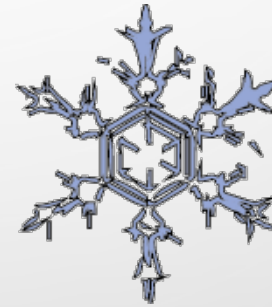


A THERMAL BASED ICE DETECTION SENSOR

FROM ACADEMIC RESEARCH TO A COMMERCIAL PRODUCT



UNIVERSITÉ
LAVAL

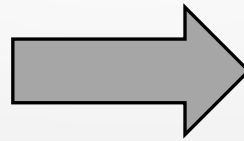


INSTRUMENTATION
ICETEK

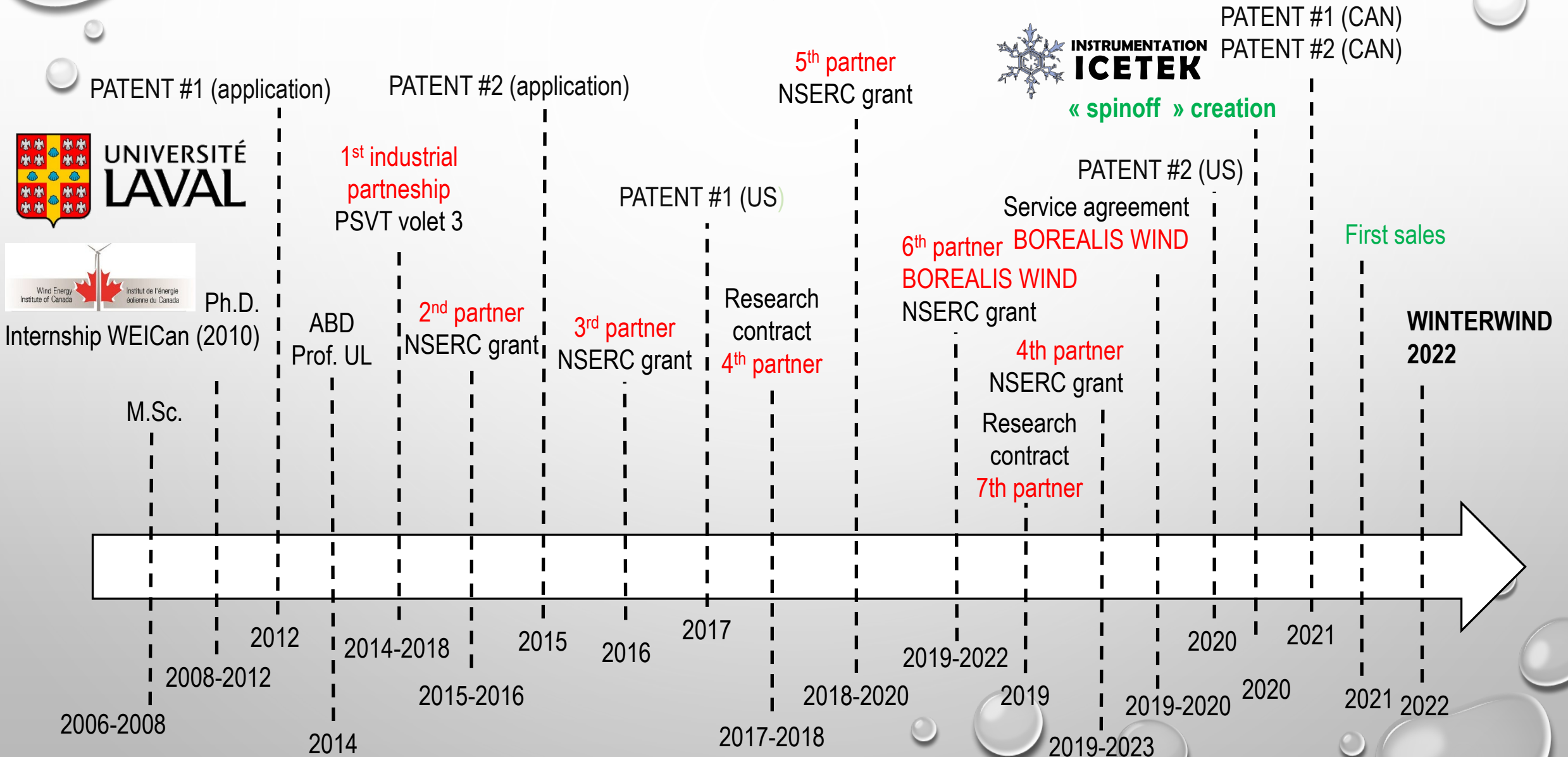
André Bégin-Drolet, ing., Ph.D.
Jean Lemay, ing., Ph.D.
Jean Ruel, ing., Ph.D.



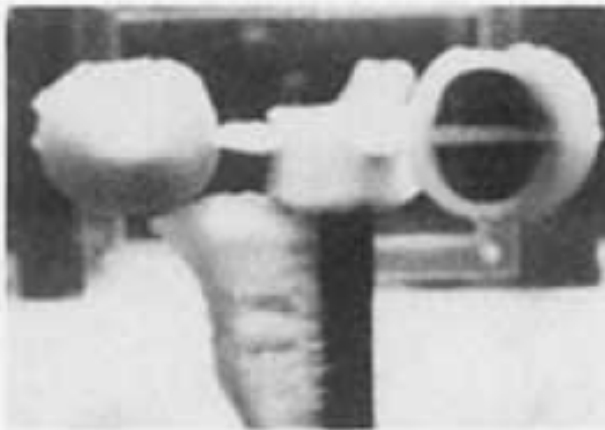
Skelleftea, Sweden, April 21, 2022



THE JOURNEY OF OUR TECHNOLOGY



THE ICING PROBLEM – SEEN BY THE ANEMOMETERS



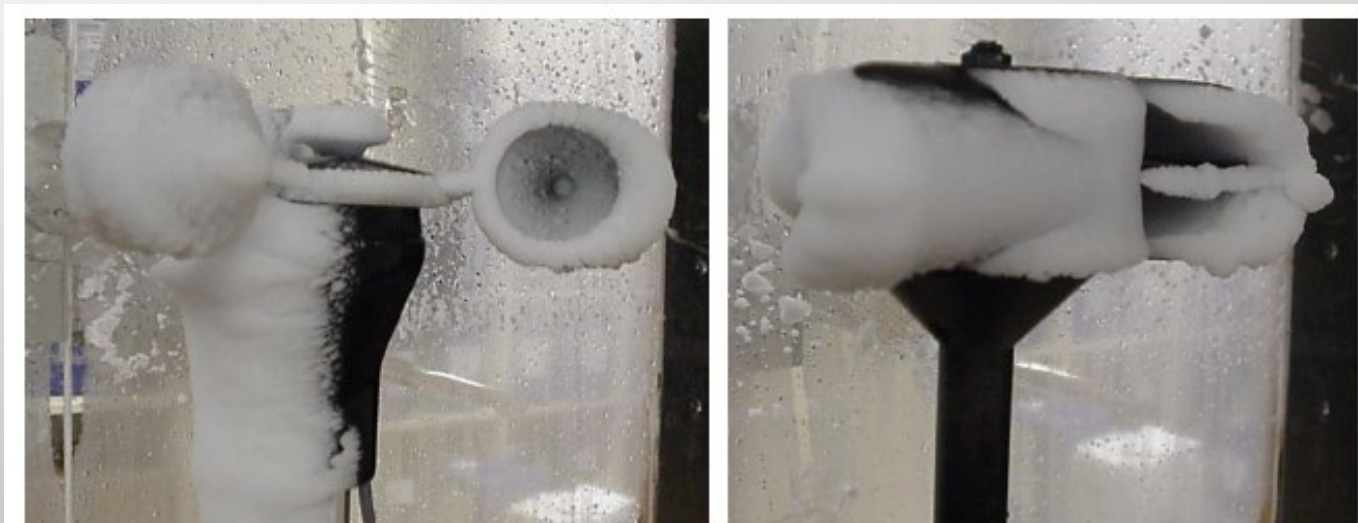
Gates and Thompson (1985)



Glidden (1970)

