Operation of wind parks under icing conditions

A balancing act between production and safety

Winterwind 2015 - Piteå

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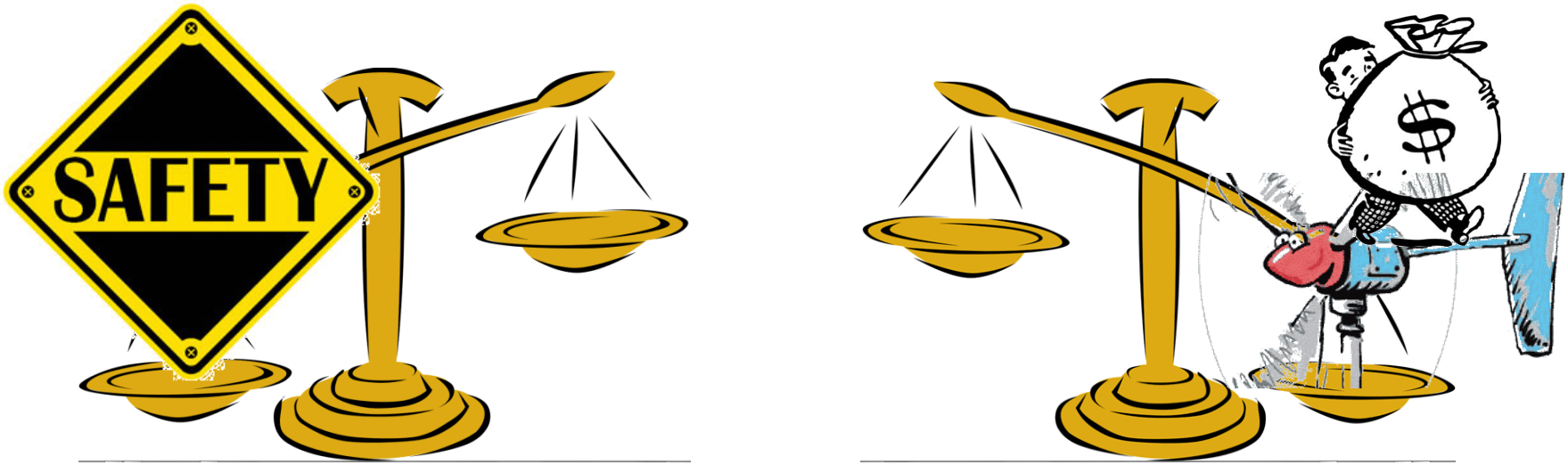
Motivation

Production

Safety

Safety versus production



Safety versus Production

What is the best strategy?

The strategy

…is **site specific** and dependant on:

Things you **cannot change** (easily):

- **Icing conditions** (frequency, loads)
- **Surroundings** (distance to houses and roads)
- **Authorities** (start/stop regulations)

Things you **can influence**:

- Turbine **equipment** (ice detection, de-icing)
- Turbine **operation mode** (stop and restart prodecure)

Icing conditions

IEA ice class	Duration of meteorological icing [% of year]	Duration of instrumental icing [% of year]	Production loss [% of AEP]
5	>10	>20	>20
4	5-10	10-30	10-25
3	3-5	6-15	3-12
2	0.5-3	1-9	0.5-5
1	0-0.5	<1.5	0-0.5

