An overview of Vattenfall´s research within turbine icing – Yesterday, today and tomorrow

Winterwind, Åre

February 10, 2016

Background

- Part of Vattenfall´s strategy is to grow in renewables and wind power
- Several large scale wind farms are under development in the north of Sweden

Afternoon February 23, 2014…   …and the next morning

Need for R&D work!

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Vattenfall´s wind farms in cold climate

- Stor-Rotliden, 40 turbines, 78 MW installed capacity, in operation since 2011
- Juktan, 9 turbines, 29 MW installed capacity, in operation since 2015
- Several new large scale wind farms under development in the north of Sweden

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Juktan

Stor-Rotliden
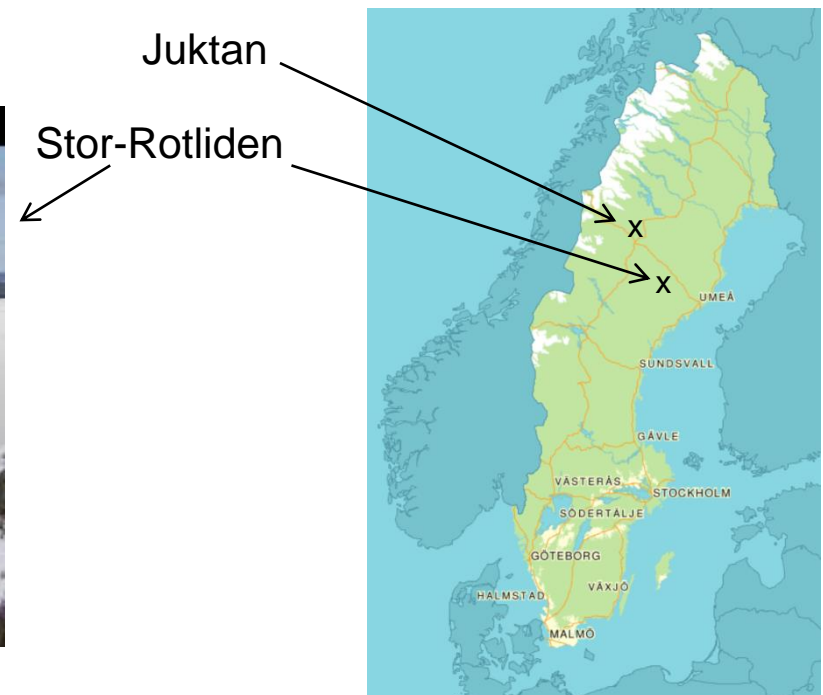
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Turbine Icing Programme

- Turbine Icing Programme (TIP)
  - Vattenfall R&D research programme for wind power in cold climate
  - Started in 2011

- Addressing the following issues within wind power in cold climate
  1. **Decreased production**
  2. **Health & Safety issues: ice falls/throws**
  3. Increased noise
  4. Increased loads

- Structure
  - In-house work, collaborations with universities/research institutes, master thesis workers…
  - Both direct problem solving and development issues (looking into new technologies)
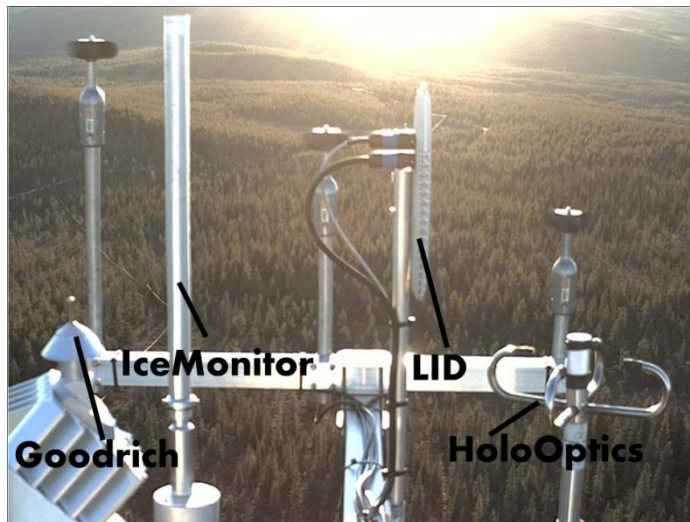
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Turbine Icing Programme

- Main topics addressed by the Turbine Icing Programme (TIP):
  - Estimation of production losses (investment support)
  - Ice event detection – performance of ice sensors
  - Ice event prediction – forecasting next days
  - Evaluation of mitigation technologies
  - Ice throw models (quantification of Health & Safety risks)
  - Operational strategies, studying icing events
  - Evaluation of de-icing systems
  - Noise, loads, ….

