Organized by Swedish Windpower Association since 2008

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

10th year ANNIVERSARY

Manufacturer’s technical sesson

Winterwind 2018 • Åre • Feb 5-7

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1. How ought the risk between the OEM and the developer be shared when developing wind farms in icing conditions?
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Panel discussion

Winterwind 2018 | Åre | February 7th, 2018

Claes Jeppsson

ENERCON
ENERGY FOR THE WORLD

Winterwind Panel 2018
Nordex Group

Hamburg, 02-02-2018

Winterwind 2018

Panel Questions

SIEMENS Gamesa
RENEWABLE ENERGY

Vestas Cold Climate Solutions and next steps

Brian Daugbjerg Nielsen, Product Management

Winterwind 2018

PUBLIC

06/02/18

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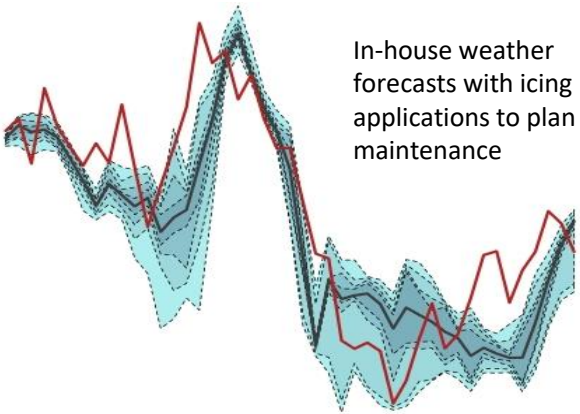
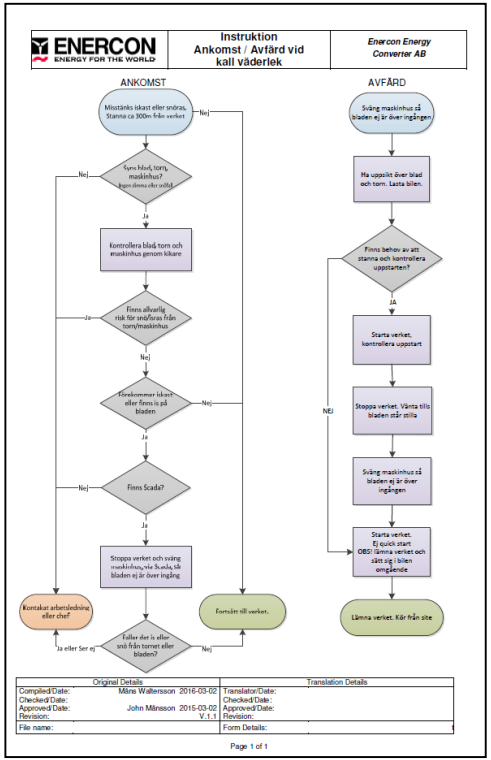
6. H&S for service technicians



In-house weather forecasts with icing applications to plan maintenance

Planning of maintenance

Roof to cover entrance



Process for service

Do you, for wind turbines to be deployed in icing conditions, offer entrances with extending roofs to enable safe access for technicians and their vehicles?

- So far we are not offering this option
- However some of our customers have deployed this safe access roofs with our turbines
- On the other end Nordex also offers complete turn key wind farms, if required this option can be discussed.

Yes this is doable – but there are still considerations that needs to be properly addressed.

Creating a roof over the entrance doesn't create a risk free environment

1. Ice throw distance up to 400m
2. Wind speed and directions
3. Field experience

Vestas answer 6

Brian Daugbjerg Nielsen

- **6. Do you, for wind turbines to be deployed in icing conditions, offer entrances with extending roofs to enable safe access for technicians and their vehicles?**
- A: Site specific solutions have been made in cooperation with customers, but main focus have been on IPS/ide detection systems.

