Standardization of Input Parameters for Ice-Throw / Ice-Fall Risk Assessments

Andreas Krenn

Energiewerkstatt e.V.

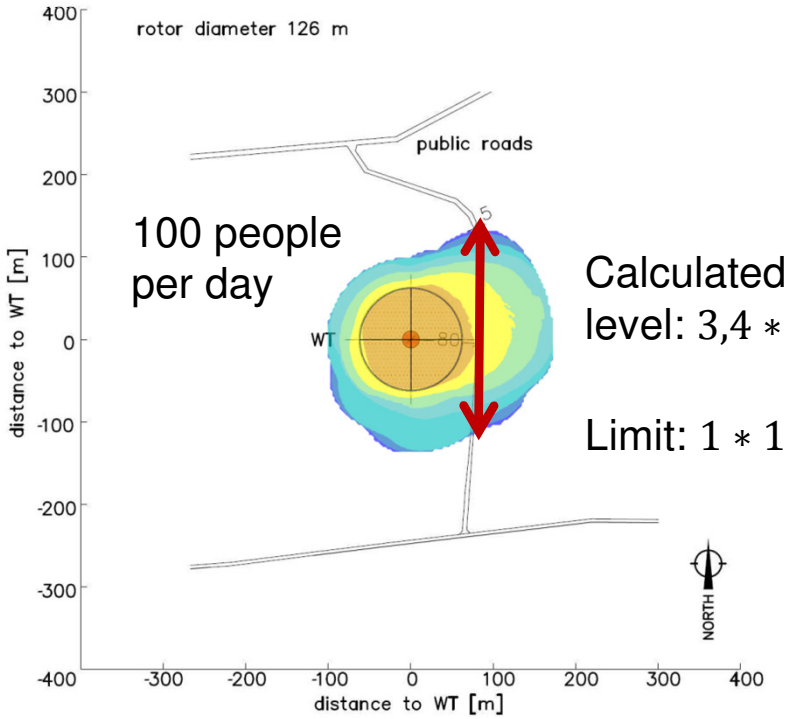
Co-Authors: J. Klappacher, N. Weber, S. Barup, S. Müller, A. Hoffmann, T. Weidl, N. Stoffels, T. Hahm, R. Bredesen, M. Lannic

01 PROJECT MOTIVATION

02 RESULTS

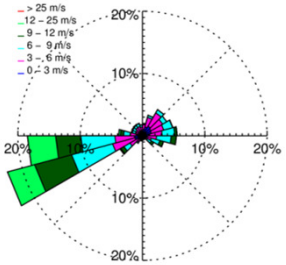
03 OUTLOOK

Prevalent approach of ice-fall risk assessments



Calculated Risk level: $3{,}4 * 10^{-5}$

Limit: $1 * 10^{-6}$



Wind Data

Dimensions	Mass	Numbers
3x5x10cm	90g	385
3x9x10cm	243g	69
10x13x20cm	1,6kg	44
16x19x20cm	5,5kg	2

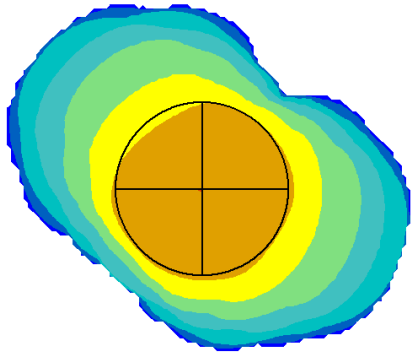
Icing Data

<u>BUT:</u> Assumptions and uncertainties!