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History of icing measurements at Vattenfall 1(2)

- History of field tests and measurements:
  - First icing measurements at Stor-Rotliden met mast: Winter 2009/2010
  - 2009-2013: Evaluation of icing measurements
    - Nacelle/mast based sensors: HoloOptics, Goodrich, LID Labkotec, IceMonitor, cup anemometers
    - Blade based sensors: Bosch Rexroth BLADEcontrol
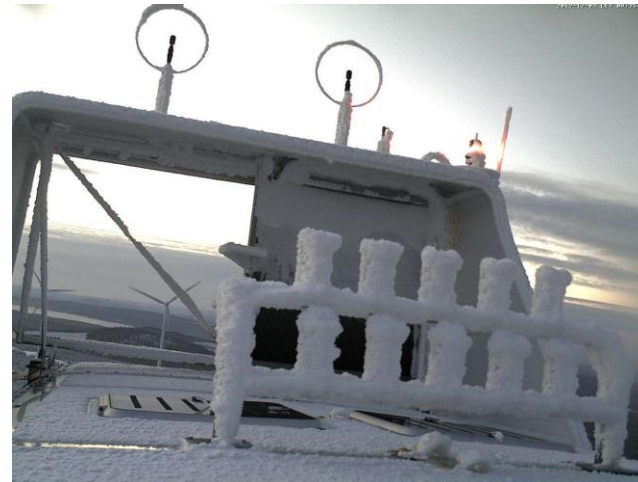
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History of icing measurements at Vattenfall 2(2)

- History of field tests and measurements:
  - 2012: Camera installations for validation (2 nacelle-based cameras) (1)
  - 2012-2014: Tests with hydrophobic/nano-coatings (validation to camera pictures) (2)

(1)

(2)

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Current icing measurements at Vattenfall 1(2)

- Current field tests and measurements:

 - 2013-2016: IceThrower (1)

    Collaboration between Vattenfall, Skellefteå Kraft, Dala Vind and Pöyry, partly financed by the Swedish Energy Agency. Estimate risk levels and distances by collecting field data of fallen ice pieces.

