Ice Detection Project for E.ON

Introduction

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Background

One2two: Best in both worlds

- E.ON T&I organisation initiated and funded the project
- E.ON Technologies developed and co-ordinated the project
- E.ON Climate and renewables provided on site support and a test turbine
- E.ON one to two project has split E.ON into two companies: E.ON and Uniper. E.ON Technologies has been allocated to Uniper
- Uniper Technologies continues to support E.ON Climate and Renewables

Project Description

Nature of the Problem:

- Icing causes safety and production issues
- Ice has proven surprisingly difficult to detect reliably
- OEM Ice algorithms are quite conservative, and are believed to cause unnecessary production losses

Work within the Projects:

- Installation and testing of Dynamic Ice Detection Sensors at an E.ON Windfarm
- Development and testing of a real-time data driven ice detection system
- Validation of both via a camera system

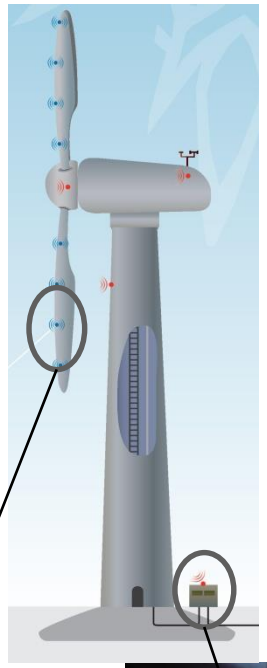
Final Goal:

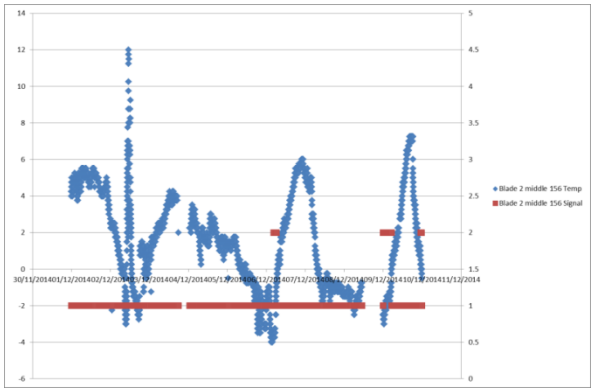
- Provide accurate notifications of ice risk
- Propose a process for implementation

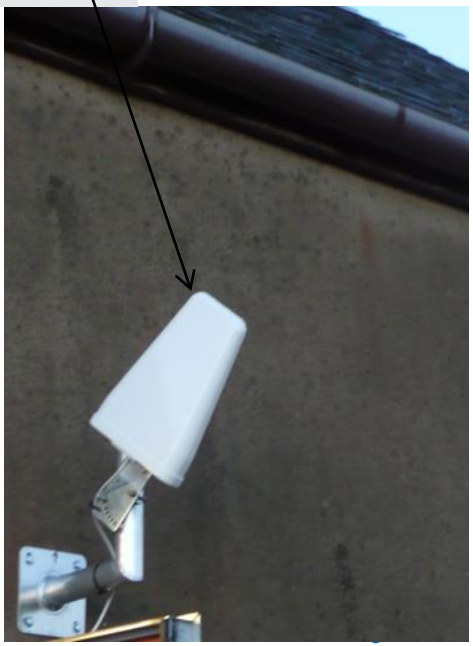
Project Outcome

Dynamic Ice Detection System:

- Applied to one Turbine
- 9 stickers (3 per blade)
- PC Basestation in site hut
- Detection via capacitance measurement of surface
- Battery Powered with Solar cell re-charging





