

# Current issues on wind energy production in cold climate

NordVind seminar Vindkraft i kallt klima

1.12.2011

Tomas Wallenius, Esa Peltola

VTT Technical Research Centre of Finland

## Outline

- VTT Wind briefly
- Icing of wind turbines
- Effect of icing
  - Power production
  - Safety
- Ice prevention vs. de-icing
- VTT's activities towards ice prevention solutions



Photo: VTT

## VTT Wind briefly

Total level of activity 35 – 40 m-years/a

Field measurements directly related to wind

- Up to 100m masts archipelago on southern coast to mountains in Lapland
- Lidar-measurements
- Power performance, loads, power quality
- Accredited laboratory for wind turbine power performance measurements acc. to IEC 61400-12
- Load and vibrations measurements and analysis

### Laboratory facilities

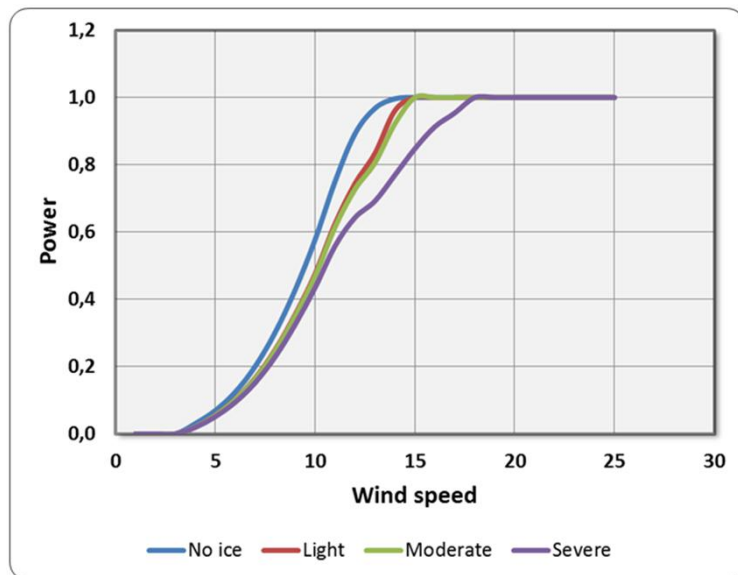
- Icing wind tunnel
- Material and component testing facilities, also in climate chamber
- Large bearing testing



## Icing of wind turbines

### Rotor blades

- High relative wind speed  
=> high icing rate
- Degradation of aerodynamics  
=> power losses & vibrations



