Wind energy production in cold climate
some international activities & experience

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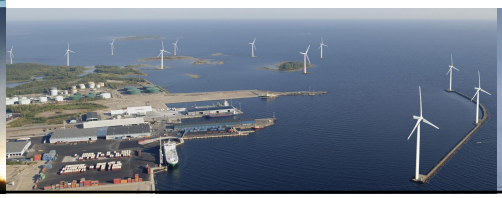
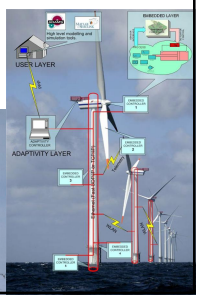
Teknologiasta liiketoimintaa

WIND ENERGY AT VTT
Technologies, materials and solutions

- Focus
  - Technology to growing wind turbines for growing domestic and export markets, especially cold climate and offshore applications
- References, solutions
  - Wind energy in cold climate projects KOLAWIND, WECO, IEA Wind Task 19 – coordination
  - New blade materials and concepts (EU-projects) TIMBER, New Generation Wind Turbine Blade, OPTIMATBLADES, UPWIND
  - Ice prevention systems for wind turbine blades
- Competences
  - Technology and market assessment
  - Cold climate and offshore technologies
  - Versatile modeling expertise from wind through somponents and turbines to electricity
  - Materials, control and expertise for future wind turbines
  - Field and laboratory testing facilities for wind turbine development, structural and performance measurements and verification
- International networking
  - Nordic co-operation
  - Several EU-projects
  - IEA collaboration
  - IEC standardization

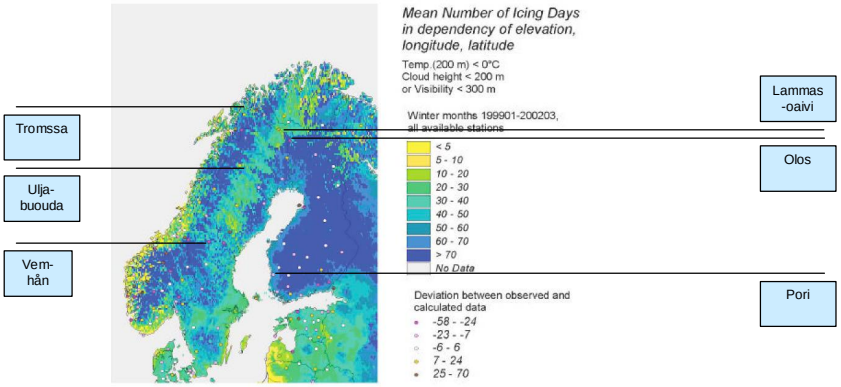






Icing risk in Scandinavia

Source: WECO-project



ure 5: Icing days in dependency from geographical coordinates and sea level height for Scandinavia

Wind energy production opportunities in Finland

Fjell areas

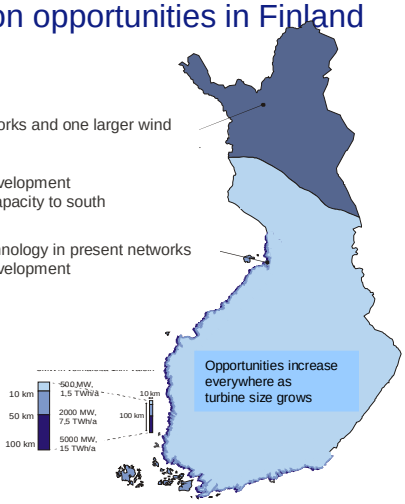
- About 200 MW in small wind farms in present networks and one larger wind farm in northmost point
- Need for cold climate blade technology
- Penetration can be increased by control system development
- Multiple opportunities by increasing transmission capacity to south

Coastal areas

- More than 1000 MW/2-3 TWh/a using present technology in present networks
- Penetration can be increased by control system development

Offshore

- Large potential, present land use plans enable installation of several thousand MW of capacity
- Need for foundation and assembly for ice infested sea areas
- Large scale production calls for development of power transmission technologies and networks



Icing prevention system for the blades of wind power plants
Part of the development in the
(EU-project New Generation Wind Turbine Blade)

- Prevents the accumulation of ice on the blades in freezing conditions
- Icing significantly reduces generating output
- Control on the basis of an ice sensor and temperature
- Consumption of heating energy less than 3 % of the power plant's annual output
- Installed in several power plants in 600 kW to 1 MW range in Finland and abroad
- Growing global market foreseen
- Next step: system development for multi-MW turbines

