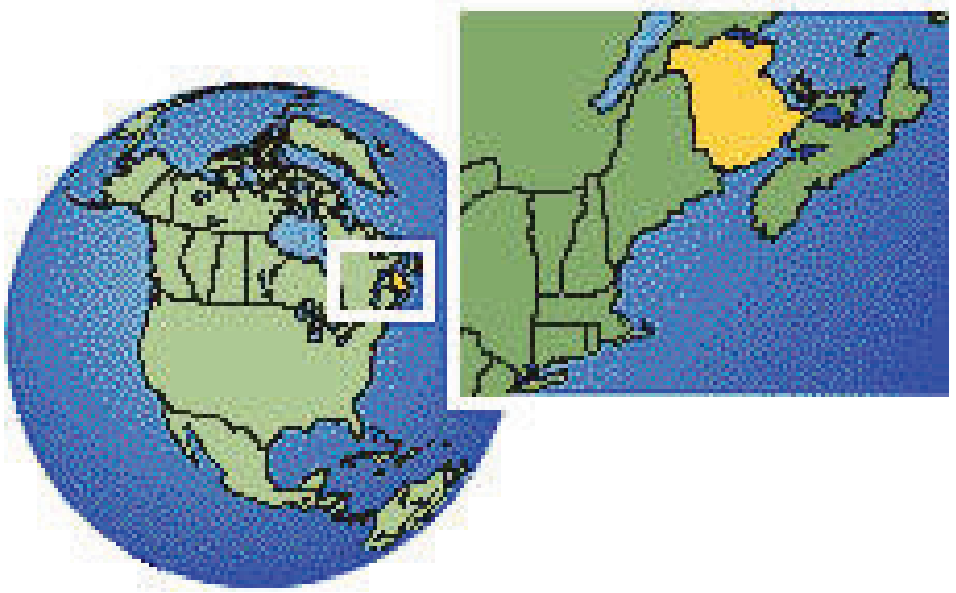
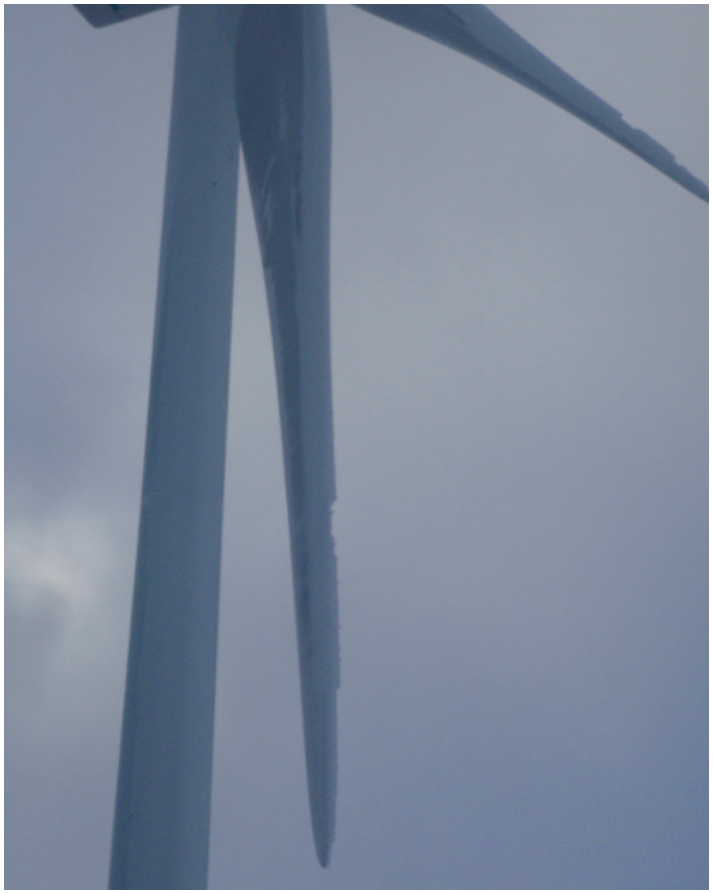
- 50 Vestas V90-3.0 MW turbines
- 150 MW output
- Phase I – 32 units – COD late 2008
- Phase II – 18 units – COD late 2010