  - 2015: Two new cameras, one nacelle-based and one on a nearby mast (2)
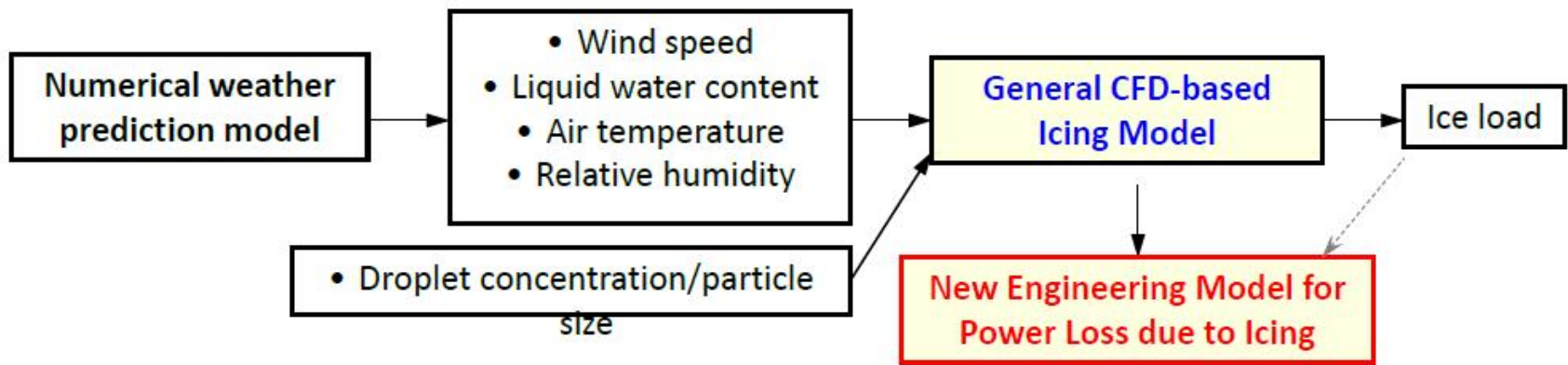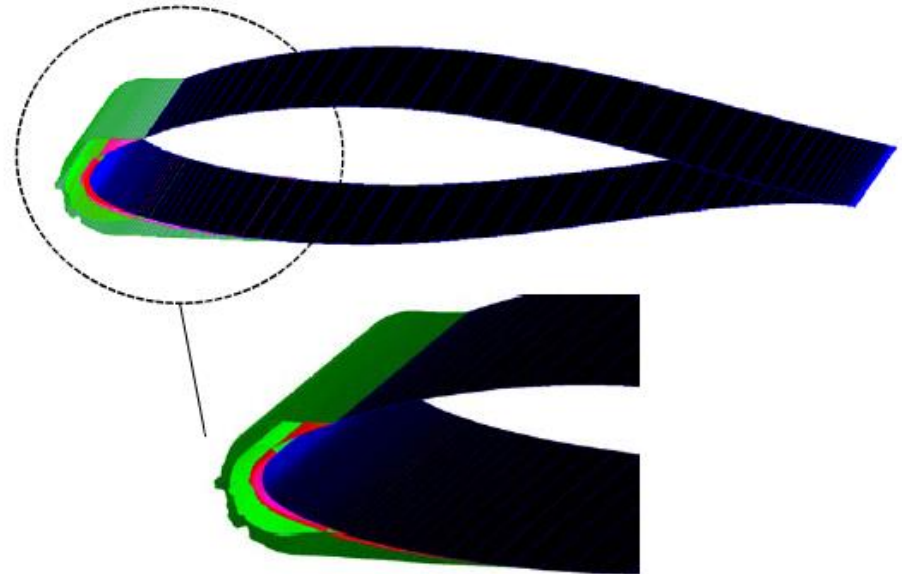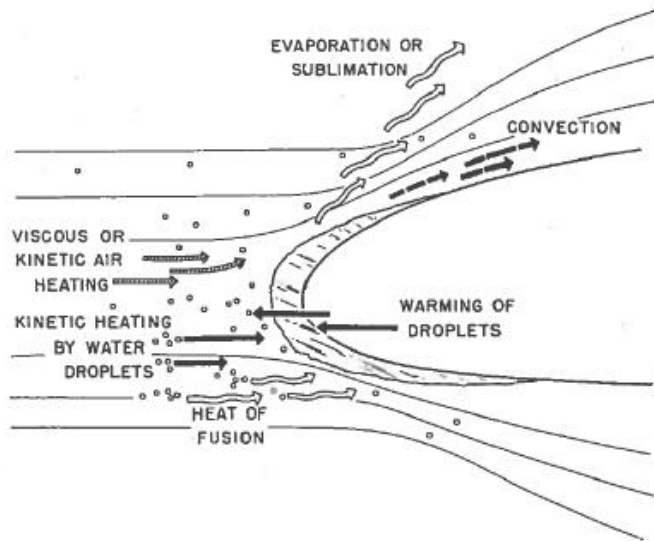
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Current icing measurements at Vattenfall 2(2)

- Current field tests and measurements:
  - 2016: Tests with new hydrophobic coatings (1)
  - 2016: Blade based sensors: ice detection system from fos4X installed (fos4IceDetection)
    - Based on blade vibrations measured by fiber optic sensors. (2)
  - 2016-2017: Blade-based camera installation
    - In order to follow the icing situation on a blade continuously.

