RISK OF ICEFALL

in the international Context

Winterwind
INTERNATIONAL WIND ENERGY CONFERENCE

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01 HISTORICAL BACKGROUND

02 RISK OF ICE-FALL IN AUSTRIA

03 INTERNATIONAL COMPARISON

Wind Energy in Cold Climates (WECO Study, 2000)

- Investigation of hazard potential through field investigations and observations
- For wind turbines up to 60 m diameter → maximum distances ≤ 100m
- Turbines were not switched off → No distinction between 'ice-throw' and 'ice-fall'

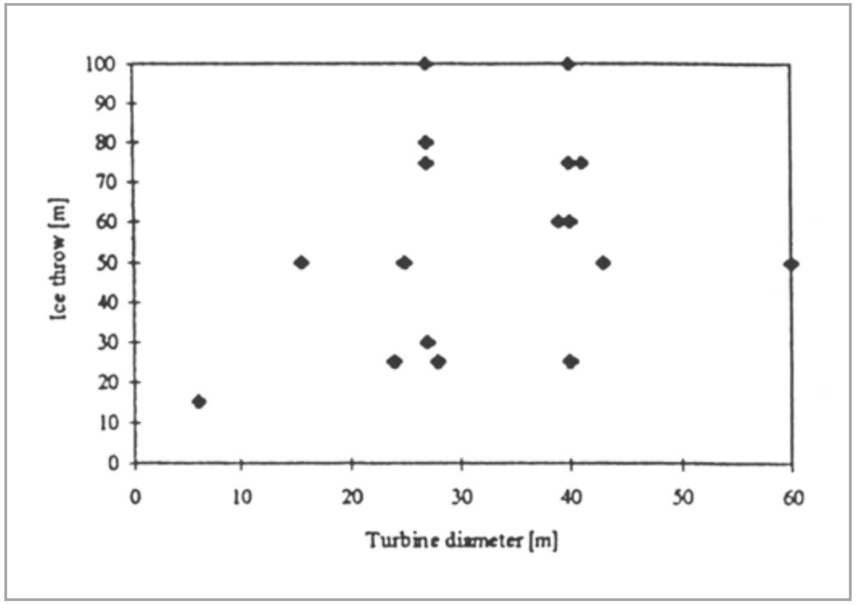

Fig.: Distance of ice fragments as a function of the diameter of the turbine

DEWI - Risk analysis of Ice-Throw (Seifert, 2003)

- Initial distinction between ‘ice-throw’ and ‘ice-fall’
- Creation of an empirical formulas for the maximum distance based on the result of WECO study and additional observations (Tauernwindfarm)

Ice-fall→ $d=\frac{\frac{D}{2}+H}{15} * \mathbf{v}$ Ice-throw→ d=1,5 x (D+H)

- Comparison between empirical calculation using Seifert formula and observations showed an overestimation in the calculation

- Situation described though formulas reflects the worst case scenario during icing conditions
- In fact, detailed risk assessment is required
- Modelling of probability of hits per m^2 and year (see Figure)

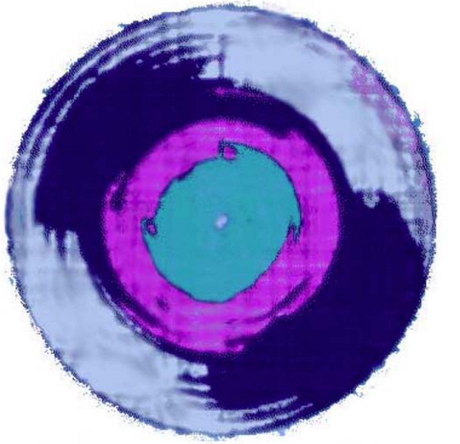

Fig.: Probability of hits per m^2 and year

Gütsch Study (Meteotest 2007)

- Investigation of an Enercon-E40 in 2.300 above sea level in Switzerland
- Automatic mode for the de-icing of the rotor blades and restart of the WKA
- No distinction between „ice-throw“ and „ice-fall“ possible
- Observation as to size and weight of ice fragments, distances, direction

