Improving performance in cold climates

Winterwind 2017, Skellefteå

Lennart Frølund, February 2017

Agenda

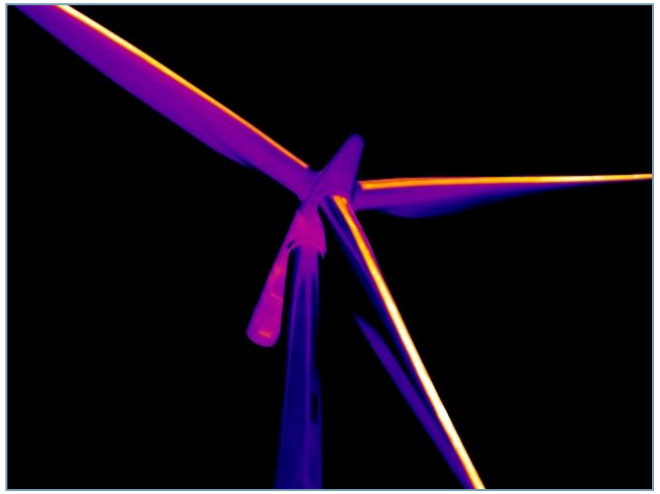
- Cold climate features
- Experience
- Testing and validation of performance
- Next steps and challenges

Integrated blade heating elements offers distinct advantages

SIEMENS

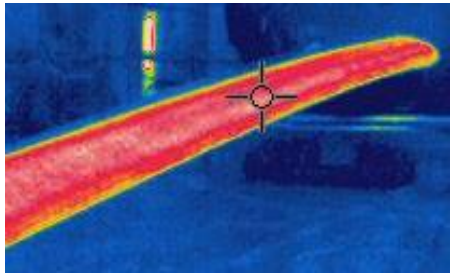
Integrated blade heating elements offers distinct advantages

- Electrical resistance heating, using integrated carbon fibre
- Covering aerodynamic relevant parts of the blade
- Heating element adjacent to surface for optimized heat transfer and minimum power losses.
- No aerodynamic penalty, noise- or structural impact



Well adapted production setup secures high quality, through extensive testing and validation

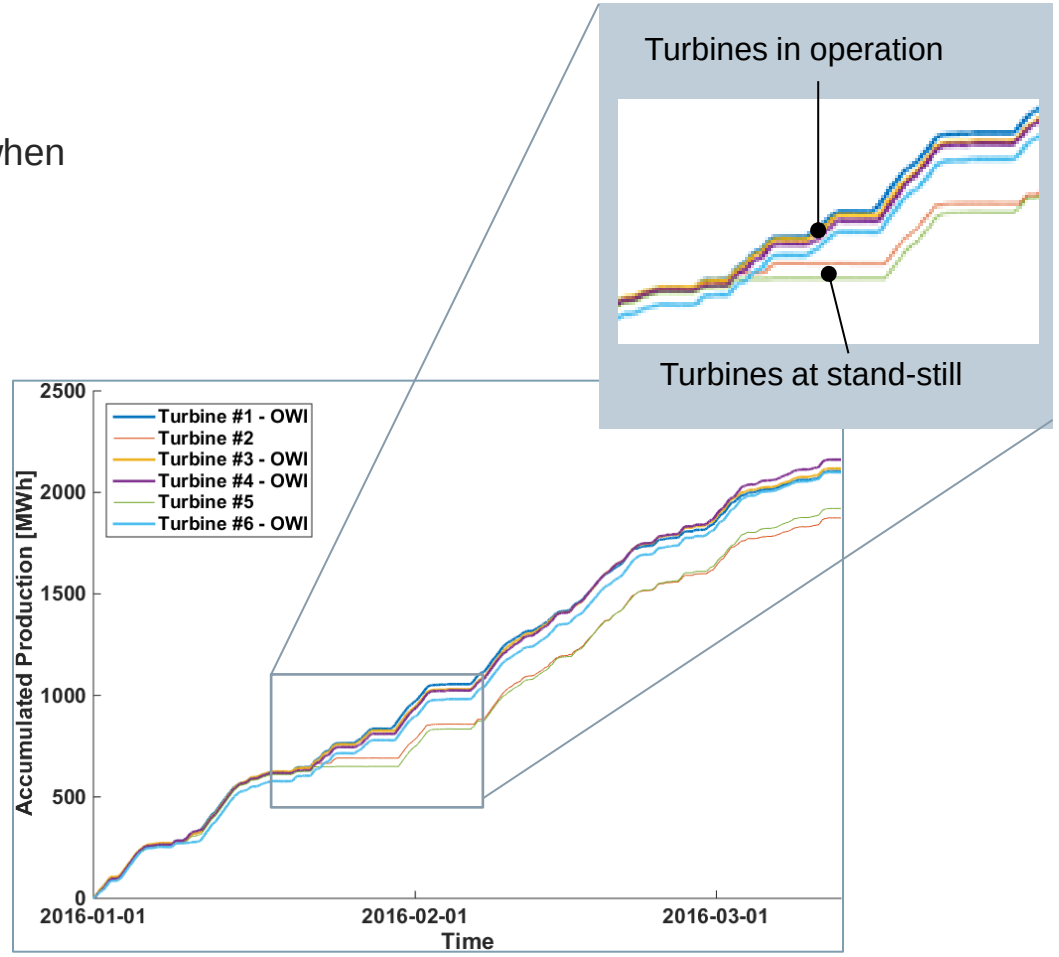
- Electrical system
- Heat distribution
- Thermocycling (1600 cycles)
- Uneven thermal expansion (glass vs carbon)
- Lightning reception