Distances

A wind turbine with anti-icing system in Finnish Lapland. © VTT 2012

Regulations

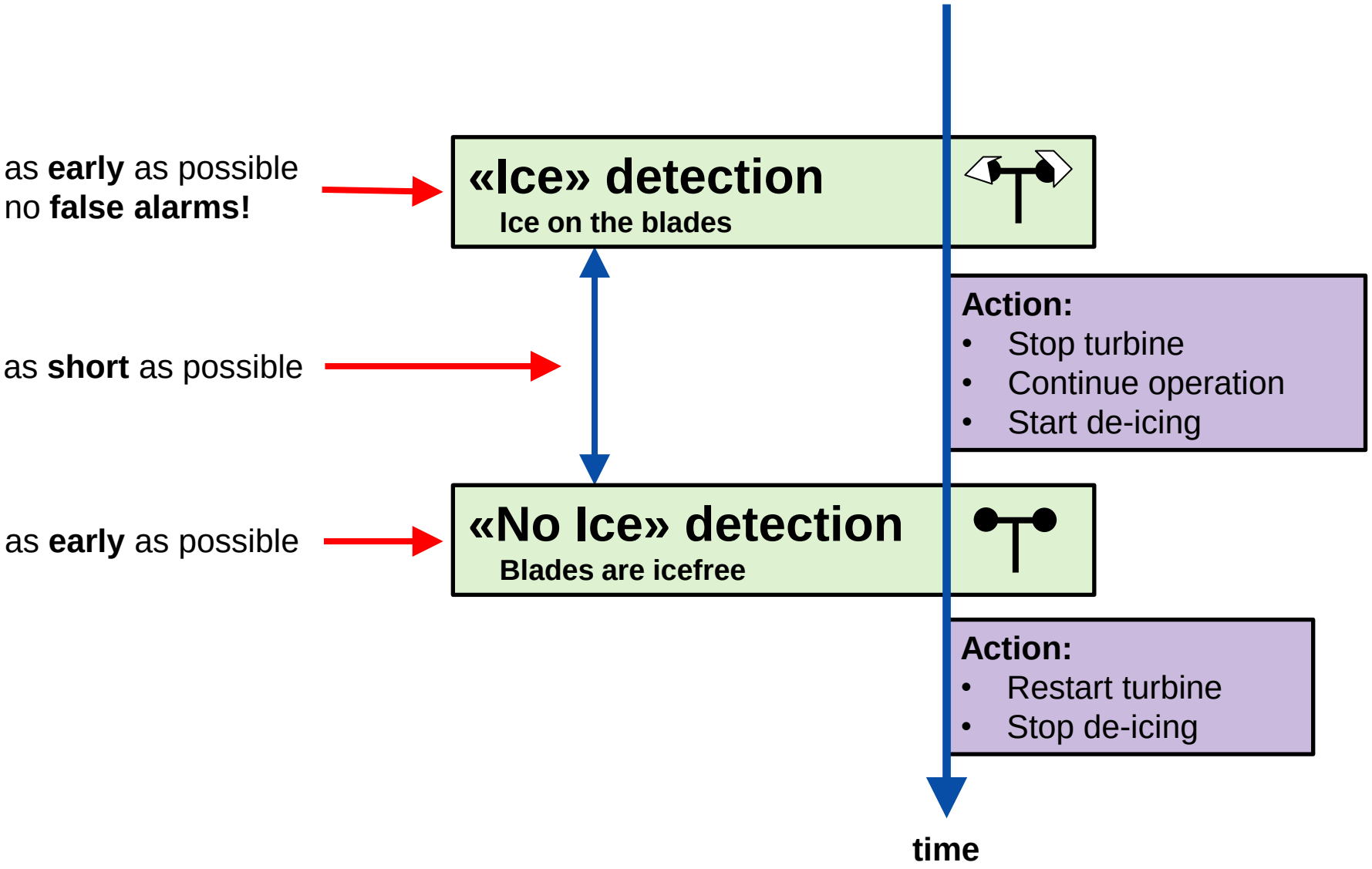
OVERVIEW MATRIX

	Response-options	Moderate icing			Varying icing				Strong icing		
		DENMARK	NETHERLAND	UNITED-KINGDOM	GERMANY	CHINA	SWITZERLAND	AUSTRIA	FINLAND	CANADA	SWEDEN
Population density per km²		130	495	257	229	140	193	102	18	3	23
Assessment of the icing frequency and intensity of the location	Not at all		■	■	■						
	By synoptic consideration	■				■		■			
	Comparison heated/ unheated anemometer						■	■		■	
	Ice Sensor					■	■		■		■
	Ice Map						■		■	■	
	Any other		■								
Definition of the extent of the danger zone for icefall/ icethrow	Not at all			■							
	Empiric formula				■		■	■	■	■	■
	Risk assessment	■	■			■	■	■		■	
	Any other				■						
Which implications/ restrictions arise for the danger zone?	No restrictions	■	■	■	■						
	Signpostings					■	■	■	■	■	
	Confirmation for affected private land							■	■		■
	Agreement to close public roads		■					■	■	■	
	Any other				■						
Is it allowed to operate the turbines with iced-up blades?	Yes						■		■		
	No			■	■	■		■			
		■	■							■	■
Automatic restart?	Yes	■	■			■	■			■	
	No			■				■		■	
	Not specified				■						■
		■	■	■	■	■	■	■	■	■	■
Which requirements are stipulated as to the detection of ice on the turbine	Manufactor solution (ice sensor, power curve)					■	■	■			
	Solution during standstill							■			
	Redundant system							■			
	Not specified				■						
Do authorities dictate/ prescribe the utilisation of a blade heating?	Yes								■		
	No	■	■	■	■	■	■	■		■	■

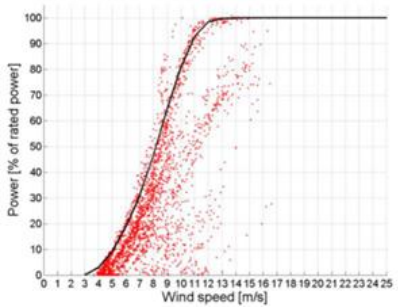
Disclaimer: Completeness of the information and data provided in the given cases and evaluations is excluded. Other cases and examples are feasible.