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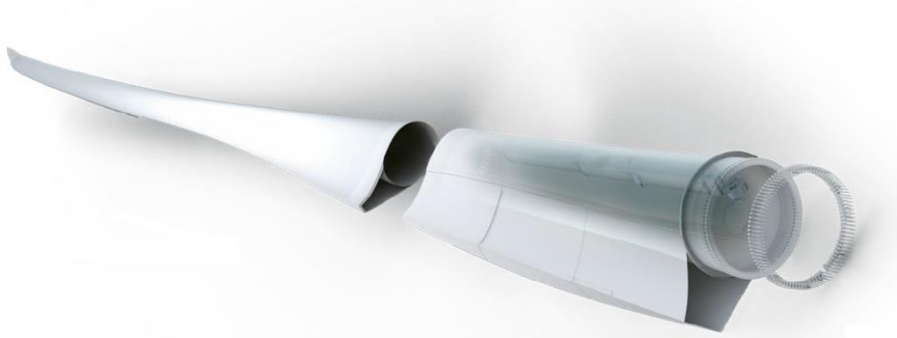
5. Hydro- or ice-phobic coatings on rotor blades

Generally ENERCON is interested in coatings because

- It is a passive ice protection system, no energy is needed
- It is retrofitable
- It can be combined with the blade heating system



ENERCON is currently investigating hydro- or ice-phobic coatings.

- Already done: Basic material testing on a cylinder in an ice tunnel
- Planned for 2018: Testing airfoils with different coating materials in an ice wind tunnel

(the above funded by the German Ministry for Economics and Energy)

→ Main issue: The coating needs to have a lifetime comparable to the turbine lifetime.

What is your opinion regarding hydro-/ice- phobic coatings on wind turbine blades?

- We are observing the market and follow closely the discussions on the different cold climate events
- So far we have not seen the break through
- We have tested an coating years ago which did not work
- If there is an promising coating we would like to test/use it, especially when it helps to reduce the cost of energy. (No need of blade heating anymore!?)

Interesting – but there are considerations that needs to be properly addressed.

1. Environmental impact
2. Life time assessments
3. Field experience

Vestas answer 5

Brian Daugbjerg Nielsen

- **5. What is your opinion regarding hydro-/ice- phobic coatings on wind turbine blades?**
- A: the technology is not mature enough to be introduced into the market. There need to be higher maturity and introduction into manufacturing have to be a robust method, to enable equal performance. The introduction is most likely going to be in connection with active systems.

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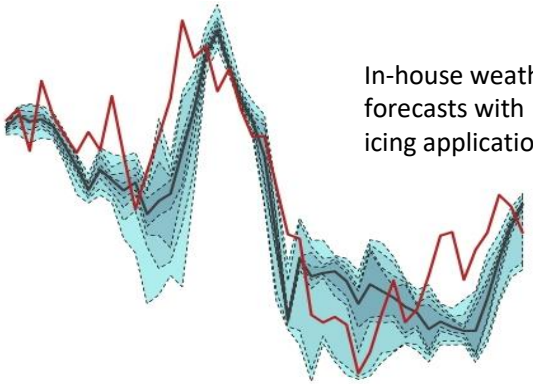
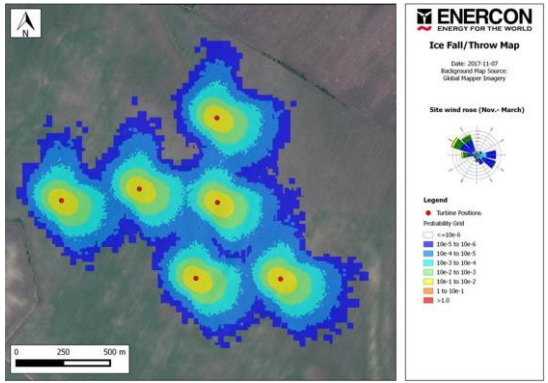
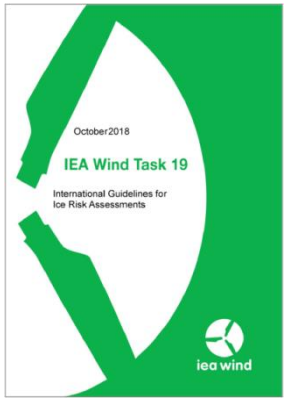
4. ENERCON R&D in Cold Climates



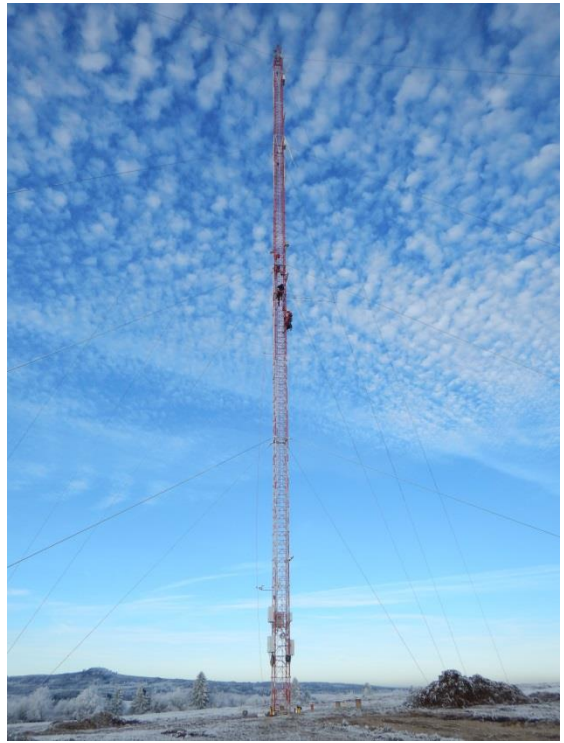
In-house weather forecasts with icing applications



