Nordex Group

Advanced Anti-Icing System for N149

Winterwind Conference, February 2020, Konrad Sachse

Agenda

01 REVIEW

02 FIELD VALIDATION OF ADVANCED ANTI-ICING SYSTEM

03 SOME THOUGHTS ABOUT WARRANTIES


Last year at
WINTERWIND…

Design goals
Advanced Anti-Icing System for N149

PERFORMANCE

AVAILABILITY

MAINTENANCE COST

COST OF ENERGY

WELL PROVEN CONCEPT

Basic features:

- Electrical resistance heaters
- No additional components in/on blade – except connections at blade root
- Low energy consumption – heating the surface rather than structure
- Fully operational during turbine operation

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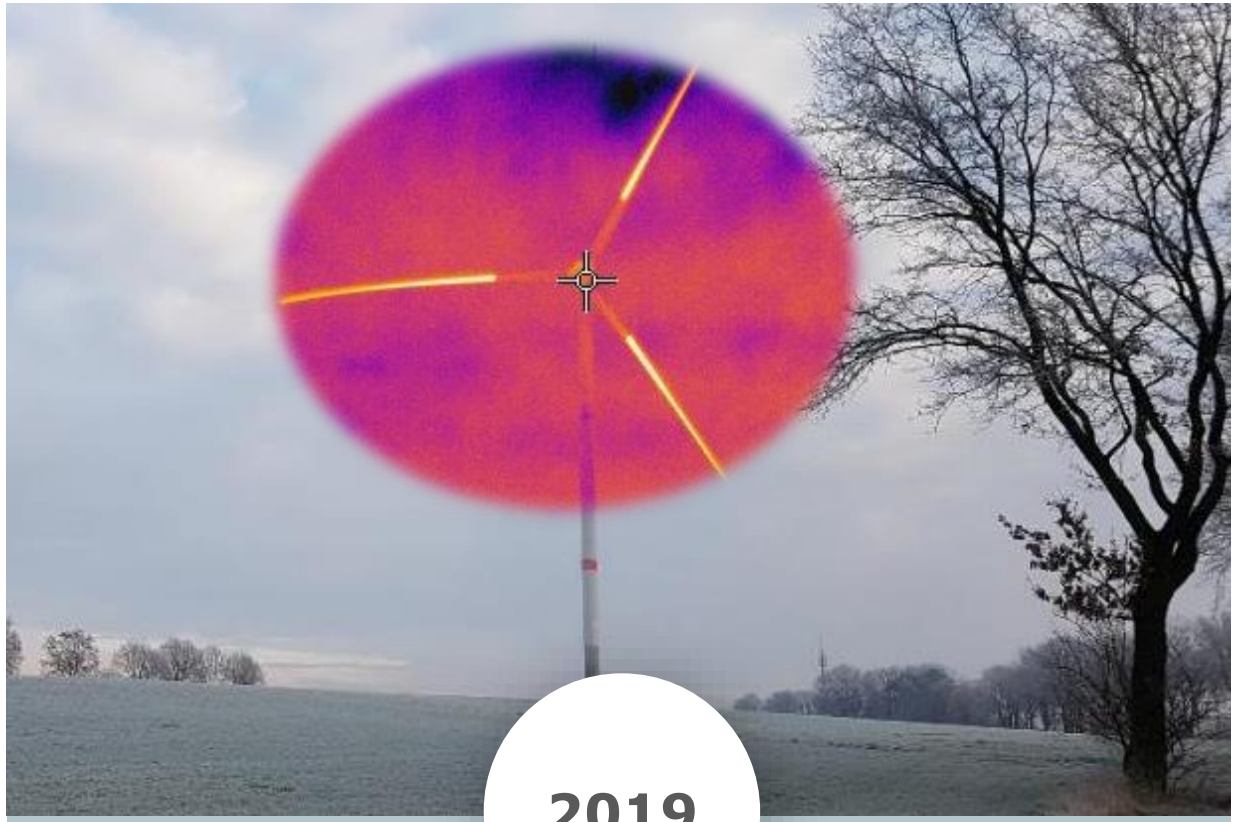
2018