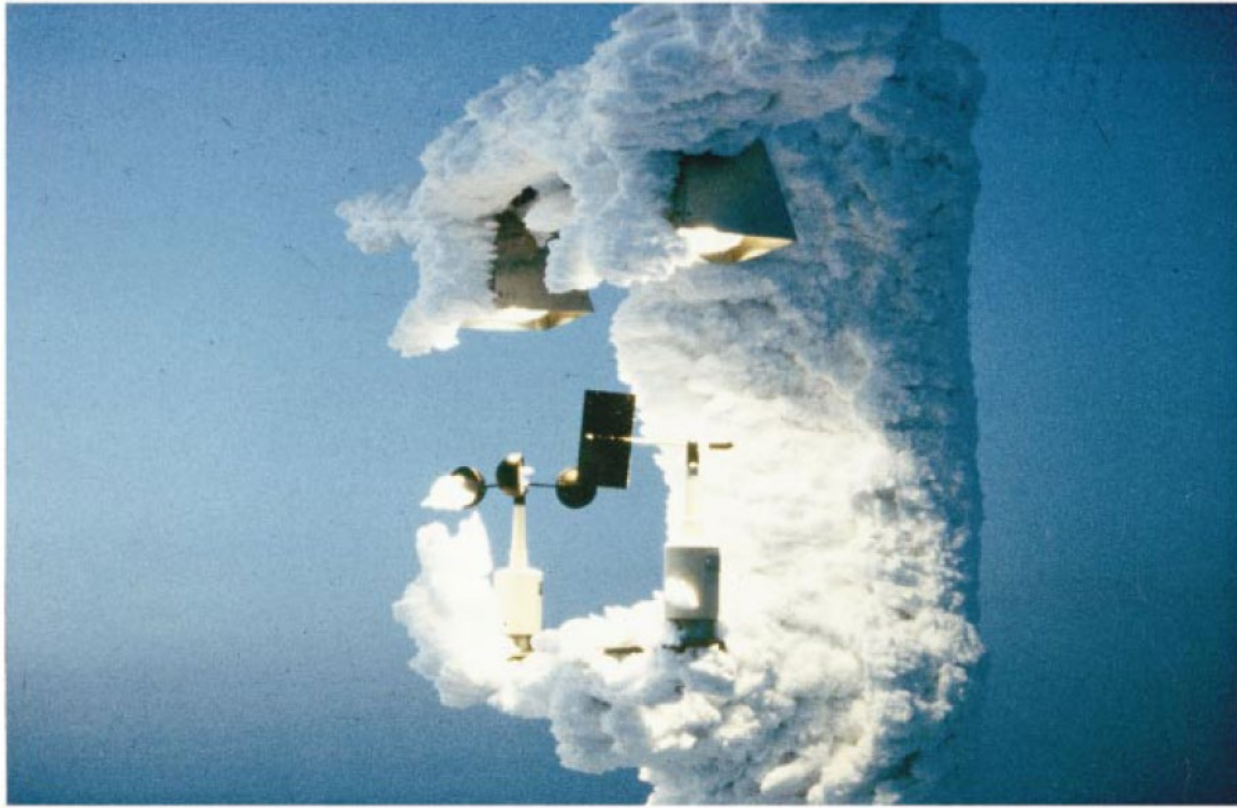


Laasko *et al.* (2003)



Fortin, Perron and Illinca (2005)

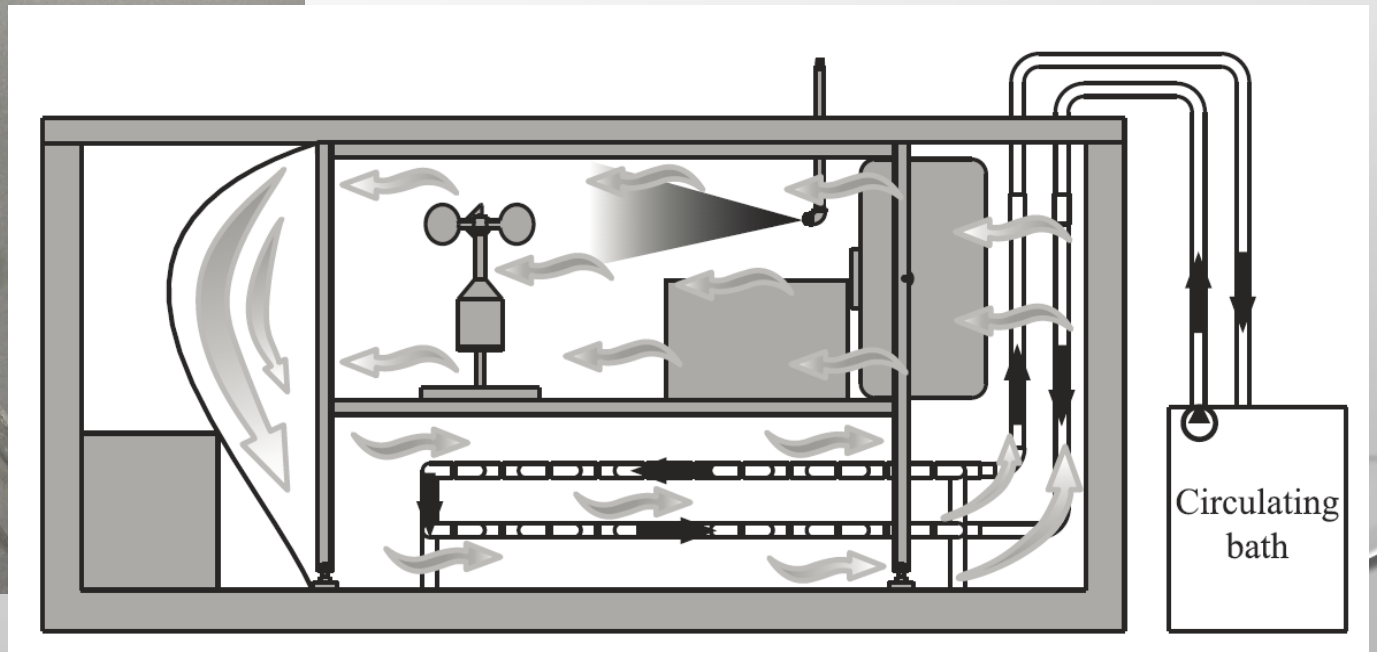
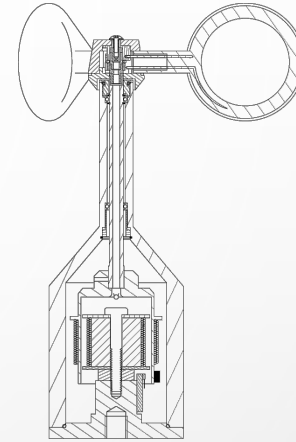
VERY CREATIVE ICE-FREE IDEAS!