(1)

(2)

fos4Acc 2D acceleration sensor

fos4Test *wind* measurement unit

Hub control cabinet
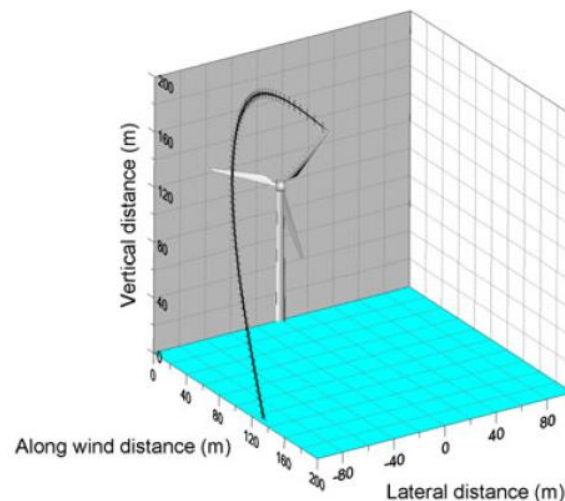
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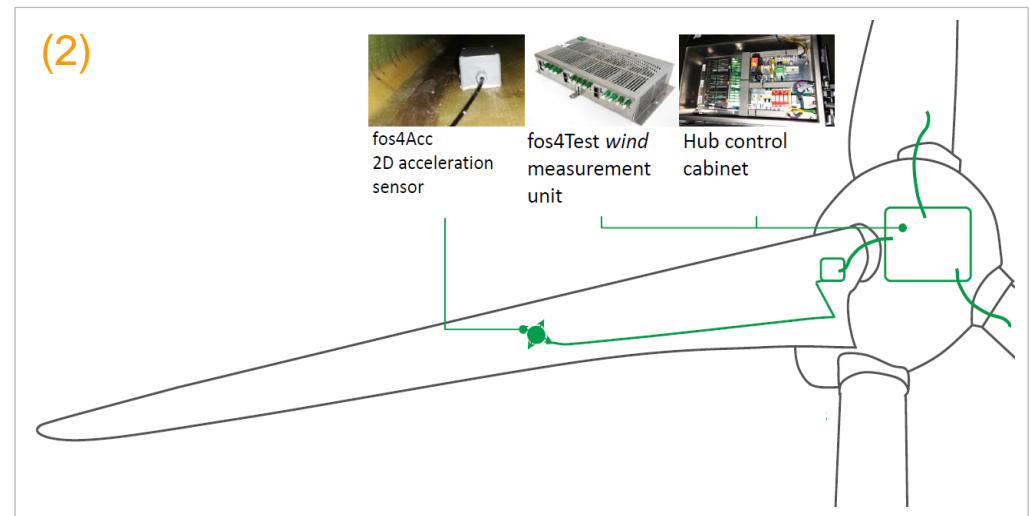
WINDICE Industrial PhD project

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Model for ice throw risk assessment

- A rule of thumb is the Seifert formula:

  Safety distance = 1.5 × (D + H)

  D=turbine diameter, H=hub height

- New advanced ice throw risk assessment tool

- The model maps the risk around a turbine

- Considers site specific icing conditions and exposure risk around the turbine

→ The results show that the standard formula is over-conservative. For Juktan, mitigation measures can be avoided for 2 out of 9 turbines.

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CFD tool for wind farm siting

- CFD (Computational Fluid Dynamics) model for wind farm siting
  - Costumization of the CFD workflow
    - → Customized Graphical user interphase (GUI)
    - → Customized Post-processing
    - → Customized report generation tool
  - CFD evaluation ongoing

+
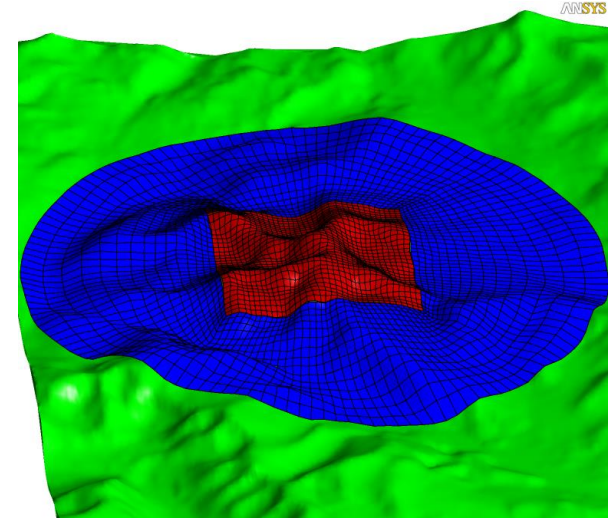
- More physical than linear models
- Better suited in complex terrain/forest
- More parameters can be included (stability, wake modelling)