Further development of in-house ice risk assessment tool

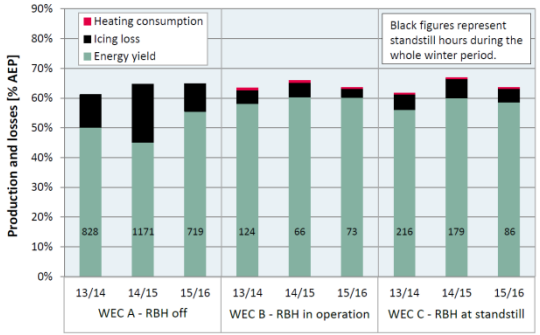


Member of the IEA Wind Task 19 subgroup for ice fall/throw risk assessments



Validation of meteorological sensors under icing conditions

Investigation of turbine behavior under different conditions



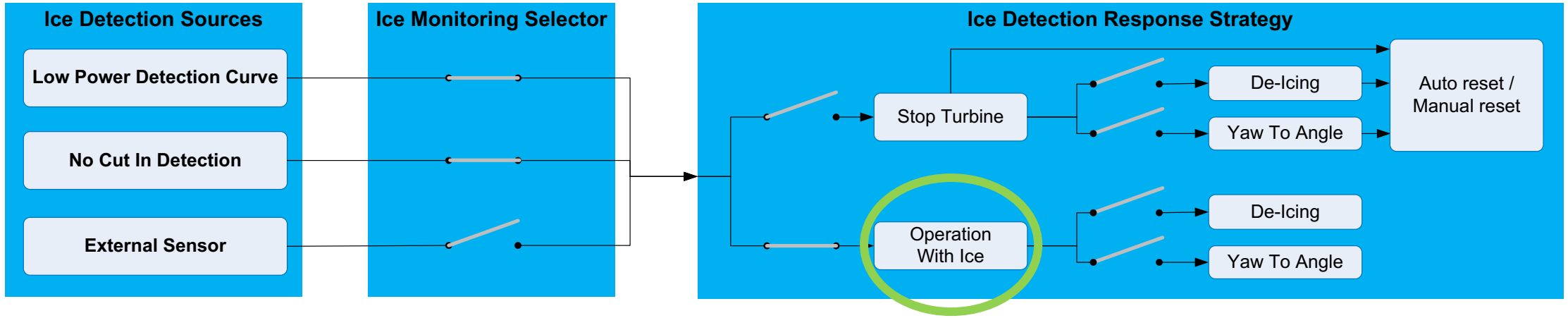
What does your company currently focus on with regards to R&D in cold climates?

- Nordex main focus is currently the further development of the Advanced Anti-icing System for the N149/4.0-4.5
  - Goal was to have an efficient and reliable system for the next generation turbine in the 150m rotor segment

- At the Kivivaara-Peuravaara wind farm an ICEMET Sensor was tested from University of Oulu, measuring liquid water content, median volume diamter, temp. and humidity.
  (currently not continued)

Flexible configuration for cold climate strategy

- Siemens Gamesa's ice detection and response system offers a functionality that extends the range of operation during ice conditions.
- The configurable options determine how ice is detected and the associated action taken to e.g. comply with building permits
- Default configuration maximizes the power production



Vestas answer 4

Brian Daugbjerg Nielsen

- **4. What does your company currently focus on with regards to R&D in cold climates?**
- A: Improvement of triggering of Hot Air de-icing (in field), this also have a effect on the anti-icing
- A: Rolling out Anti-icing, V136 anti-icing testing
- A: Ice detection development for optimized performance in ice throw sensitive markets, and the combination of anti-icing and ice detection