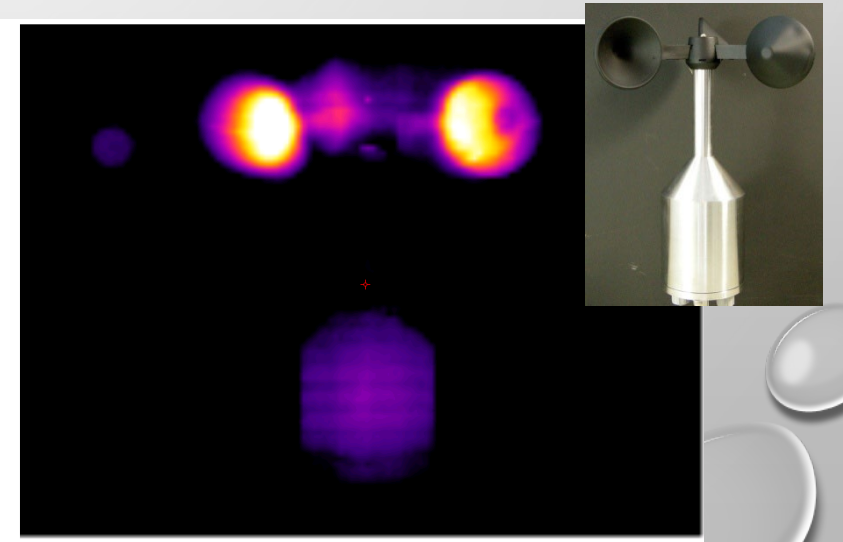
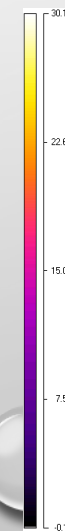
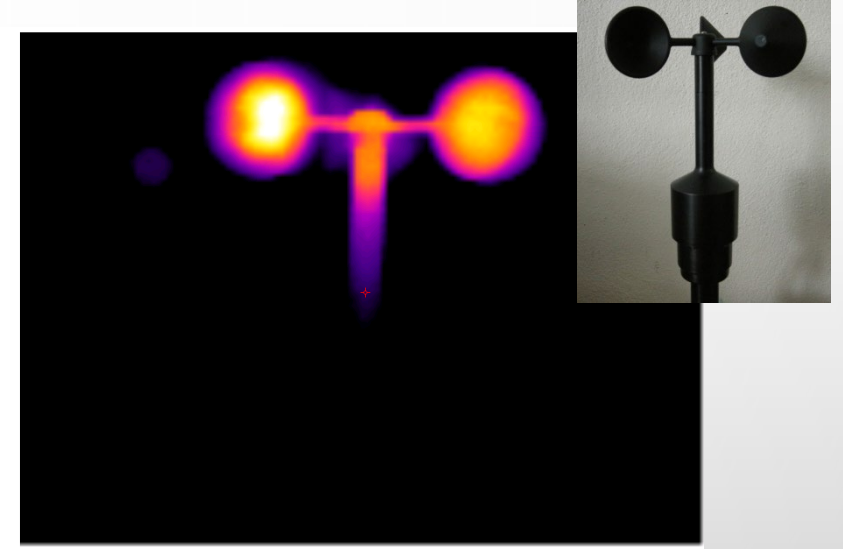
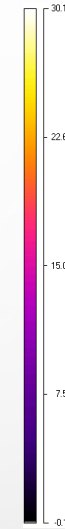
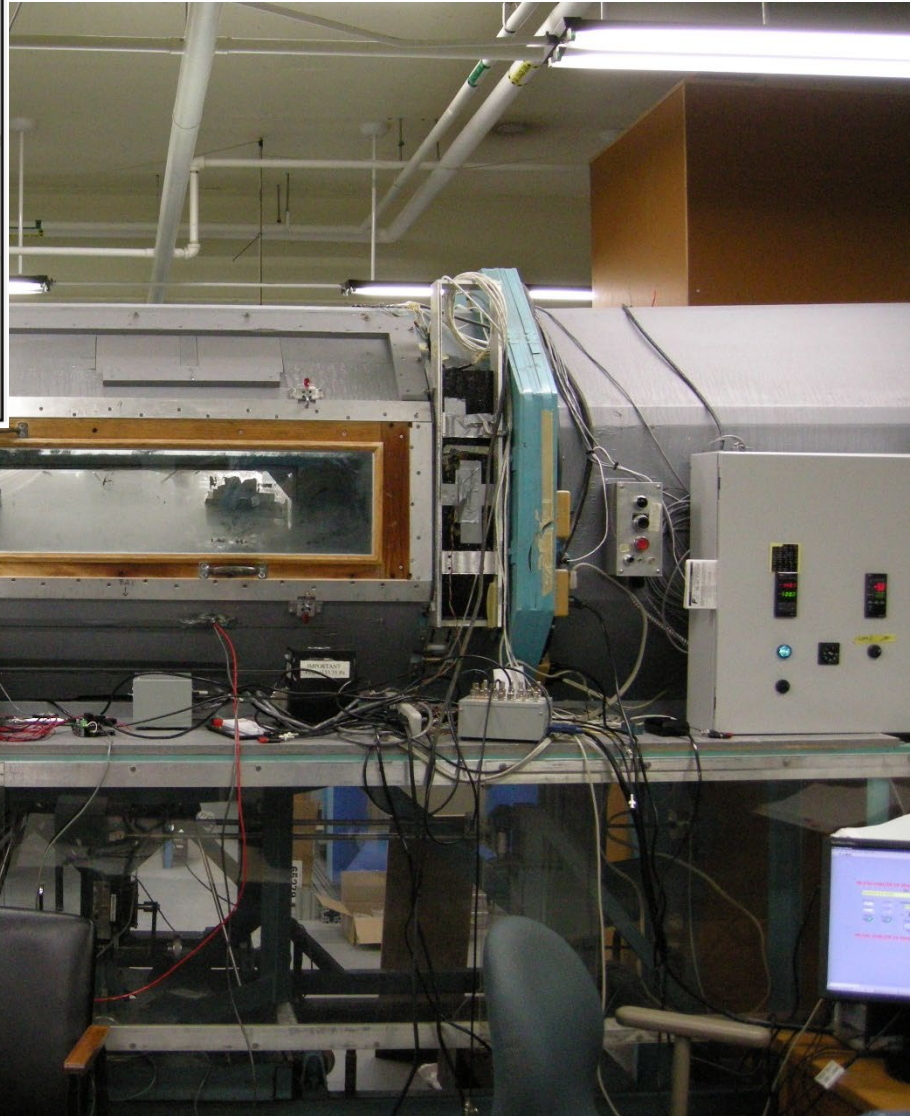
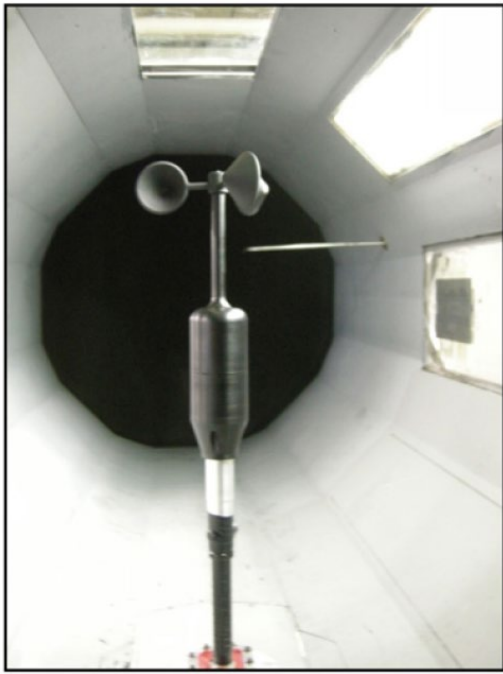
Makkonen (2001)



OUR 1ST PROTOTYPE - 2009



REFRIGERATED WIND TUNNEL - 2010



NERGICA

SITE INSTALLATION - 2011



Wind Energy
Institute of Canada



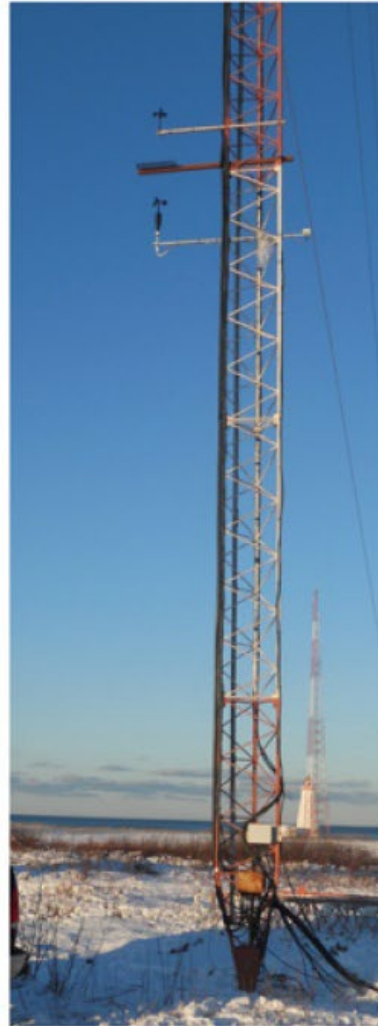
Institut de l'énergie
éolienne du Canada

FIELD TESTS - 2011

NRG #40C

Ice shield

UL 3rd generation ice-free
anemometer



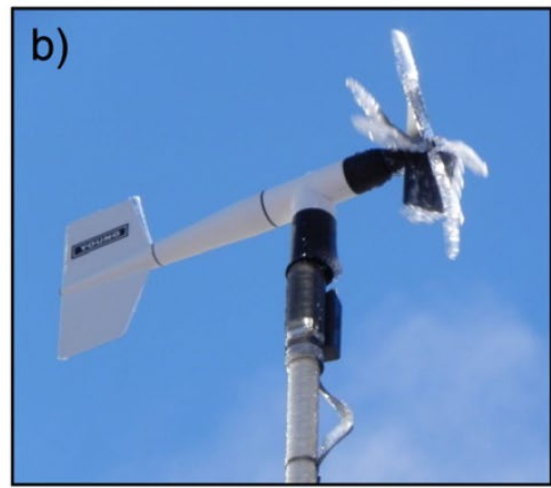
Bégin-Drolet *et al.*, Commissioning of a new ice-free anemometer: 2011 Field tests at WEICan, Measurement 45 (2012)

FIELD TESTS - 2011



Bégin-Drolet *et al.*, Commissioning of a new ice-free anemometer: 2011 Field tests at WEICan, Measurement 45 (2012)