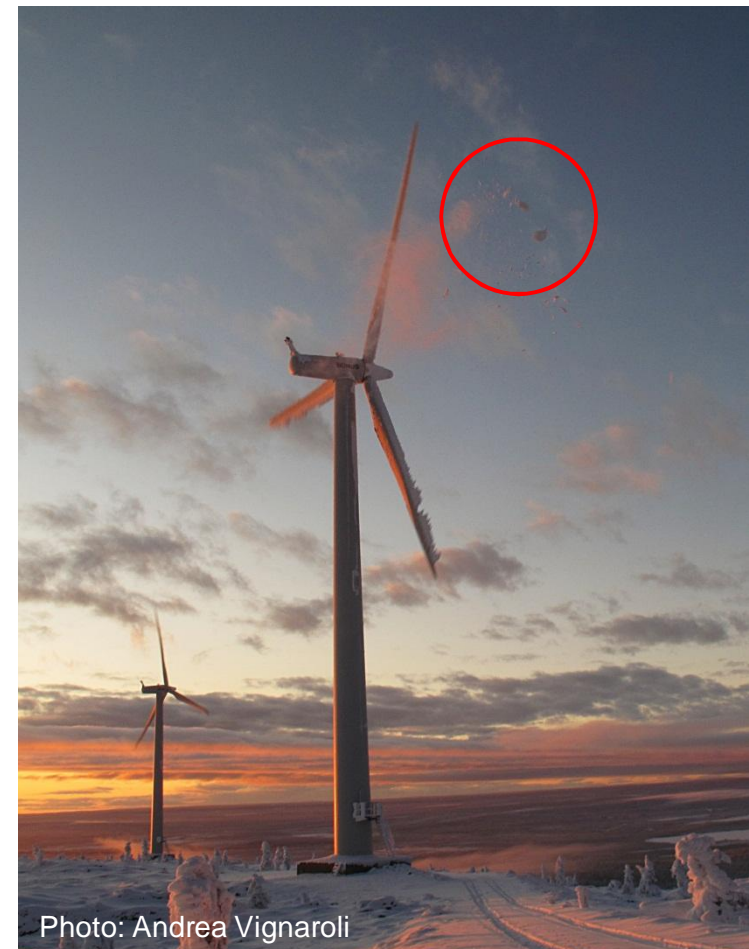
### Sensors

- Anemometers, wind vanes, mounting booms  
=> control errors

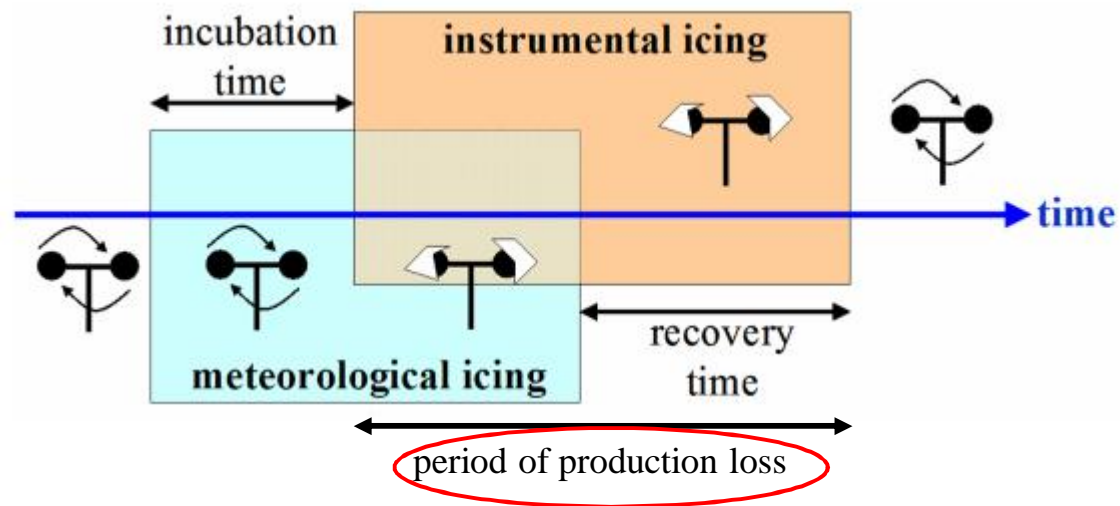
## Safety: Ice throw

- Safety risk for
  - Labour
  - Public
  - Property
- Mitigation of ice throw
  - Safety zones
  - Warning signs and lights
  - Reduce the amount of ice on blades with ice prevention or de-icing

1.5 \* (hub height + rotor diameter)



## Ice prevention vs. de-icing normal turbine



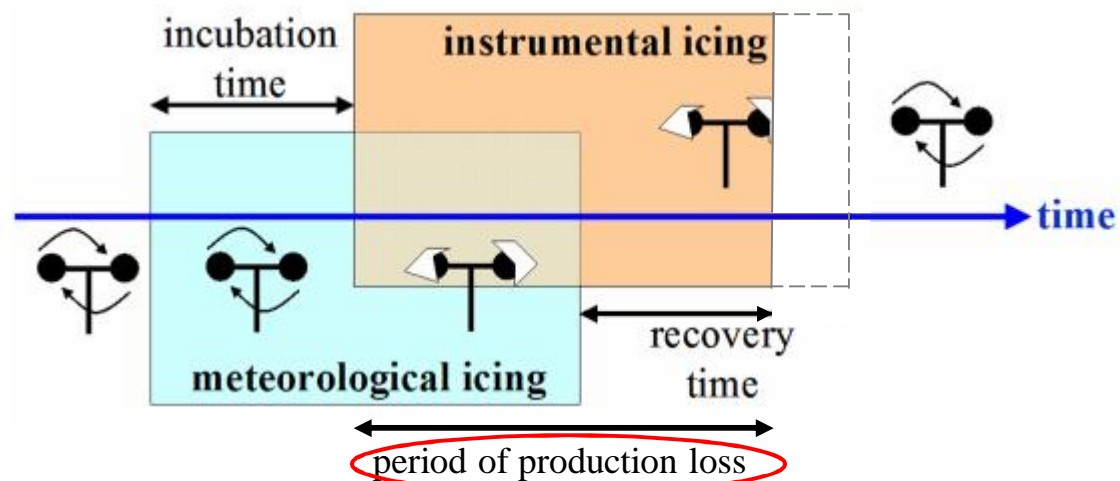
### Meteorological icing

- Period with icing weather conditions

### Instrumental icing

- Period when a wind turbine is disturbed by ice
- Typically 2...5 times longer than meteorological icing event

