Calculation tool, advanced turbine simulations at ice conditions

Welcome

- Anders Wickström, Scandinavian Wind AB
- Ingemar Carlén, Teknikgruppen AB
- Hans Ganander, Teknikgruppen AB

~90 years of wind energy experience

Vasaloppet
Strange hobby!?

Short about the companies behind the presentation

Teknikgruppen

- Small private consultant company since 1982
- National / international R&D
- Design / analysis / measurements
- Inhouse development of analysis tools

Scandinavian Wind

- Independent consultant company since 2012
- Core team of ScanWind / GE Offshore Wind
- Experience of Vidyn simulations since 1991
- Concept and detail turbine design, technology review
- Test centre for cold climate

Short about the VIDYN calculation tool

- Developed since 1984, EU-project bench marks
- Initially for the two Swedish 2-bladed MW turbines
- Fast design tool, to be used in the design process
- Flexible approach regarding concept (model DOFs)
- Onshore, offshore and floating applications
- Linearized rotor blades (non-linear aerostatics) coupled flap-edge-torsion

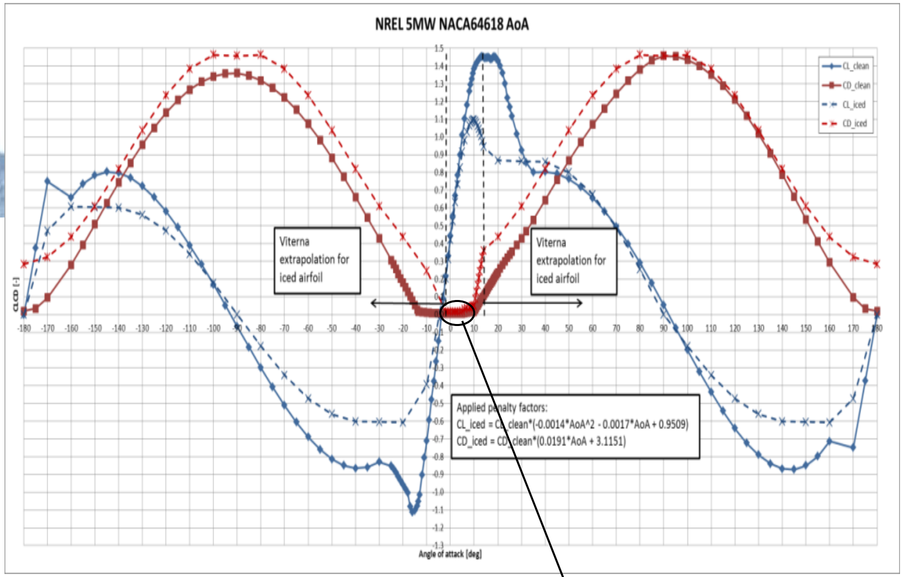
New:

