VTT ICING WIND TUNNEL 2.0

Winter Wind 2016

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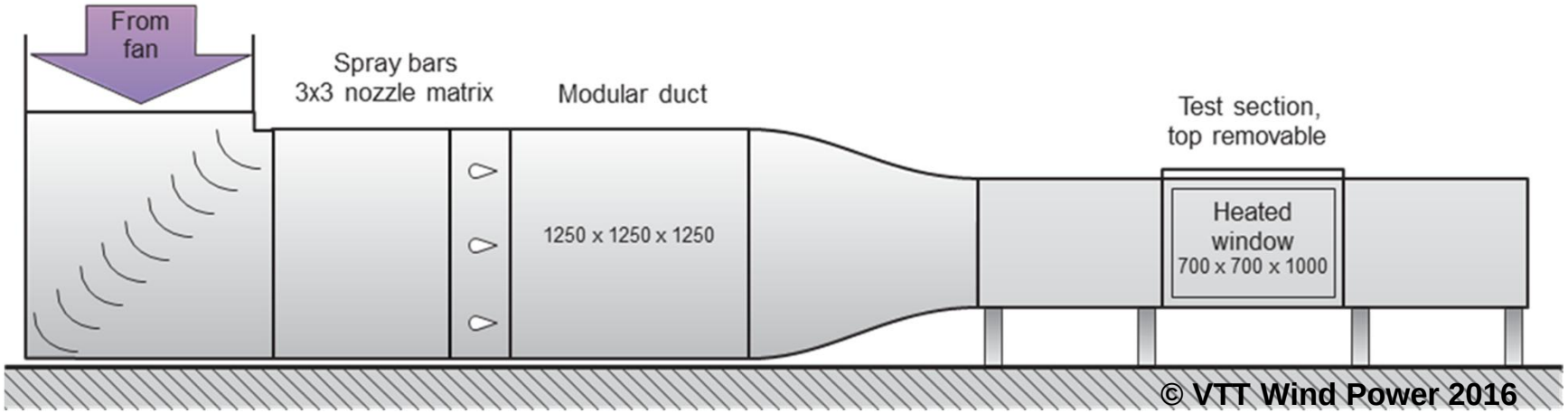
NEED – Icing Wind Tunnel 2.0

- By 2012, 24% (69 GW) of global wind in Cold Climate (CC) /2/
- 2013-17 forecasts 10 GW/a in CC!! /2/
- Cold Climate solutions, especially the different anemometer, ice detector and coating markets in the wind power industry, resemble *"the Wild West"*
  - *Missing standards and guidelines to verify* the instruments and coatings for CC!
- Controlled laboratory environment is needed to solve the above mentioned challenge to accelerate R&D cycles and lower LCoE

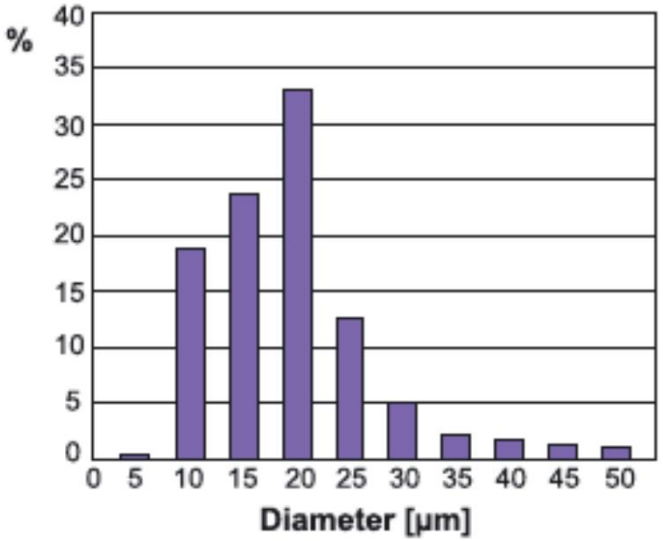
Approach – Icing Wind Tunnel 2.0 (est 2007)