FIELD OBSERVATIONS - 2011



North Cape Wind Farm
16 turbines
V47/660 kW
Commissioned in 2001-2003

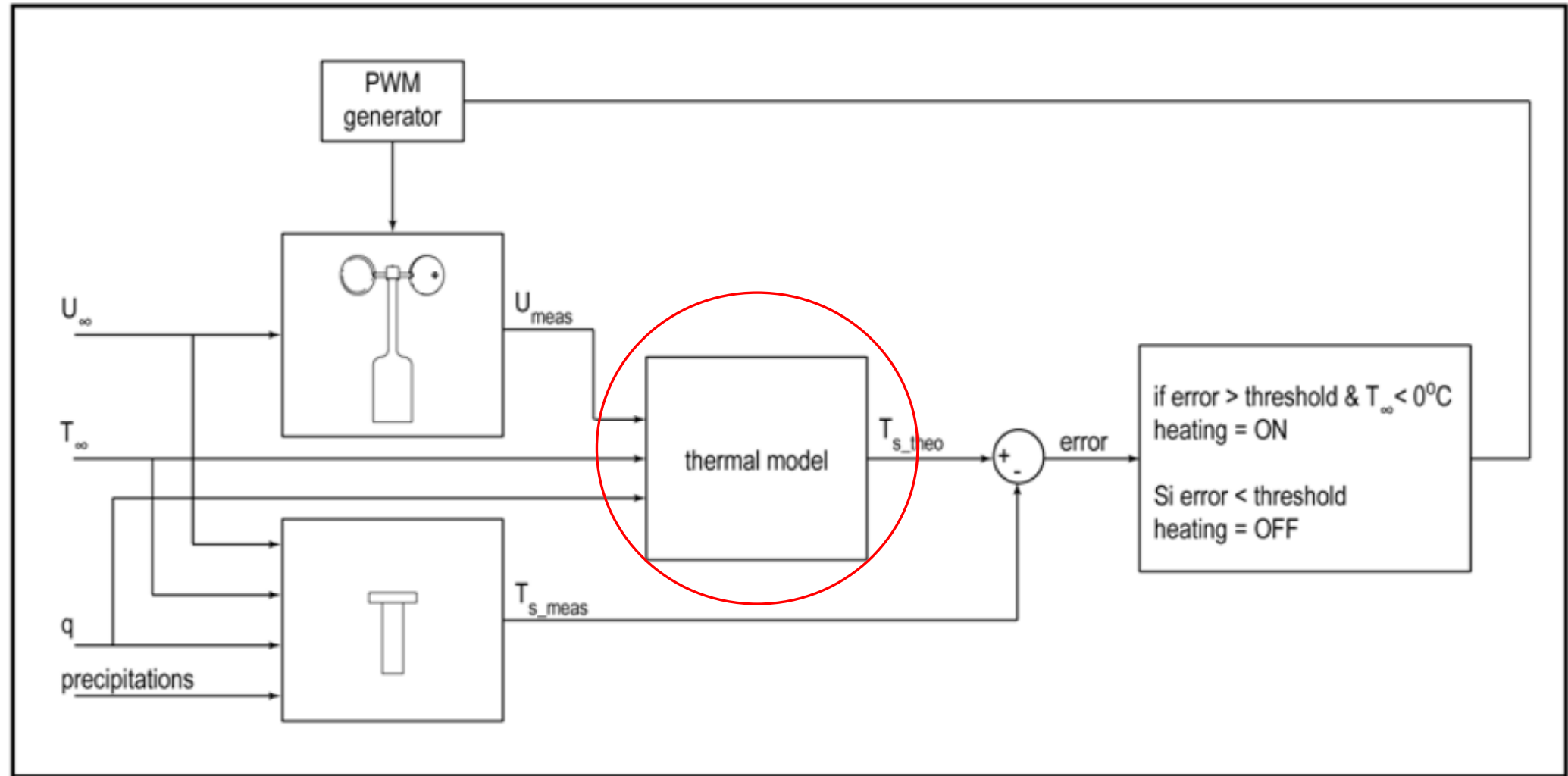


THERMAL ICE SENSOR - 2012

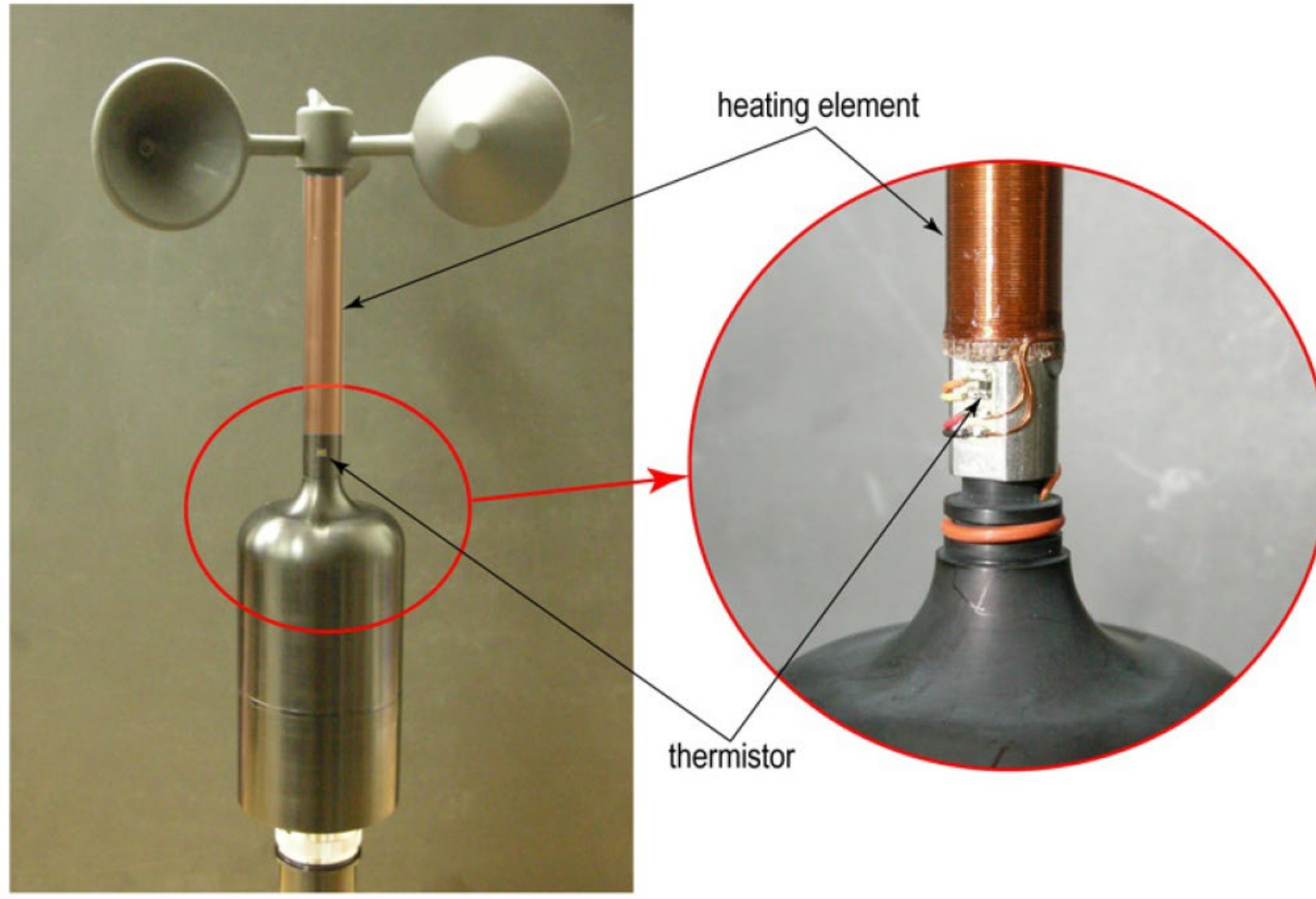


Bégin-Drolet *et al.*, Novel meteorological sensor for anemometer heating control purposes: Part A proof of concept, Cold Regions Science and Technology 96 (2013)