- Individual aero- and mass properties for each blade

3 MW, 1982

4.1 MW, 2011

Ice on blade: Impact on both mass and aerodynamics



~3.5 x Cd_{clean}

- Upcoming update of IEC 61400-1
- Availability of data on iced air foils

Need for understanding of various aspects of rotor icing

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Anders Wickström

Winterwind
2014-02-11

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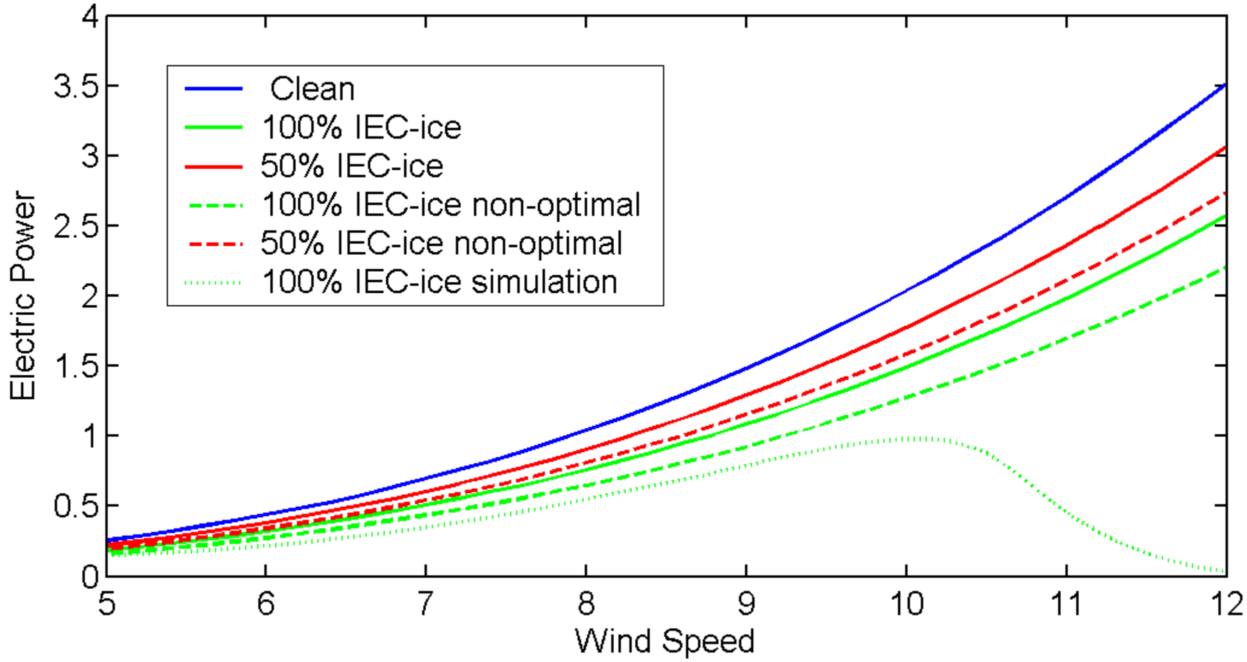
Application I: Production

- Initial analysis using IEC proposal for airfoil icing (3.5 MW *generic* turbine)



Simple controller falls through in case of full application

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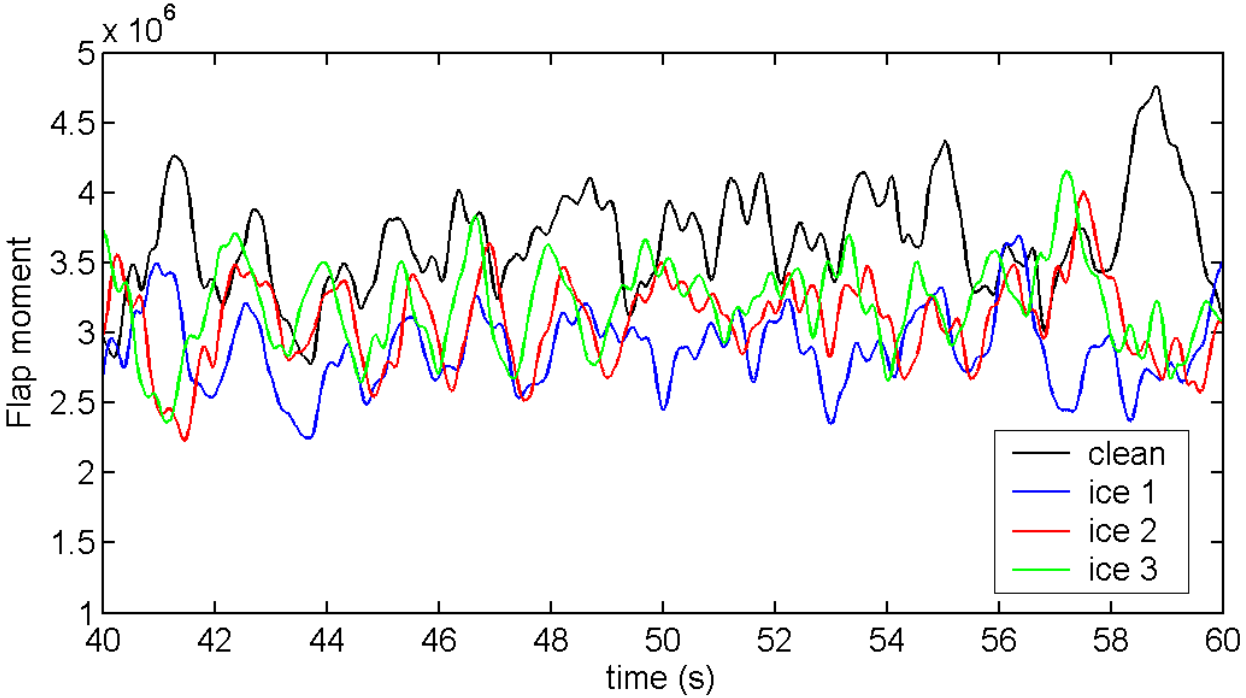
Application II: Load analysis