## Ice prevention vs. **de-icing**

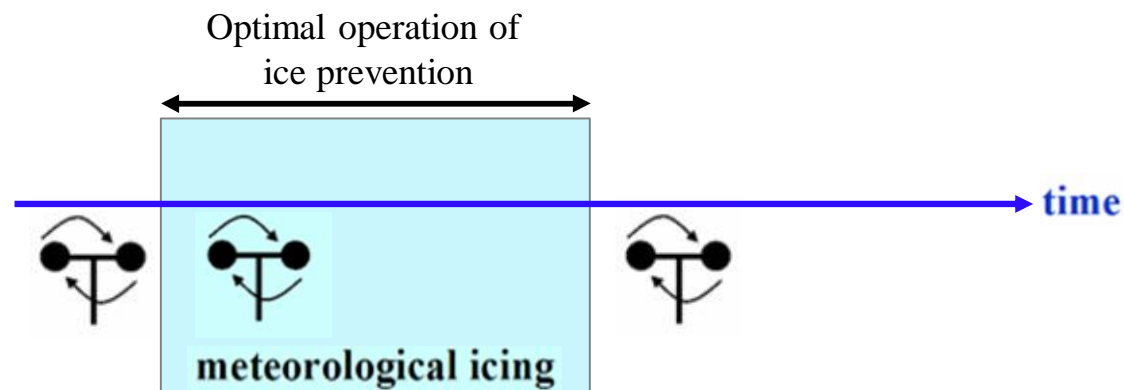


Recovery time shortened with de-icing

De-icing = to remove ice from blades after ice has formed

- Turbine operates with iced rotor blades before de-icing
  - => reduced power production
  - => aerodynamic/mass unbalance of rotor
  - => ice throw risk high during de-icing and/or start-up

## Ice prevention vs. de-icing



Instrumental icing can be avoided by efficient ice prevention!!!

Ice prevention (anti-icing) = to prevent ice formation on blades

- Turbine operates as usual -> no power degradation, no unbalance
- Required heating power minimal compared to produced power (wind speeds > 5m/s), but power reserve needed for harsh conditions -> higher power demand than de-icing
- Typical ENERGY consumption 0,5...2% of AEP

## Requirements for ice prevention system

- Advanced heating arrangements
  - Demanding conditions for operation and for design
    - allowed effects to aerodynamics and structural integrity minimal
    - rotation, erosion, lightning
  - Serviceability
- Control
  - Icing detection -> heat only when needed
  - Heating control -> heat enough when needed

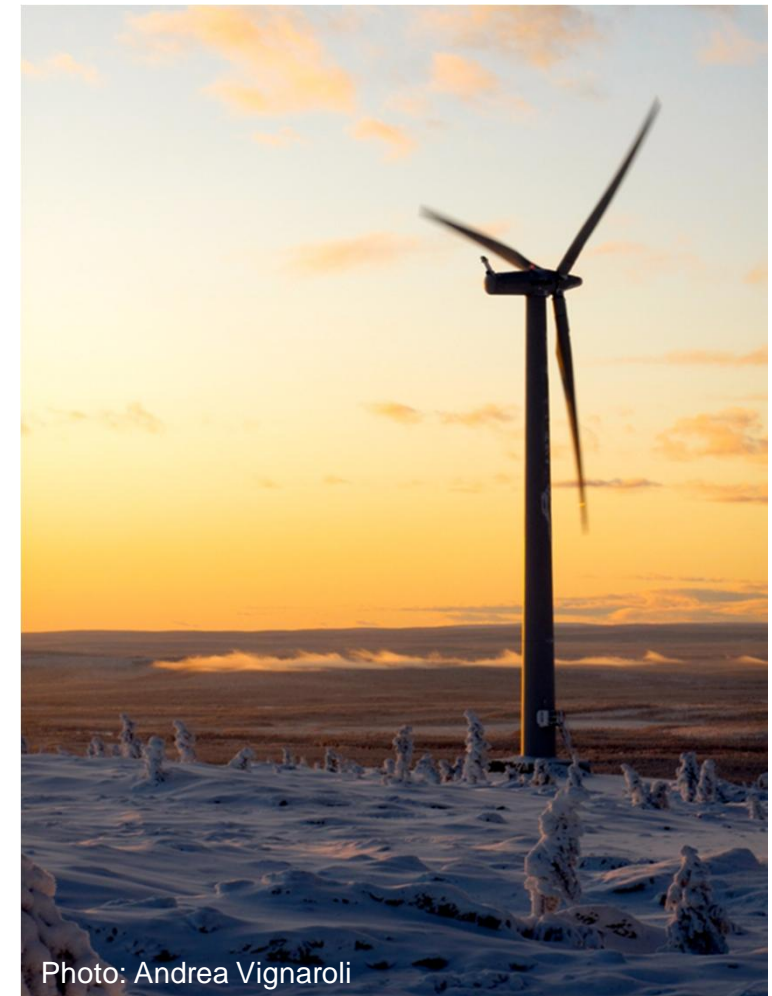


Photo: Andrea Vignaroli

## In practice



1

3

2

Olos wind farm February 2008  
(in operation since 1998)