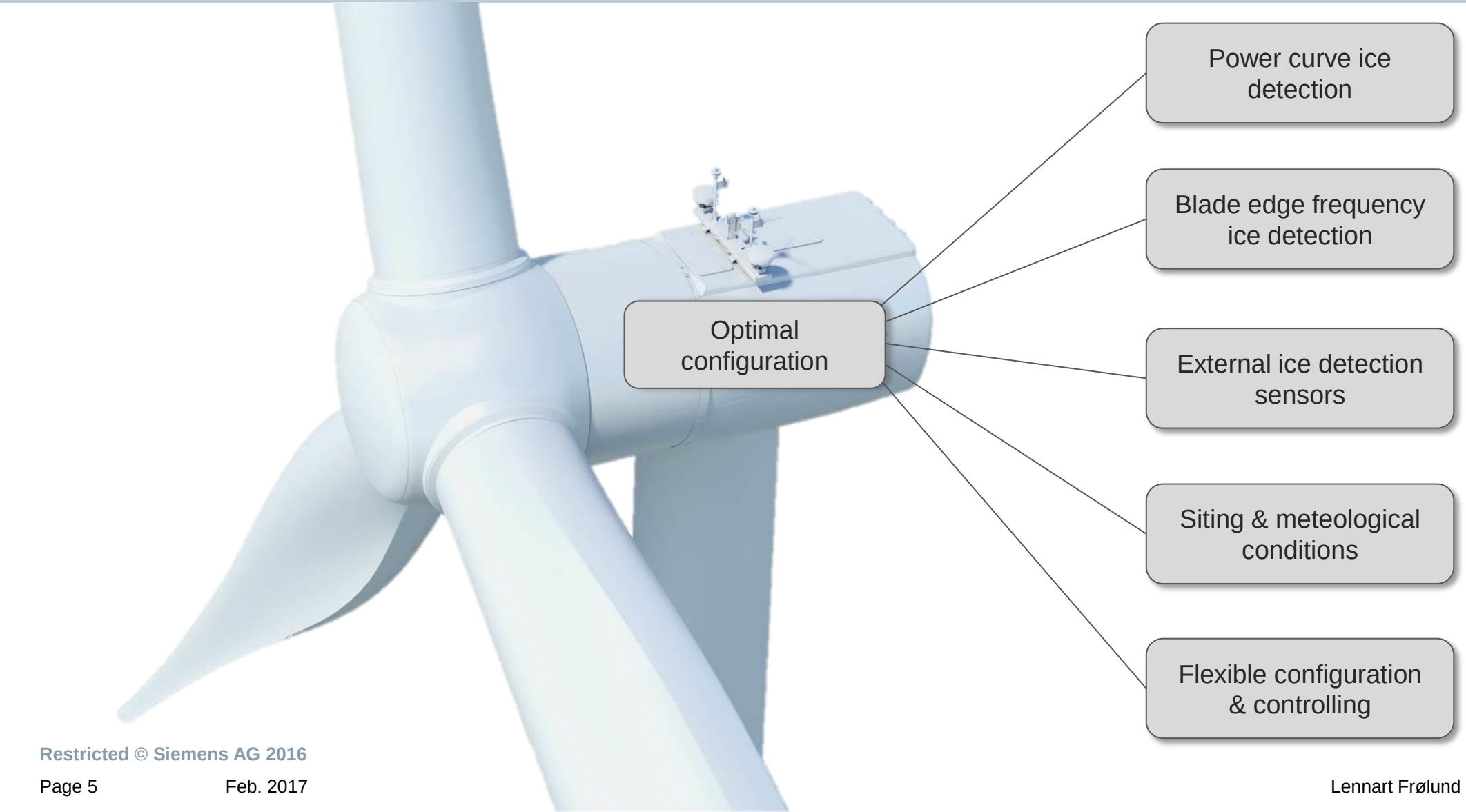
Special designed operation mode for cold climate