Erection of Prototype

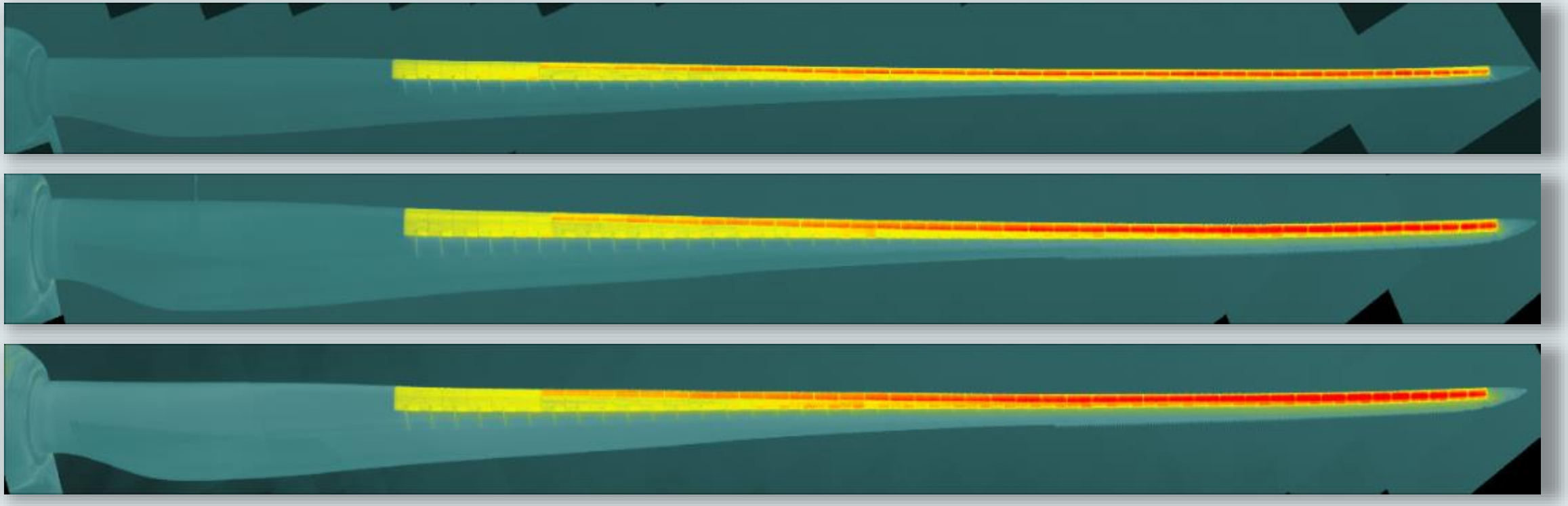


2019

Functional Tests Successful

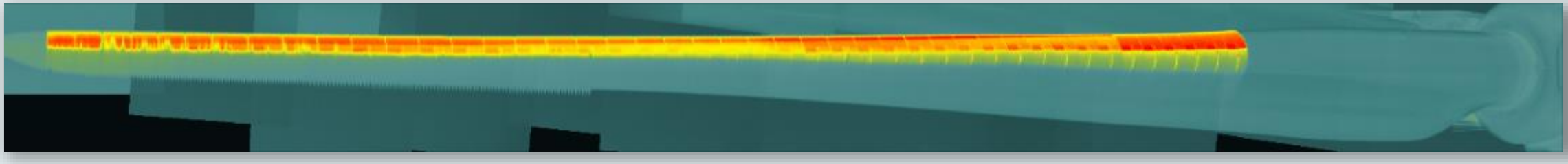
Field Validation

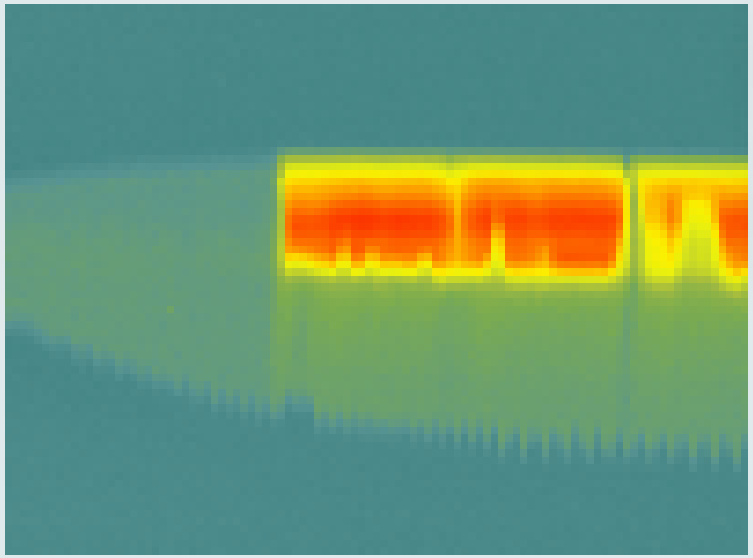
High resolution infrared imaging during standstill



- Reliable quality of suppliers and manufacturing process
- Higher temperatures towards the blade tip as designed