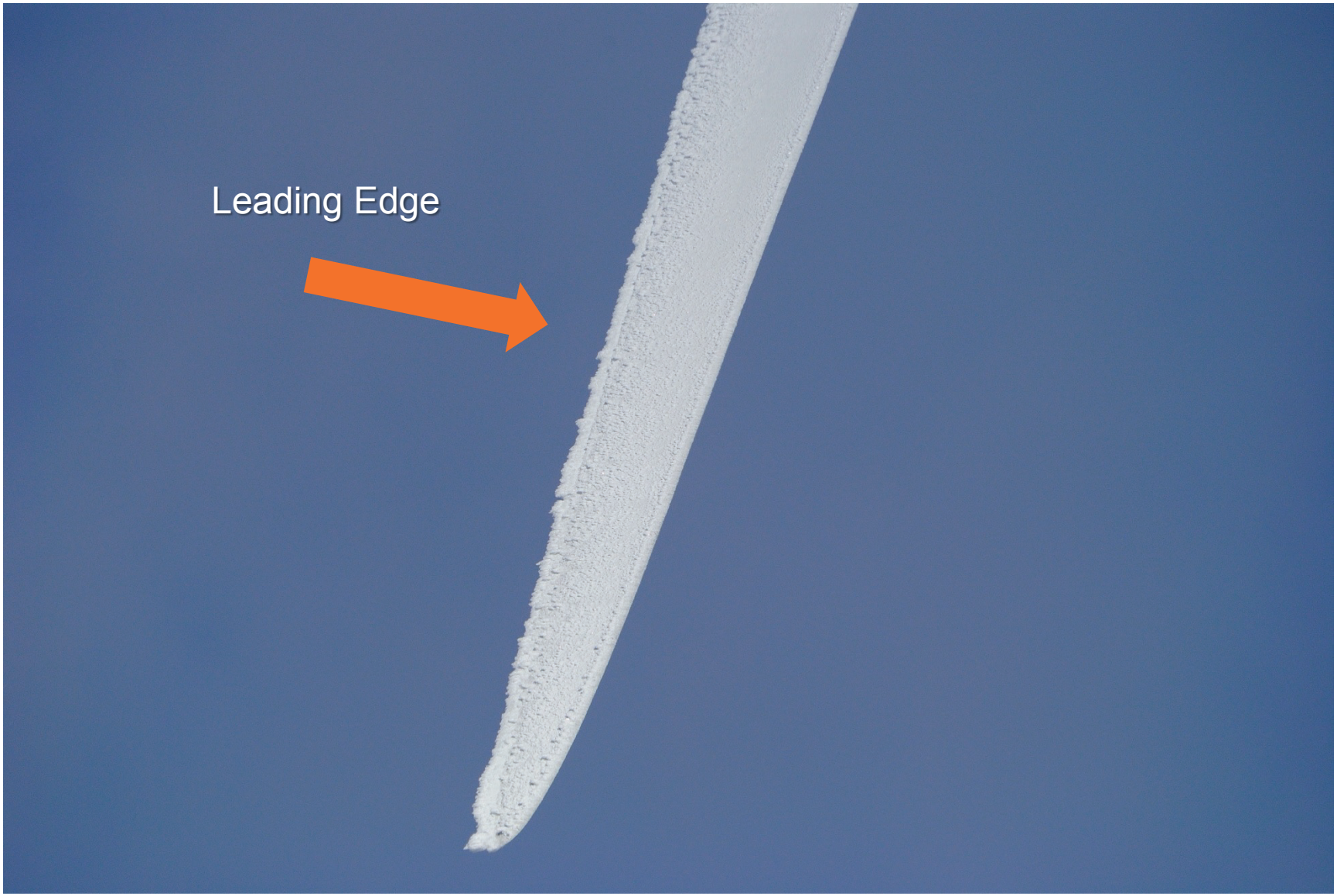
- Icing identified in long-term resource assessment
- Icing down time budgeted in yearly production estimates
- Icing estimates fairly accurate
  - Cold weather following an icing event causes a majority of downtime
- No OEM ice detection capability for the V90-3.0