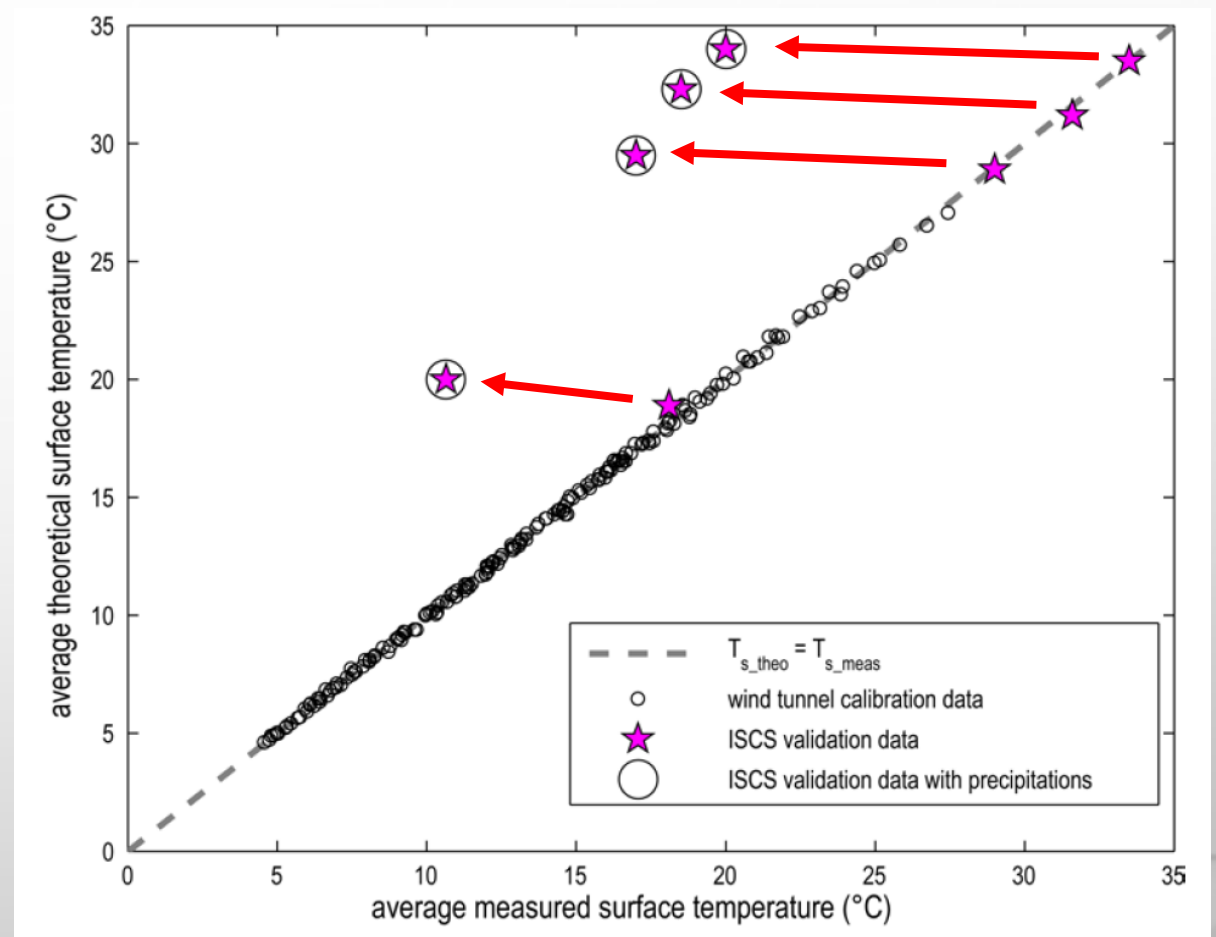
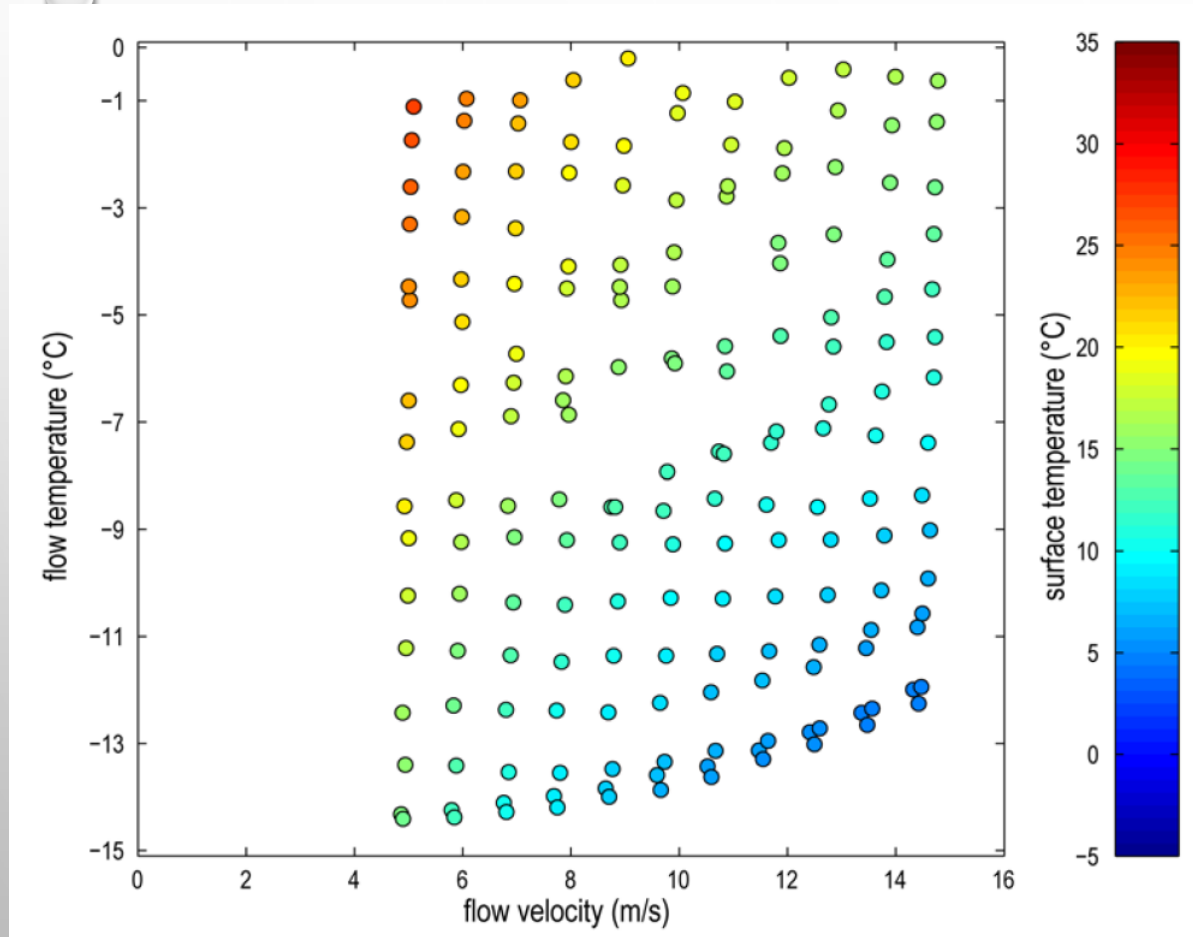
THERMAL ICE SENSOR - 2012



THERMAL ICE SENSOR - 2012



THERMAL ICE SENSOR - 2012



THE ICING PROBLEM – SEEN BY THE TURBINES!



Bégin-Drolet et al. (2018) *The importance of accurate detection for turbine ice prevention systems*. Winterwind international conference 2018



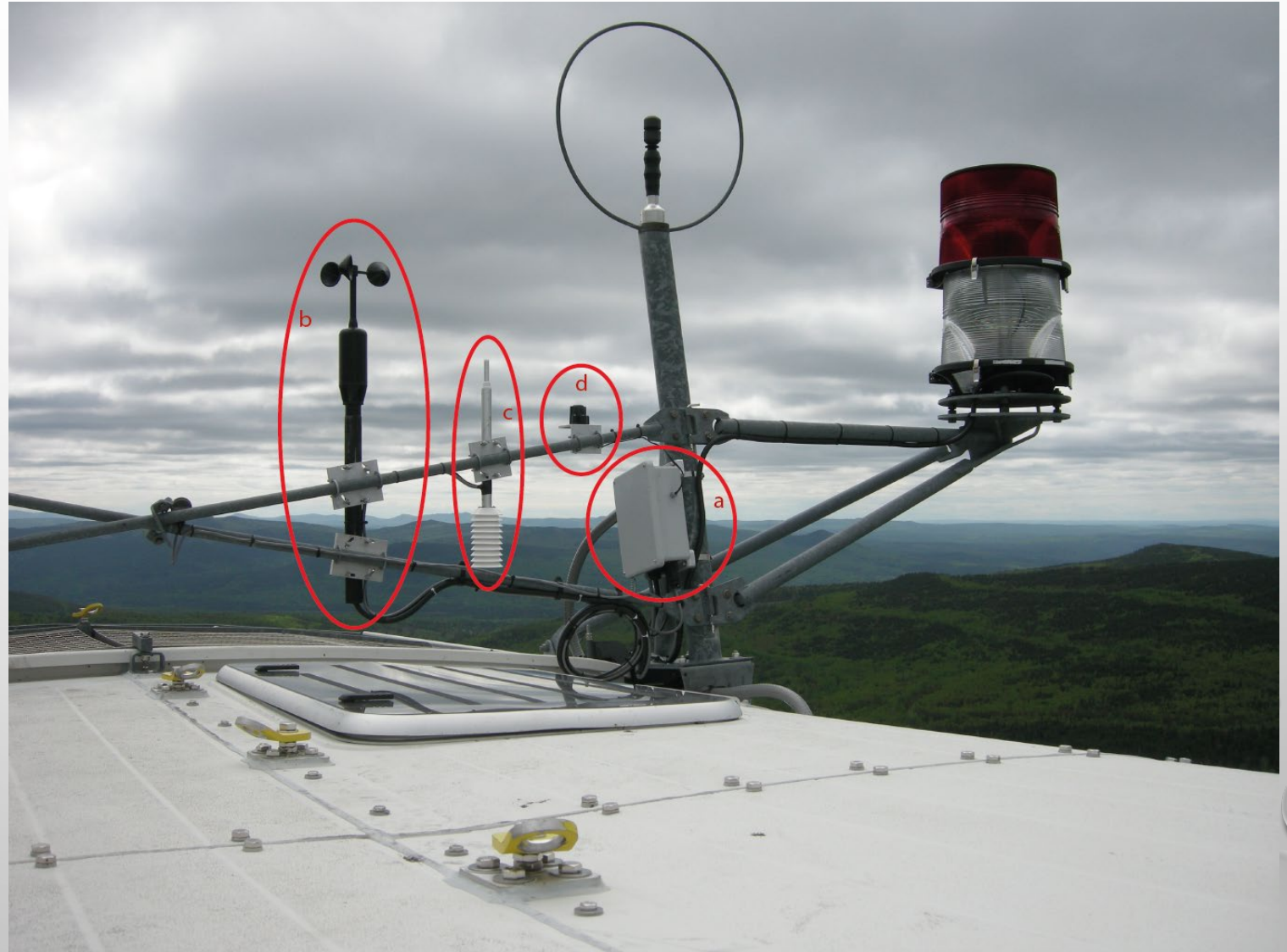
source: InnovWeek ENGIE

- Production losses;
- Excessive turbine loads;
- Health/safety issues.