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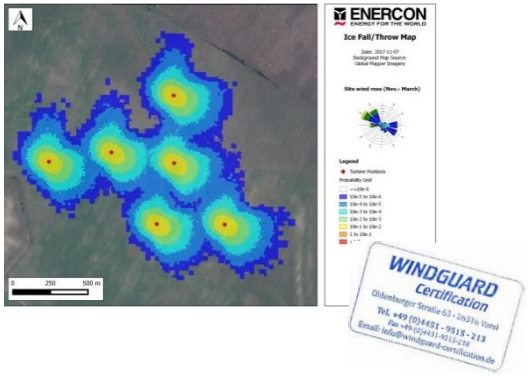
3. Ice throw mitigation and IPS

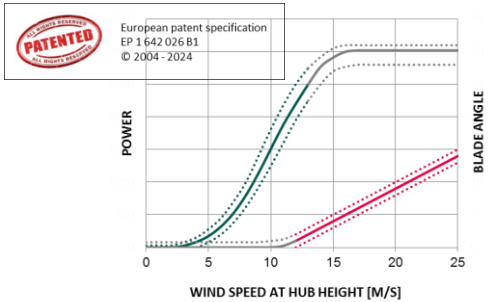
IPS – a combination of sub-systems

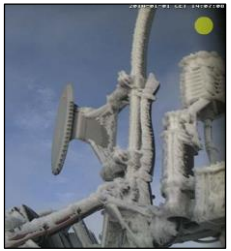
- Ice Detection
  - Several systems available which can mitigate risks
  - Settings important
- RBHS
  - Purpose to decrease yield losses (20y experience)
  - Influence depending on operational mode
- Operational Mode
  - Influence ratio between fall and throw
  - Influence on the amount and sizes of the ice pieces
- Auxiliaries
  - No influence

→ **Several factors interacting**

→ **Risk Assessments to find the best combination**







Does your IPS help mitigate ice throw hazards?

- **YES**

- Anti Icing System oeprates while turbine is running and prevents ice from attaching to the blade (at heated areas and downstream of the heating mat).
- Side effect: Due to sublimentation and pressure difference the unheated root end part of a running turbine blade loses also quicker the ice.

Health and safety under icy conditions for Siemens Gamesa turbines

- The risk of ice throw cannot be entirely eliminated by the current technologies within the area of de-icing and anti-icing, as their purpose is to reduce ice buildup primarily on the leading edge.
- The risk of ice throw can be contained by acknowledged guidelines of safe zones, typically in the order of 250 m to 400 m depending on the turbine type.
- The turbine owner is responsible for taking the appropriate risk mitigation measures to protect the public from being exposed to falling ice in accordance with local legislation.
- The site personnel are typically more exposed to ice-throw than the public. Site personnel must, in the event of icing conditions, always follow the health and safety rules and procedures provided by Siemens Gamesa

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Vestas answer 3

Brian Daugbjerg Nielsen

- **3. Does your IPS help mitigate ice throw hazards?**
- A: it might. The key to reduce ice throws is ice detection. This have to be a reliable system, that can detect ice. Ideally this is combined with more sensors/data input about icing, which can lead to pre-heating to the blades to avoid/reduce ice throws. Ice fails will happend.

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2. Preferred IPS functionality tests

Functionality tests of components

- Basis would be the clear definition of measures and thresholds which prove the functionality of the IPS.
- Proof of functionality should be as easy as possible and executable with already installed measurement devices to limit the costs (temperature sensors, blade based ice detection etc.)

Winter power curves

- Would have to be defined for every single site because they are not transferrable
- Power performance measurements are very expensive – who pays for the proof?
- Uncertainty of the measurement would not be satisfying due to site complexity and variability of icing severity.

Annual average wind speed (Rayleigh-Distribution)	Uncertainty of the measured power curve, represented as the standard uncertainty of the AEP	
[m/s]	[MWh]	[%]
4.0	166	8.9
5.0	237	6.8
6.0	293	5.4
7.0	324	4.4
8.0	331	3.7
9.0	325	3.2
10.0	310	2.8
11.0	291	2.5

Examplary uncertainty for IEC power performance measurements in simple terrain during summer.

What are your preferred IPS functionality tests?