Icing Events Experienced

- Both super cooled (rime) and freezing rain (glaze)
- Ice builds up as turbines operate through the icing event
- Not all turbines experience icing at the same time – site size
- Turbines eventually fault and shut down with no operator intervention, in some case up to 250 mm of ice
- Extended periods of downtime if ambient temperature drops significantly, ice unable to shed, up to 3 weeks



Icing Events Experienced



2008 - Initial Practices

Turbines do not have ice detection capabilities, operators relied on:

- Visual indications
  - Low cloud around nacelle
- Increased sound level
- Manual power curve comparison
- Temperature and RH comparison
  - 0°C region
- Moncton, New Brunswick weather forecast
  - Cloud ceiling
  - Temperature
  - Precipitation
- Site only manned during the day
- Finding the right time to shutdown the units was highly manual and not accurate

Our experience has shown pausing the units proactively is the best method of reducing ice build up

Risks

- Injury due to falling ice
  -Crown land, public access
  -No recorded injury to date
- Public Safety Campaign
  -Signs in multiple locations
  -Local media ads
- Damage to equipment
  -Blade damage
  -Skylight hatch damage
  -Stair damage
- Tower access issues
- Procedures in place when ice is present – do not approach

Production Lost Due to Icing Events

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- Icing has the most significant impact on lost production at Kent Hills

- Since 2008 icing lost production has ranged from 4% to 11% on a yearly basis

$$\text{Lost Production} = \frac{\text{Lost Production Due to Icing}}{\text{Total Theoretical Production}}$$

Technology Review

In 2010, reviewed technologies/research currently on the market and in development.

Present day, still reviewing emerging technologies.

- Detection
  - Ice sensors, cameras, blade loading
    - Economical/Proven
- Prevention (Anti-icing) and Removal (De-icing)
  - Blade coatings, leading edge heating - retrofits
    - Uneconomical/Un-proven

Our conclusion: No well established standards that operators can refer to for icing detection, prevention and removal