1ST INSTALLATION ON A WIND TURBINE - 2014



GDF SUEZ



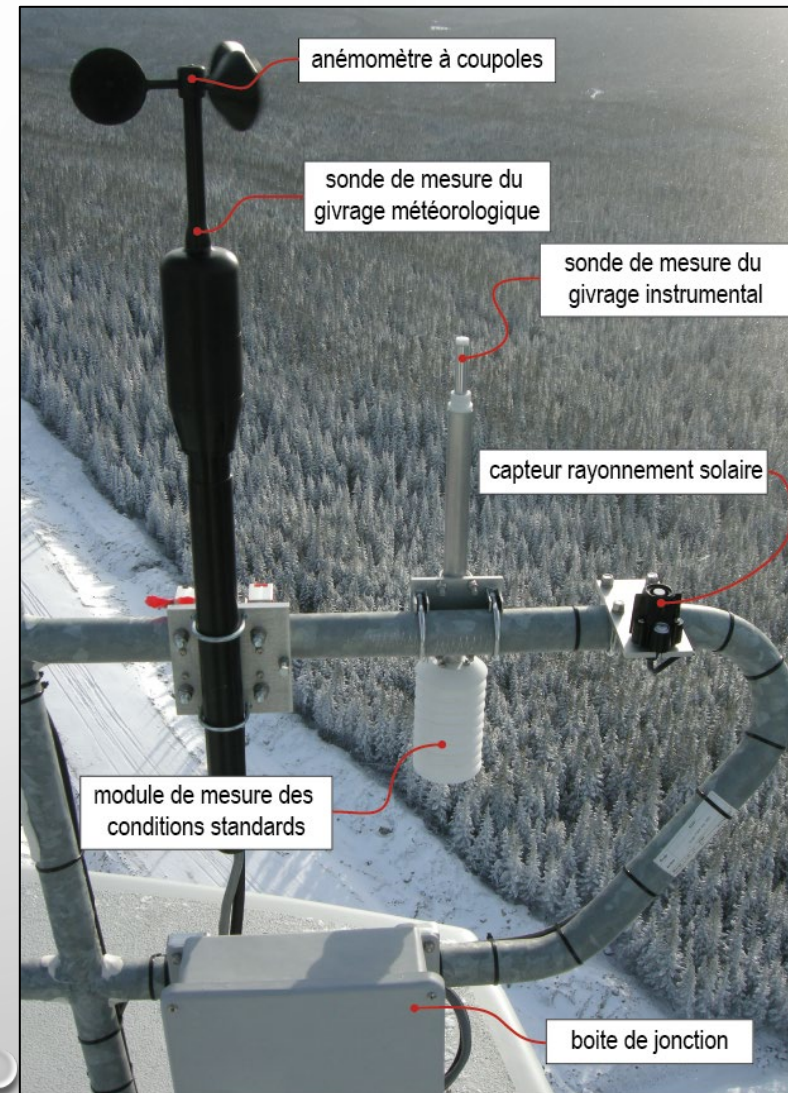
1ST INSTALLATION ON A WIND TURBINE - 2014



