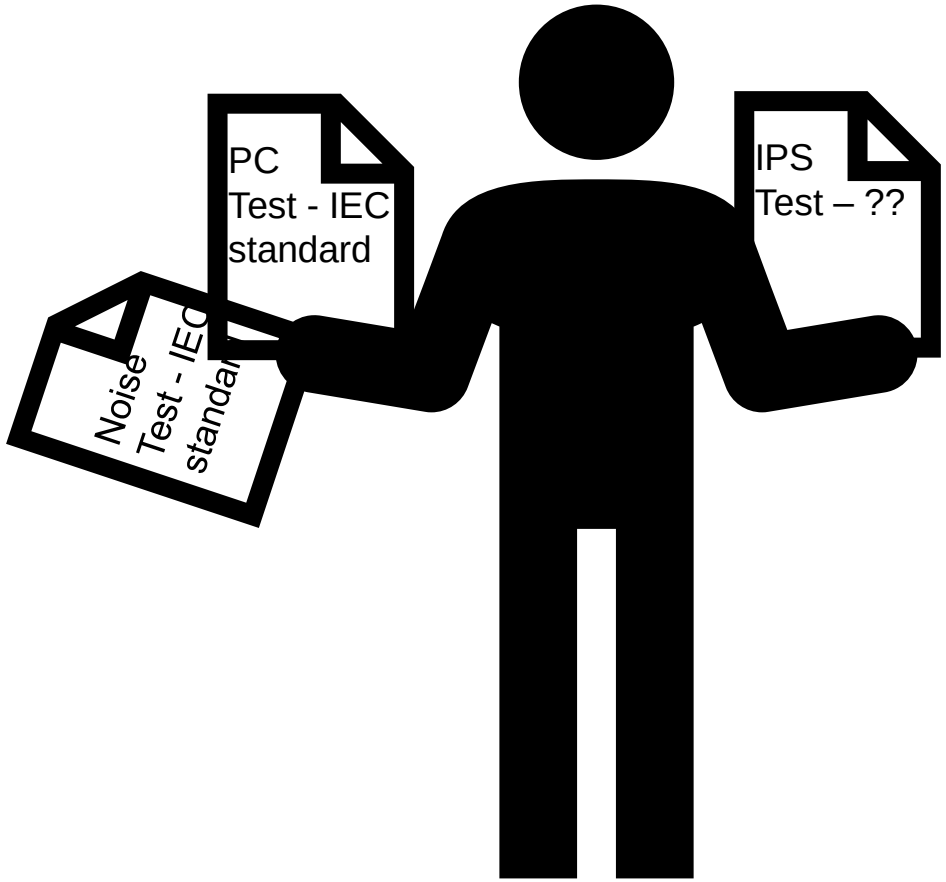
Performance Warranty Guidelines
for Wind Turbines in Icing Climates

Summery of IEA Wind Task 19 report update

2021-04-19, Helena Wickman

Motivation

- Today: No international standard for performance testing of turbines in icing climates
- Task 19 considers wind turbine performance testing in icing climates as a key element to:
  - Mitigate risks in wind farm development in icing climate
    → Decrease uncertainties in investments
  - Accelerating wind turbine technology improvements
    → Increase understanding of the performance and limitations
    → Increase incentive to optimize the Ice Protection System (IPS) and turbine operations