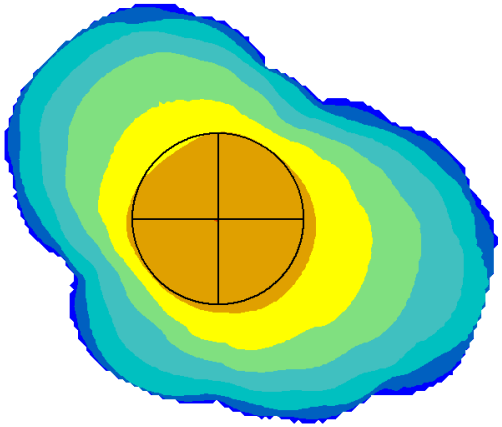
- Mathematical model
- Data basis for the location
- Risk Assessment

energiewerkstatt

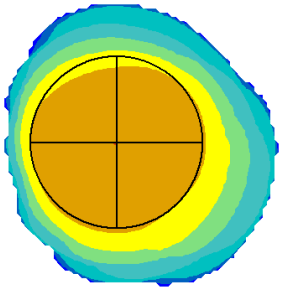
Wind speed data



10 Minutes averages,
Measuring height = 50m



3 sec. Maximum readings
Measuring height = 50m



1-h Reanalysis Data
Measuring height = 50m

Wind Data	Max. Wind speed [m]	Max Range [m]	Average hits per sqm
10 Minutes averages	21	154	$9{,}7 * 10^{-3}$
3 Seconds maximum readings	27	180	$8{,}4 * 10^{-3}$
1 Hour reanalysis Dara	17	118	$1{,}6 * 10^{-2}$

Size and weight distributions

	Dimensions	Mass	Numbers
50 %	3x4x8cm	86g	250
35 %	5x8x10cm	240g	175
10 %	5x10x50cm	1,5kg	50
5 %	3x20x100cm	5,4kg	25

	Dimensions	Mass	Numbers
77 %	3x5x10cm	90g	385
14 %	3x9x10cm	243g	69
9 %	10x13x20cm	1,6kg	44
0,4 %	16x19x20cm	5,5kg	2

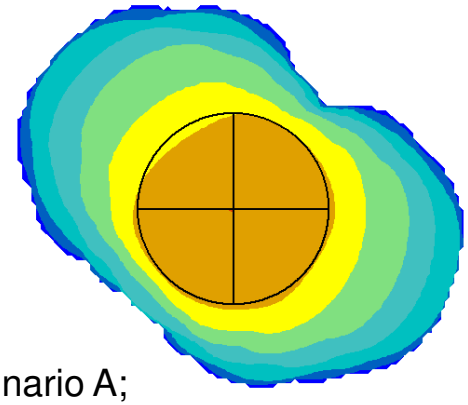


Fig.: Scenario A;
Dmax = 154m

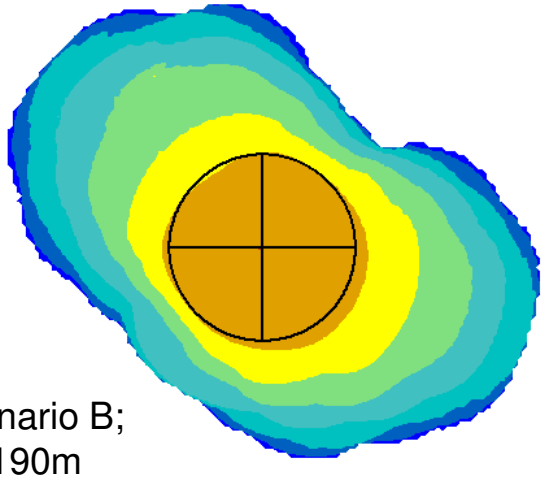


Fig.: Scenario B;
Dmax = 190m

Motivation and Project Objective

Large deviations in:

- Requirements of national / regional authorities how to assess the risk
- Stipulation of mitigation measures / regulatory requirements
- Methodologies / results of individual consultants

Project Objective:

- International guidelines/recommendations for the elaboration of ice-throw / ice-fall risk assessments
- Awareness of authorities and wind energy community about crucial parameters → Paving the way to more transparency

Project Organisation

8 international Partners (with different background):