GDF SUEZ

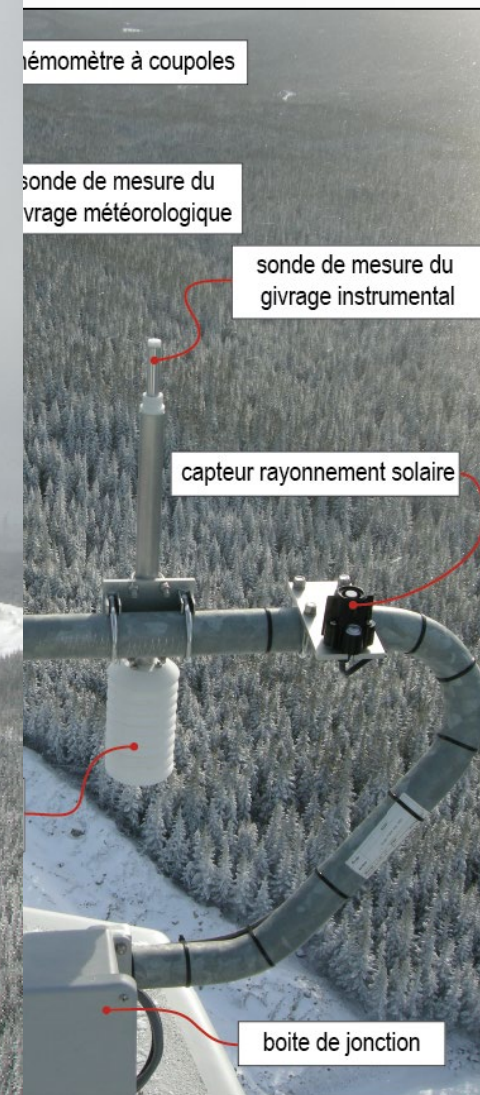


2ND INSTALLATION ON A WIND TURBINE - 2015

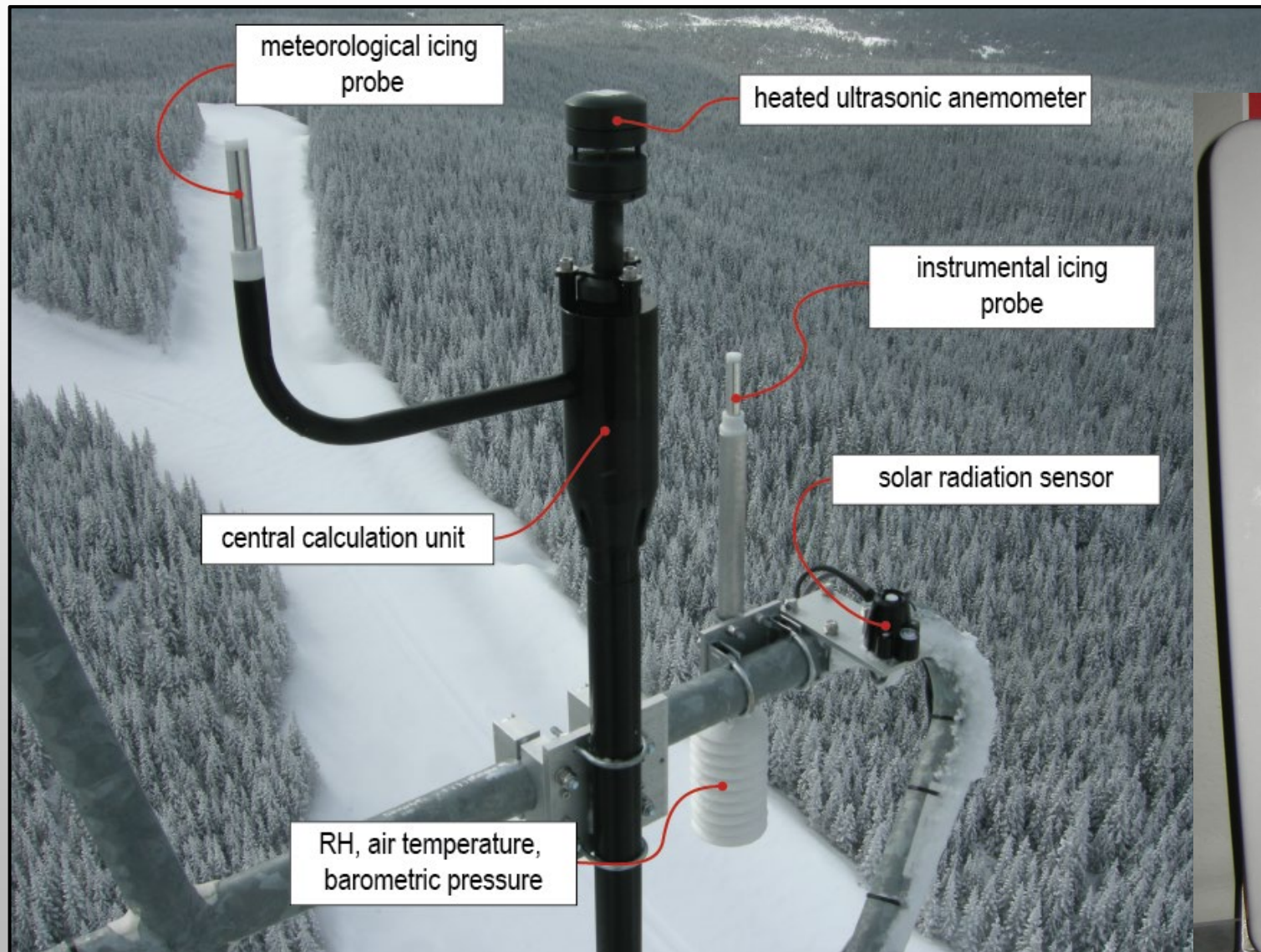




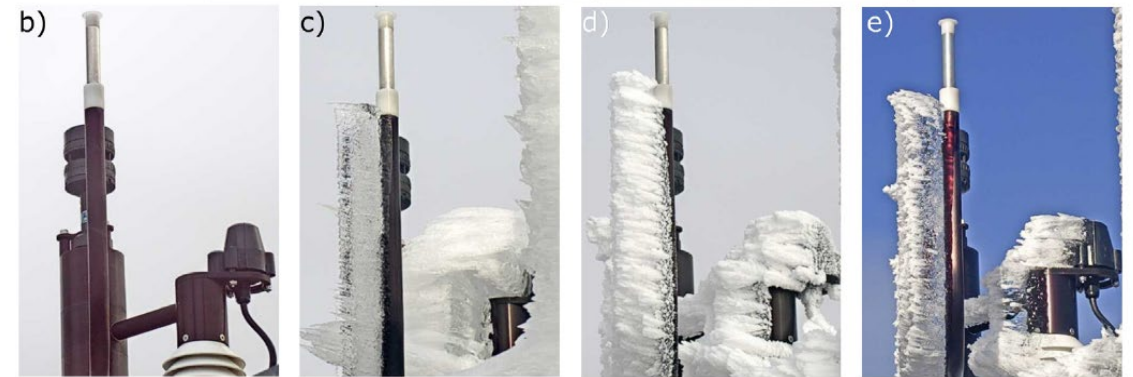
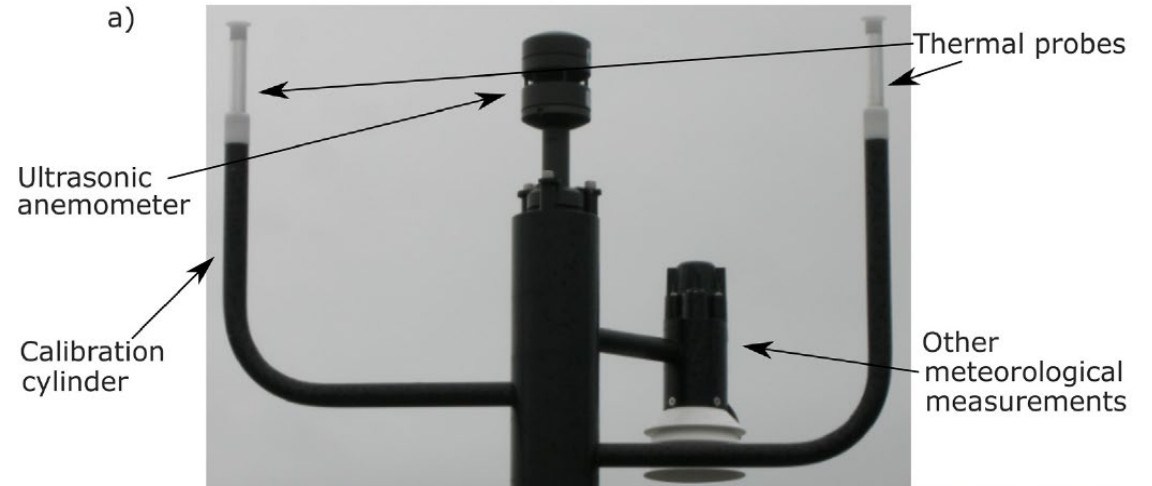
ND TURBINE - 2015



TOWARDS A METEOROLOGICAL CONDITIONS MONITORING STATION (MCMS) - 2015

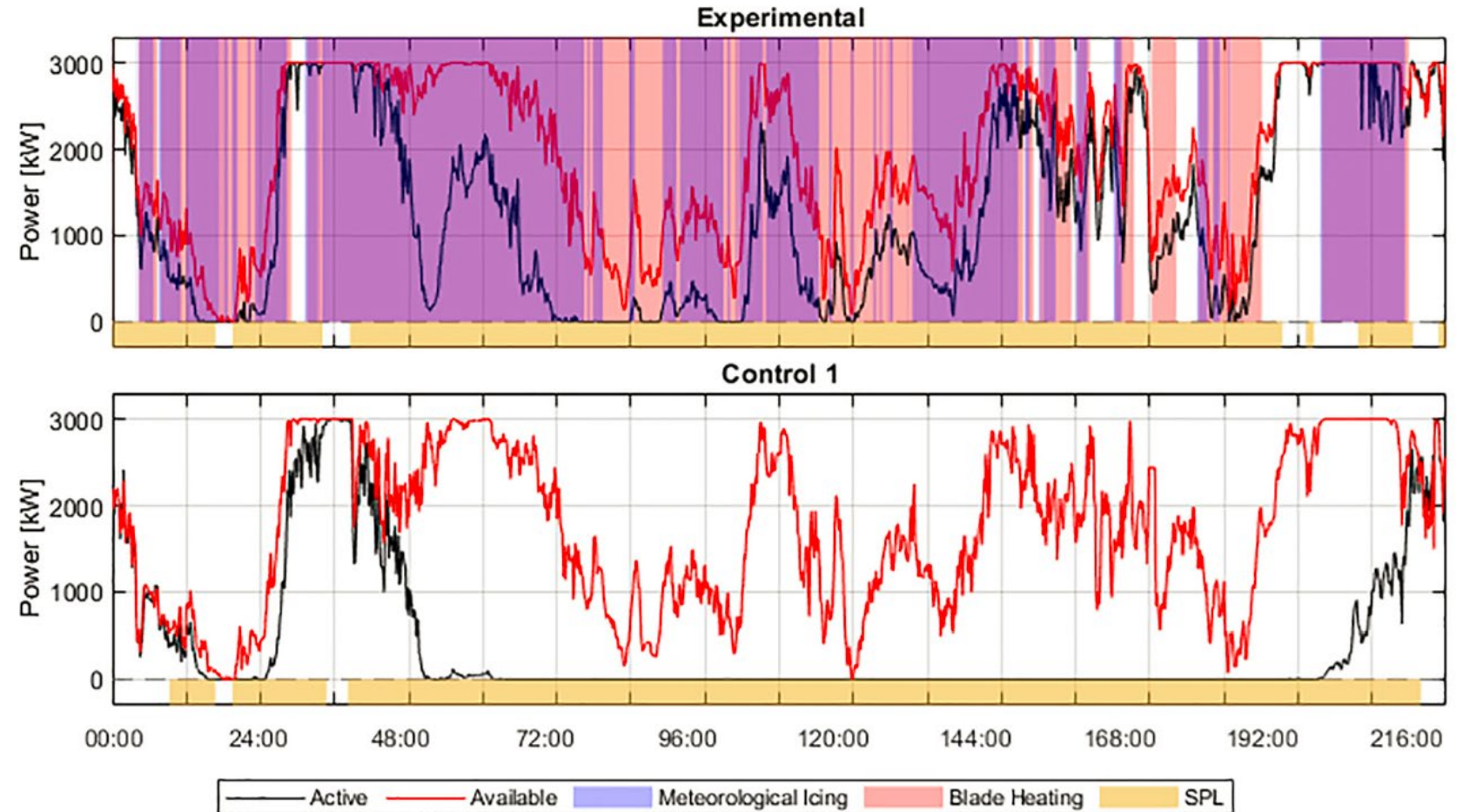
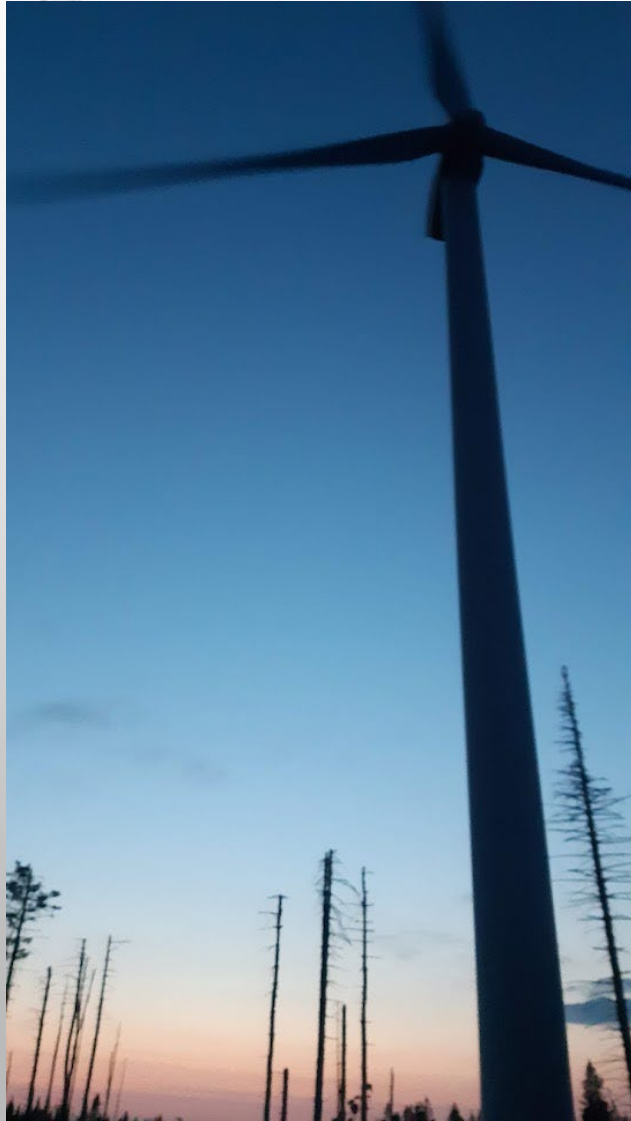