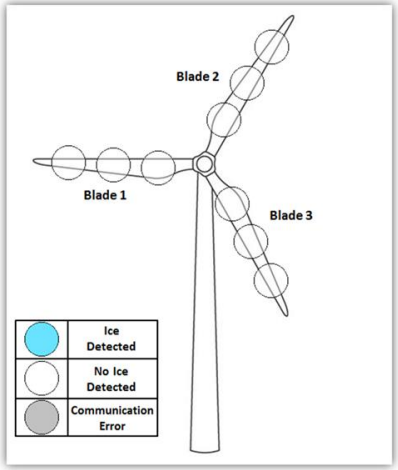


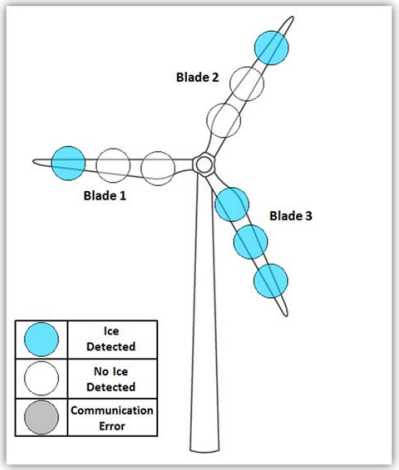
Project Outcome

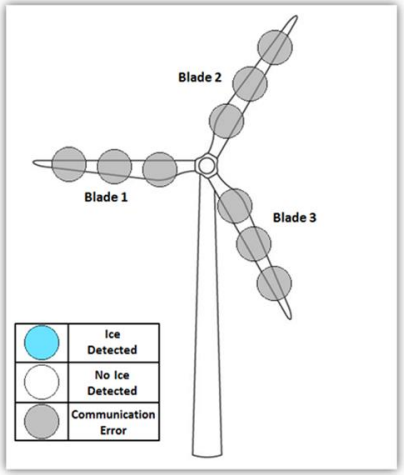
Dynamic Ice Detection System:

- Eologix proved to be helpful and responsive suppliers
- Installation was carried out from a MEWP and was completed within 1 day, despite some problems due to low temperatures
- Four levels of detection:
  1. No Ice
  2. Ice formation activity
  3. 2-10mm ice
  4. >10mm ice
- Level 3 possibly too sensitive; level 4 seems to correlate well with significant icing.
- Eologix now also testing a level 5; >20mm ice.

Project Outcome



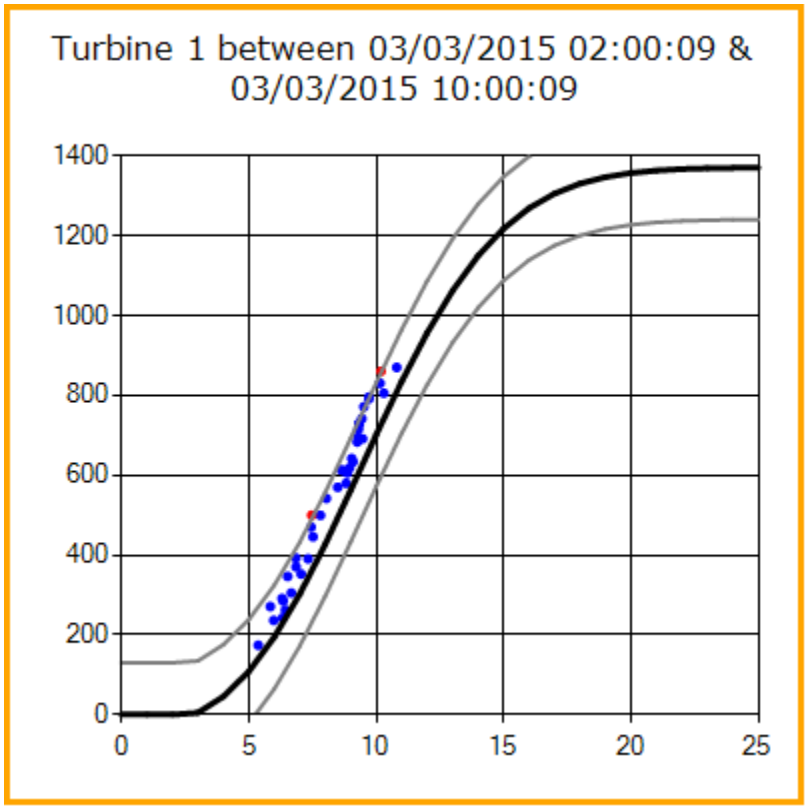




Clockwise from top left:
- No Ice
- Ice detected
- Communication Error

- Reporting of ice sensor status automated.
- Ice detected refers to level 3 or level 4 (configurable)
- Alarm generated in the event of data loss