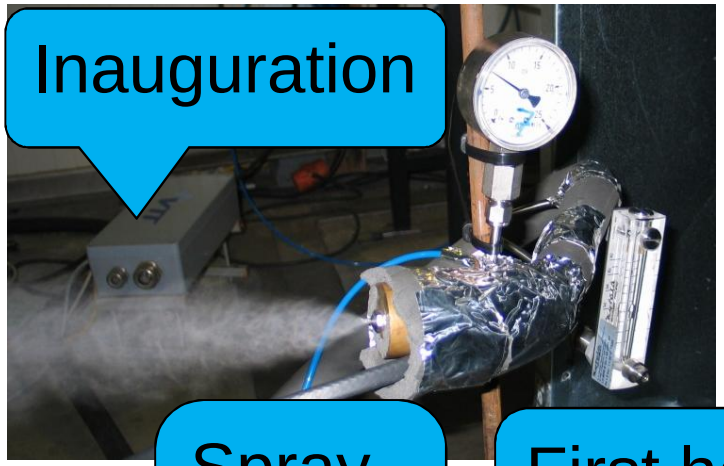
Performance of Icing Wind Tunnel:

Property	Range in the facility	VTT's Reference conditions	
		In-cloud icing, stationary components	In-cloud icing, wind turbine rotor blades
Temperature [°C]	-20…+25	-5	-5
Wind speed [m/s]	0…50	7	40
Water content [g/m³]	0.1…1.0	0.2	0.2
Droplet size, MVD [µm]	17…35	20	20

Droplet size distribution:



The journey of the VTT Icing Wind Tunnel

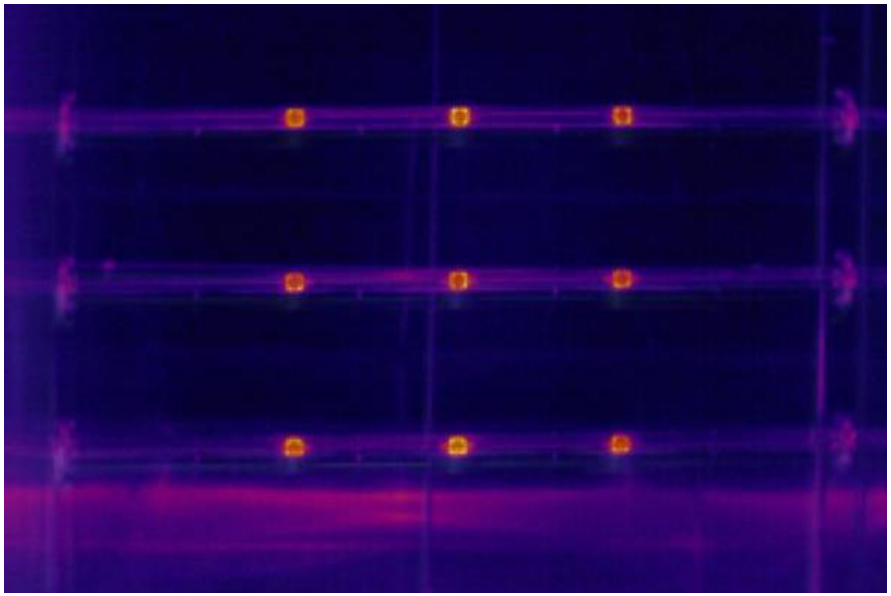


Inauguration

Spray nozzle matrix

First heated blade demo

Spray bar nozzle update



First commercial tests

MVD validation

Spray bar heating update

MVD validation

2008 2009 2011 2013 2015

Approach – Icing Wind Tunnel 2.0

- Controlled, calibrated and proven laboratory environment provides repeatable in-cloud icing conditions in the VTT wind tunnel
  - ➢ glaze, rime and mixed ice can be formed on the surface of different test specimens