High resolution infrared imaging during turbine operation





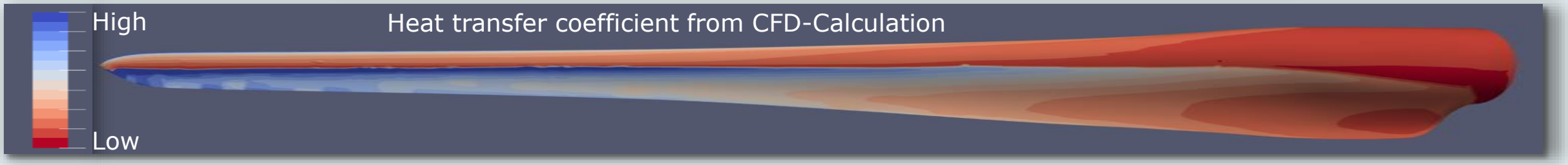
- Equal temperature along blade length
- Avoidance of ice accretion towards trailing edge

CFD-Calculation during turbine operation

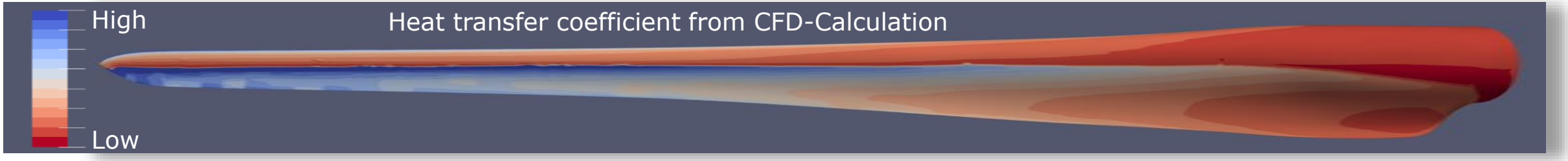
Heat transfer coefficient α: defines the amount of heat that is transfered from the blade into the air flow, „cooling“ the blade