Defect in the JE-System (turbine no 2)  
(JE = ice prevention system,  
supplied by Kemijoki Arctic Technology  
KAT codevelopment with VTT)

## The difference



Turbine 3  
- Ice prevention in operation



Turbine 2  
- Ice prevention system fault

## and the consequence



## **VTT's activities towards ice prevention solutions since 90's**

## Basic features of the solution

### Ice prevention

- Designed to be used during turbine operation
- Design can be adapted to different weather conditions
- Demonstrated lifetime > 10 years
- Demonstrated scalability from 220kW to 3MW turbines

### Track record

- System installed in >40 turbines
- First commercial demonstration in 1996 (Bonus)

### Tailored design

- Level of system integration to turbine control
- Level of manufacturing integration in the blade manufacturing
- Re-design for customer needs

Research			
location	size		
Pyhätunturi	2.5 kW	1991	
Jyppyrä (Hetta)	65 kW	1993	Nordtank
Pyhätunturi	220 kW	1993	Wind World
Demonstrations and commercial projects			
Lammasoivi	2 x 450 kW	1996	Bonus
Olostunturi	5 x 600 kW	1998-99	Bonus
Suorva (Sweden)	600 kW	1998	Bonus
Rodåvålen (Sweden)	600 kW	1998	Bonus
Pori	4 x 1 MW	1999	Bonus
Kotka	2 x 1 MW	1999	Bonus
Uljabuouda	(4 + 6) x 3 MW	2009-10	WinWinD
Jokkmokksliden	(1 + 4) x 2.5 MW	2010 -11	Nordex
Storliden	10 x 2.5 MW	2011	Nordex
Blaiken	60 x 2,5 MW	2012-13?	Nordex



There are over 150 heating seasons using solutions based on same principles.

## WinWinD Oy, Uljabuouda wind farm (10x3MW)

### World's largest wind turbine model with ice prevention of blades

#### Activities (2009-):

- Design and development of blade heating system in close collaboration with WinWinD engineering department
- Development of the next generation ice prevention system

#### Results:

- Minimizing power production loss due to icing
- Enabling efficient production

*WinWinD website: “The system has been proven to work perfectly with heat distributing evenly. [...] blade heating has enabled non-stop operation of the turbine. Without Ice Prevention the turbines would not have been operational during the harsh winter. Therefore, Ice Prevention has paid itself back in Uljabuouda already after the first winter.”*



# Nordex Energy GmbH, Jokkmokksliden wind farm (5x2.5MW)

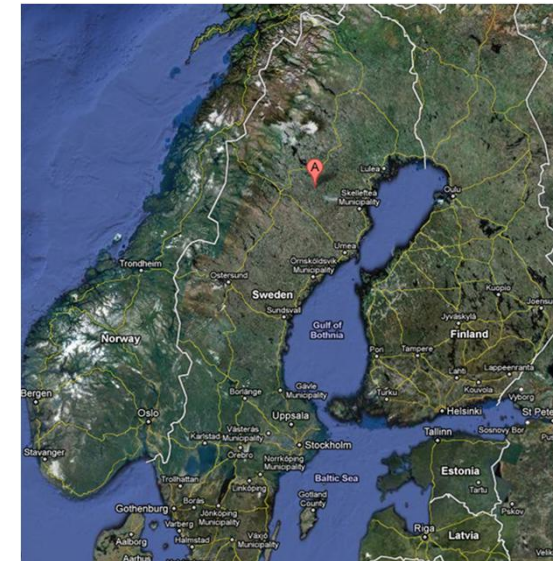
## Development and serial production of VTT Ice Prevention System

### Activities (2010-):

- Design and development of blade heating system in close collaboration with Nordex engineering department
- Support in the serial production and further optimization

### Results:

- Minimizing power production loss due to icing
- Enabling efficient production



*Nordex press release, 11 May 2011: **Anti-icing system secures 150 MW order***

*Nordex has won the largest order awarded for an onshore wind project in Sweden to date: as of summer 2012 the turbine manufacturer will be building “Blaiken”, a 150 MW wind farm.*

**Nordex:** *“The successful development of the anti-icing system was a key criterion for the order.”*

**Risto Andsten, Vice President Renewable Energy, Fortum:** *“The cost-benefit ratio of anti-icing persuaded us to have all the turbines equipped with this innovative system,”*



**VTT creates business from  
technology**