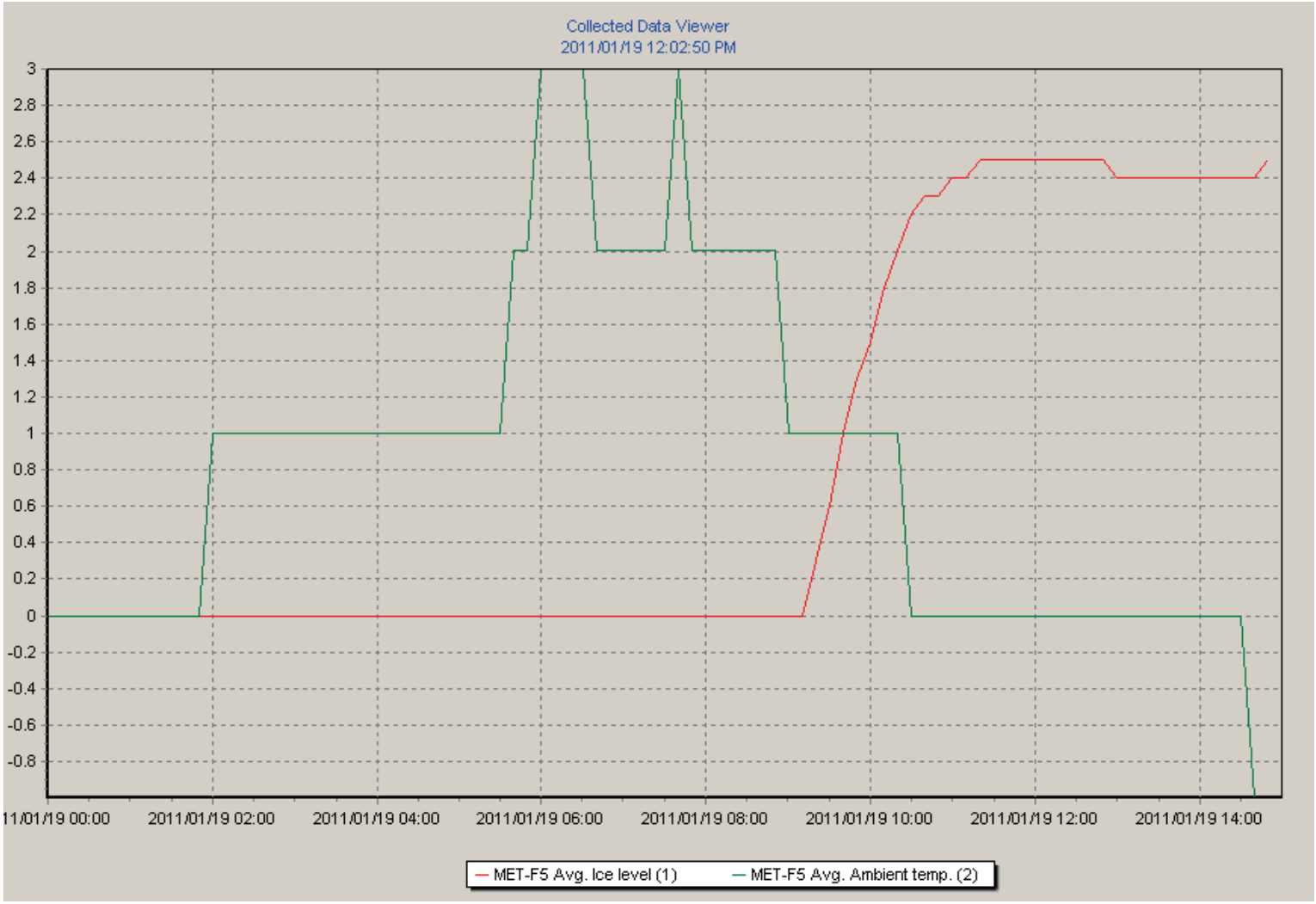
Practical Operational Plan

- Ice detectors installed on 3 met towers
- Nacelle top cameras installed on 4 turbines for visual verification of icing
- Blade accelerometers on 11 turbines to notify of build up and shedding
- Afterhours monitoring of ice detector and cameras at the centralized TransAlta Wind Control Centre
- Continue with manual power curve review, not accurate in low winds
- Operational procedures in place for unit shutdown

Detection: Ice Sensor

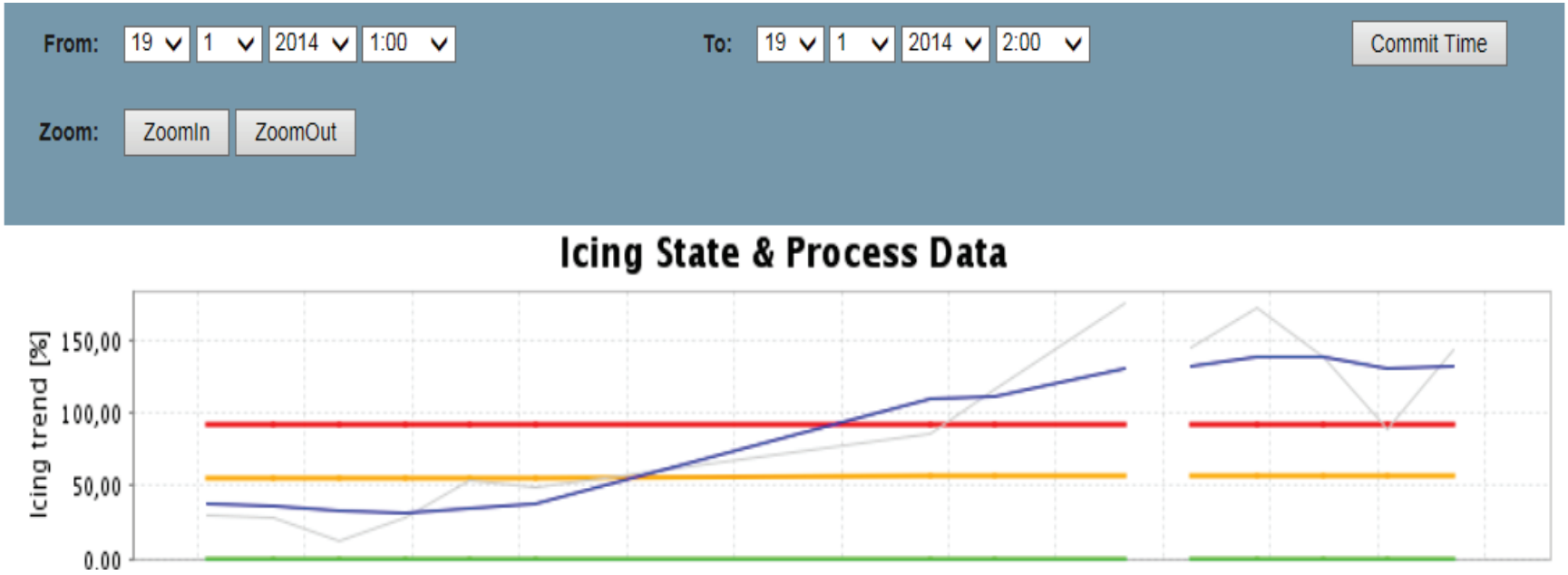
- Goodrich freezing rain detector installed on met tower
- Ultrasonic axially vibrating probe to detect ice accretion
- Samples every 15 seconds
- Data sent to SCADA system