- 4x Consultants
- 2x Certification bodies
- 1x WF operator
- 1x OEM

TÜV Süd

Under the umbrella of IEA Wind Task 19:

- https://www.ieawind.org/task_19.html
- Publication of International Guidelines (not a standard)

Methodology

Unbundling in three separate sub-processes:

- Details of the mathematical model
- Relevant data basis (wind and icing)
- Risk aspects

} Phase I (today's topic)

} Phase II (ongoing)

Working approach:

- Cross-comparisons on predefined case scenarios
- Sensitivity analysis with different parameters

Identification of so-called **Highly Recommended Aspects**

(Recommendations about the 'Must-haves')

01 PROJECT MOTIVATION

02 RESULTS

03 OUTLOOK

Mathematical Model

(i.e. statistical trajectory model)

Highly recommended aspects for the trajectory model:

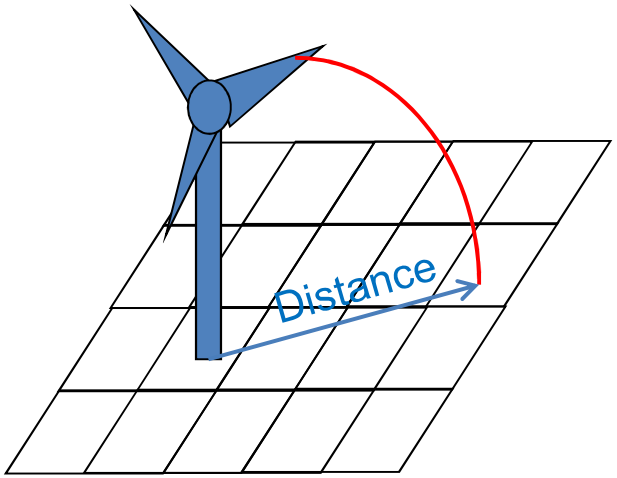


Fig.: Calculation of Trajectories

- Turbine parameters:
  - Hub height, rotor diameter, operational mode.
- Consider drag! (Lift can be neglected.)
- Topography in case of complex terrain (DGM or via post-processing)
- Physical parameters:
  - Air density, vertical wind profile, radial distribution of ice on the blade, no. of relevant fragments.

Wind Data Basis

Highly recommended aspects:

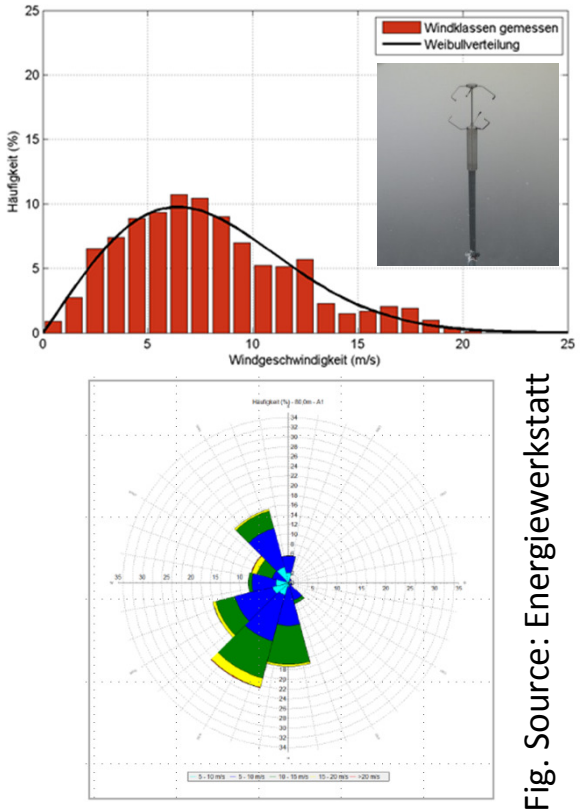


Fig. Source: Energiewerkstatt

- Based on 10 minutes' averaging, covering at least one icing season:
  - Wind speed & direction
- Long term correction (if available dataset cannot be regarded as a long term)
- Representative for the turbine location (horizontal and vertical extrapolation)
  - Wind shear
- Wind statistics representative for periods when icing and melting may occur
  - Filtering shall not be done to narrow!