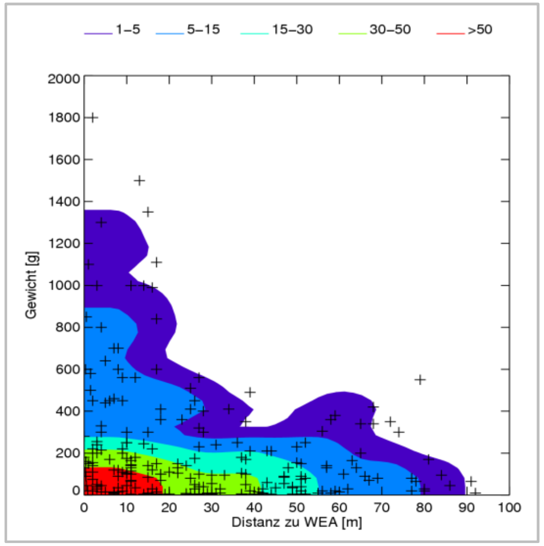

Fig.: Weight vs. distance according to the number of ice-pieces

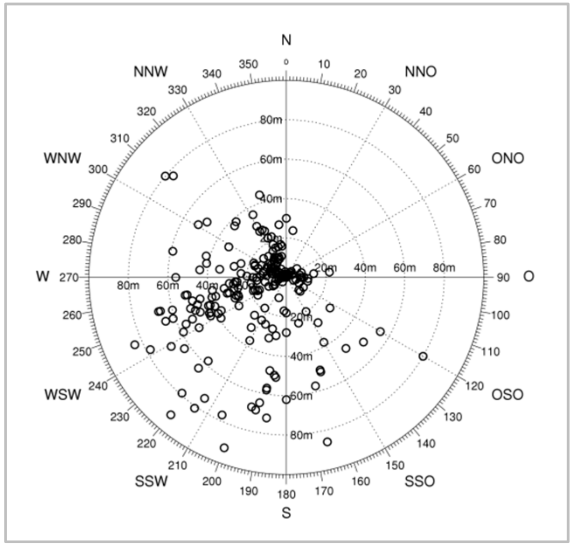

Fig.: Distribution of ice throw around the wind turbine

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Permission practice in Austria until 2009

- Condition in the notification of approval: No “Ice-throw”, only “Ice-fall”
- Minimum distance to public roads through Seifert Formula (unless possibility to close)
- Land utilization agreement required only for (horizontally) swept rotor area

Precedent WF Pöttelsdorf in Burgenland

Withdrawal of approval for operation of a SWT (D_R = 82m)

- Location with very moderate icing (3-5x events per year)
- Owner of adjacent land plot (~50m away from the turbine tower) argued that he cannot proceed with his farming activities during winter
- Approval from cantonal government in 2009
- In 2010 High Administrative Court: WT has to be dismantled
- Remark: Different decision regarding the installation of a telecom mast

Fig.: WF Pöttelsdorf

Necessity for Risk assessment

- Research Project Energiewerkstatt et al.
  - Comprehensive Observations: Trajectories…
  - Modelling of risk zones
- Probability consideration
  - Parameter to be considered:
    - Size of Turbine
    - Meteorology at the site: Frequency/intensity of icing events, frequency of strong winds, wind rose
    - Danger of ice pieces (i.e. size) for human beings
    - Probability of presence of people in the surrounding
- Comparison of the risk with values of commonly accepted risk
  - 1x 10^{-5} (i.e. the risk for death during office works)

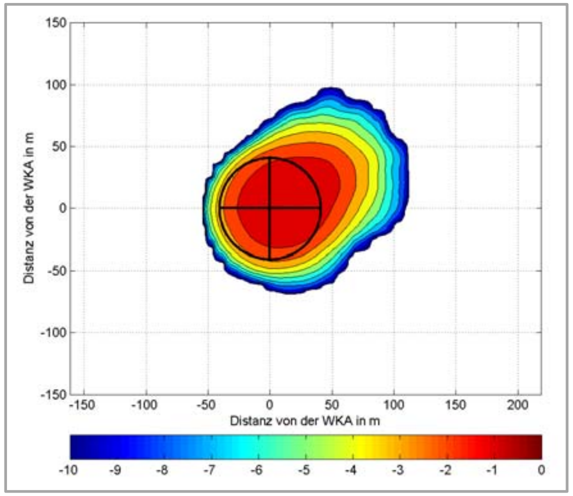

Fig.: Example for risk zone

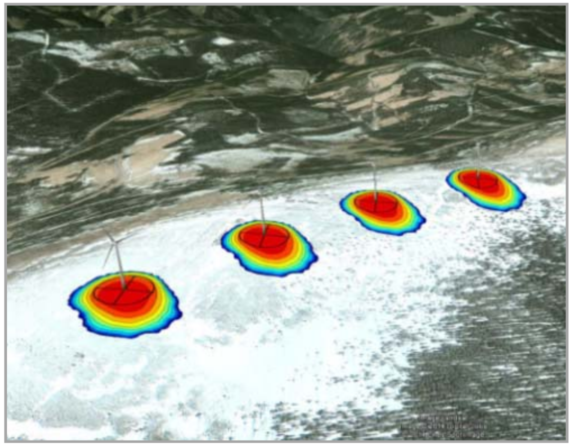

Fig.: Example for a risk zone in the Alps

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Current legislative requirements

- Land utilization agreements:
  - Necessary distance to next property line: Blade-tip-height + 20%
- Additionally, Risk Assessment for public infrastructure
- Manifold conditions in approval to build
  - Two independent ice detection systems
  - Automatic shut-down of the WT in case of ice accretion
  - Automatic restart is not allowed; visual inspection through wind farm attendant
  - Signposting: Warnings Signs, Flashing Lights…

→ Interesting for Austria to have an international comparison!