Detection: Ice Sensor Typical Event



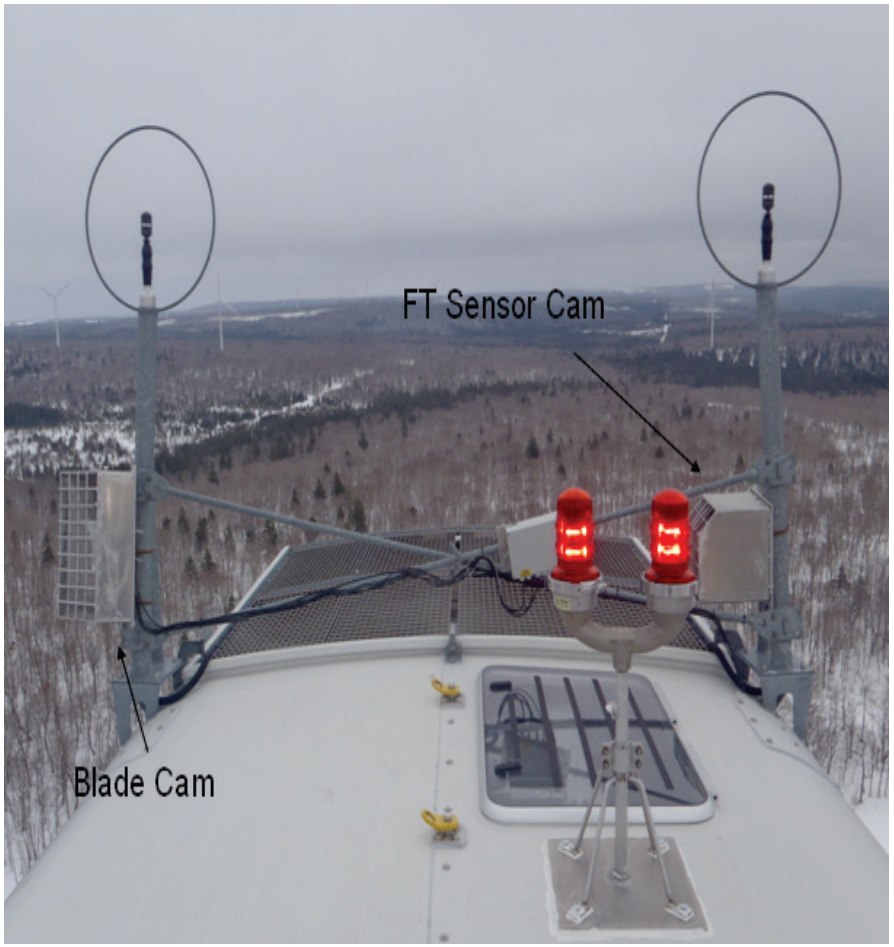
Detection: Blade Accelerometer

- Blade mounted accelerometers on 11 turbines
- Additional ice detection capability to provide redundancy
- Group control functionality, zone control allows for optimized curtailment
- Integrated directly into SCADA system for operator interface
- Also identifies when ice has shed
- “Red” warning matches up with ice detector

