Comparison of four blade-based ice detection systems installed on the same turbine

VGB research project 401

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The experiment

polytech fos4X
Beyond the idea streaming like wind

Rotor blade ice detection

Weidmüller

BLADEcontrol®

Wölfel

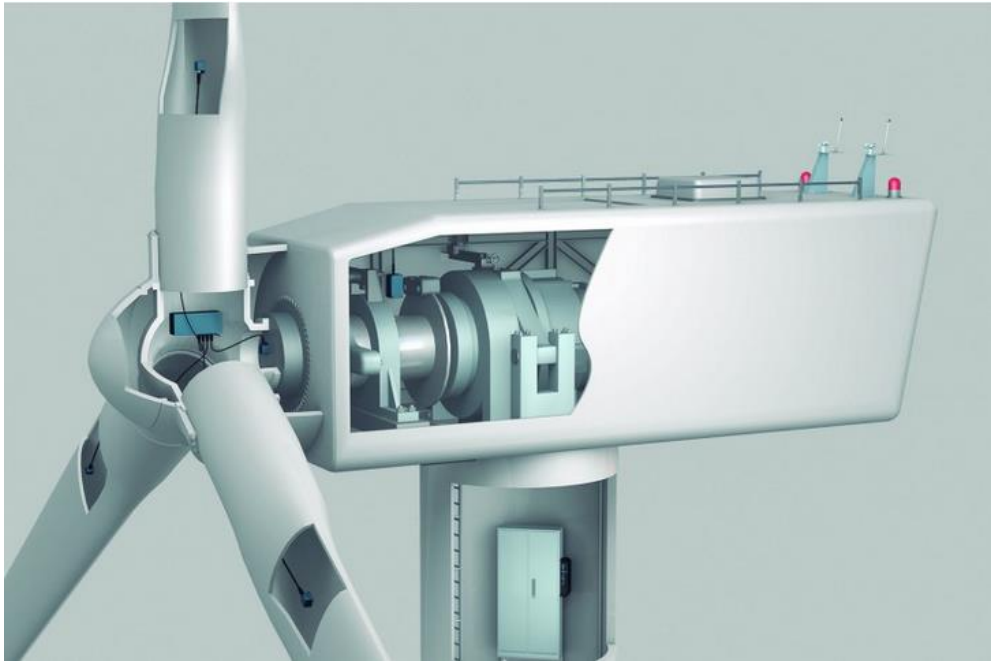
IDD Blade

Vibration-based systems
Wölfel, Weidmüller, fos4X

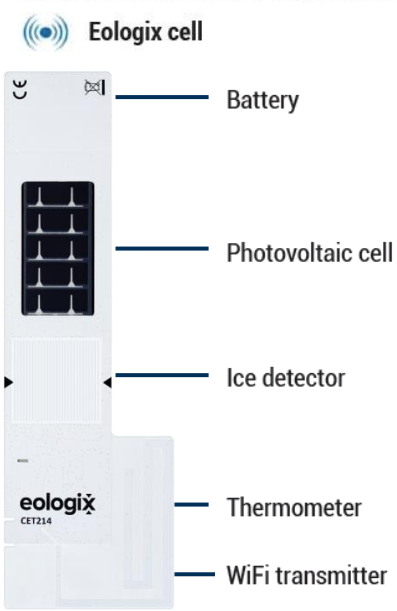
Blade vibration frequencies
are related to the overall blade mass

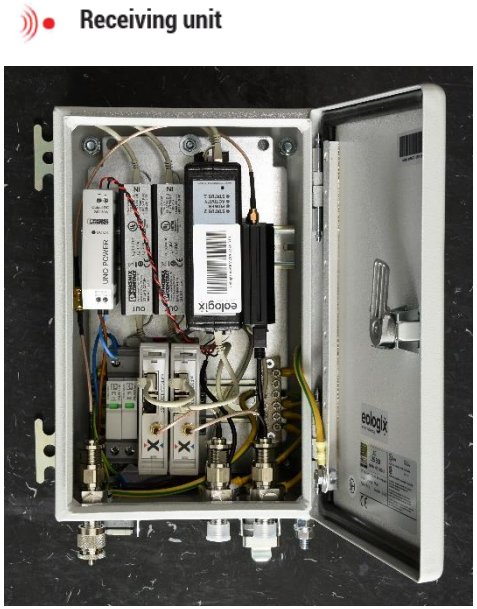
→ indirect measurements
of the **overall ice load**