Turbine equipment and operation mode

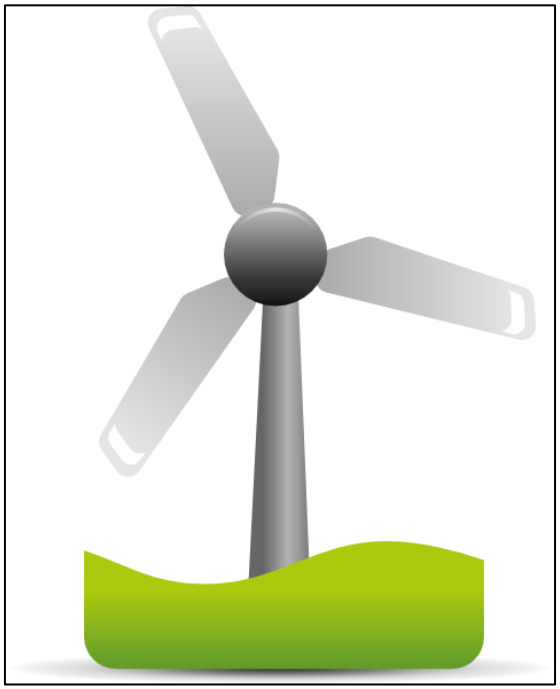
Ice and «no ice» detection



Not so efficient strategy



Ice detection
(power curve)



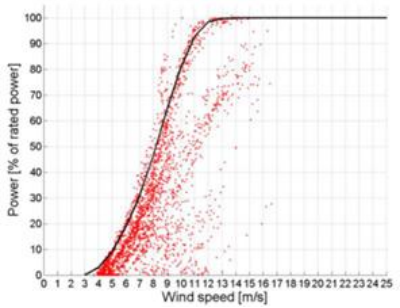
Manual restart

Automatic
turbine stop

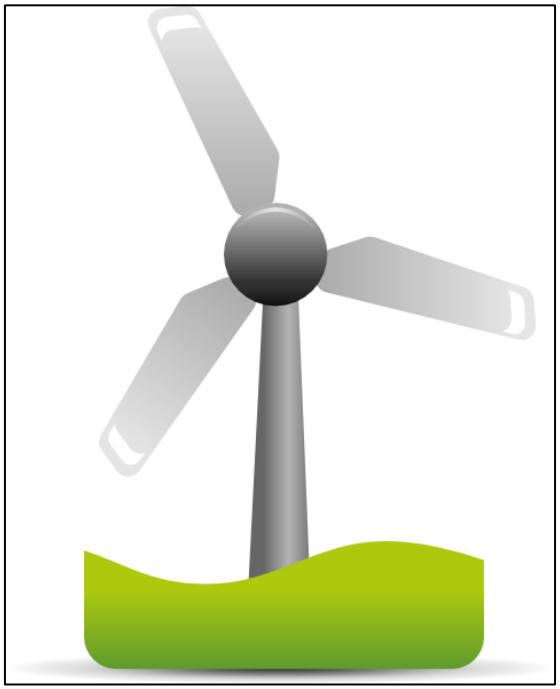
Ice melting

Visual inspection
(«no ice» detection)

More efficient strategy



Ice detection
(power curve)