The result of collaboration between VTT Processes and Kemijoki Oy Spin off:
Kemijoki Arctic Technology Oy in 1998

This slide was made in 2002

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Cold climate wind technology at VTT

- General research related to icing
  - Evaluation of icing risks
  - Material research one clean surfaces
- Modelling and tools
  - TURBICE, calculation of heating demand
  - PSCAD-ADAMS-SIMULINK , performance, dynamics and loads wind turbines in icing conditions
- Wind and icing measurements in cold climate
  - Follow-up and assessment measurements
  - Ice-free anemometry, evaluation of icing
  - Power performance and loads of turbines in cold climate
  - Performance of heating systems and ice detectors

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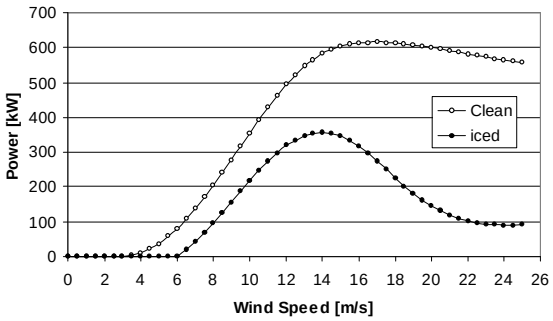
Effect of ice on the basis of theories



Result of WT-perf calculation when 100% increase in drag, -2 degree stall angle reduction, 15% decrease in maximum lift of profiles are assumed.

Corresponds surface roughness of around 1mm!

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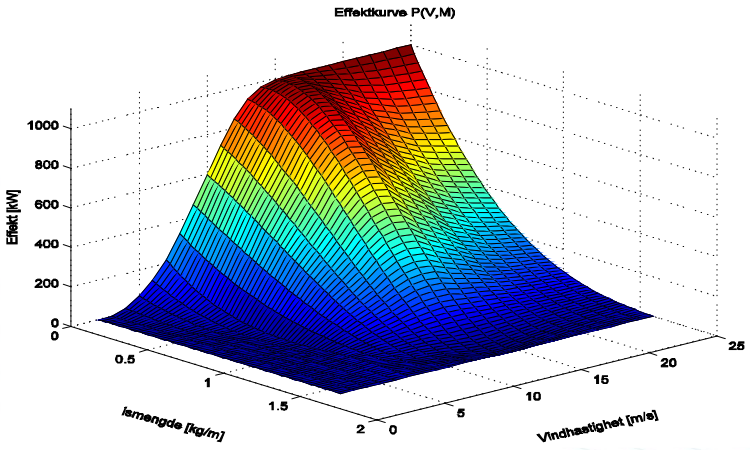
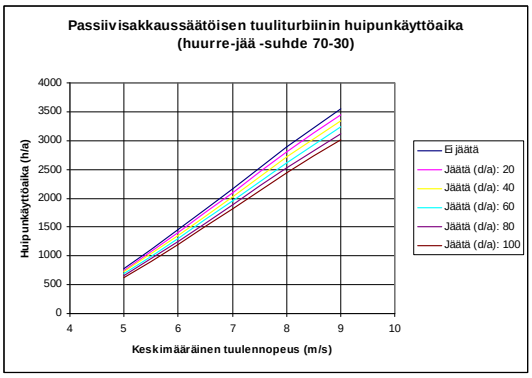
Two-parameter power curve

(Kjeller Vind teknikk, IEA R,D&D Wind Task 19)



KJELLER VINDTEKNIKK

Heating system concept development
- effect of icing on the performance of a stall regulated wind turbine



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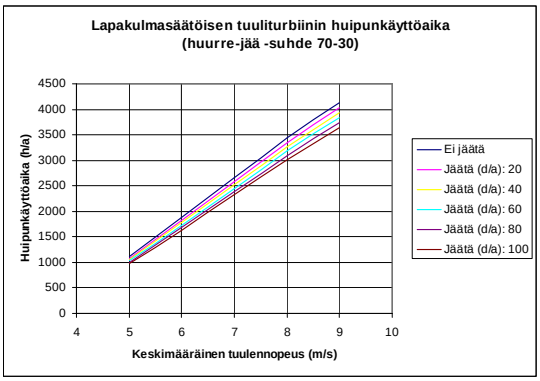
Heating system concept development
- effect of icing on the performance of a variable speed pitch regulated wind turbine