- Since Nordex offers a Winter Power Curve Warranty we are following the IEC standard as far as possible (with met mast).
- Following the same principle as for a normal summer power curve warranty and test.
- We are supporting the Task 19 effort in defining guidelines for IPS performance tests. Ultimate goal: everyone is using the same test procedure
- We are flexible and open for new ideas and approaches

Calculating the relative ice loss recovery based on field tests

1. Select a pair of turbines with same conditions, where one is operating with a cold weather feature, and the other one is not.
2. Create “warm power curves” for both turbines based on operational data with no icy conditions.
3. Compensate nacelle wind speed for stopped operation based on wind speed at the peer turbine.
4. Calculate ice loss based on difference between actual power and the “warm power curve”.
5. Calculate relative ice loss recovery by comparing the cumulated ice loss of the turbine with and without cold climate feature.

$$RILR = \frac{E^{B}_{iceloss,\%} - E^{A}_{iceloss,\%}}{E^{B}_{iceloss,\%}}$$

Vestas answer 2

Brian Daugbjerg Nielsen

2. What are your preferred IPS functionality tests?

- A: full scale product level testing with reference turbines to measure the performance is required to understand the performance, and how the site can be tailored in operation. When that is established the performance can be correlated to new turbine types, and less test can be done. Structural, vibration, lightning and other functional test is also important steps in the verification.

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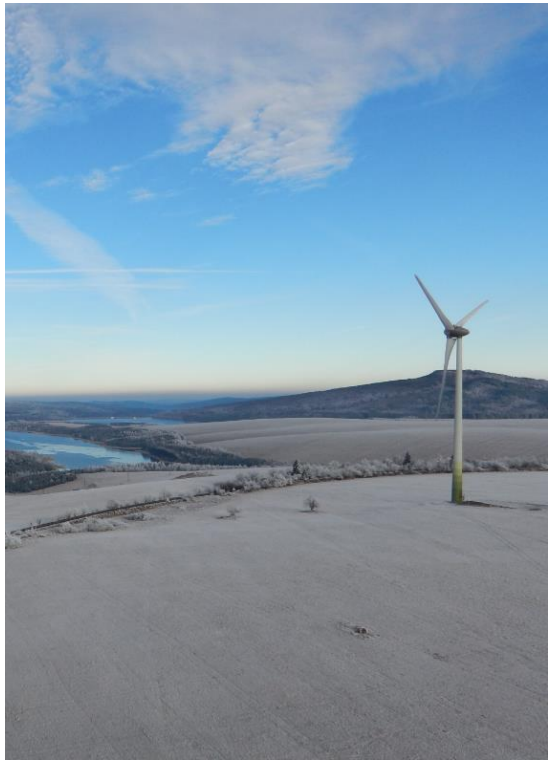
1. How to share risks when developing wind farms

The losses due to cold climates will never be zero! The remaining risk should be shared.

- ENERCON supports the customer even during the planning phase of a wind farm in finding the most suitable turbine configuration.
- ENERCON includes the RBHS in availability warranties.

BUT

- → Turbine operation shouldn‘t be continued for all icing severities in order to prevent turbines from damage!
- → Component warranties might be one solution but must be well-defined. The component efficiency should be measurable without circumstances.



1. How ought the risk between the OEM and the developer be shared when developing wind farms in icing conditions?

HSE Risk

- HSE Risk Mitigation Owner: For public → distance from the public roads, skiing centers, warning signs/signals etc. For workers → easy access to WTG with car, entrance on the position of prevailing wind direction, safety procedures, stopping and parking the turbine
- Mitigation measures against ice throw are to be managed by the Owner in accordance with the site HSE plan and I line with any statutory and permit requirements
- OEM needs however to ensure that its own procedures for ensuring HSE protection of its employees (service technicians) are in place and are followed

AEP Risk

- Nordex offers warranties for (winter) power curve performance and turbine availability

- Force majeure events excluded when conditions outside the operational limits of the Anti-Icing System

