On the importance of control for the performance of ice protection systems and wind turbines

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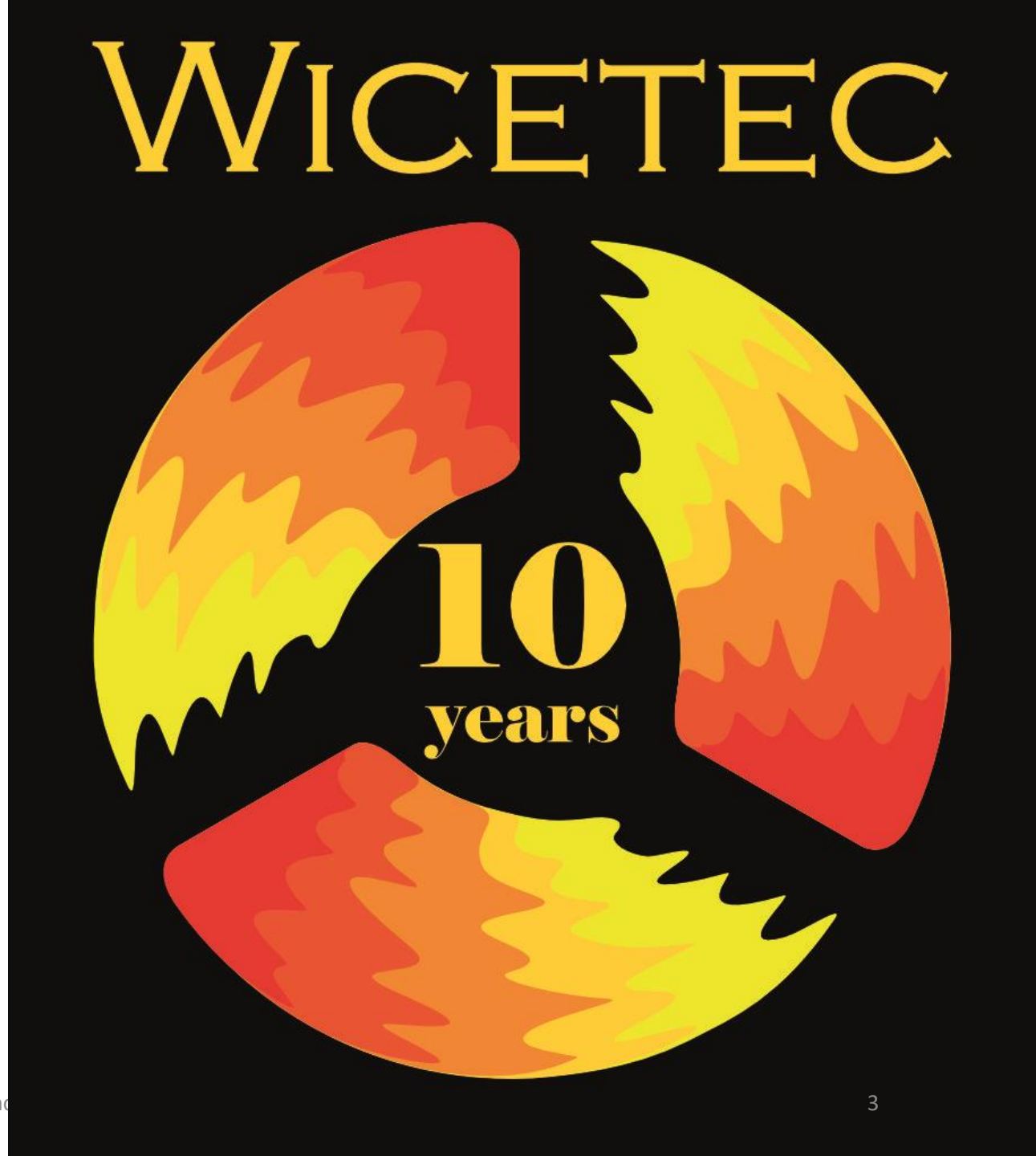
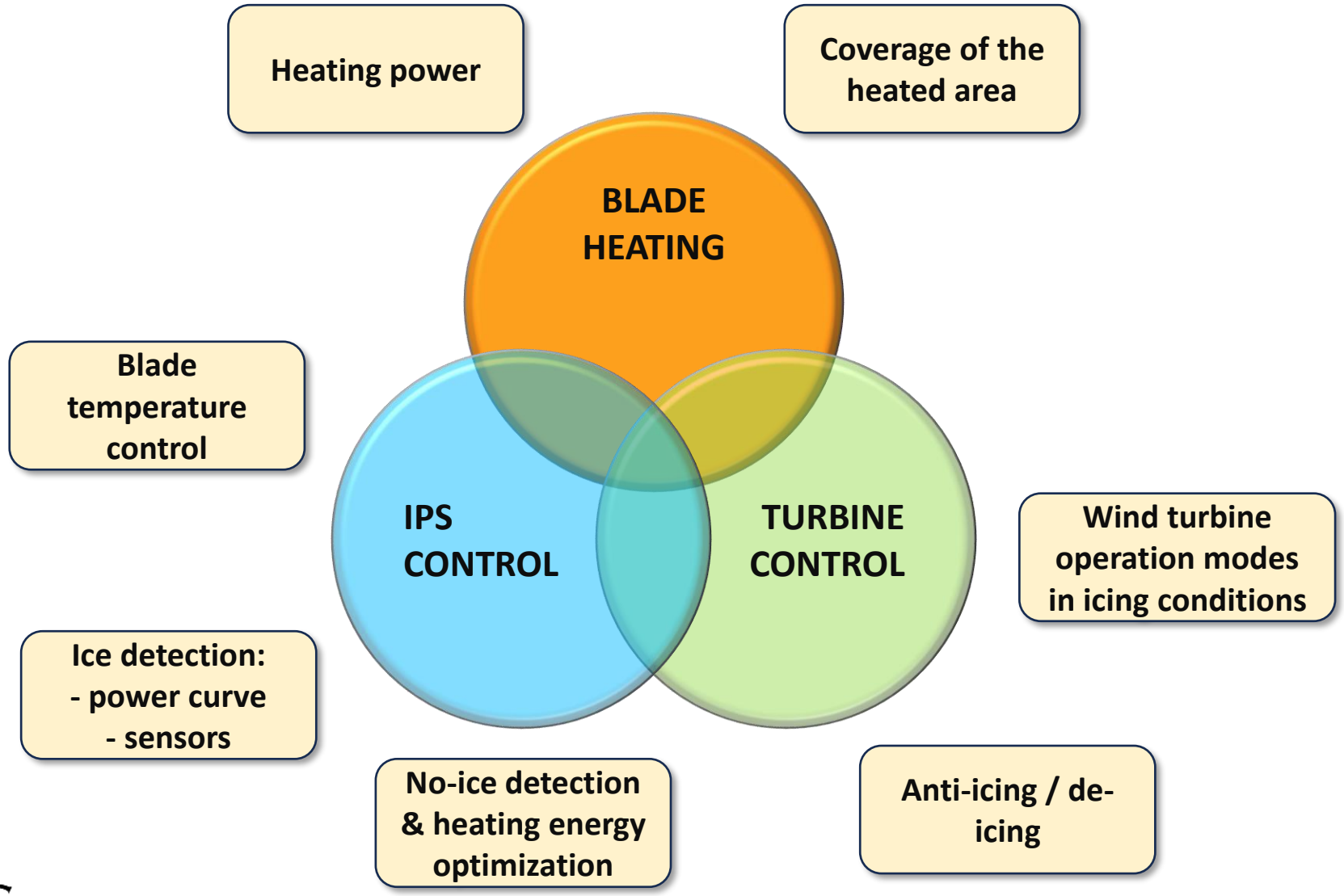
WICETEC Ice Prevention Systems