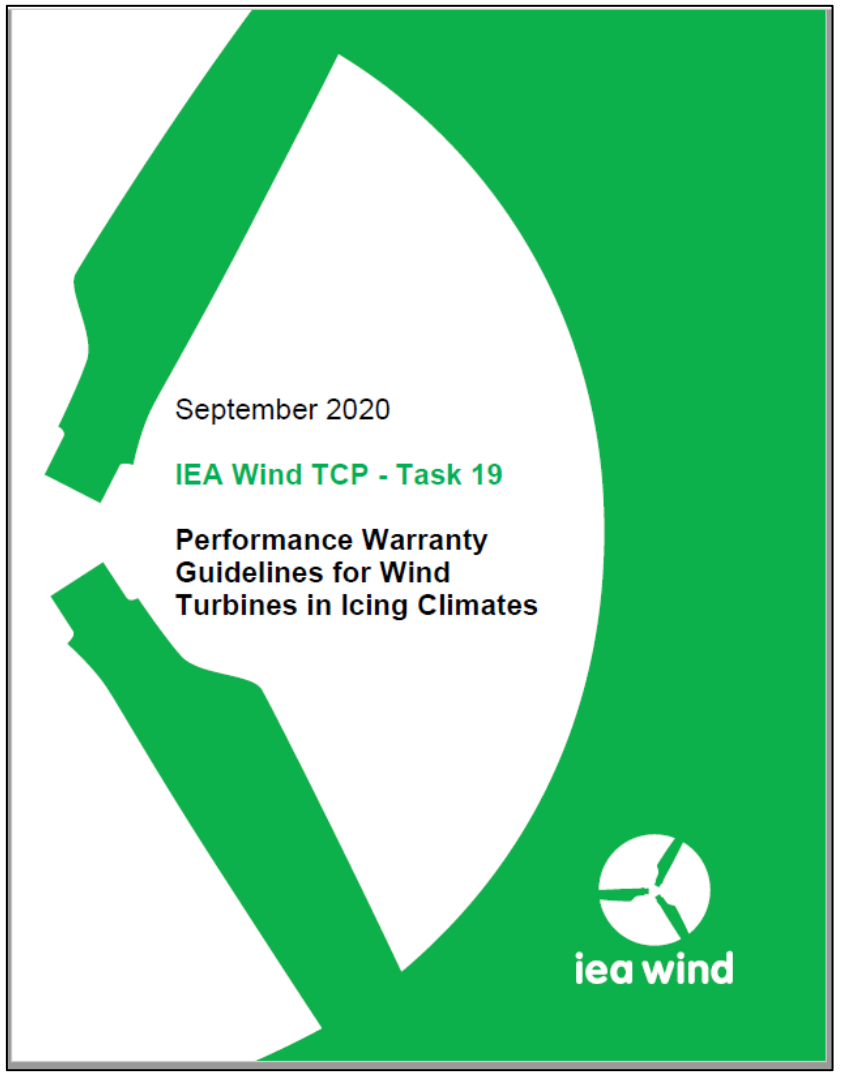
Project summary

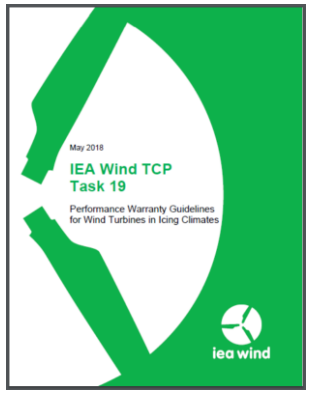
Project group

- Helena Wickman, Vattenfall, Sweden
- Charles Godreau, Nergica, Canada
- Timo Karlsson, VTT Technical Research Centre of Finland
- Stefan Söderberg, DNVGL, Sweden

Project timeline

HT 2019-HT 2020

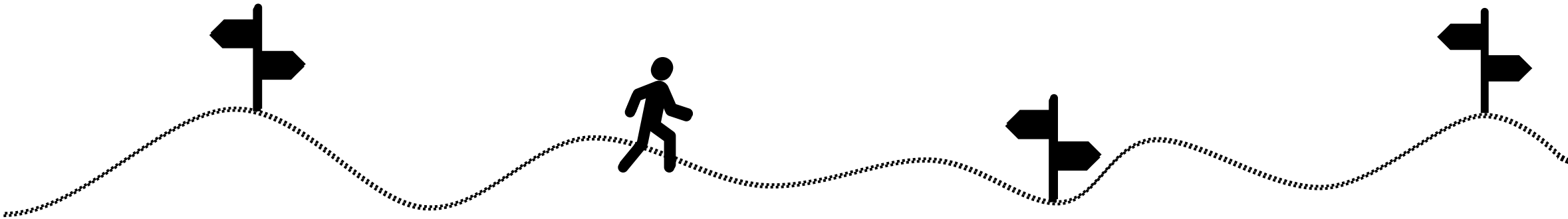




Version 1 → Version 2

- A first guide to include the Ice Protection System (IPS) in a turbine procurement contract
- Showed that it is possible to guarantee and test the performance of an IPS in several ways

- Further detailing the most promising available warranty options and tested methods
- Moved towards fewer and standardized warranty options and test methods



Process

Year	Month	Activity
2019	July	Project started
	Feb	**Winterwind 2020 workshop (36 participants: 8 countries, 27 organizations)**
2020	June-Sept	Review of drafts by an external group from the workshop
	Oct	Final report ready for approval by IEA ExCo
2021	**March**	**Report officially published**