Pictures from Weidmüller
as example



eologix





"**ice thickness** measurements at **multiple representative points** of the **external blade surface** by means of capacitive sensing"

The field test : Data collected

On a Vestas V90 in Scandinavia, blades not heated, no ice safety stop

All 4 ice detection systems running simultaneously + blade webcam available during :

- 3 winter seasons
- 5’700 hours of turbine operation
- ~ 2’500 hours of icing
- ~ 60 icing events
- up to ~ 300 kg of ice per blade

→ **Robust results !**

Results

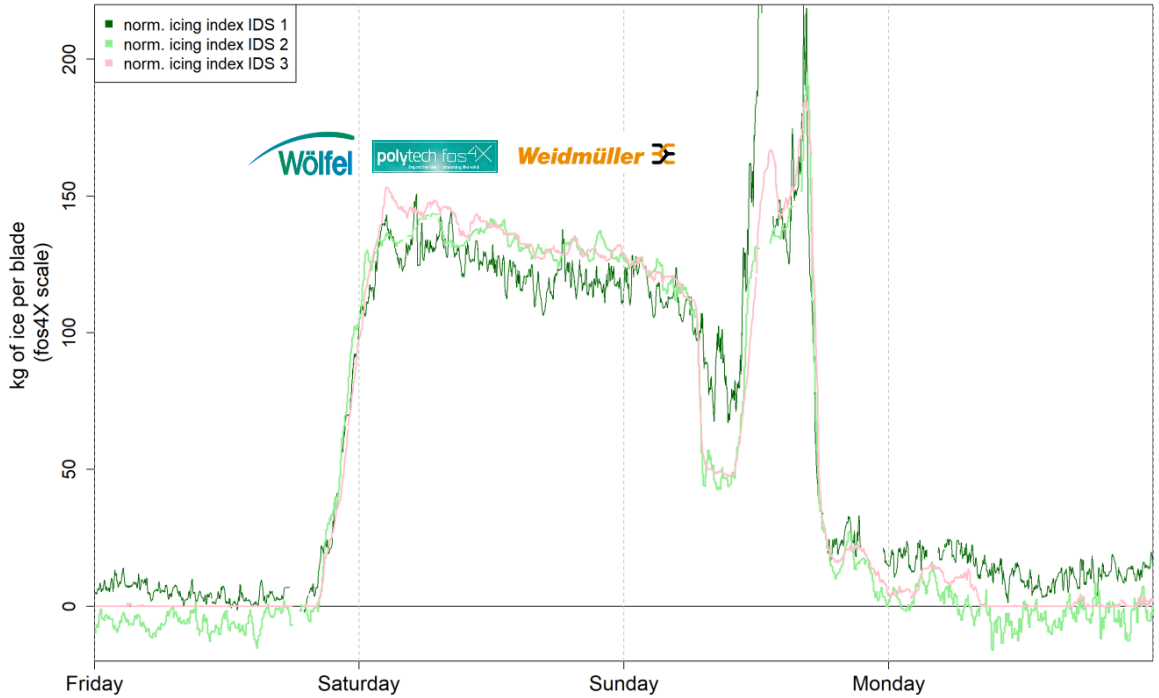
The whole story through one case study…

Results: Vibration-based systems

- **Icing indexes**

Results: Vibration-based systems

- **Icing indexes**



IDS 1,2,3 =
Wölfel, fos4X, Weidmüller
in random order

Very good agreement
of the icing indexes
of the three systems !