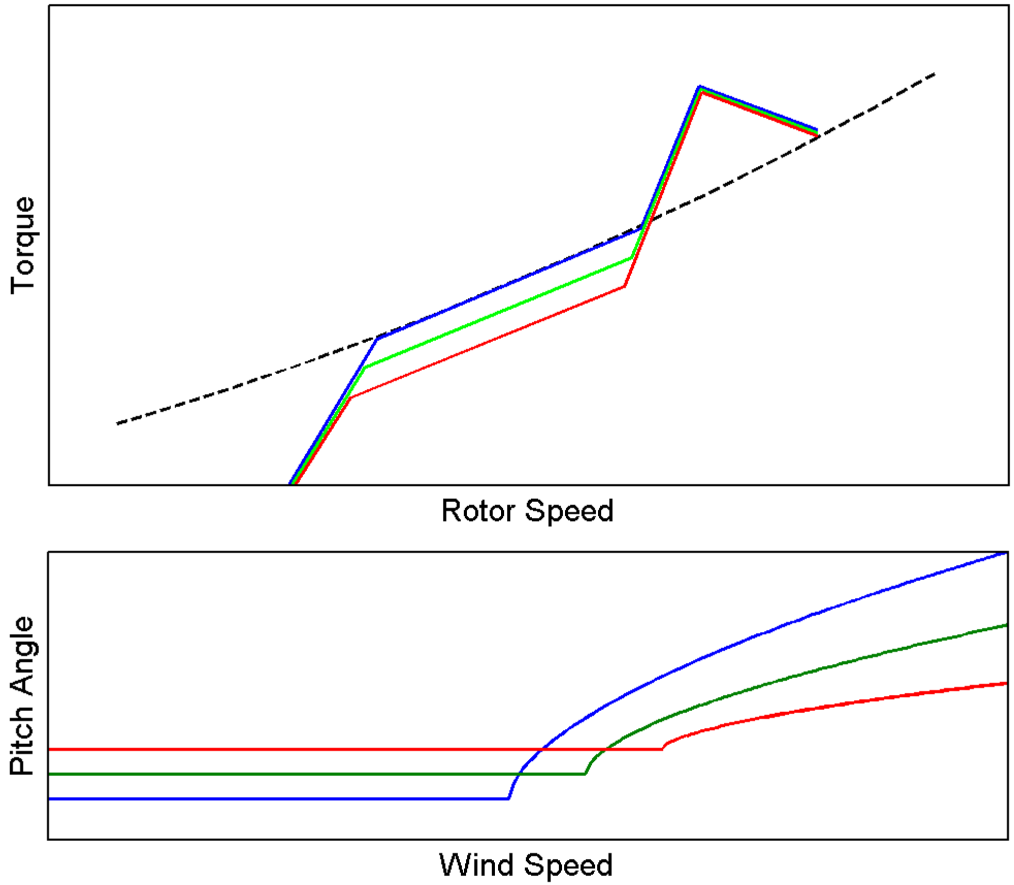
- Initial analysis using IEC proposal for airfoil icing



Less performance might result in less loads

Application III: Ice-Adaptive control design

- Avoid stall operation
- Low torque/wind ratio
  stay idling ?
- Gain adjustments ?
- Wind reference ?
- Other signals/info ?