Summary of updates

1st version vs 2nd version

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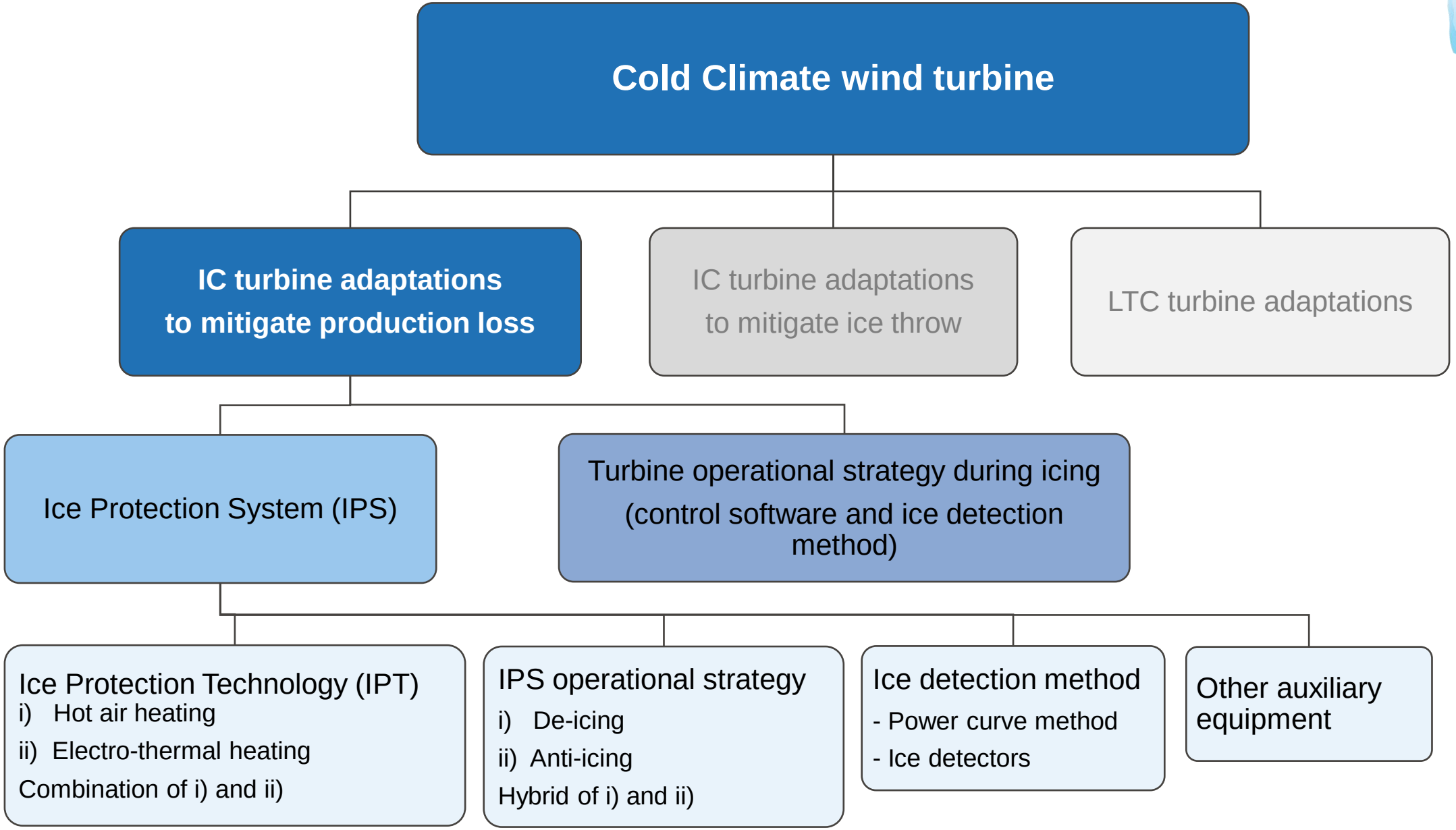
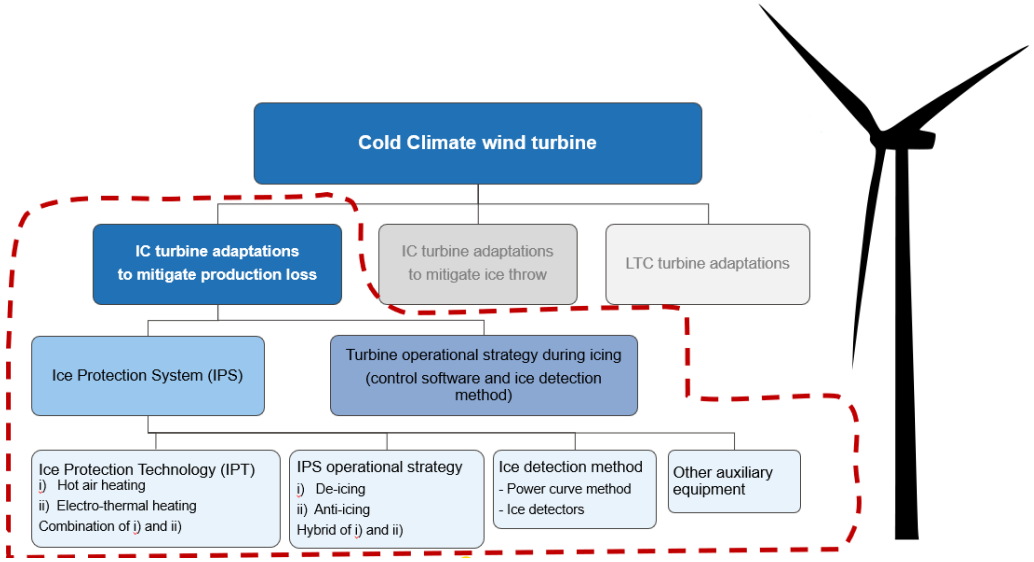