The Leader in Blade Heating

- Wicetec Ice Prevention System (WIPS) technology
  - New turbines & Retrofits
- Company founded in 2014
  - a spin off from Technical Research Centre of Finland (VTT)
- Located in Helsinki, Finland



Performance of ice protection systems and wind turbines



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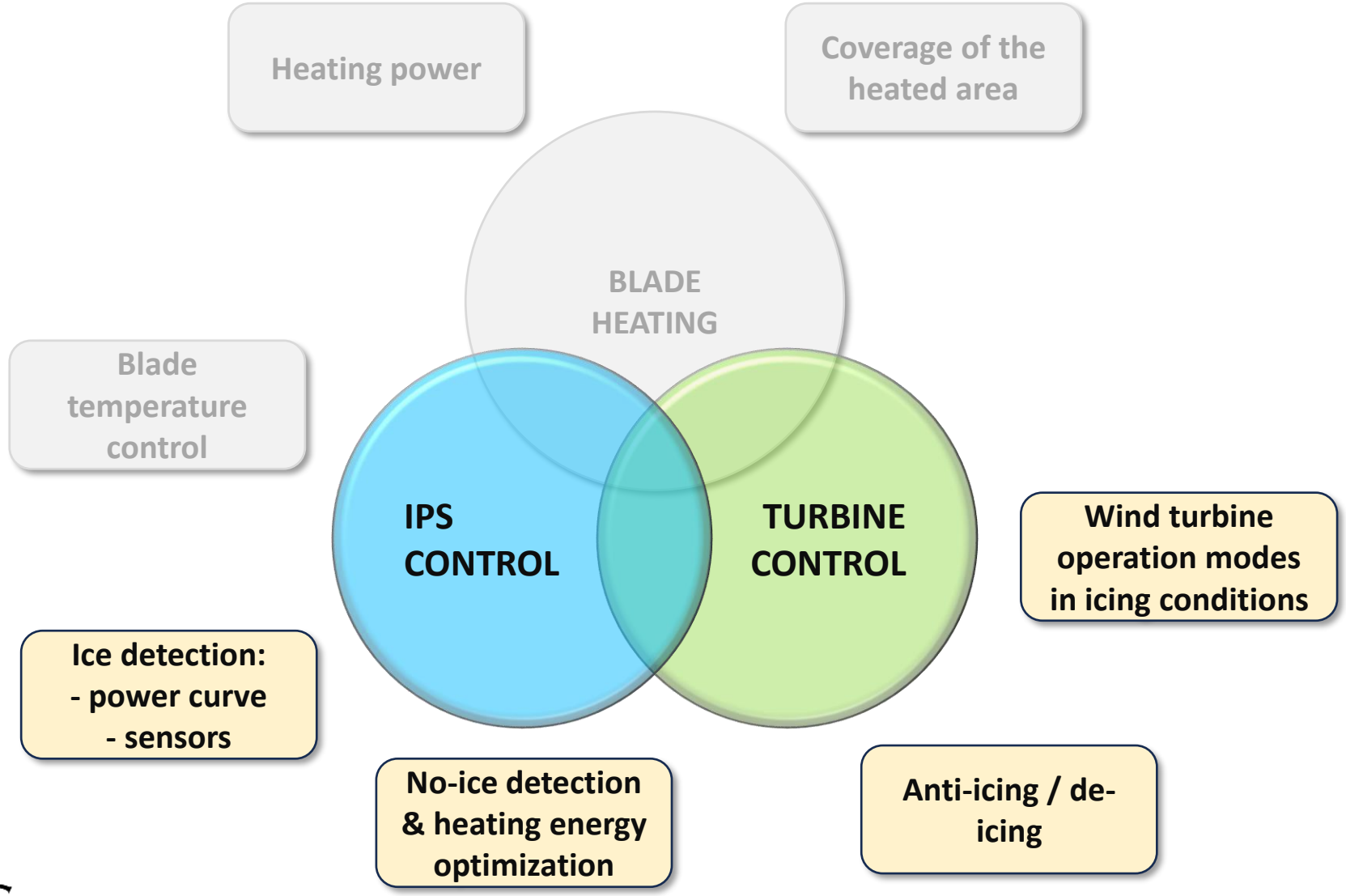