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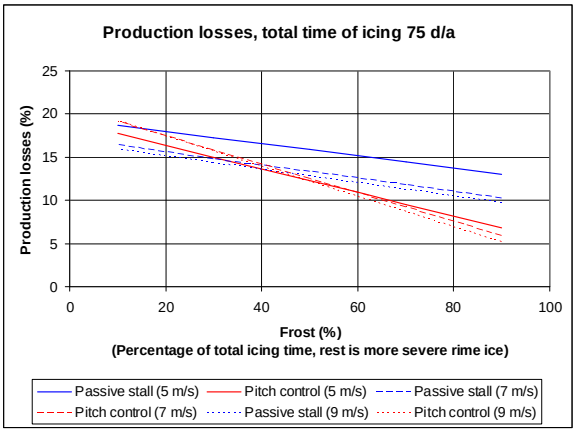
Heating system concept development

- modeling results on the effect of icing on the performance of a stall and pitch regulated wind turbines



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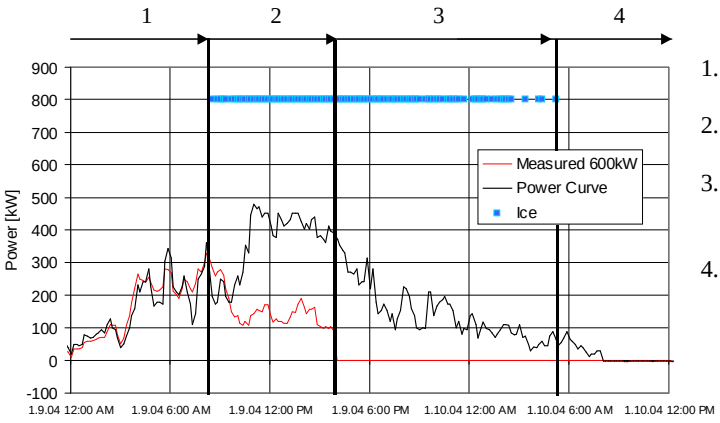
Wind turbine icing in practice



1. Normal operation.
2. Beginning of icing.
3. Turbine stops and icing continues.
4. Turbine has stopped due to ice. No further icing.

North Finland in January 2004

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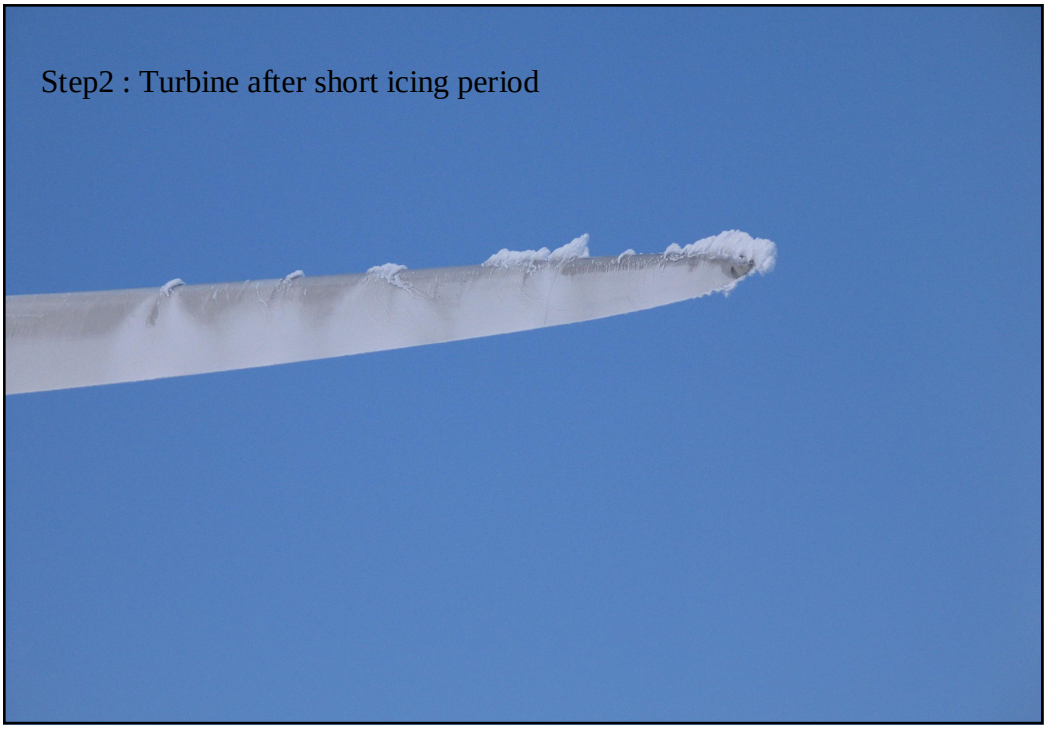
Step2 : Turbine after short icing period