ALMOST FINAL INCARNATION (or not...) – 2017-2019

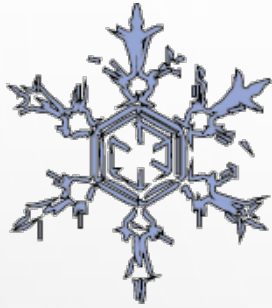


Roberge et al. (2019) *Field analysis, modeling and characterization of wind turbine hot air ice protection systems*. Cold Regions Science and Technology 163 (2019) 19-26

FANTASTIC PARTNERSHIP WITH BOREALIS WIND 2019-2022



SPINOFF LAUNCHED NOVEMBER 2020

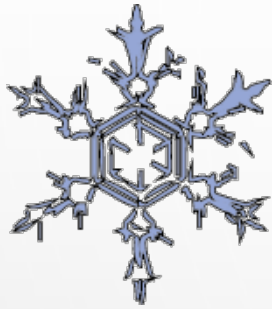


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www.icetek.ca



SPINOFF LAUNCHED NOVEMBER 2020

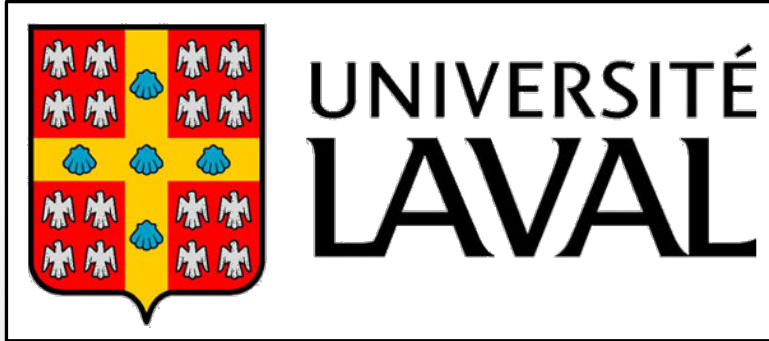


INSTRUMENTATION
ICETEK

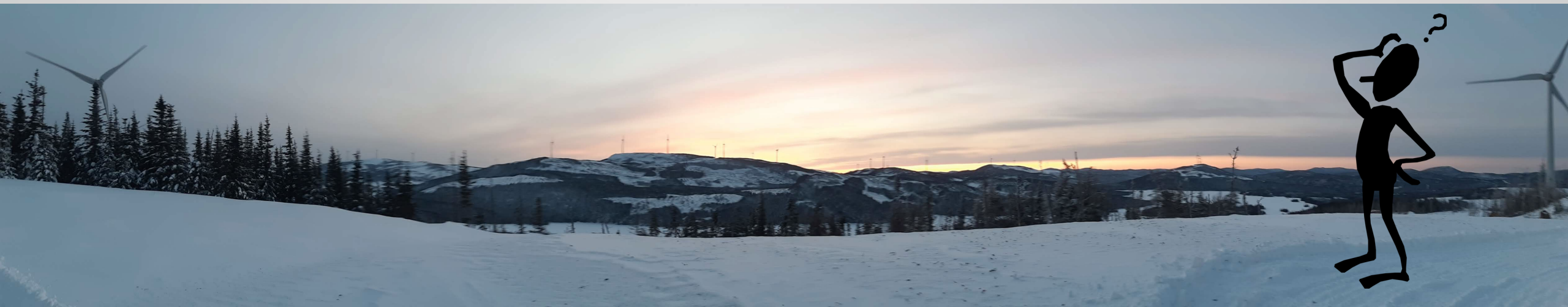
Meteorological Conditions Monitoring Station (MCMS)

- All-in one meteorological station
- Detects the onset of icing, the intensity, the end, estimates the LWC, estimates the thickness of ice accumulated, ...
- Used for turbine IPS control
- Used for ice assessment





ENJOY THE CONFERENCE!



Meteorological Conditions Monitoring Station (MCMS)

Technology licensed to icetek

www.icetek.ca

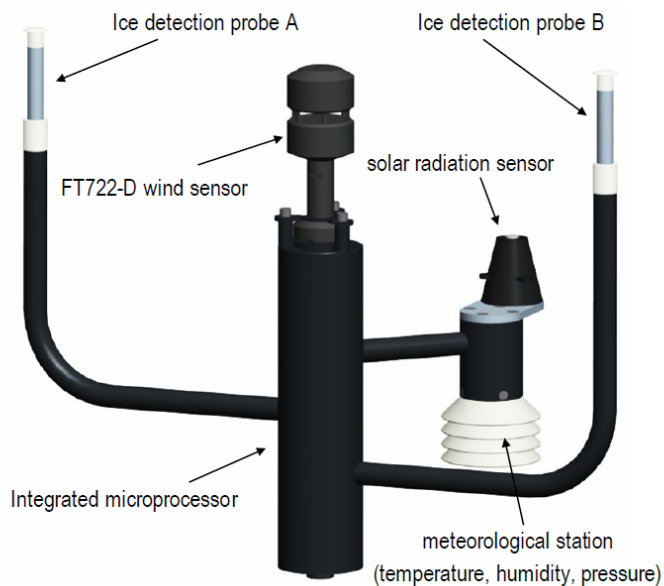
info@icetek.ca



Measurements

Wind speed	0 to 50 m/s	± 0.5 m/s (0 to 15 m/s) ± 4 % (>15 m/s)
Wind direction	0 to 360°	$\pm 4^\circ$
Temperature	-40 to 60 °C	$\pm 0.1^\circ\text{C}$ (-18°C to 30°C) $\pm 0.5^\circ\text{C}$ (else)
Relative humidity	0 to 100 %	± 3 % RH
Barometric pressure	30 to 110 kPa	± 0.1 kPa
Solar radiation	0 to 1800 W/m ²	± 5 %
Liquid water content ²	Typ. 0 to 1 g/m ³	
Icing severity ²	Typ. 0 to 10 g/(sm ²)	
Ice accumulation ²	mm	
Icing type ²	glaze, soft rime, hard rime	
Precipitation	on/off	
Meteorological icing	on/off	
Instrumental icing	on/off	

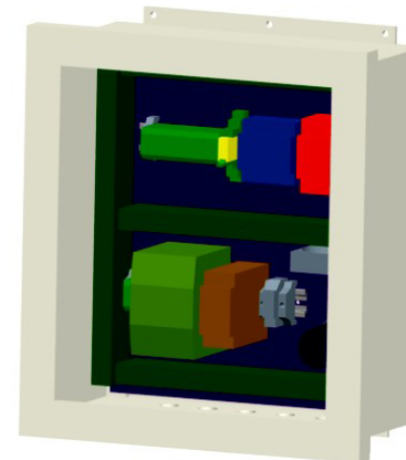
MCMS (nacelle or mast)



24 VDC, 10 A
surge protected

digital communication
surge protected

Electrical box (in the nacelle or on the met mast)



ETL Certified *Intertek*

115/230 VAC

Ethernet