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Direct Target:

- Working out the different approaches to elaborate overview on the different rules and regulations as to the assessment of the “danger due to ice-fall“

Indirect Target:

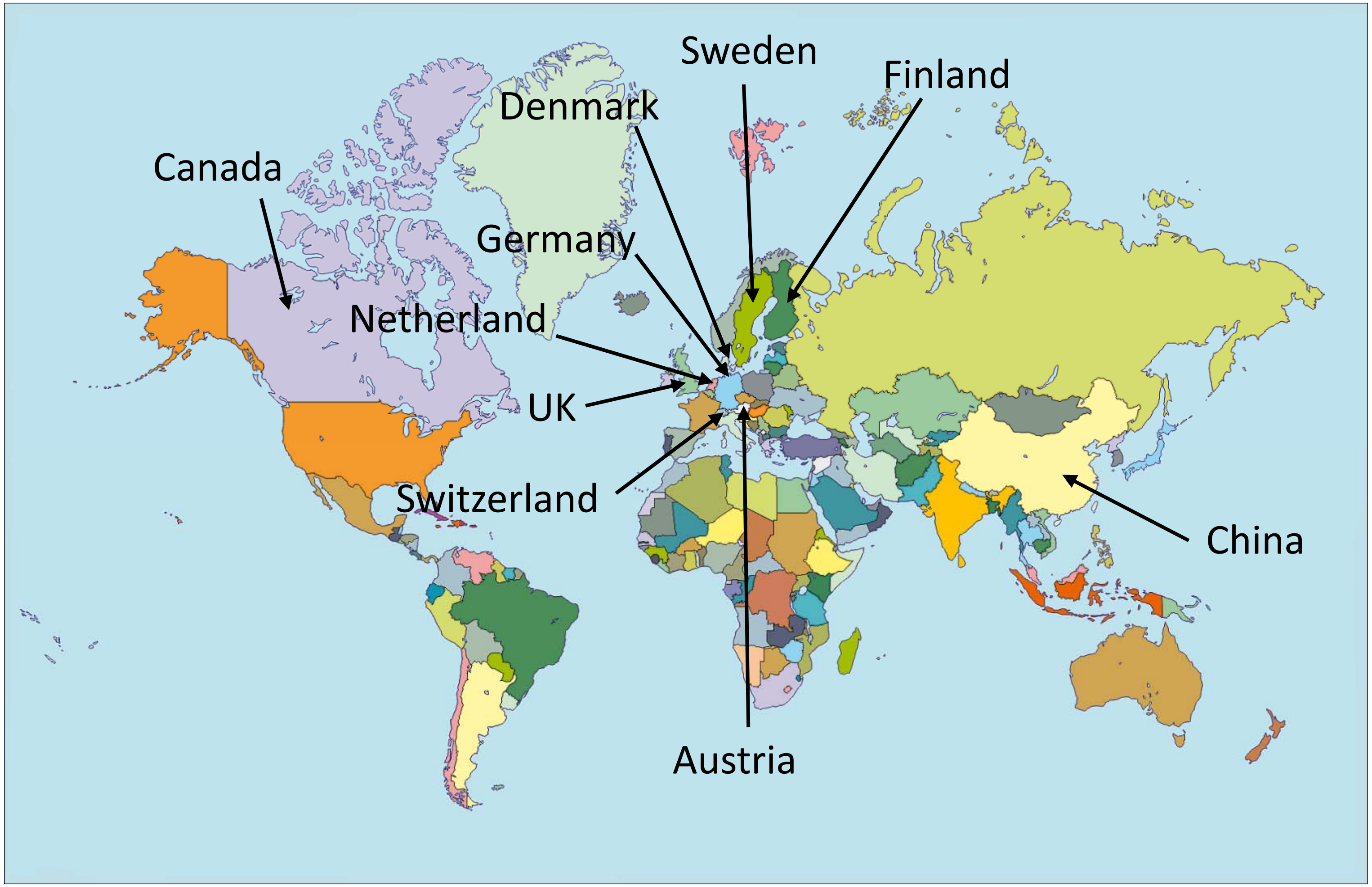
- Paving the way to more transparency
- Common, international standard for ice throw

Method:

- Development of a questionnaire about „Risk of ice-fall“
  - Starting point is the Austrian perspective
- Questions regarding requirements as to:
  - Ice-detection, extent of danger area, operational modes…
- Submitted to the partners in IEA Task 19 ‘Wind Energy in Cold Climates’
- In order to cover different approaches in cantons → asking for three different cases

Return of questionnaires

Thanks for the contributions!