Cold Climate wind turbine
IC turbine adaptations to mitigate production loss
IC turbine adaptations to mitigate ice throw
LTC turbine adaptations
Ice Protection System (IPS)
Turbine operational strategy during icing (control software and ice detection method)
Ice Protection Technology (IPT)
i) Hot air heating
ii) Electro-thermal heating
Combination of i) and ii)
IPS operational strategy
i) De-icing
ii) Anti-icing
Hybrid of i) and ii)
Ice detection method
- Power curve method
- Ice detectors
Other auxiliary equipment

Warranty options

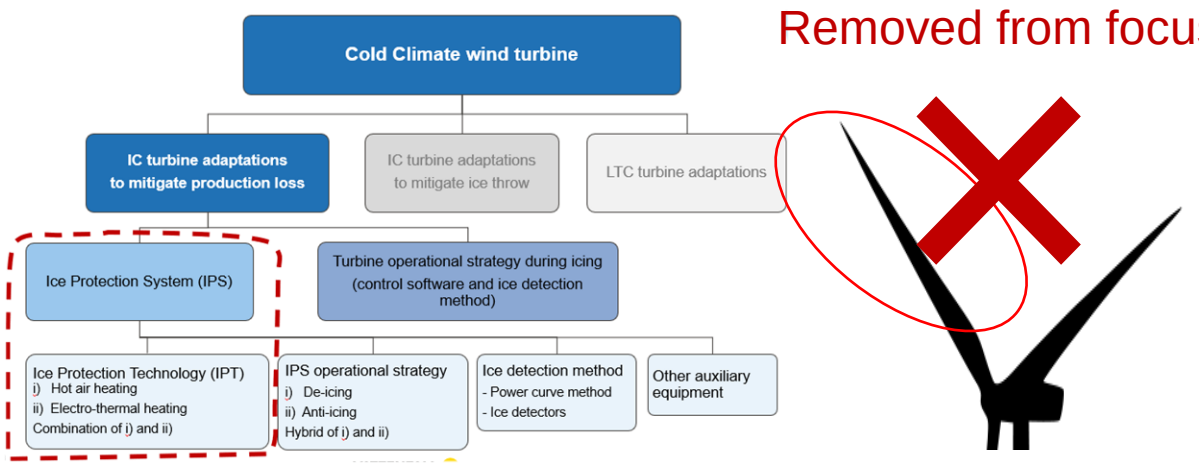
Turbine performance

- Warranty that provides coverage for energy production during icing



Ice Protection Technology performance

- Warranty that focus on the functionality of the IPT
- Recommended as validation of the IPT design envelope and specifications