Results: Vibration-based systems

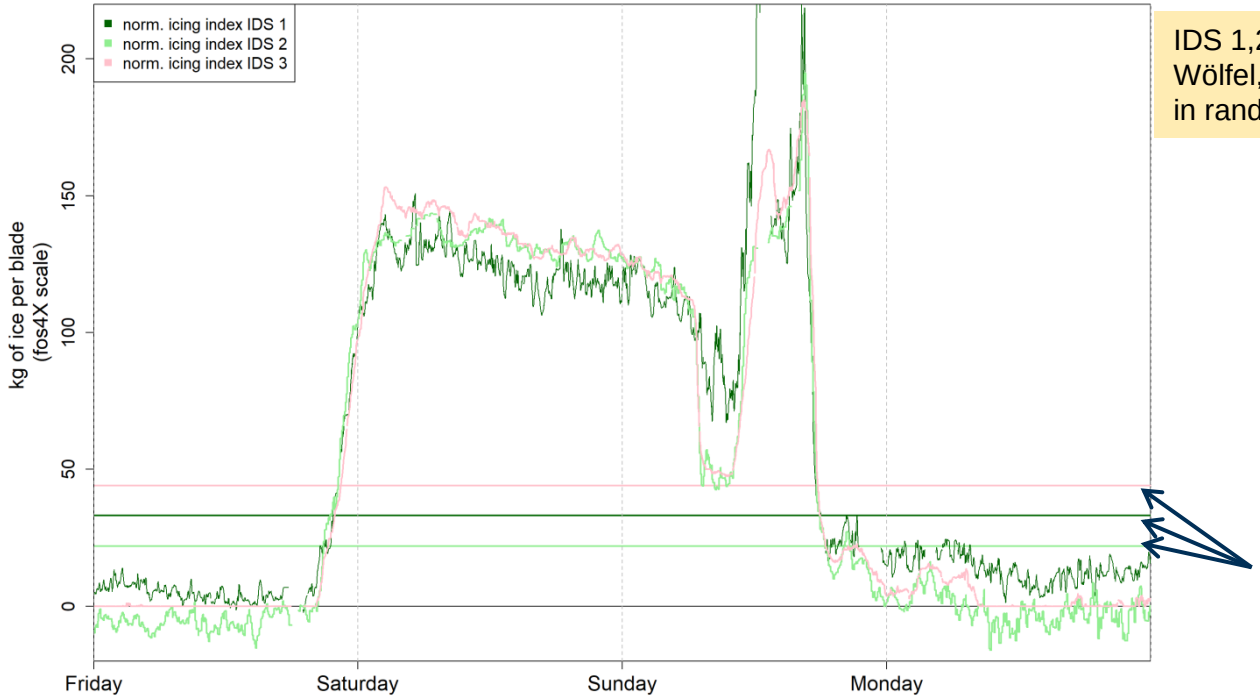
- **Alarm thresholds**

All systems certified by DNV GL
for the same use case:
Insuring a safe operation
with regard to ice throw

Dangerous ice: ~1.5-2 cm of
glaze ice along the leading edge

Results: Vibration-based systems

- **Alarm thresholds**



IDS 1,2,3 =
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All systems certified by DNV GL
for the same use case:
Insuring a safe operation
with regard to ice throw

Dangerous ice: ~1.5-2 cm of
glaze ice along the leading edge

But different
alarm thresholds !