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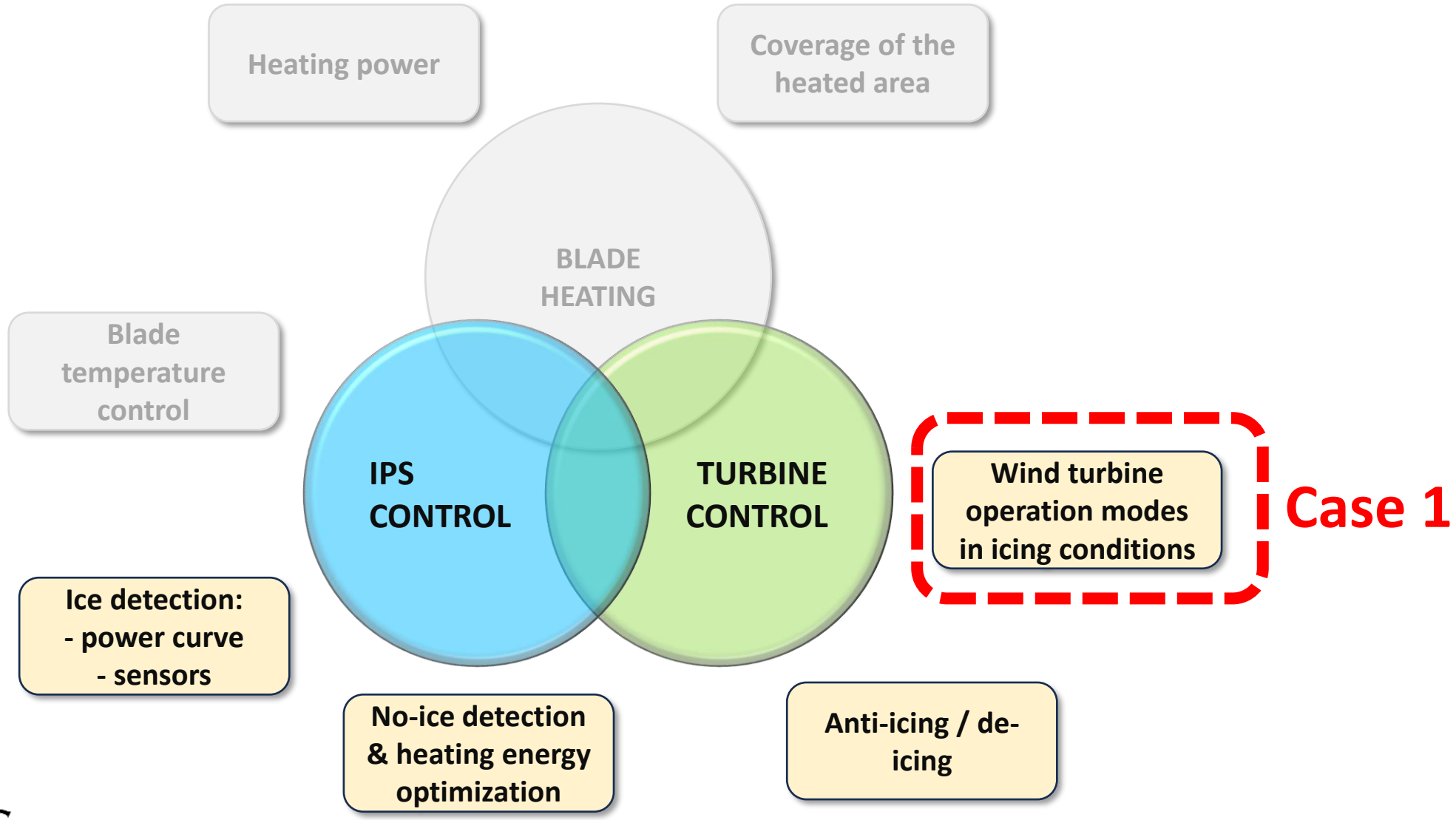
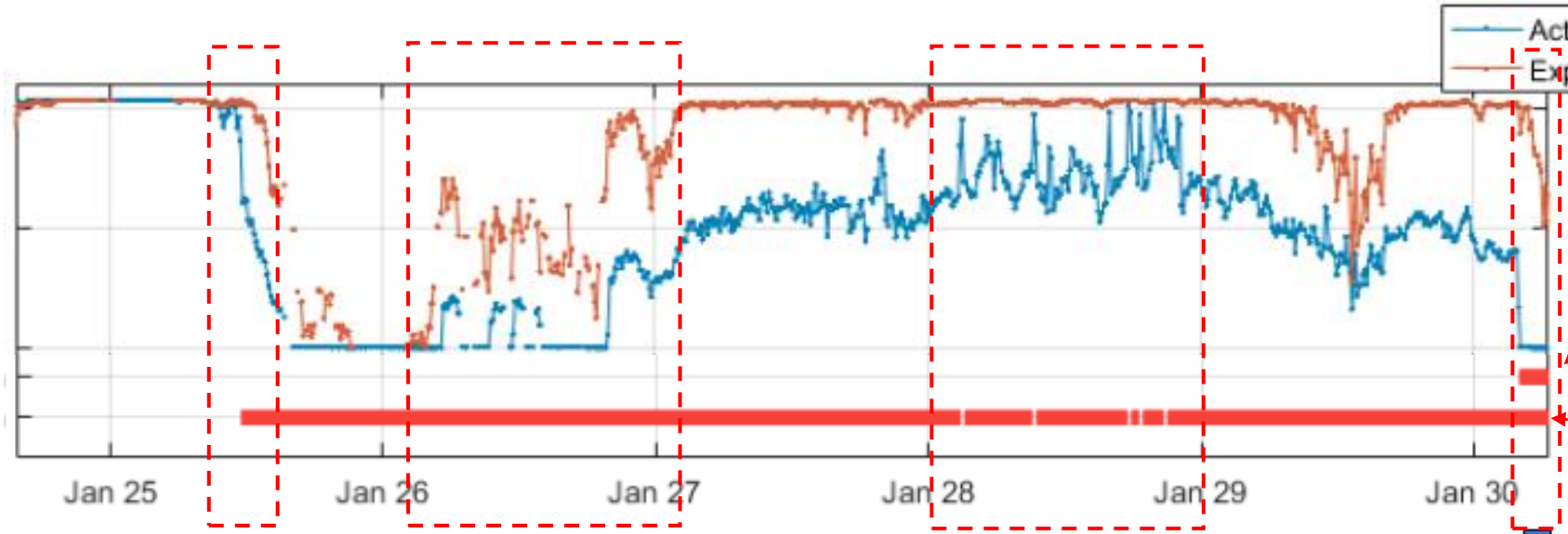