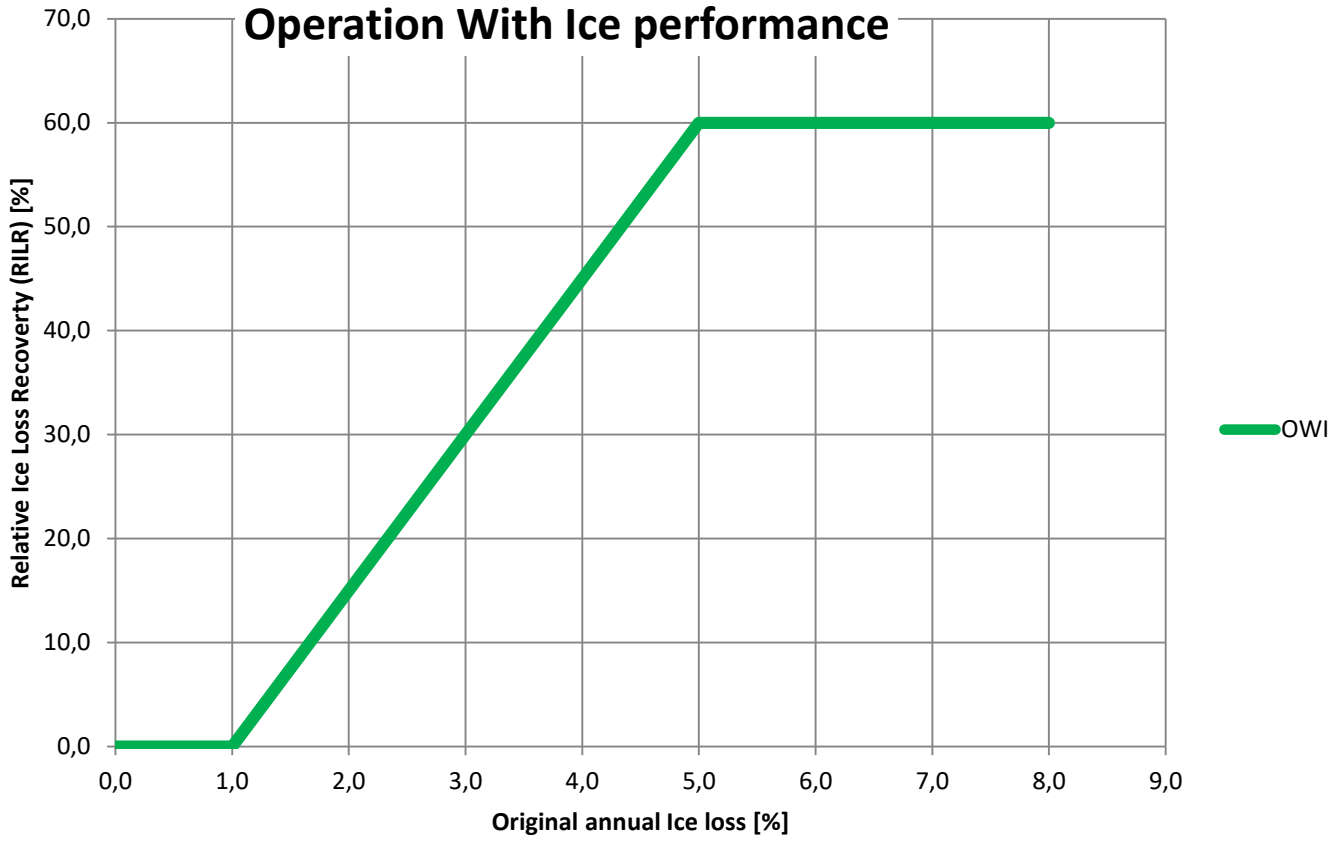
Why do developers go to icy sites?
Ice being the negative there are several positives for developers:

- Less people live in CC areas and less conflicting permitting process
- Box permits, optimization opportunities utilization of the latest technology (highest tip heights)
- Getting volume benefits as project areas are greater and the # of WTGs

→ So, on a balance a level where the parties share the icing problems is probably fair.

Place the risk reasonably and with the one having the experience

- Developer: Knows the climatic conditions of the site
- OEM: Knows the performance of its product and can predict the performance levels for most conditions
- Siemens Gamesa has field data from 500 WTGs with cold climate features operating in cold climate for 2-7 winters



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Vestas answer 1

Brian Daugbjerg Nielsen

- **1. How ought the risk between the OEM and the developer be shared when developing wind farms in icing conditions?**
- A: The IPS warranty principles should be made from a system perspective. The performance and thereby the warranty should be a extraction into the predicted ice losses and in the event that the system does not perform, the penalty should be linked to the shortfall of the test multiplied with the predicted ice losses. In that way there is a balance between what the O&M can warrant, what the system can do, and the assumptions made by the developer.
- A: Vestas strive for operation during icing (with the new anti-icing product), and warranty is based on full coverage of icing : Meteorically and instrumental icing
- A: The correlation between icing event to ice load to location on blade to power curve is still a unknown equation.

THANK YOU FOR YOUR ATTENTION

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Thanks for your attention

Thank you!

Per Egedal

Chief Engineer, Control and Monitoring, Siemens Gamesa Renewable Energy

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