Adjust turbine control at ice

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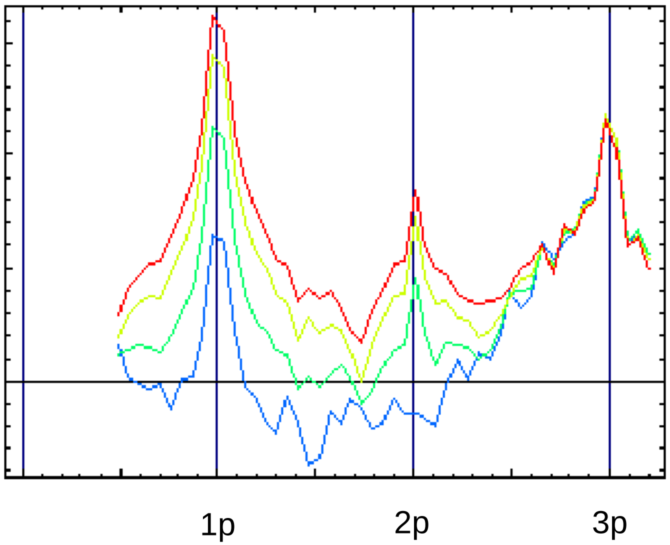
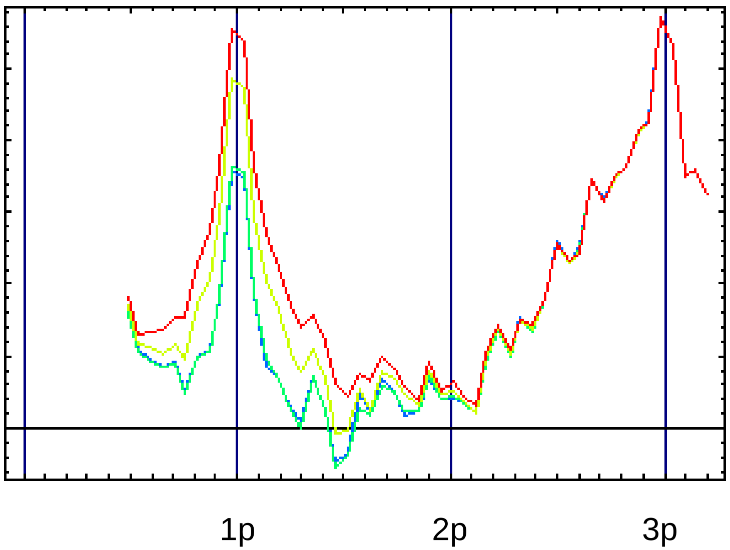
Application IV: Ice detection concept analysis

- Nacelle acceleration *footprint* identification
- Ratios/levels 1p , 2p , 3p
- Tower frequency *band*





Frequency analysis can support identification of ice

Thank you and Questions

Nice feeling!?

Backup

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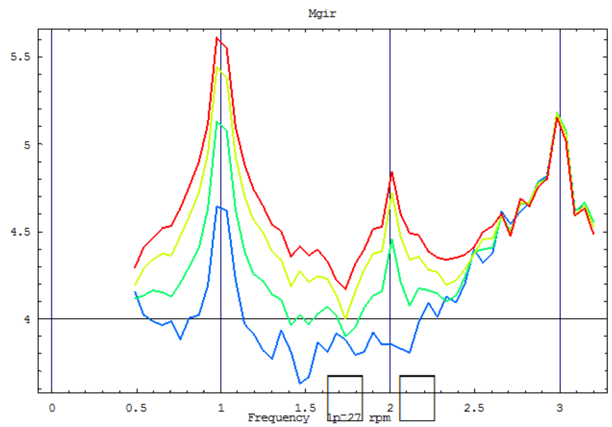
Short on previous ice activities