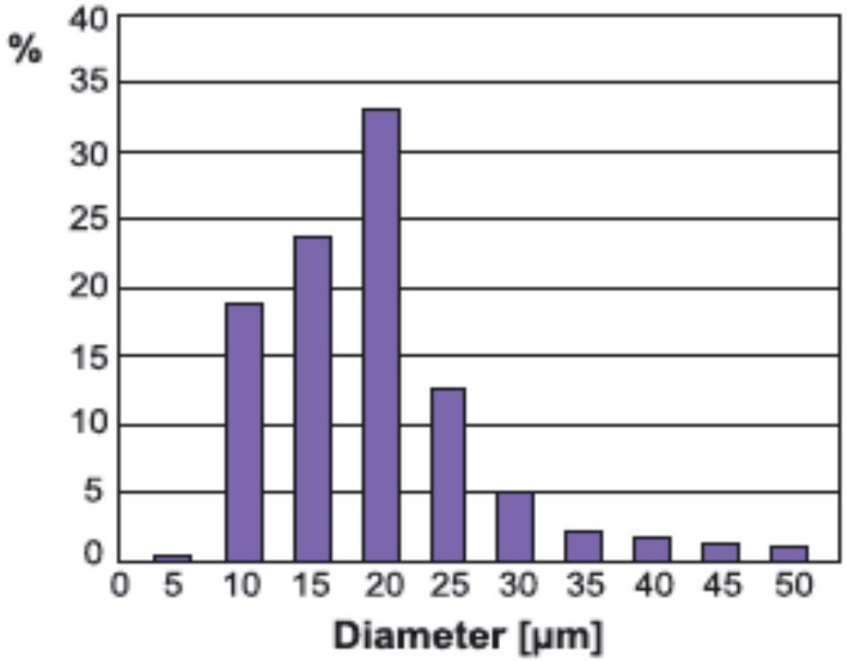
Approach – Icing Wind Tunnel 2.0

- For creating new ideas, testing prototypes and their functionalities, optimizing design and performing verification of different products in controlled testing environment
- Pre-certification test procedure & test conditions -5°C, 10 m/s:
  - LWC_1 = 0.1 g/m^3; Light icing condition
  - LWC_2 = 0.2 g/m^3; Standard icing condition
  - LWC_3 = 0.4 g/m^3; Harsh icing condition
  - LWC_3 = 0.6 g/m^3; Extreme icing condition
- VTT is an independent research institute that has globally unique capabilities to provide development services and pre-certification tests for different instruments, coatings, products and concepts for Cold Climate conditions.

Validation of MVD

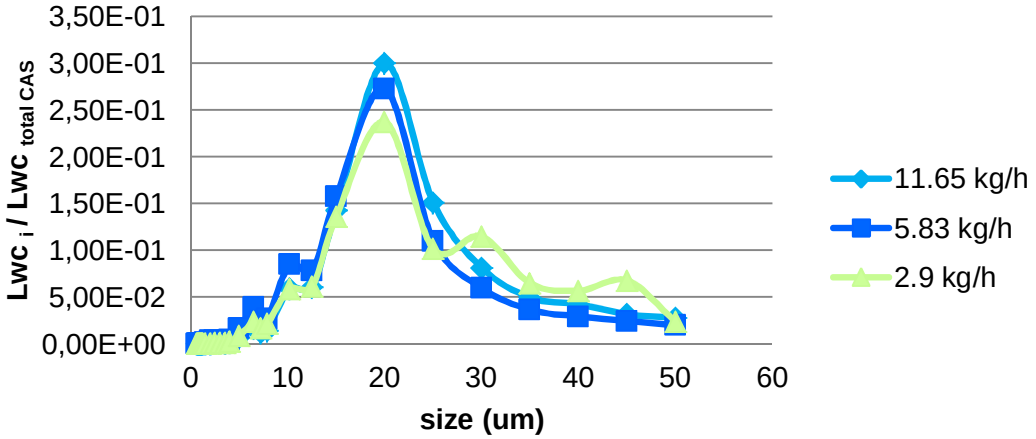
- Validated by FMI with CAPS (Cloud, Aerosol and Precipitation Spectrometer Probe)
- MVD was just right, not what we feared ☺

Droplets size distribution:

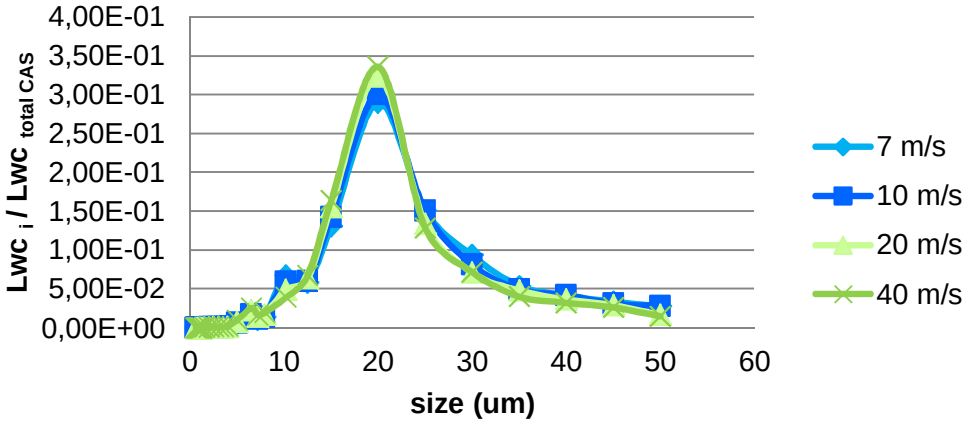


Validation of MVD

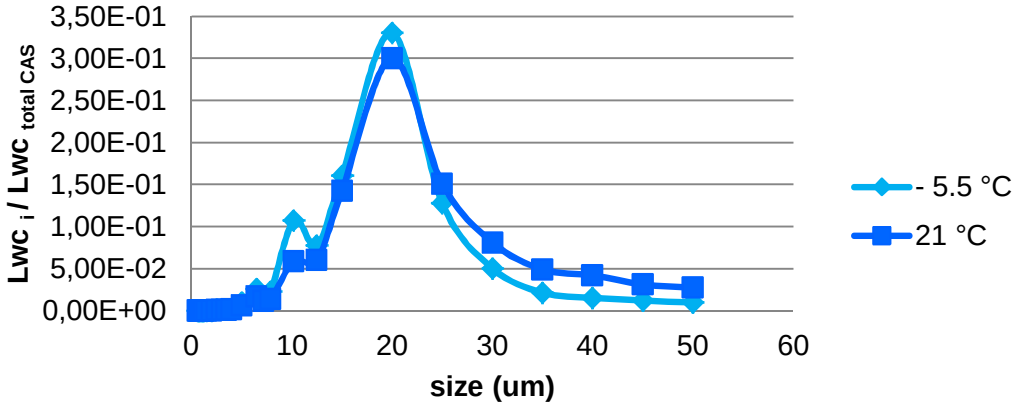
MVD vs. water amount



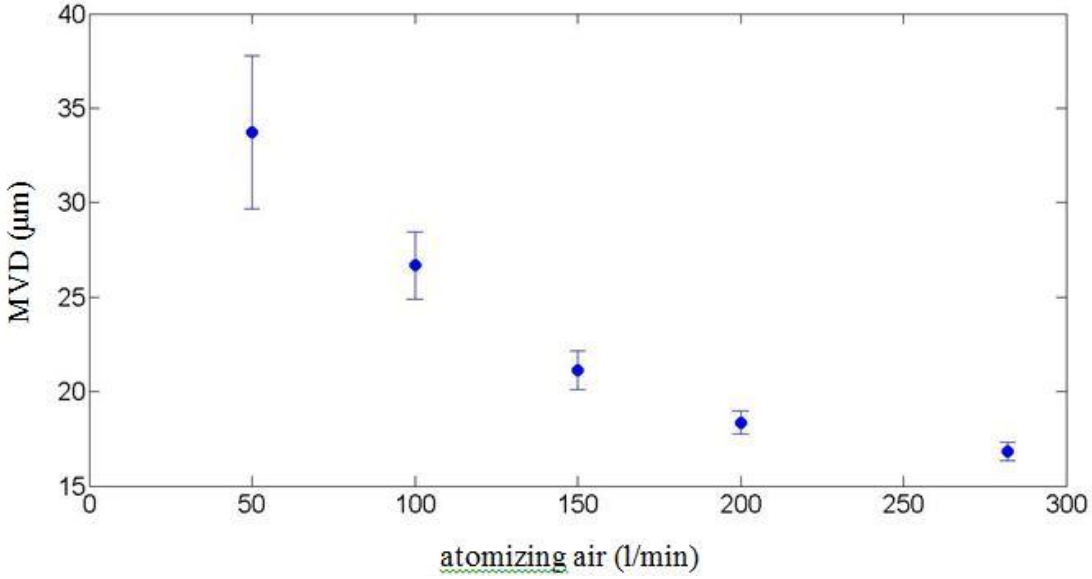
MVD vs. wind speed



MVD vs. temperature



MVD vs. atomizing air



Benefit – VTT Icing Wind Tunnel 2.0

- What is the benefit for the customer?