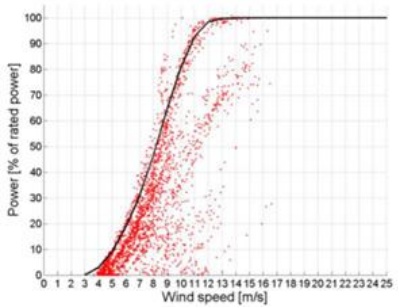
Automatic restart

Automatic
turbine stop

Ice melting

Automatic
«no ice» detection

Even more efficient strategy



Ice detectio
(power curve

omatic restart

Reliable technology required for
«Ice» detection & «No ice» detection

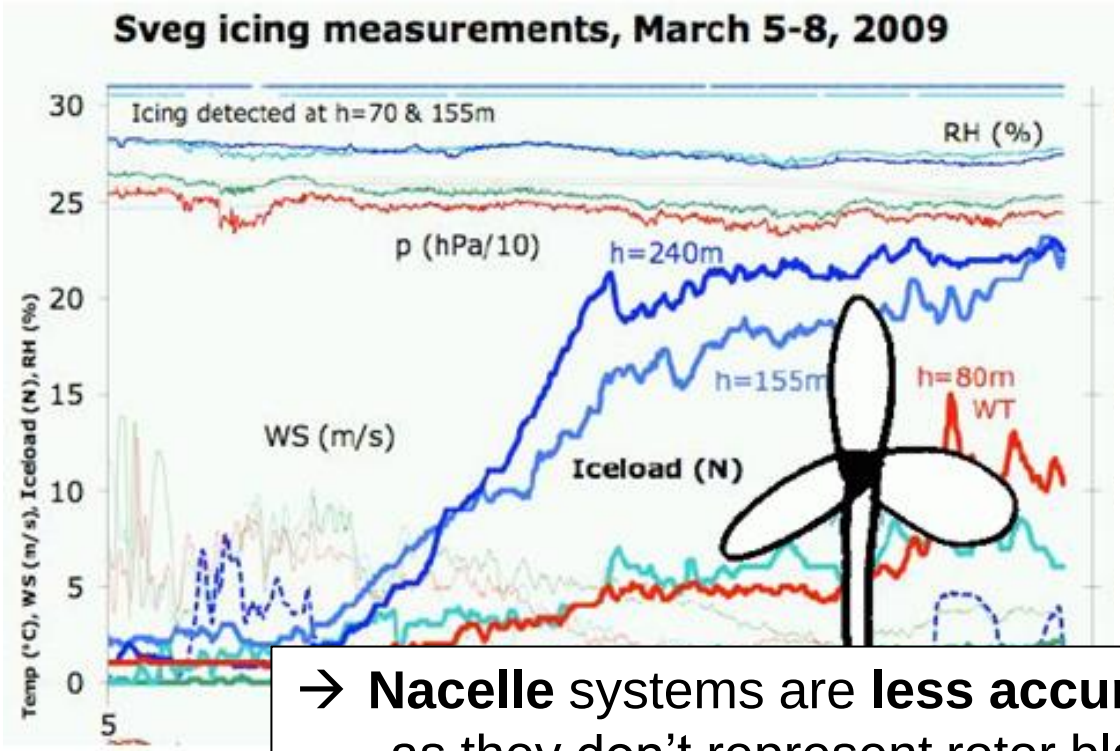
Automatic
turbine stop

De icing (heating)

Automatic
«no ice» detection

«Ice» and «no ice» detection

- Option 1: Point measurements at the **nacelle**
- Option 2: Measurements at the **rotor blade**



Ice load

→ **Nacelle** systems are **less accurate** as they don't represent rotor blade

«Ice» detection options

Nacelle based systems

- **Environmental** conditions (temperature, humidity)
- **Stop of** anemometer or wind vane
- **Ultrasonic** probes
- **IR reflection**
- **Load cells**
- **.....**

→ Nacelle conditions do **not represent rotor blade**

→ Big differences in **technical maturity**

→ **Inter-comparisons and REX** available

→ **No new systems** being developed

«Ice» detection options

Rotor blade systems

- **Operational data** (power curve, pitch angle)
- **Accelerators/Strain Gauges** (pitch data required)
- **Radio Frequency Electromagnetic Fields RFID**
- **Impedance/capacitance sensing technology**
- **.....**

→ Big differences in **technical maturity**

→ **Robust systems** available

→ **Hardly any inter-comparisons or REX** available

→ **New developments**

→ **Low acceptance by authoritites**

«No ice» detection options

Nacelle

- Temperature **above 0° C** for xx hours
- Anemometer or wind vane **resume operation**
- **Load cell** does not indicate ice anymore

Rotor blade

- Operational data → requires turbine **operation**
- Accelerators/Strain Gauges
- Impedance/capacitance
- RFID

→ **More focus on «no ice» detection required**

Wrap up

- The strategy “production vs. safety” is always **site specific**
- **Turbine equipment** and **control strategy** have a lot of room for improvement (automatic restart)
- **Nacelle** based ice detection systems are **less accurate**
- **Robust systems for “ice” detection** on rotor blade available, timing can be improved
- “No ice” detection has **to be more in focus of developments**
- Nacelle systems **not suitable** for “no ice” detection
- There is a need for **field studies** and **inter-comparisons** of rotor blade systems


Thank you for your attention!
Meteotest
Vástan
Östan
Hauguil
Helm
Aill na Searrach
Wisperwind
Galerne
Noroet
Föhn
Böhmwind
Höllentäler
Krowotenwind
Jinovec
Halny
Bise
Drévent
Joran
Ora
Furiani
Tramuntana
Austru
Košava
Karajo
Gornjak
Vardarac
Crivăț
Suchowej
Gallego
Criador
Cers
Mistral
Libeccio
Marin
Garbé
Xaloc
Xaroco
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