Icing Data Basis

Estimation of Amount of ice fragments:

1. Scaling of in situ ice fall / throw observations (e.g. Gütsch, Icethrower, R.Ice…)

$$N_{site} = N_{obs} * sf_{ice} * sf_{rotor} * sf_{op}$$

   - N_{site}…amount of ice at the site of interest
   - N_{obs}…amount of ice from site measurements
   - sf_{ice} , sf_{rotor} , sf_{op}…scaling factors for site icing conditions, rotor dimensions and operational mode

2. Ice load distribution formula (e.g. IEC 61400-1 Ed.4): Not site-specific!
3. Ice accretion simulations: Future potential?!

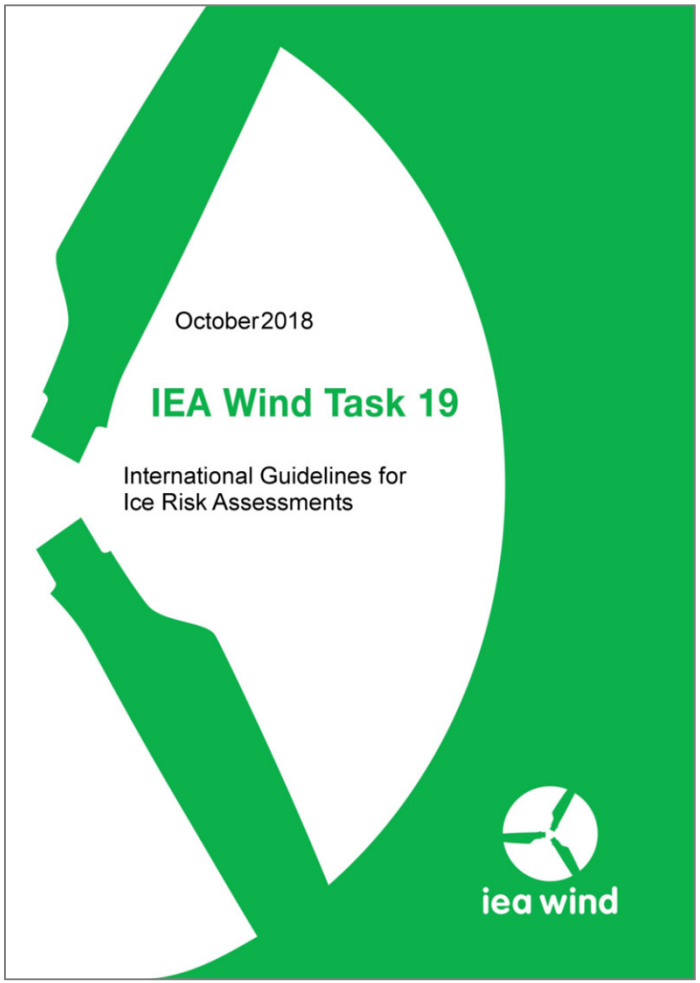
01 PROJECT MOTIVATION

02 RESULTS

03 OUTLOOK

Aspects of Risk Assessment (Phase II)

- General approach of risk assessment
  - ALARP / MEM vs. LIRA
  - Individual risk vs. collective risk
- Thresholds and factors of uncertainty
  - Kinetic energy vs. weight of relevant ice fragments
  - Acceptable risk levels for different stakeholders
- Mitigation measures (warning signs, flashing lights…)
  - Efficiency / effectiveness of the individual measures
  - Reduction ration: Which order of magnitude?



International Guidelines for the Elaboration of Ice-fall / Ice-throw Risk Assessments

(To be published in Fall 2018)

Contact details:

Andreas.Krenn@energiewerkstatt.org

+43 7746 28212 17

Thanks for your Attention.