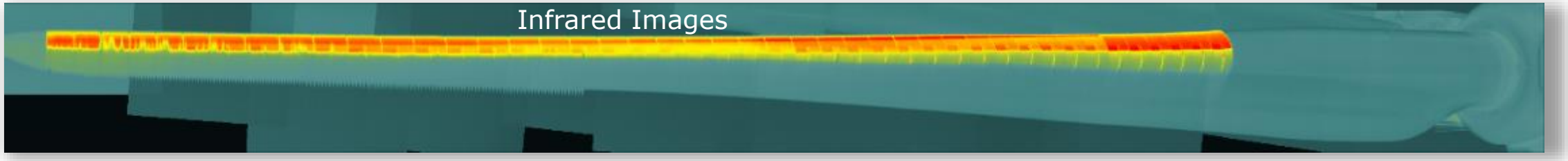
$$\alpha = \frac{Q}{\Delta T}$$

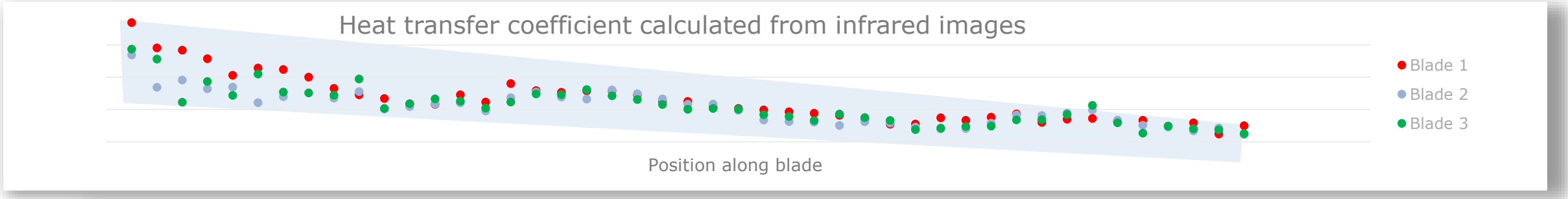
Q: heating power per square meter;
ΔT: temperature difference between blade and air flow



Comparison of CFD-Calculation and measured Data

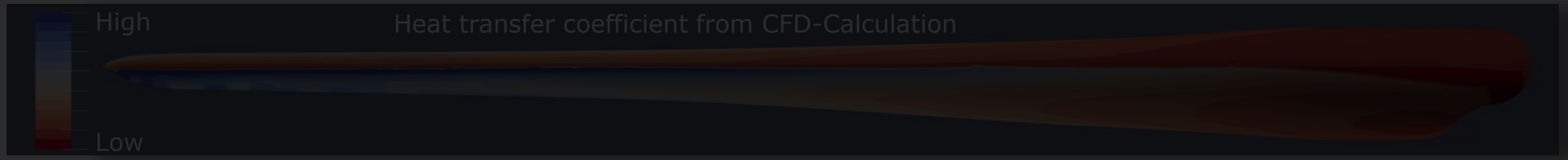


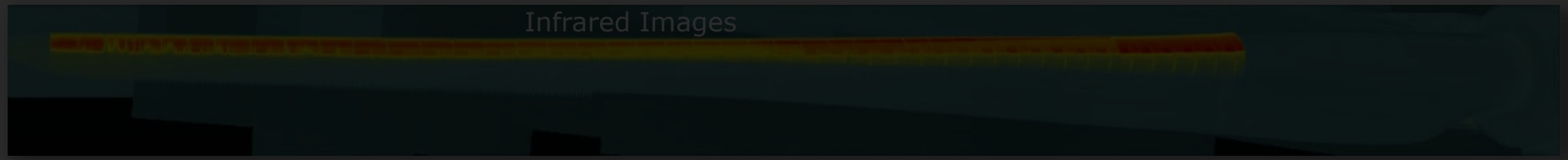


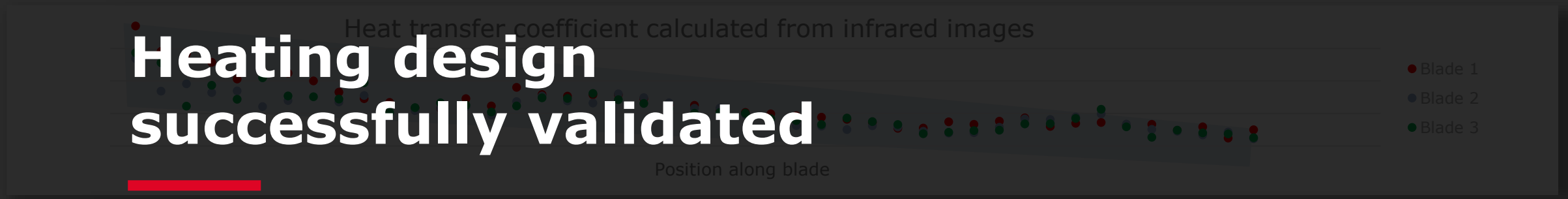


- Calculated behaviour of heat transfer coefficient is reproduced in the field measurements
- Higher scattering of values at the tip due to more turbulent air flow

Comparison of CFD-Calculation and measured Data







Heating design successfully validated

- Calculated behaviour of heat transfer coefficient is reproduced in the field measurements
- Higher scattering of values at the tip due to more turbulent air flow

Excursion:
Some thoughts about warranties

Talking about **warranties** for ice prevention systems

WHAT DOES THAT MEAN?

