Performance benchmark analysis of four Ice prevention systems

Winterwind 2019, Umeå

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Motivation

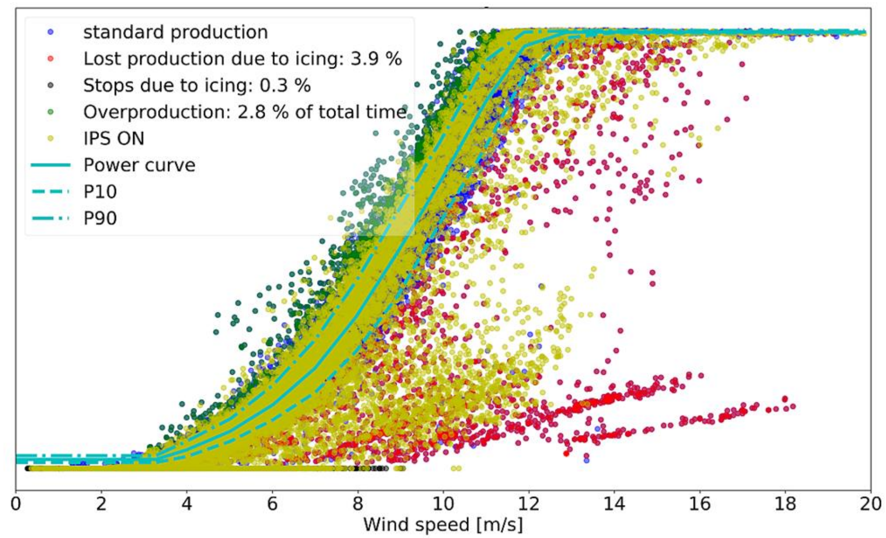
- Little to no publicly available data to answer the following questions:
- What is the performance and maturity of current state-of-the-art wind turbine Ice Protection System (IPS) solutions available on the markets?
- How to choose the correct IPS & OEM for your site?

Benchmark study

- Partners
  - VTT
  - Blaiken Vind AB
  - Taaleri Energia Oy
  - Vattenfall AB
- Material
  - Four sites in Europe
  - Four different IPS manufacturers
  - One winter of data

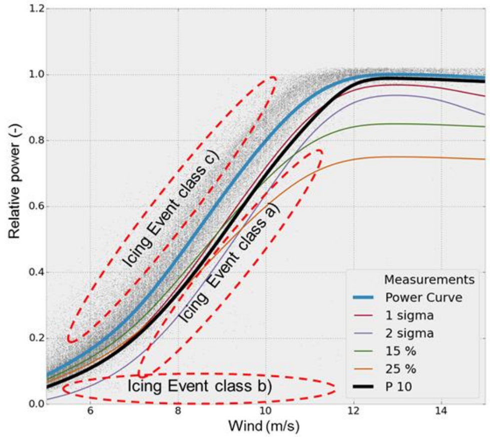
Methods

- No reference turbines
- Estimate production losses against an ideal case
  - No icing losses à turbine always at power curve
- Losses consist of:
  - Heating self consumption
  - Porduction losses due to icing while heating
  - Production losses due to icing when not heating



T19IceLossMethod

1. Publicly available free software for calculating icing losses on any SCADA dataset developed by IEA Wind Task 19
2. Method uses the rotor as an ice detector
3. Result robustness achieved by using 10th percentile (P10) of non-iced power curve
4. False alarms minimized by including the ”memory effect” of icing: more than one 10-min datapoints needed to trigger positive rotor ice detection



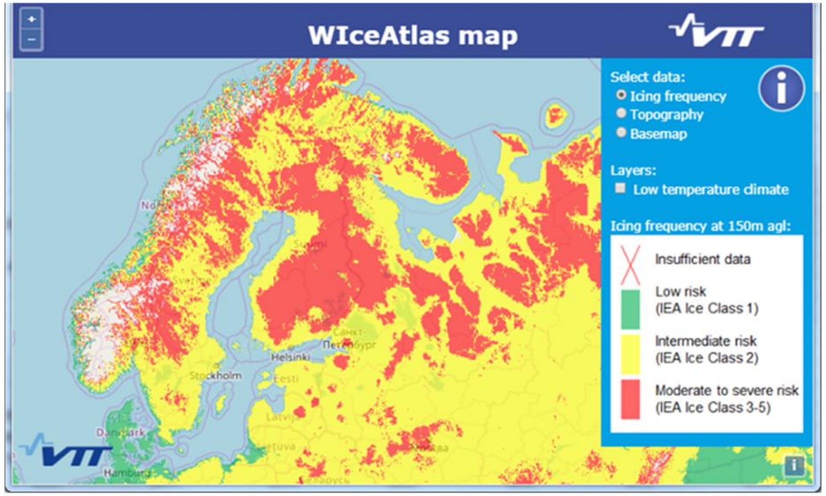
Download software here:
https://community.ieawind.org/task19/t19icelossmethod