Results: Vibration-based systems

- **Reconstructed turbine stops**

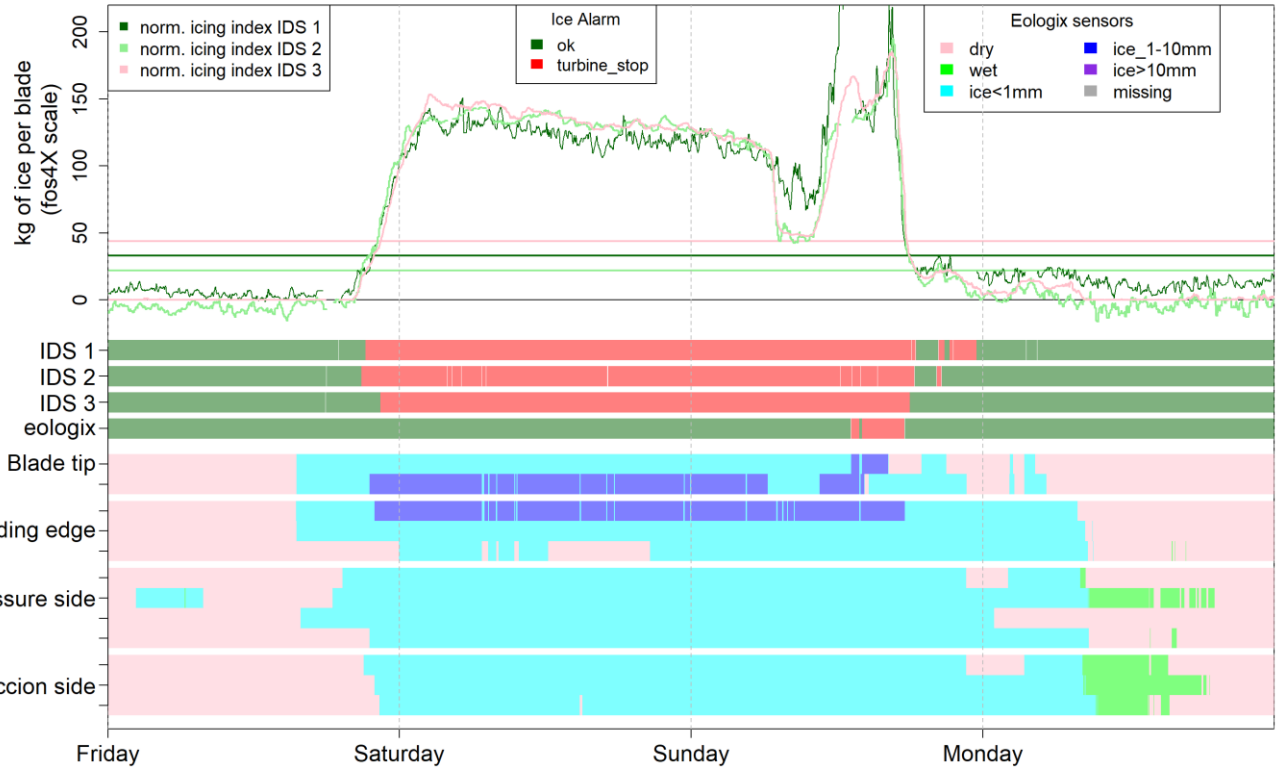
IDS 1,2,3 =
Wölfel, fos4X, Weidmüller
in random order