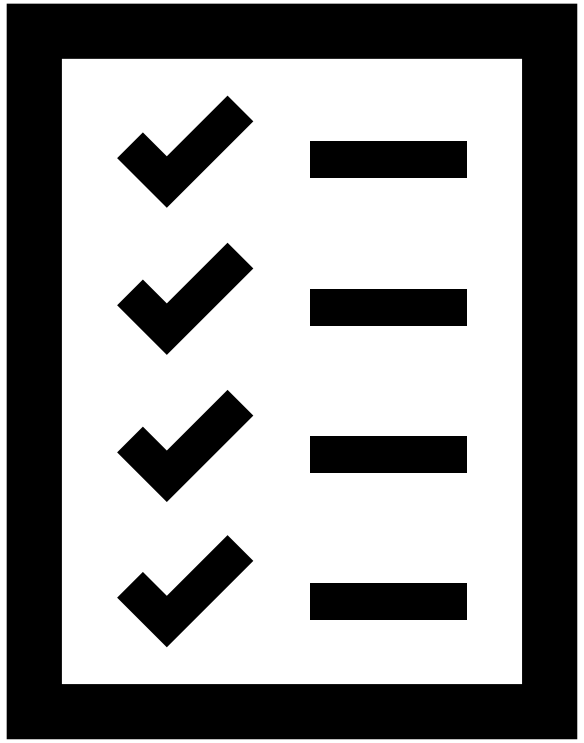


Removed from focus

VATTENFALL

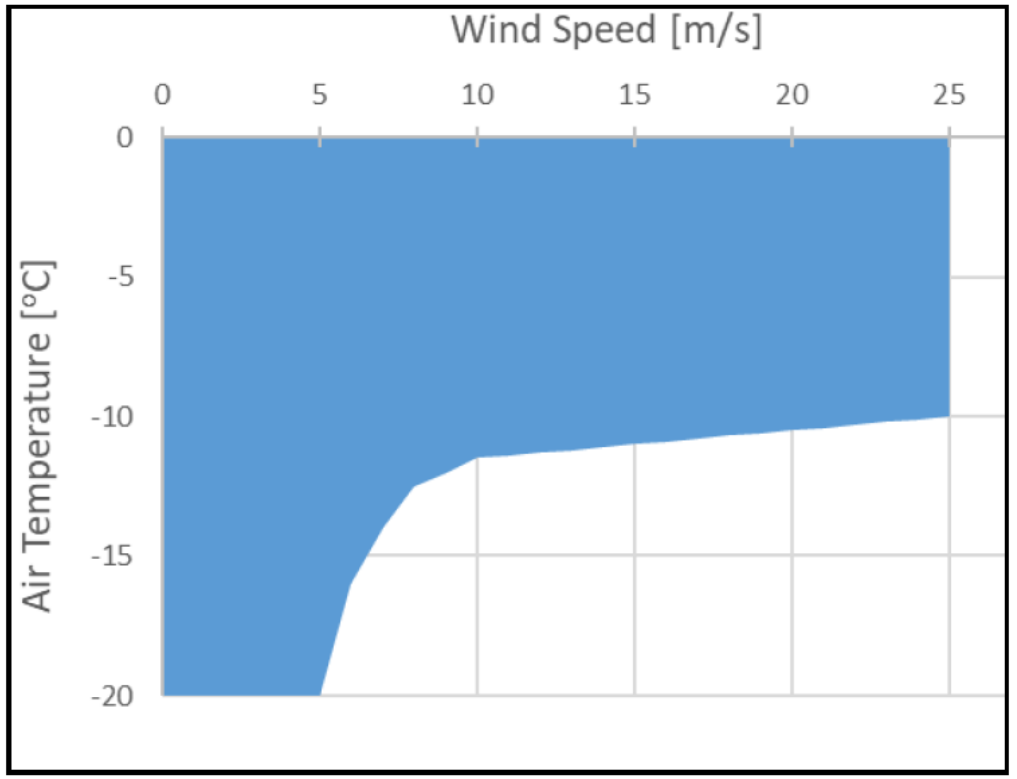
Basic warranty document

- Defined **Operational Envelope** for which the warranty is valid
- Defined **data selection and filtering**
- Clearly defined and warranted **performance criteria**
- **Methodology** for measuring the Performance Criteria within the Operational Envelope
- **Consequences** based on the result of the test



Operational envelope

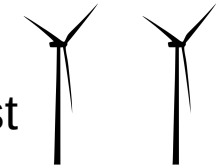
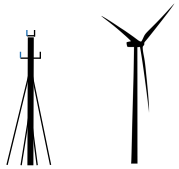
- The performance of a wind turbine in IC shall be warranted within a clearly specified operational envelope
  - Design envelope of the IPS
  - Determine when it is suitable to conduct the performance test and how to filter the data
- There needs to be an overlap with the local site conditions!