Case 1: Wind turbine operation modes in icing conditions

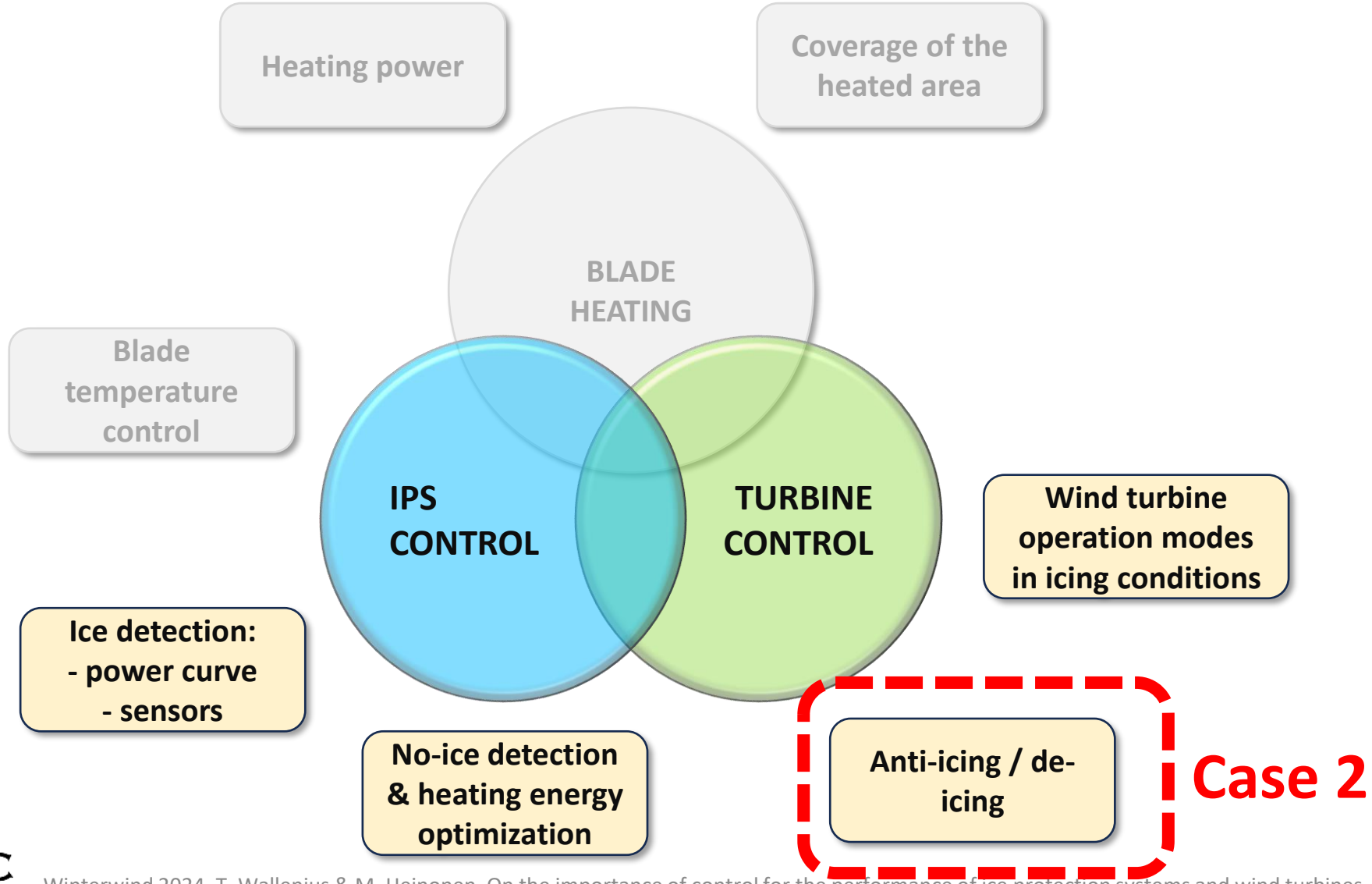


WTG ice operation mode codes:

- Stop turbine due to ice
- Curtail turbine power due to ice

2 MW turbine with retrofitted WIPS
WTG control were not adapted

Performance of ice protection systems and wind turbines



Case 2: De-icing (-ish) vs. anti-icing

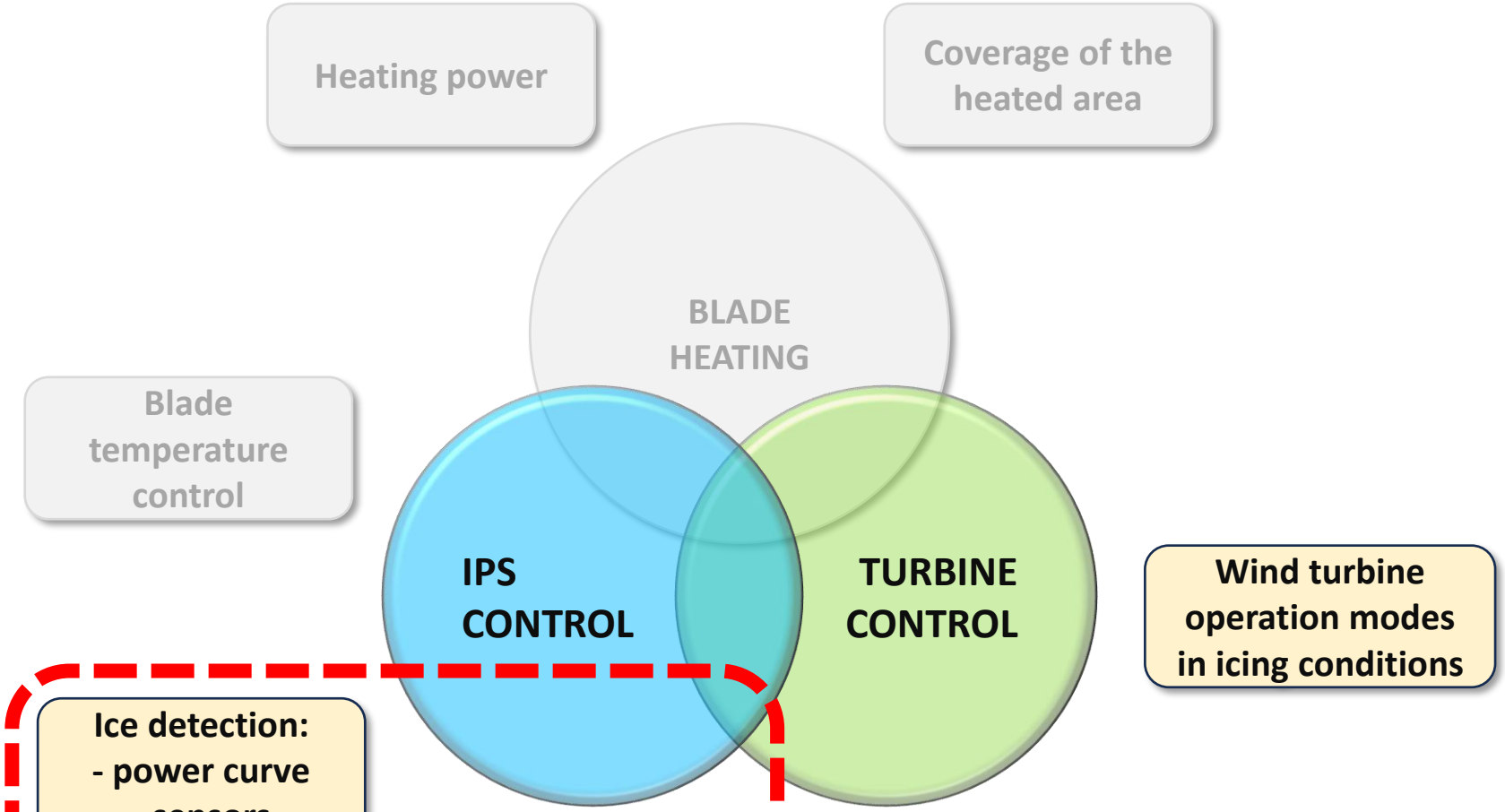
	Period 1	Period 2
Turbine & ice protection system	Multimegawatt wind turbine with Wicetec Ice Prevention System	
Blade heating operation mode	"De-icing" Anti-icing first, if production is not recovered to normal then de-icing was triggered	Anti-icing De-icing used only if turbine re-start fails
Duration of period	75 days	77 days
Blade icing time based on a weather model	57 %	60 %
Ice Production Ratio % "IPR"	59 %	75 %

$$IPR = 100 * \frac{Actual\ Energy\ Production\ (during\ icing)}{Potential\ Energy\ Production\ (during\ icing)}$$

~30% better performance with anti-icing!

WICETEC Ice Prevention Systems

Performance of ice protection systems and wind turbines



Case 3

Case 3: Ice detection, no-ice detection & heating energy optimization

Modernization project in collaboration with:

Skellefteå Kraft

	Group 1 (two turbines)	Group 2 (two turbines)
Turbine & ice protection system	2.5 MW with IPS Wicetec heater technology **Original IPS control system**	2.5 MW with IPS Wicetec heater technology **Modernized IPS control system**
Ice detection & no-ice detection	Power curve	Labkotec Ice Detector Power curve
Heating energy optimization scheme	"Save heating energy"	"Do not save heating energy"
Duration of test period	103 days (appr. 12/2023 – 2/2024)	
Ice Production Ratio % "IPR"	X (=original IPR value)	1.23*X

~23 % increase in performance!