- End user: developer or turbine OEM
  - Know what you are buying!
  - Know ice detector performance and application options!

- Sensor manufacturer
  - Faster R&D cycles
  - Increase sales & confidence with pre-certification report

Benefit – VTT Icing Wind Tunnel 2.0 Applications

- New advanced VTT ice adhesion test method with high accuracy and repeatability compared to the rotational ice adhesion testing method /3/
  - Multiple, simultaneous coating specimens for faster and more comparative results /4/

- Coating tests can be performed on blade section /4/
  - Coating durability tests also possible

VTT Icing Wind Tunnel 2.0 Applications

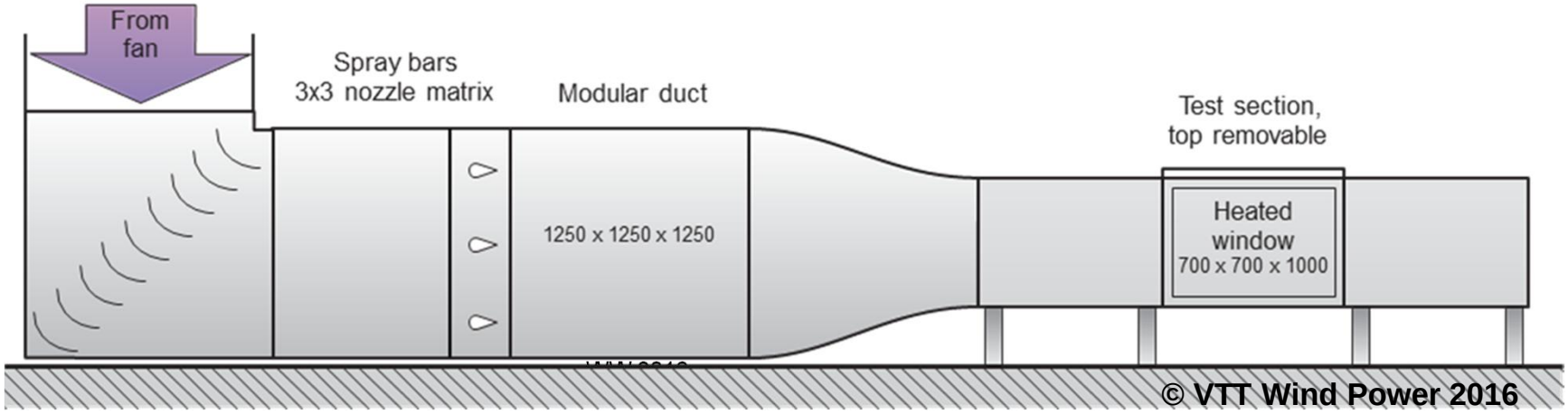
VTT basic ice adhesion tester /4/

VTT multiple coating specimen /4/

Summary

- VTT Icing Wind Tunnel facility has a unique potential for creating new ideas, testing prototypes and their functionalities, optimizing design and performing verification of different products in controlled testing environment

- Droplet size distribution (MVD) is <u>validated</u> by Finnish Meteorological Institute (2015) /1/



References

1. Droplets Size Distributions Measurement by Finnish Meteorological Institute (FMI), Atmospheric Composition Research with CAPS (Cloud, Aerosol and Precipitation Spectrometer Probe) at VTT Icing Wind Tunnel 2015.
2. A BTM Wind Report. 7 Special Chapter: Cold Climate Turbines (“CCTs”). Navigant Research. World Market Update 2012. International Wind Energy Development Forecast 2013-2017. 26th March 2013.
3. Makkonen, L., 2012: Ice adhesion – theory, measurements and countermeasures. Journal of Adhesion Science and Technology 26(4), 413-445.
4. Makkonen, L., 2014: TopNANO Final Seminar. Designing and testing coatings for easy ice release. VTT Technical Research Centre of Finland. 6.5.2014. Power Point presentation.

TECHNOLOGY FOR BUSINESS

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