90 minutes difference

Difference with eologix

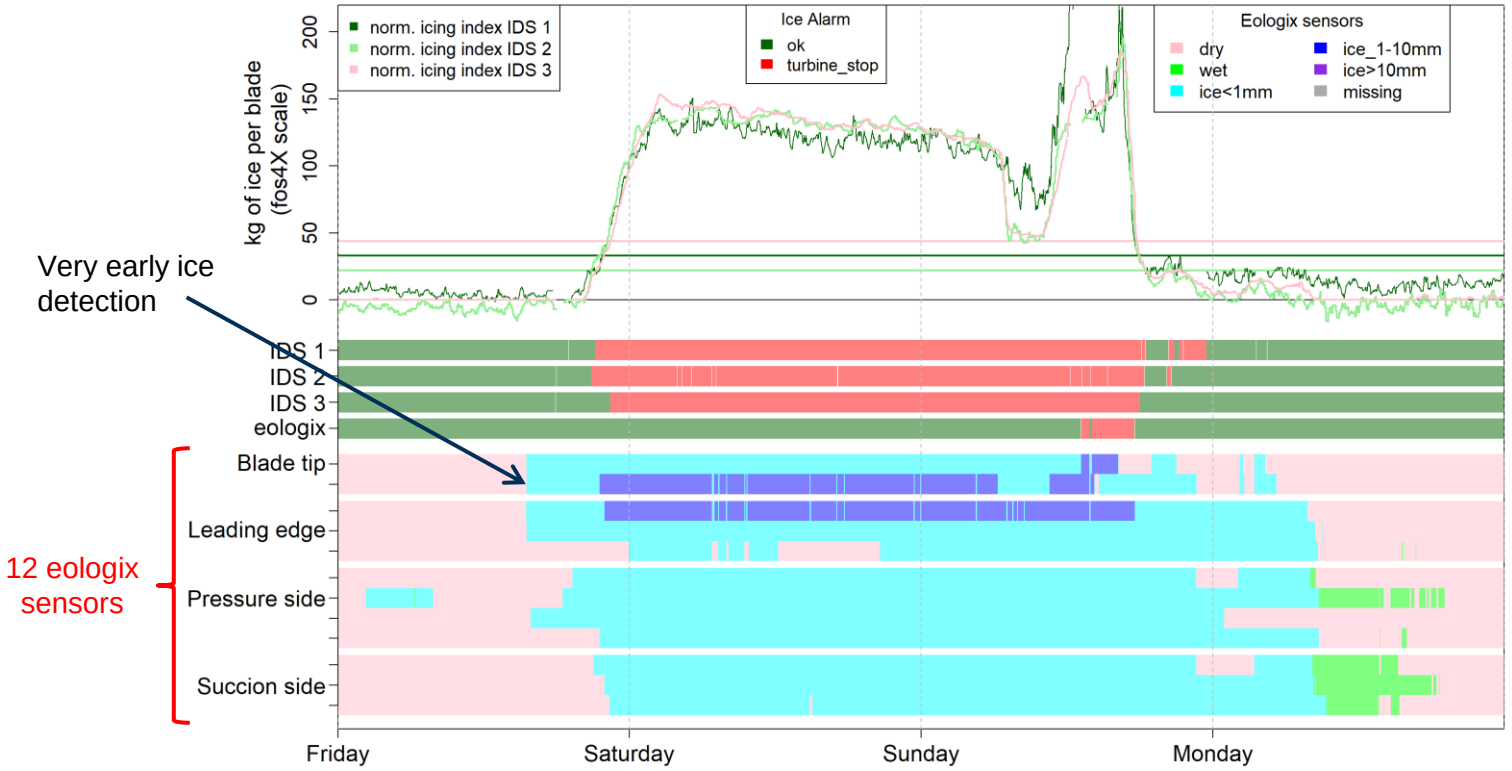
eologix would have stopped the turbine much later !