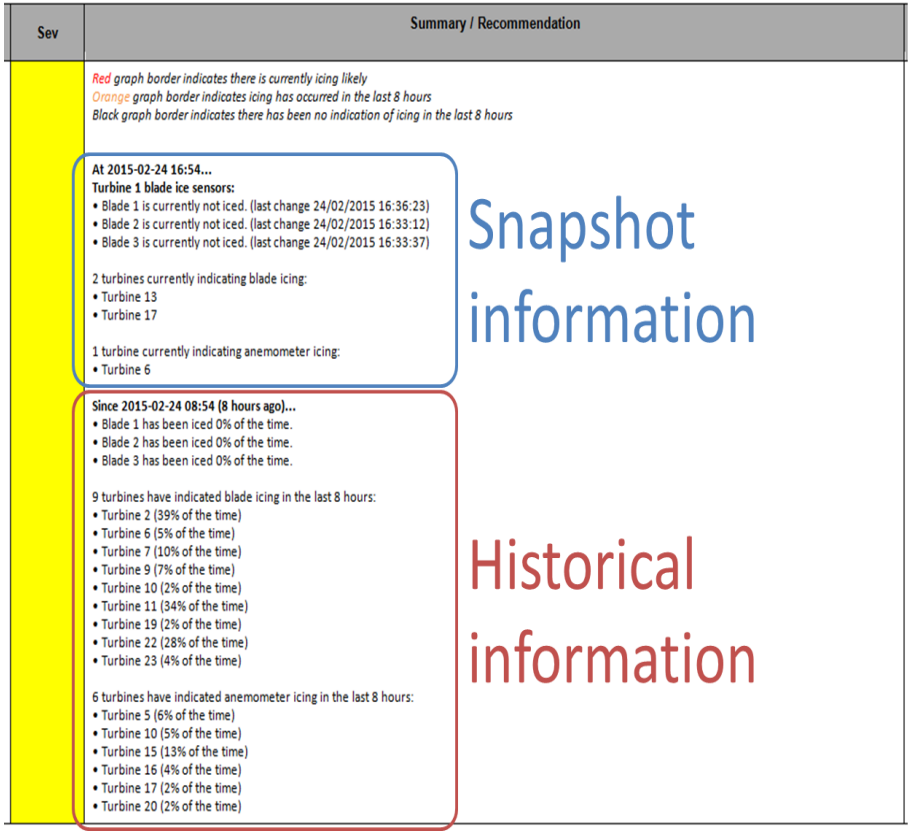
Project Outcome



Data Driven Ice Detection

- Upper limit indicates potential anemometer icing
- Lower limit indicates potential blade icing
- Alarm only active at temperatures below 2°C (configurable)
- Other logical tests could be included
- Integrated reporting with ice detection by the sensors

Project Outcome



Sev	Summary / Recommendation

Red graph border indicates there is currently icing likely
Orange graph border indicates icing has occurred in the last 8 hours
Black graph border indicates there has been no indication of icing in the last 8 hours

At 2015-02-24 16:54...
Turbine 1 blade ice sensors:
- Blade 1 is currently not iced. (last change 24/02/2015 16:36:23)
- Blade 2 is currently not iced. (last change 24/02/2015 16:33:12)
- Blade 3 is currently not iced. (last change 24/02/2015 16:33:37)

2 turbines currently indicating blade icing:
- Turbine 13
- Turbine 17

1 turbine currently indicating anemometer icing:
- Turbine 6

Snapshot information

Since 2015-02-24 08:54 (8 hours ago)...
- Blade 1 has been iced 0% of the time.
- Blade 2 has been iced 0% of the time.
- Blade 3 has been iced 0% of the time.

9 turbines have indicated blade icing in the last 8 hours:
- Turbine 2 (39% of the time)
- Turbine 6 (5% of the time)
- Turbine 7 (10% of the time)
- Turbine 9 (7% of the time)
- Turbine 10 (2% of the time)
- Turbine 11 (34% of the time)
- Turbine 19 (2% of the time)
- Turbine 22 (28% of the time)
- Turbine 23 (4% of the time)

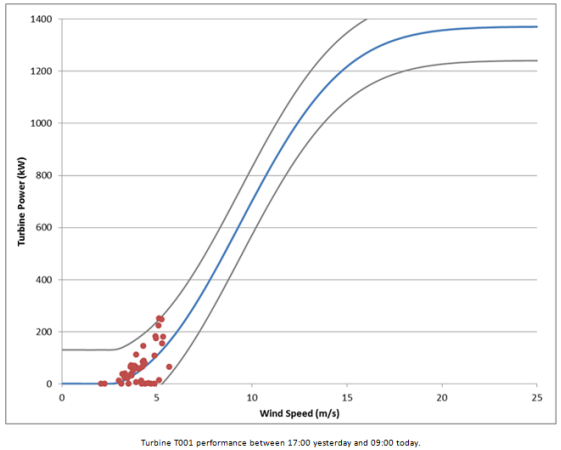
6 turbines have indicated anemometer icing in the last 8 hours:
- Turbine 5 (6% of the time)
- Turbine 10 (5% of the time)
- Turbine 15 (13% of the time)
- Turbine 16 (4% of the time)
- Turbine 17 (2% of the time)
- Turbine 20 (2% of the time)