Ice Loss Recovery? Power Curve?

Talking about warranties for ice prevention systems

There are different types of warranties…
… and even more ways to validate them!

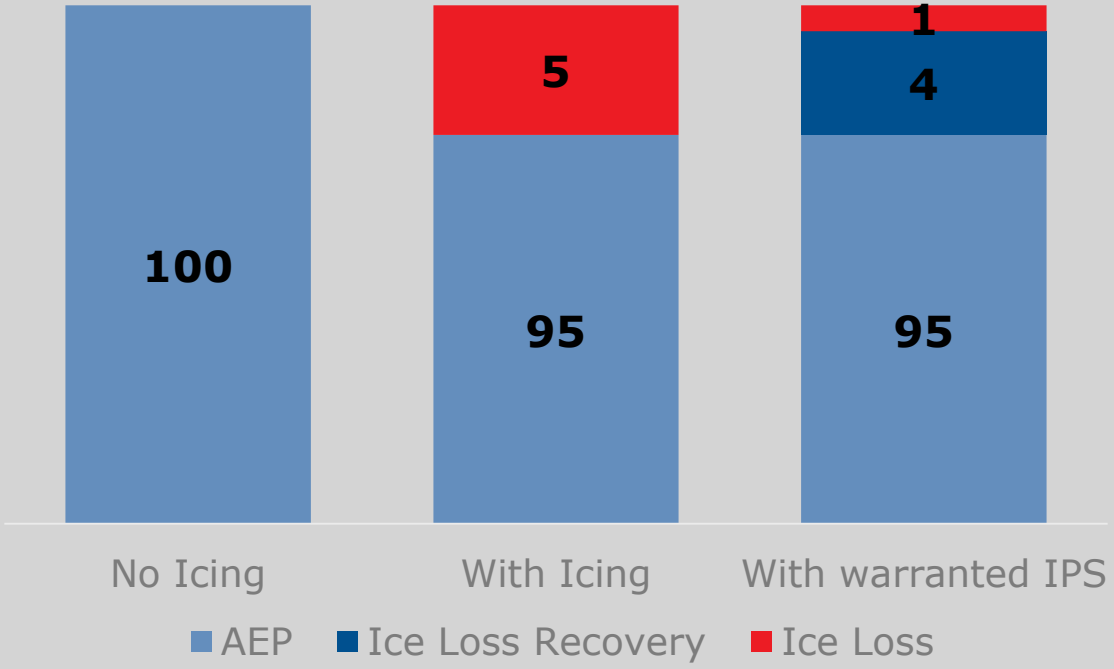
WHAT DOES THAT MEAN?

Ice Loss Recovery? Power Curve?