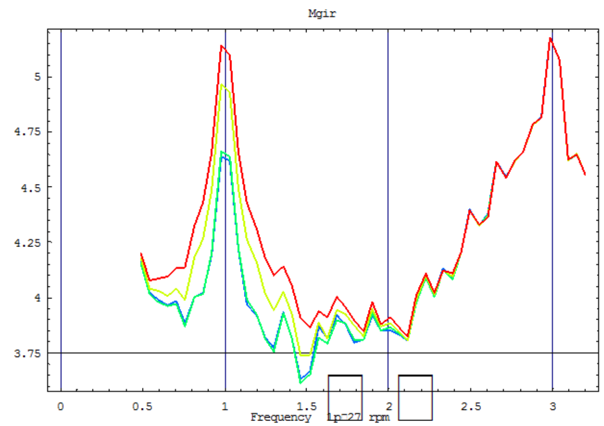
- EU-project: NNE5-2001-00259; New Icetools (NICE)
  - Simple approach regarding ice (aero + mass)
  - Production losses
  - Dynamic consequences at asymmetric rotor properties

PSD of calculated tower top lateral bending moment (Mty) for different values of ice parameters

Pitch differences: **0**,**1**,**2**,**3** [dgr]



Mass imbalance: **0**,**25**,**50**,**75** [kg]



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The Swedish wind turbine research program previous century





Näsudden I, Ø75m, 2MW   Maglarp, Ø80m, 3MW   Zephyr, Ø28m   Näsudden II, Ø80m, 3MW   NWP1000,1MW

The Swedish design at that time was typically two bladed turbines
the hard way of learning structural dynamics

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Turbines designed by Vidyn, last decade

Technical data SW 90-3500

Rated power:	**3,5 MW**
Turbine diameter:	**90 m**
Windclass:	**IEC IA**
Power control:	**Pitch and torque control**
Pitch system:	**Individual electric**
Yaw system:	**Electric**
Rotor:	
No. of blades:	**3**
Swept area:	**6447 m^2**
Rotor speed:	**9 – 20 rpm**
Cut-in wind speed:	**3 m/s**
Cut-out wind speed:	**25 m/s**
Blade:	**LM 43.8p**
Blade material:	**GRP**
Electrical system:	
Generator:	**Direct drive, PM-generator**
Transformer:	**Cast resin dry transformer**
Electrical voltage level :	**690 V / 22 kV**
Frequency	**50 Hz / 60 Hz**
Remote control:	**SW SCADA**

Turbines designed by Vidyn, last decade

Technical data, Nordic 1000

- 1000 kW
- 2-bladed
- Stall control
- Teeter hinge
- Soft yaw control
- Yaw stable > 8 m/s
- Fully damped edge vibrations
- Five in Sweden, about 100 in China

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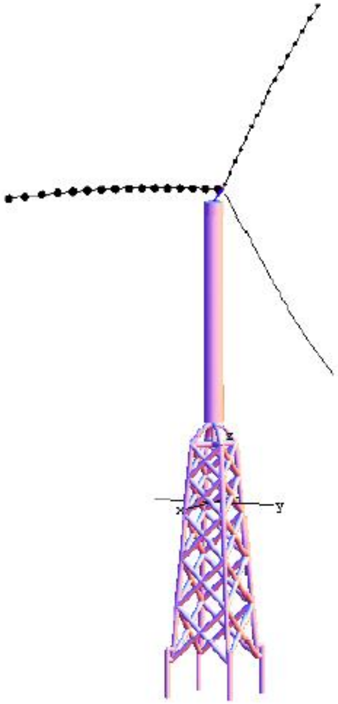
The EU project DOWNVInD

Distant Offshore Wind farms with No Visual Impact in Deep water



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Some characteristics of the VIDYN code

- Symbolic computing for derivation of the dynamic equations
  - geometry
  - degrees of freedom
  - components
- blade modes regarding flap+edge+torsion
- 3D wind and wave input
- Implementation of user control algorithms