Historical information

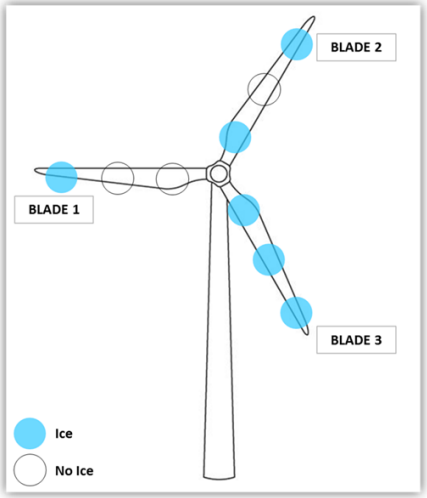
- Load curve monitoring running continuously
- Temperature also used in logic
- Modular system – other data could be introduced (eg humidity)
- System generates reports manually:
  - Snapshot is current status
  - Historic is based on previous 8 hours when the button is pressed

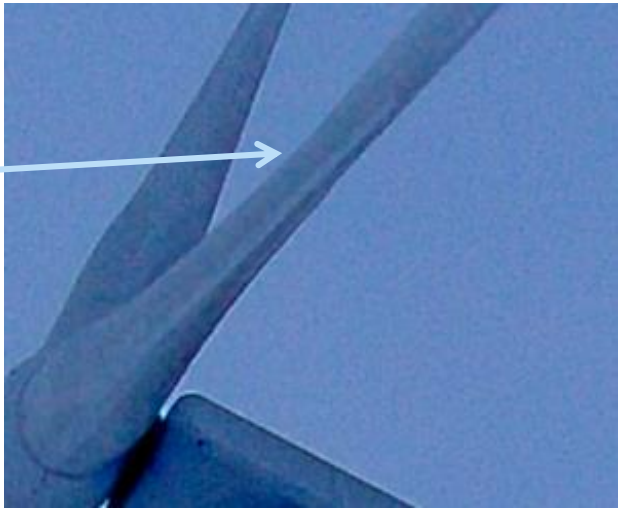
Project Outcome

Generally accurate information, corroborated with site observations



Turbine T001 performance between 17:00 yesterday and 09:00 today.





Project Outcome

Based on analysis of trial results:

- Combination of indicators seems best
- Near real time ice status can be generated
- Suggested ice detection is a combination of:
  - Small number of turbines (eg one per site) fitted with ice detectors
  - Power curve system applied to all turbines.
  - Configure such that neighbouring turbines showing ice acts as extra indication
  - Temperature data used to reduce false alarms

This provides a basic ice detection system

Project developed system to a “manumatic” stage (someone still has to press a button!), but further automation is relatively straightforward.

Possibilities for Implementation

Potential extensions:

- Refinements to Power Curve ice detection such as:
  - Filtering out start up and shut down events (potential false alarms)
  - Distinguishing between “no ice” and “no generation” indications from the Power Curve
  - Include additional sensors such as humidity sensors or static ice detection where available
- Use system as a general Power Curve deviation detection (to alert performance teams to carry out a more detailed analysis)
- Potential to extend the system to an ice forecast system to give day-ahead warnings of potential icing, and assist with yield forecasts.
- Generate specific “icing” alarm

Potential benefits

Tangible:

- Reduce unnecessary shut-downs

  Only applicable where sites currently shut down on risk of ice. Potential to save circa 30% of shutdowns
- Reduce exposure of staff to ice throw

  Tangible benefit from not mobilising staff to sites where work cannot be carried out due to ice
- Early detection of Power Curve issues (could run all year)
- Reduced Insurance premiums?

Intangible:

- Mitigate HSSE Risk
- Reduce exposure of staff to ice throw
- Provide accurate notifications of ice risk to neighbours

Summary

- T&I Project has shown that ice can be detected reliably
- Suggested method is sensors on one turbine per farm plus continuous power curve monitoring for all others
- Sensor installation can be integrated with scheduled blade maintenance
- Continuous Power Curve monitoring requires real-time access to load and wind speed data.