Step 4: Turbine has stopped, no further icing

In practice

1 3 2
Olos wind farm February 2008

Defect in the JE-System (turbine no 2)

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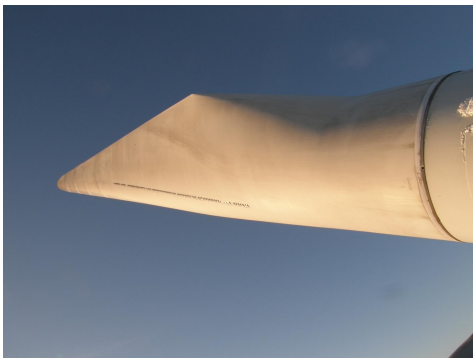
The difference



Turbine 3
- Ice prevention in operation

Turbine 2
- Ice prevention system fault

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and the consequence

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Wind energy in cold climate
esp. icing environment

- Need: ice-free solutions for 1-3 MW variable speed turbines with modern control capabilities
- Steps
  - Evaluation of wind resources and evaluation and verification of icing risks (work carried out partly within IEA Task 19)
  - Performance of wind turbines in icing conditions, verification of models
  - Technology and product development for ice free blades
  - Demonstration in sites with different conditions

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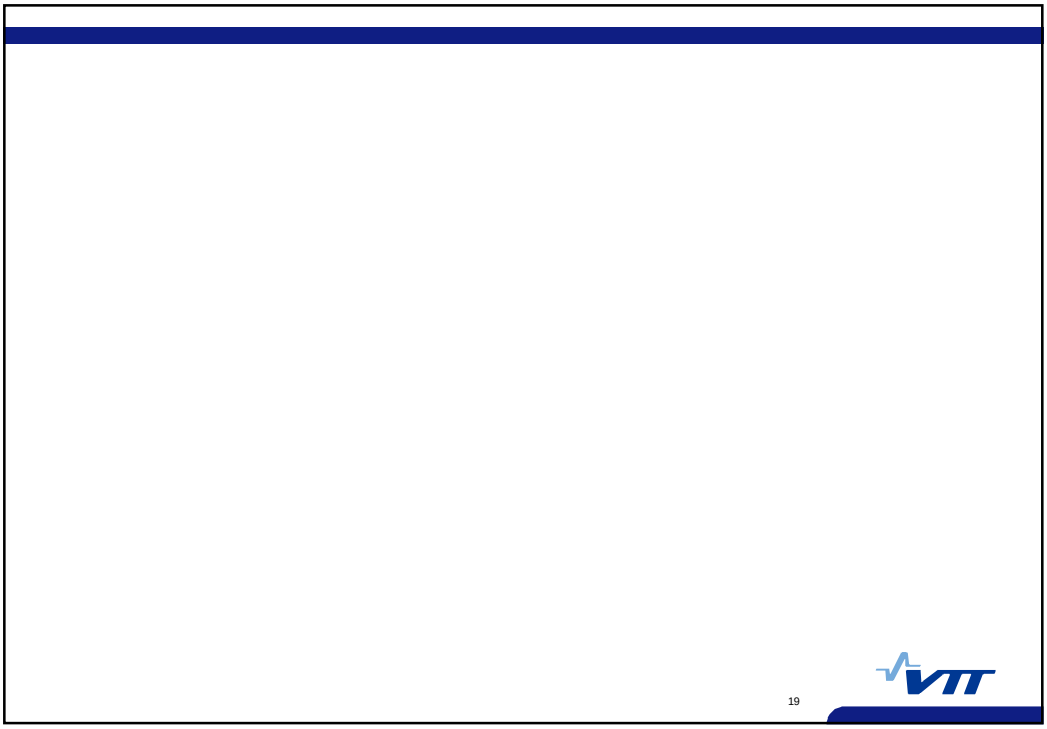
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