Heated turbine handling

- Use statuscode from the SCADA system to identify periods when heating is on
- Use this flag to differentiate heated and unheated behaviour
- Estimate heating losses based on heating time
- Do same if data contains ice detection signals, get behaviour when turbine iced or not

Reference

- Estimate losses at the site in question based on
- VTT WIceAtlas
- MERRA2 re-analysis data
- Numerical weather model (Kjeller Vindteknikk)
- Estimate ice class and losses



Conditions

- All sites in Europe
- One site (C) noticeably warmer than others
- Weather model data not available for C
- Different data from different sites
  - Metorological icing from WIceAtlas
  - Rotor icing form SCADA
  - Modeling results for meteorological icing and icing losses
- Use ice class as common denominator

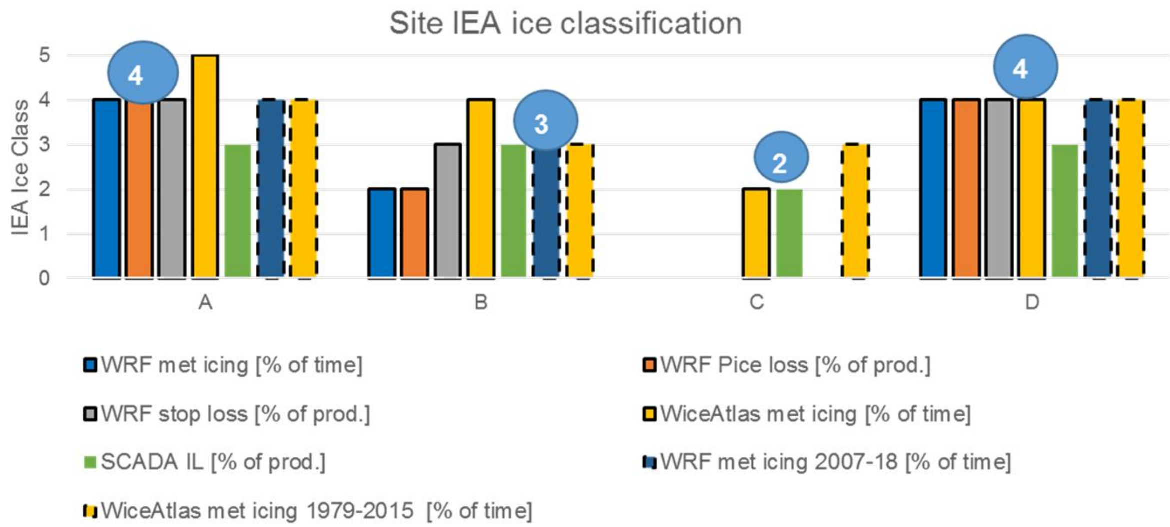
Site	MERRA2 Mean Winter Temperature Dec-Mar
A	-10.7°C
B	-7.6°C
C	+1.5°C
D	-10.5°C

IEA Ice Classification[1]

IEA Ice Class	Duration of Meteorological Icing [% of Year]	Duration of Instrumental Icing [% of Year]	Production Loss [% of AEP]
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

1: IEA Wind Recommended Practices for wind energy projects in cold climates edition 2011

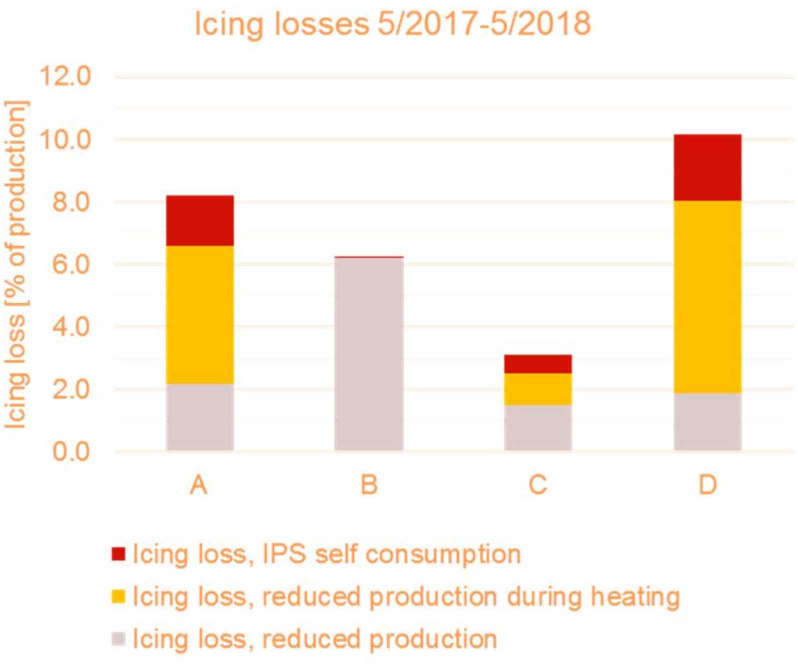
Ice classes



Site IEA ice classification
IEA Ice Class
0
1
2
3
4
5
4
3
2
4
A
B
C
D
WRF met icing [% of time]
WRF Pice loss [% of prod.]
WRF stop loss [% of prod.]
WiceAtlas met icing [% of time]
SCADA IL [% of prod.]
WRF met icing 2007-18 [% of time]
WiceAtlas met icing 1979-2015 [% of time]