Warranted Ice Loss Recovery Rate

Ice loss: lost energy production due to icing

Ice loss recovery rate: regained portion of the ice loss



ASSUMPTIONS

- Site with 5 % ice loss
- Warranted Ice Loss Recovery Rate of 80 %

RESULTS

- Ice loss reduced from 5 % to 1 %
- Calc. AEP: 99.0 %

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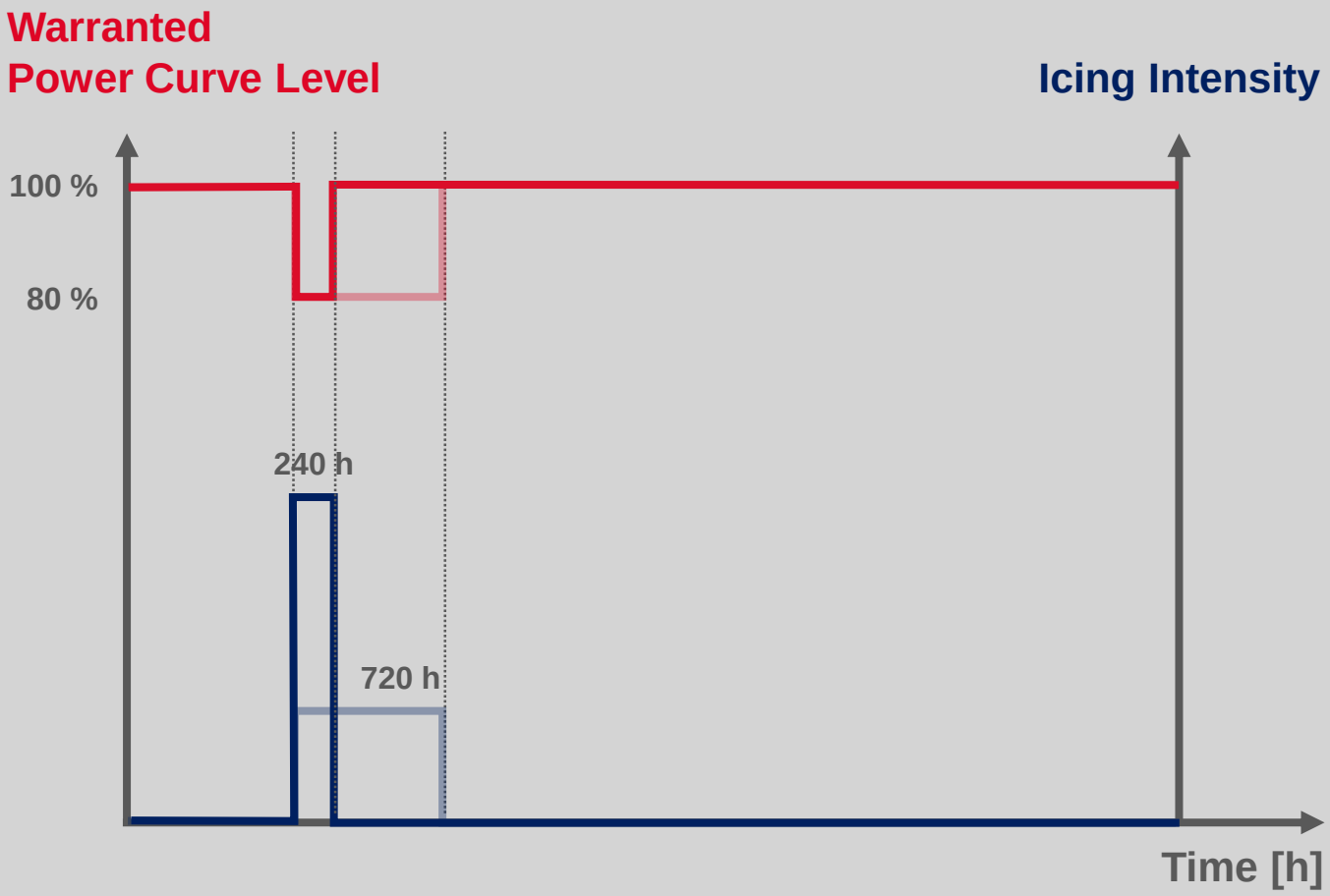
Warranted Power Curve during icing conditions



Case 1: Light icing during 720 h of the year
Case 2: Heavy icing during 240 h of the year

ASSUMPTIONS

- Site with 5 % ice loss
- Warranted Power Curve of 80 % during icing conditions

RESULTS

Case 1:

- Calc. AEP: $\frac{720\,h * 80\,\% + 8040\,h * 100\,\%}{8760\,h} = 98.4\,\%$
- Ice loss reduced from $5\,\%$ to $1.6\,\%$
- Ice loss reduction rate: $1 - \frac{1.6\,\%}{5\,\%} = 70\,\%$

Case 2:

- Calc. AEP: $\frac{240\,h * 80\,\% + 8520\,h * 100\,\%}{8760\,h} = 99.5\,\%$
- Ice loss reduced from $5\,\%$ to $0.5\,\%$
- Ice loss reduction rate: $1 - \frac{0.5\,\%}{5\,\%} = 90\,\%$

Warranties for blade heating systems

CONCLUSION

- Clarify what you are talking about
- You can convert one variant into the other (ice loss & icing hours required)
- Both variants have advantages and disadvantages regarding validation
- There are probably more ways to provide warranties
- Implementation of standards could help the industry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