Siemens Wind Power offers *Operation With Ice*

- Special designed operation mode for turbines in icing conditions
- The turbine controller automatically activates *Operation with Ice* mode when ice is detected
- Turbine operational parameters optimizes for operation with changed aerodynamic profile
- Design turbine lifetime not compromised
- Tested and validated on 45 turbines, in winter 2015/2016
- Compatible with de-icing system



Flexible ice detection solutions
Reliable and sensitive ice detection provides higher performance



Siemens have long experience with de-icing turbines
More than 300 turbines with de-icing installed

1994-	**18 x** Bonus turbines	Lammasoeivi, Suorva, Vemhån, Olos, Katka, Pori
2011	**1 x** SWT-2.3-101	Kyrkberget
	9 x SWT-2.3-101	Korpfjället
	4 x SWT-2.3-101	Raftsjöhöjden
	1 x SWT-2.3-101	Brahehus
2012	**6 x** SWT-2.3-101	Åsen-Kapstenberget
2013	**1 x** SWT-2.3-113	Stamåsen
	26 x SWT-3.0-113	Mullberg
	10 x SWT-2.3-101	Falläsberget
	37 x SWT-2.3-113	Mörtjärnberget
	30 x SWT-2.3-101	Trattberget-Skallberget
2014	**33 x** SWT-3.0-113	Ögenfägnaden
	90 x SWT-3.0-113	Björkhöjden 1 & 2
	15 x SWT-3.0-101	Raggovidda
2015	**9 x** SWT-3.2-113	Juktan
	11 x SWT-3.2-113	Port of Antwerp
2016	**5 x** SWT-3.2-113	Stormon

Siemens utilizes track record to improve performance

Basis for the analysis:

- Three sites in central Sweden, covering 64 turbines
- Turbine production data from 2 - 3,5 years of operation

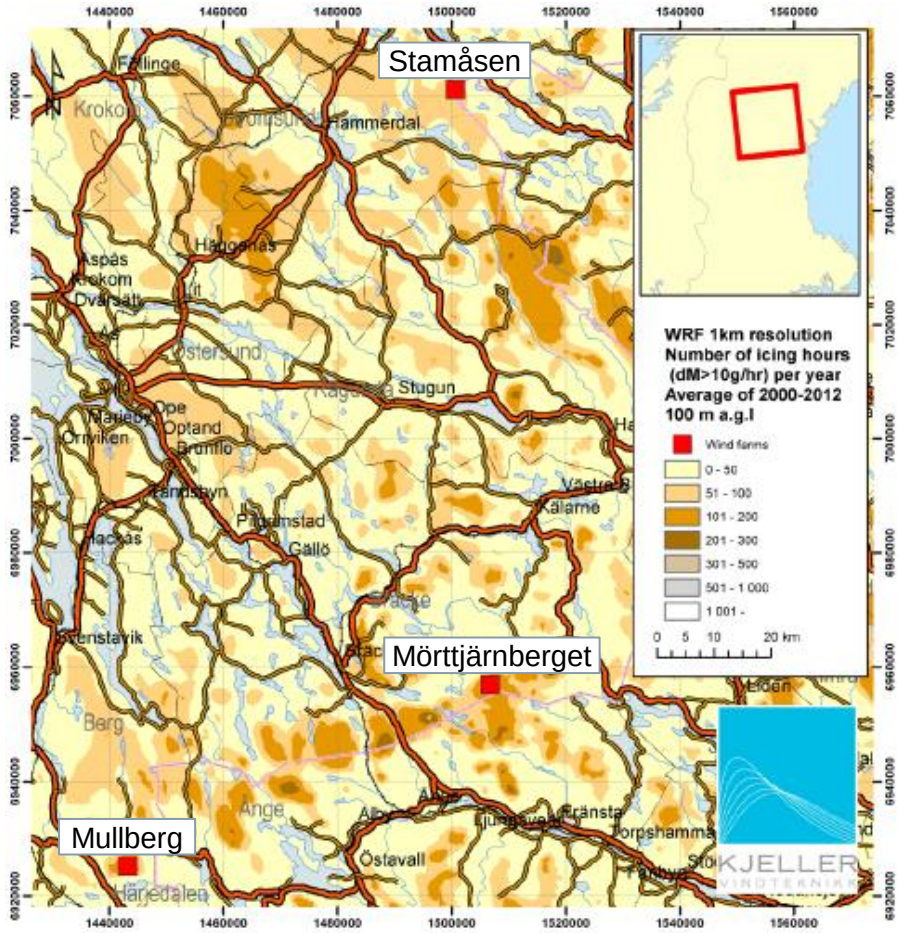
Key areas of interest:

- Validation of de-icing performance
- Feasibility of using reference turbines
- Influence of site- and meteological conditions
- Variations and uncertaincies

Aims and next steps:

- Baseline for optimization of de-icing site configuration and control strategies
- Validation and proof of efficiency
- Improving knowledge on warranty validation methods
- Take-aways and statistics used in new product development

Selected sites in Sweden



Thanks for your attention