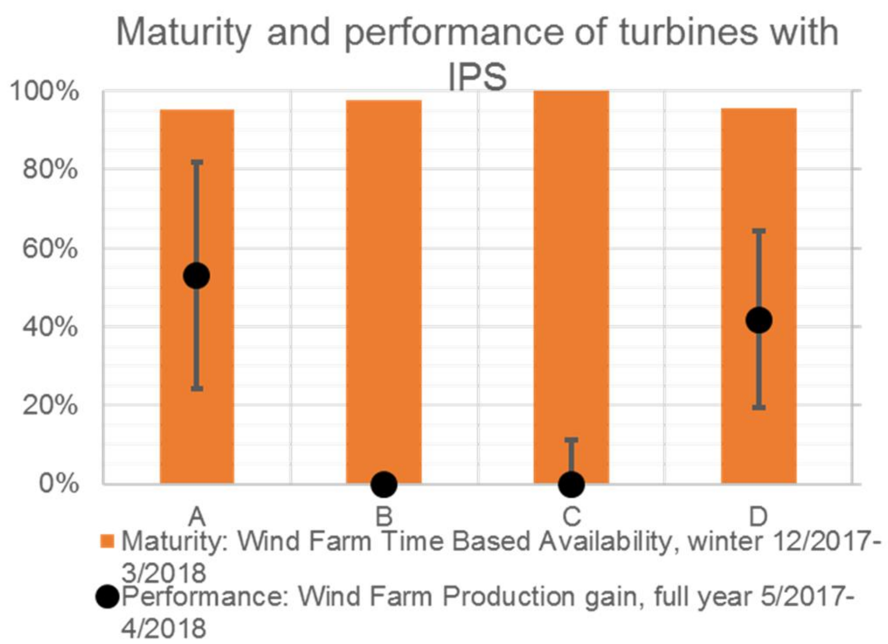
Losses

- Production losses still high
- Issues with heating at site B
- On A and D reduced production during heating
  - Turbines not at power curve when heating on



Gain and maturity

- Turbines work reliably in wintertime
- Availability high in all
- Production gain against reference 40 – 50 % at most
- Issues at two sites out of four



Conclusions

- Only two of the four systems in the study showed a production gain during the test period
  - One case system had issues
  - Other case winter was too mild for there to be gain from heating
- In two remaining cases gain was 40% - 50%
  - Losses were smaller than they would be with no heating
- Remaining icing losses due to undetected icing or losses during heating
  - Losses during heating can be indicator of too low heating power

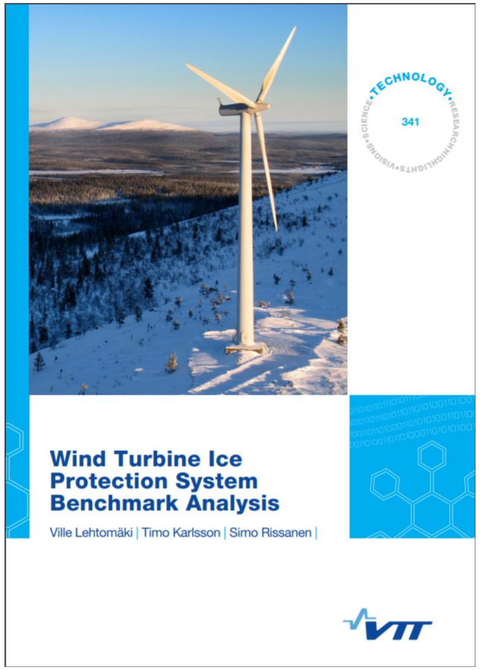
Future: More study needed

- Effect of site:
  - similar machines at different site conditions
- Year-over-year variation:
  - Icing has a large variation, effect of that on IPS gain interesting
  - Need a long-term dataset
- Reduction of uncertainty:
  - Larger dataset, would gain more turbine-years

Project public report

Project report has been made publically available as:

Lehtomäki, V, Karlsson, T & Rissanen, S 2018, *Wind Turbine Ice Protection system Benchmark Analysis*. VTT Technology, no. 341, VTT Technical Research Centre of Finland.



Full report available at:

https://www.vtt.fi/inf/pdf/technology/2018/T341.pdf

Thank you.

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