-

- Computationally expensive

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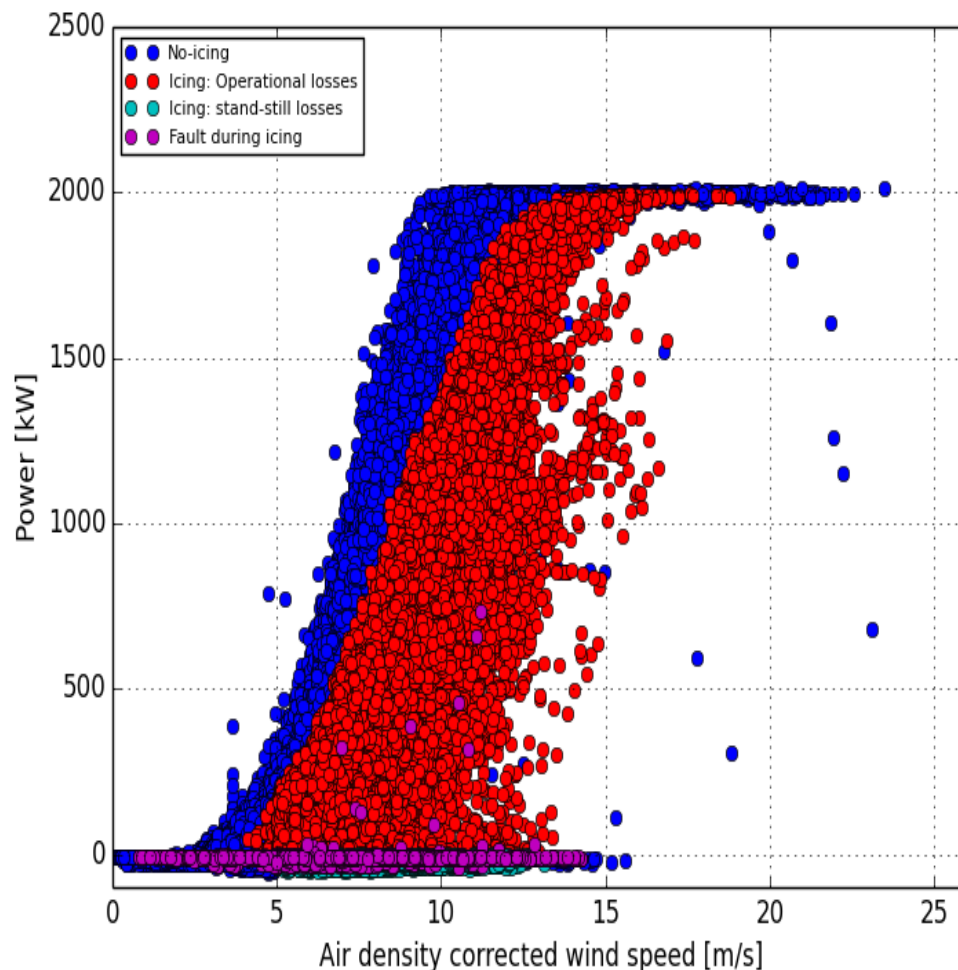# Calculation of production loss due to ice

Standardized ice loss evaluation from SCADA data

New method defined by IEA Task 19

- Objective: establish validated industry standard methodology
- Based on time series of 10-min mean SCADA data. Identify start/end of icing events.

Icing losses in 3 categories:

- Operational
- Stand-still
- Fault due to icing

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Outlook

- New camera installations in Juktan
  - Image processing techniques for ice detection and production loss evaluation

- Evaluation of data from ice sensors
  - Finding optimal combination of measurements?
  - New measurements and sensors: liquid water content?

- De-icing systems → Performance, operation and control

Thank you!

SRL IceThrow cam 2015-02-18 07:37:35

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