Difference with eologix

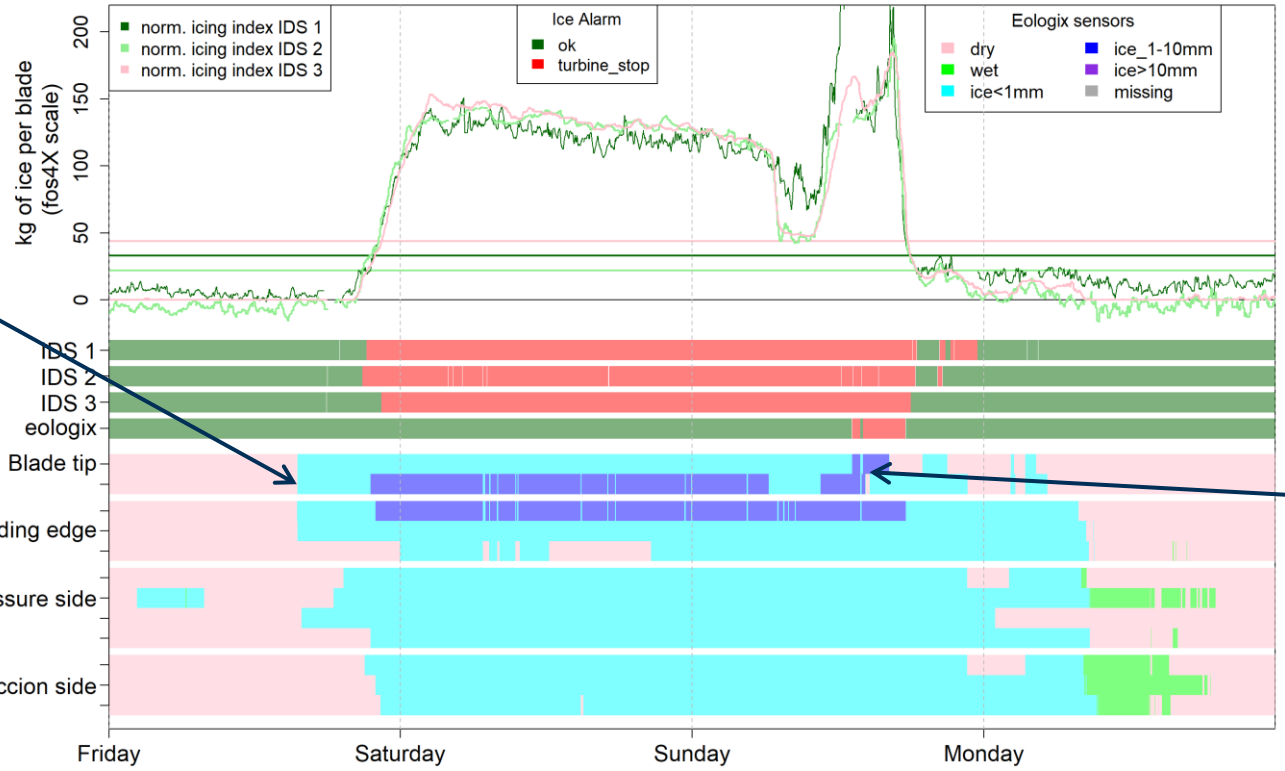


12 eologix sensors

Difference with eologix



Difference with eologix



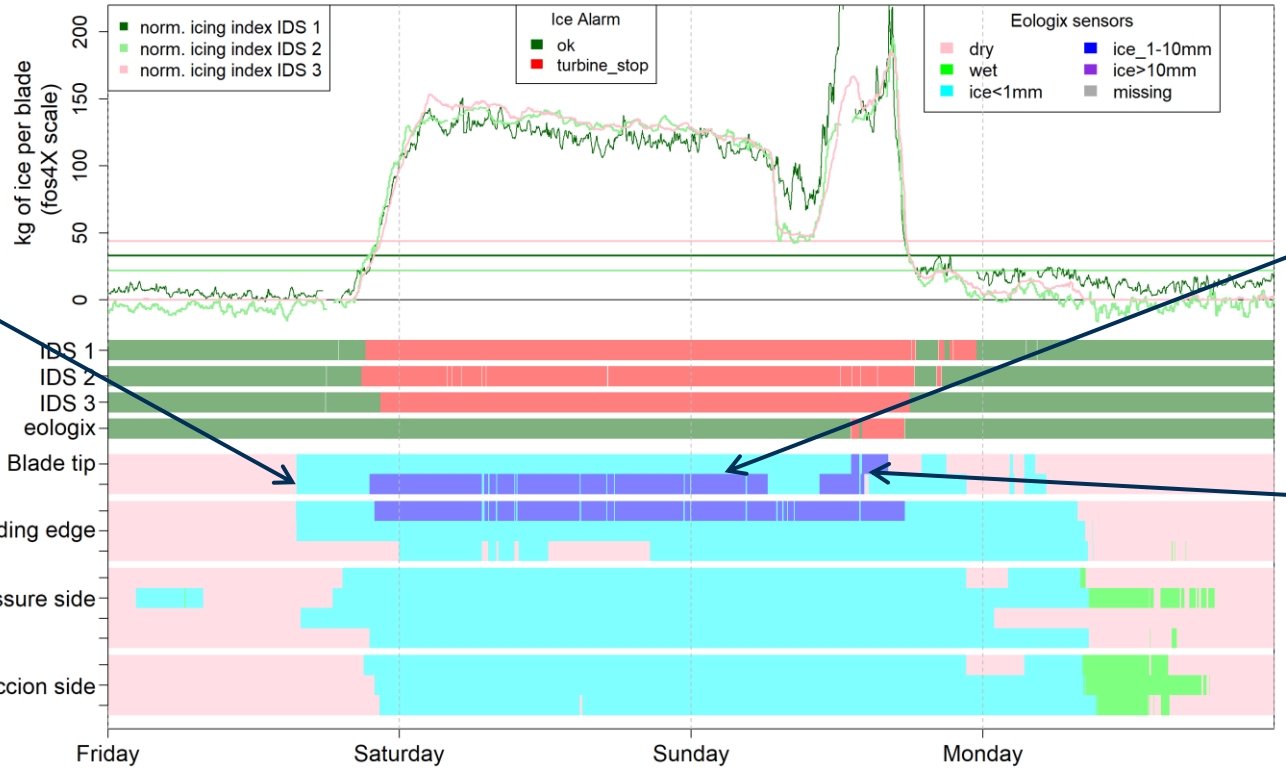
Very early ice detection

12 eologix sensors

eologix would have stopped the test turbine once the two tip sensors reach level 3 simultaneously

«two third of all tip sensors at level 3 or higher» according to certification

Difference with eologix



Very early ice detection

12 eologix sensors

Two neighbor sensors (same blade, 2m from each other) with different ice levels (level 2 and level 3) → heterogeneous ice cover

eologix would have stopped the test turbine once the two tip sensors reach level 3 simultaneously «two third of all tip sensors at level 3 or higher» according to certification

What do we want finally ?

What do you want your turbine
to be doing
at this particular moment ?

Is this ice dangerous ?

Vibration-based IDS → STOP
eologix IDS → OK

The vibration-based IDS would have stopped the turbine already according to their certification.

eologix did detect icing but would not have stopped the turbine according to DNV certificate (only two from twelve sensors indicated >1mm of ice). Some ice is clearly thicker than 1 cm but is also rime ice (porous and very heterogeneous).
eologix can of course always be parametrized to stop the turbine earlier (e.g. 1 sensor at level 3).

Most operators contacted would prefer to actually stop at this point.

Take home messages

Meteotest

polytech fos4X — Beyond the idea — streaming like wind

Rotor blade ice detection

Wölfel

IDD Blade

Weidmüller BLADEcontrol®

- Very similar icing indexes !
- Different alarm thresholds