Side note: problem with the “industry standard” methodology*

**Task 19 ice loss tool*

3.5.1 Icing event class a)

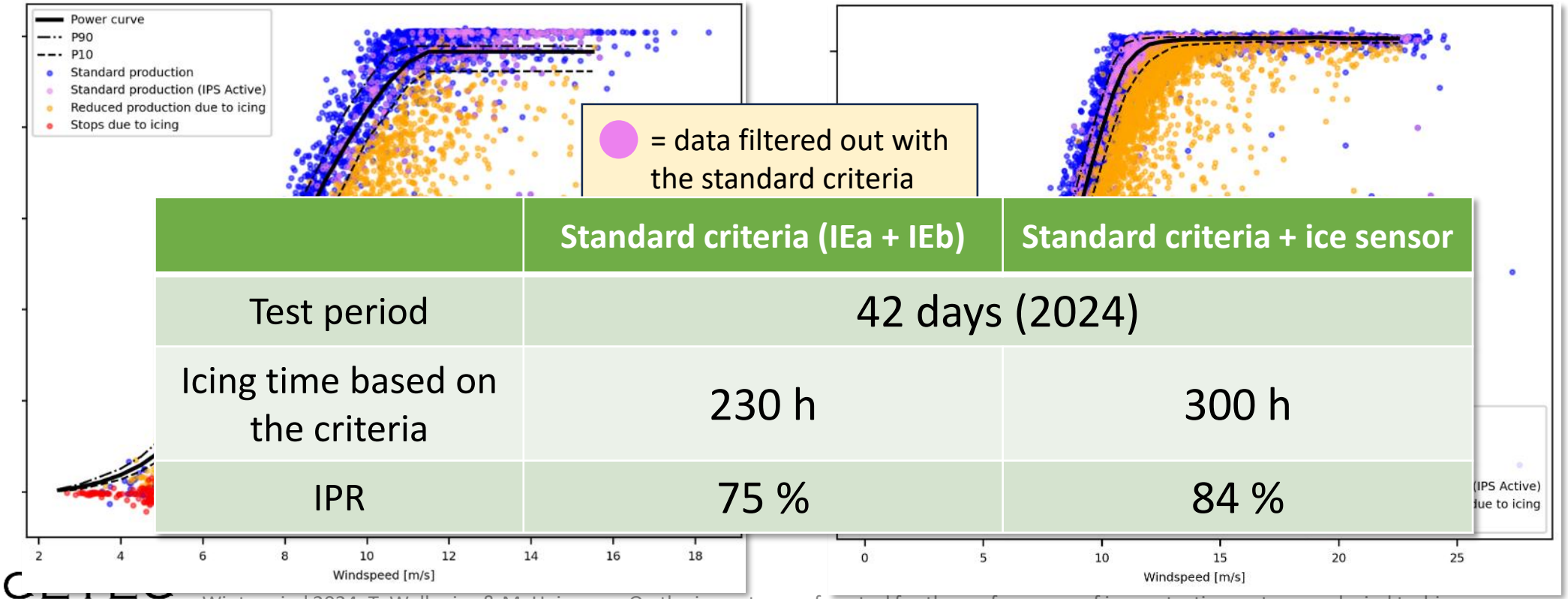
The start of a typical reduced power output icing event class a) [IEa] for an operational turbine is defined as follows:

If temp is below 0°C AND power is below 10th percentile of the respective reference (non-iced) wind bin for 30 minutes or more, THEN icing event class a) starts

An icing event class a) ends as follows:

If power is above 10th percentile of the respective reference wind bin for 30-min or more, THEN icing event class a) ends

The events when anti-icing system keeps the power above the 10th percentile are filtered out
→ **Negative effect to the results!**



= data filtered out with the standard criteria

	Standard criteria (IEa + IEb)	Standard criteria + ice sensor
Test period	42 days (2024)	
Icing time based on the criteria	230 h	300 h
IPR	75 %	84 %

Summary

To get all the benefits of ice protection system:

1. Wind turbine control adaptation & coordination with ice protection system control
2. Use multiple input ice detection with high sensitivity: dedicated ice sensors & power curve detection
3. Favor anti-icing over de-icing
4. Do not save heating power

5. Proposal for Performance assessment methodology: add new Icing Event class for events detected by ice sensor

Thank you

for your attention!

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