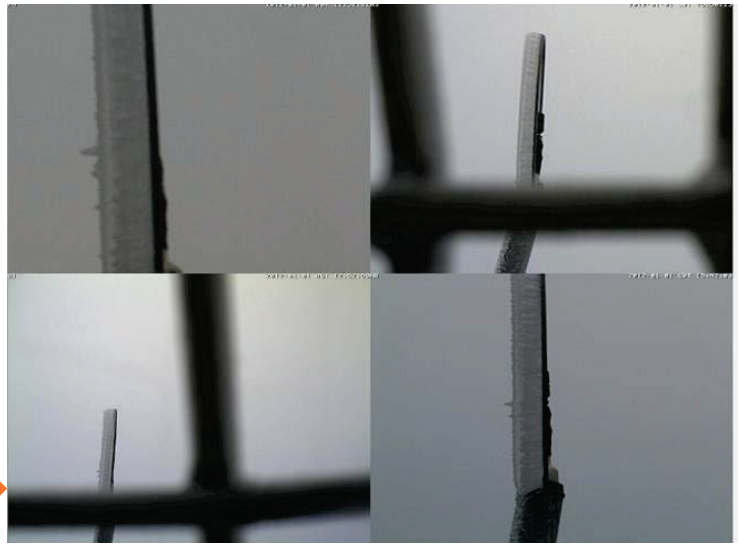


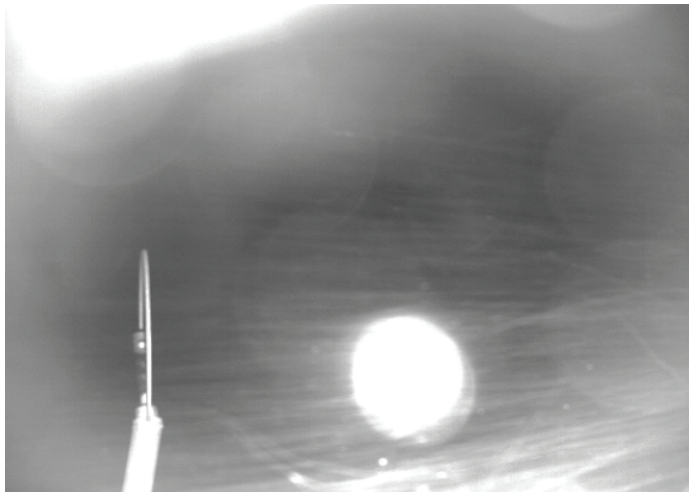
Detection: Visual Identification

- Four nacelle top cameras for visual detection identification
  - Fixed point reference
  - Blade camera removed
- IR light installed for night vision, although aviation lights work fine
- Protective covers on camera and light to protect from falling ice
- Assistance from Rene Cattin COST Action 727 - Alpine Test Site Gütsch project by providing experiences and technical information for camera selection



Detection: Anemometer Cameras





Detection: Operational Procedures

- Review weather forecast for possible icing events
- Day shift monitors conditions, as well as ice detectors and cameras
- After hours WCC monitors ice detectors and cameras
- Shutdown units typically at 1.0 mm of ice on detector
- If shutdown at night, units are restarted in the morning if conditions permit

Detection: Benefits

- Approximately 15% additional production achieved by proactively shutting down and avoiding large ice build up
- Long freezing rain events make return to service challenging
- Difficult to assess, assumptions required

- Assumptions
  - Assume no after hour monitoring to proactively shutdown turbines between 5PM and 7AM
  - Assume all turbines will ice up with 6.0mm and 6 hours of operation
  - Units are able to restart when temperature is 1°C or greater

Key Learnings

- Afterhours Control Centre able to catch icing events and shutdown turbines, minimizing long-term downtime when ambient temperature drops significantly
- Instrumentation is helping identify events earlier
- Ice detector works well for us
- Anemometer camera was very valuable
- Blade accelerometers are a good redundant system for detection

Recommendations

- Have a stakeholder plan in place for safety
- 24/7 operations is essential to monitor icing conditions
- Know the icing frequency at your site and have a plan in place
- Know the ice detection capabilities of the chosen wind turbine
- Simple technologies are available, so review what's best for your site

Ongoing Work

- Investigate solution as they emerge onto the market
  - Blade heating, coatings, improved detection
- Network with other owners and develop best practices
- Share our experiences with others

Questions

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