All 4 systems
*detect blade ice **reliably***
in the range of icing alarms

eologix sensor technology

- First system to detect ice
- Last system to stop the turbine
  (in case of light rime)

More results ?

Overall results over three winters…

- Total duration of turbine stops
- Average turbine stop delays
- Availability of ice detection
- Which system is best suited for which use case ?

Meet us at the **VGB PowerTech webinar**
in Autumn 2021

Operation of Wind Power Plants in Cold Climate

***Public report** : coming soon, free of charge*
please e-mail to
ulrich.langnickel@vgb.org

Many thanks !

First summary

- **All four systems** detect blade ice reliably in the range of the icing alarms

- **Wölfel, Weidmüller, fos4X**
  - remarkably good agreement in their icing indexes
  - different alarm thresholds for turbine stops/restarts
    - → thresholds should be harmonized among systems

- **eologix**
  - first system to detect icing
  - last system to stop the turbine (if turbine stops according to systems certifications)
  - over three winter seasons the eologix system would have stopped the turbine ~2.5 times less than the 3 other systems. This difference is probably specific to the light rime ice observed on this test site.

- **Note:** We **never observed thick glaze ice** on the test site, only light (although thick) rime ice.

VGB PowerTech

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In this context, our wind energy community has been sharing experiences and knowledge on a high level of expertise since the year 2001. Currently, more than 130 experts from the operating companies are actively participating in VGB´s wind committees.