OVERVIEW MATRIX

	Response-options	DENMARK	NETHERLAND	UNITED-KINGDOM	GERMANY	CHINA	SWITZERLAND	AUSTRIA	FINLAND	CANADA	SWEDEN
		Moderate icing			Varying icing				Strong icing		
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		X	X	X						
	By synoptic consideration	X				X		X			
	Comparison heated/ unheated anemometer						X	X		X	
	Ice Sensor					X	X		X		X
	Ice Map						X		X	X	
	Any other		X								
Definition of the extent of the danger zone for icefall/ icethrow	Not at all			X							
	Empiric formula				X		X	X	X	X	X
	Risk assessment	X	X			X	X	X		X	
	Any other				X						
Which implications/ restrictions arise for the danger zone?	No restrictions	X	X	X	X						
	Signpostings					X	X	X	X	X	
	Confirmation for affected private land							X	X		X
	Agreement to close public roads		X					X	X	X	
	Any other				X						
Is it allowed to operate the turbines with iced-up blades?	Yes						X		X		
	No			X	X	X		X			
	Both	X	X							X	X
Is an automatic restart allowed after de icing or is an verification at the site required?	Yes	X	X			X	X			X	
	No			X				X		X	
	Not specified				X						X
Which requirements are stipulated as to the detection of ice on the turbine	None	X	X	X	X		X		X	X	X
	Manufactor solution (ice sensor, power curve)					X	X	X			
	Solution during standstill							X			
	Redundant system							X			
	Not specified				X						
Do authorities dictate/ prescribe the utilisation of a blade heating?	Yes								X		
	No	X	X	X	X	X	X	X	X	X	X

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

Countries with moderate icing conditions

- Denmark (1 questionnaire)
  - Necessity for risk assessment (despite of only moderate icing)
    - Report (Risø-R-1788): Treats risk assessment of siting WT close to highways
  - No restrictions as to safeguarding of danger areas (e.g. confirmation for affected private land plots, agreement to close public roads)
  - No restrictions as to ice detection during operation
- Netherland (1 questionnaire)
  - Assessment of icing frequency or intensity with CFD-Model (Meso scale data)
  - Necessity for risk assessment (despite of only moderate icing)
- United Kingdom (1 questionnaire)
  - Assessment of the danger area is not required
  - No restrictions as to safeguarding of danger areas
  - Not allowed to operate the turbines with iced-up blades

Countries with diverse icing conditions

- Germany (3 questionnaires)
  - No assessment of icing frequency or intensity
  - Definition of the danger area through empiric formulas (Seifert)
  - No land utilization agreement necessary with neighbours
- China (1 questionnaire)
  - Necessity for risk assessment
  - Assessment of icing frequency or intensity by the use of sensors or synoptic considerations
  - Turbines need to be shut-down in case of iced-up blades
- Switzerland (1 questionnaire)
  - Different approaches as to assessment of site-specific icing conditions (incl. ice map)
  - Risk assessments and empiric formulas
  - Allowance to operate WT with iced-up blades

Countries with strong icing conditions

- Finland (1 questionnaires)
  - Ice sensors and ice map to assess the site-specific icing conditions
  - Definition of the danger area through empiric formulas ($H_{bladetip}$ + safety margin)
  - Allowance to operate WT with iced-up blades, if not very close to houses or roads
  - Utilisation of a blade heating system is prescribed, if public roads are in the risk area
- Canada (1 questionnaire)
  - Utilization of empiric formulas for the definition of the danger area
  - Tailor-made solution as to operational mode (different approach for WT near settlements than for more remote ones)
- Sweden (1 questionnaires)
  - Definition of the danger area through empiric formulas (Seifert), recommendation to do a further risk assessment, if people live there
  - General recommendations as to the safeguarding of the danger zone
  - Requirement to detect icing on the WT in a reliable way.

Conclusions

- Results from the survey:
  - Far away from a uniform licensing practice in the evaluated countries (huge differences even in between different cantons)
  - No interrelation visible in between legislative requirements, population density and icing conditions
- Next steps:
  - Awareness among the authorities
  - Further improvement of technical solutions and meteorological models
  - WT manufacturers have to assume their responsibilities

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Thanks for your Attention.