Data selection and filtering

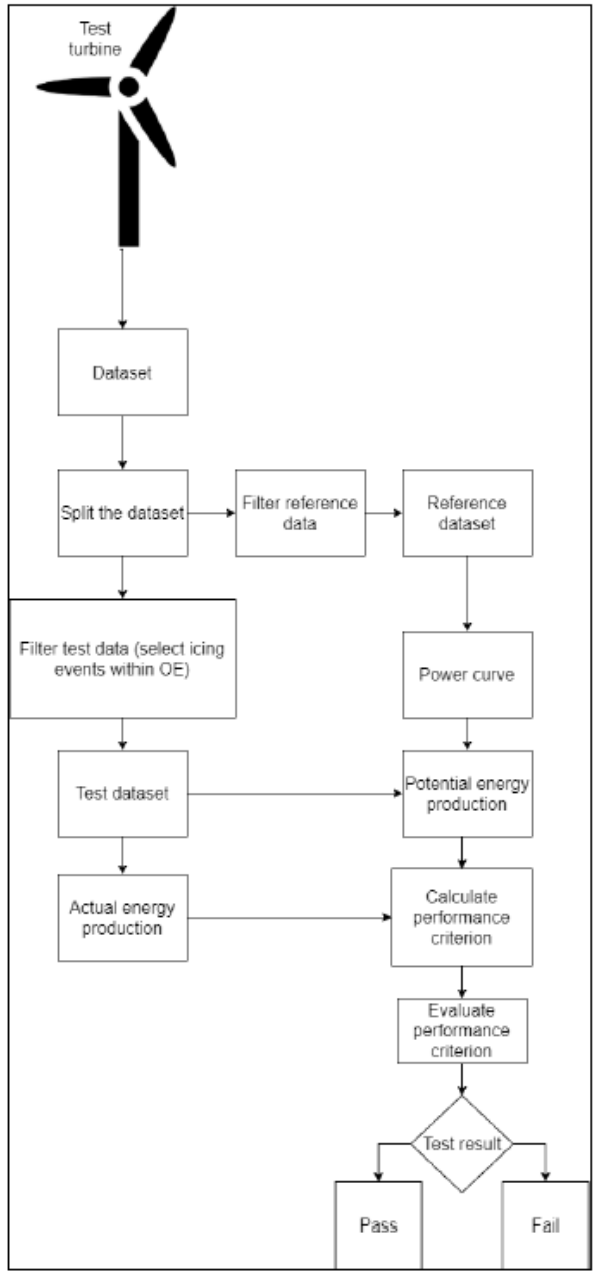
- **Duration of test**
  - time period, number of ice events or number of icing hours
- **Required data coverage of the test**
  - Untested conditions, gaps in data
- **Exclusions**
  - non-icing-related faults, maintenance periods, data outside of the OE
- **Icing event definition**
  - detector, pc deviation
- **Reference and test datasets**

Test methods

- Self-comparison test 
- Side-by-side comparison test 
- Power performance test 

Guidance on:

- Choice of test turbines
- Data collection and processing
- Performance criteria
- Advantages, disadvantages



Performance criteria

- Two equations that can be used in combinations with the test methods
- Examples on how they work and what the difference between them are

Equation 1 – Performance criterion that calculates the maintained energy

$$\frac{E_{A,IPS}}{E_{P,IPS}} \geq Warranted\ percentage$$

Equation 2 - Performance criterion that calculates the recovered energy.

$$\frac{\left(\frac{E_{A,IPS}}{E_{P,IPS}} - \frac{E_{A,No\ IPS}}{E_{P,No\ IPS}}\right)}{\left(1 - \frac{E_{A,No\ IPS}}{E_{P,No\ IPS}}\right)} \geq Warranted\ percentage$$

Summary

- A second step towards standardization
- More focus on turbine performance
- More details and practical guidance
- Remaining challenges
  - Uncertainties
  - More field studies needed