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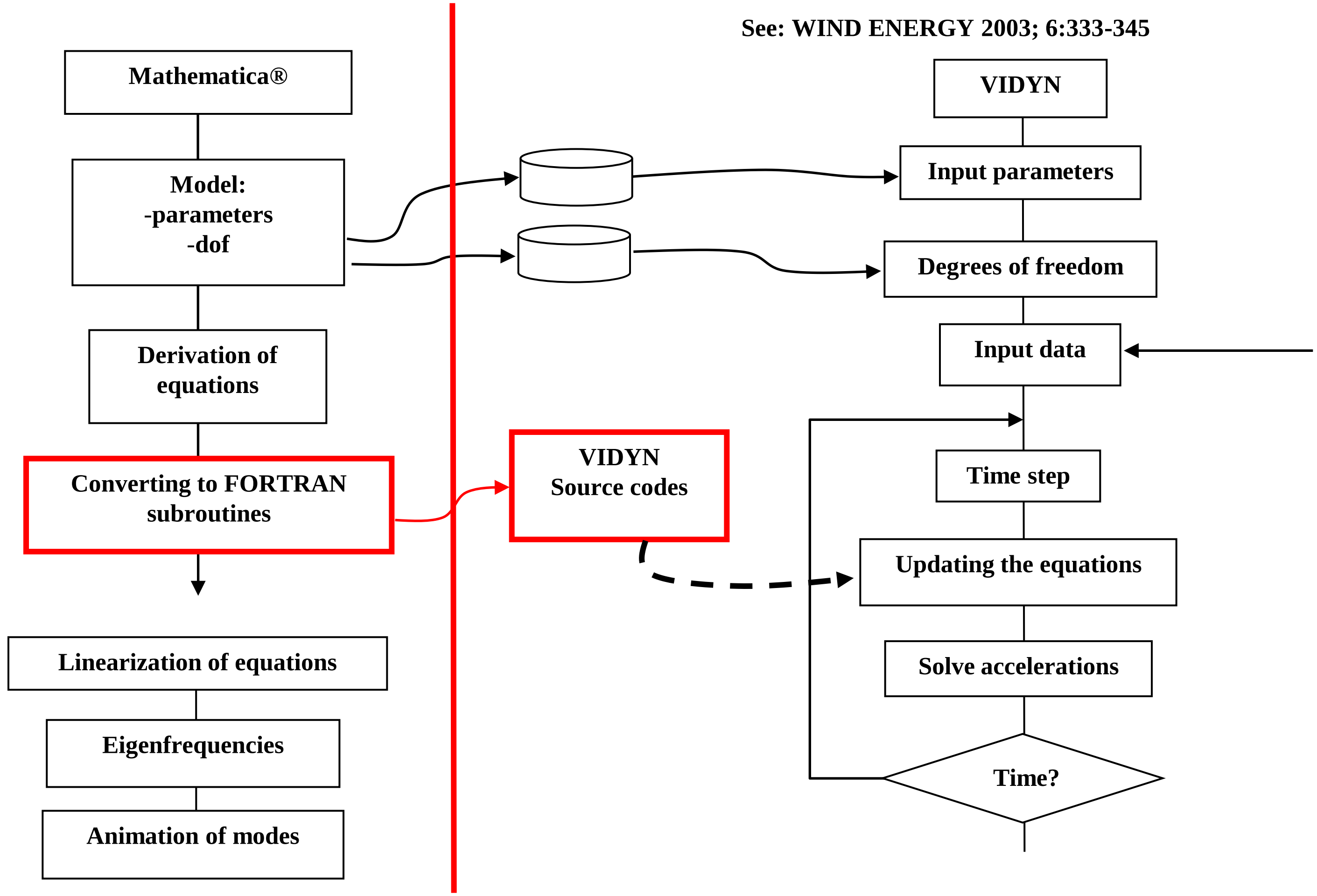
Model development

The VIDYN code

See: WIND ENERGY 2003; 6:333-345



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