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CONSULTING ENGINEERS FOR RENEWABLE ENERGY

IEA Wind TCP Task 19

# International Recommendations for Ice Fall and Ice Throw Risk Assessment

## Edition 2 – What's new?

# “To save all we must dare all.”

Friedrich Schiller, Fiesco‘s Conspiracy at Genoa

# Agenda

1. **Starting point for the revision process**
2. Effect of WTG and IPS operating modes on icing
3. Risk acceptance with respect to background risk levels
4. Placement of warning signs
5. Proposal of a general “Ice Fall Zone“ warning sign

# Starting point for the revision process

- First edition published in October 2018
- Since then widely adopted standard within wind community
- In-depth treatment of site-specific icing risks enables less excessive distance requirements
  - ➢ Opening up new opportunities

# Starting point for the revision process

- Division of risk assessment process into
  - Mathematical model for trajectories
  - Site- and turbine-specific icing input data
  - Risk analysis and evaluation
    - ➢ Process as is remains unchanged
- Amendments in the form of
  - More detailed discussions
  - Additional background information/references

# Effect of WTG and IPS operating modes on icing

- Numerous possible combinations of operating modes of WTG and IPS when icing occurs
  - WTG in operation
  - IPS in anti-icing mode
  - No active IPS / IPS inactive
  - WTG stand-still/idling
  - IPS in de-icing mode
- Number of ice pieces falling / being thrown also highly dependent on location and turbine itself
  - IEA icing class
  - WTG make and model

# Effect of WTG and IPS operating modes on icing

- Table for number of ice pieces updated by information on operating turbines w/ and w/o active IPS
- (a), (b) and (d) obtained by measurement campaign
- (c) extrapolated from (a)

| IEA Icing Class | Meteorological icing (% of year) | Instrumental icing (% of year) | Production loss (% of year) | Yearly number of ice pieces per wind turbine (ice pieces/year) | | | |
|---|---|---|---|---|---|---|---|
| | | | | Idling No active IPS (a) | Idling IPS de-icing (b) | Operational No active IPS (c) | Operational IPS anti-icing (d) |
| 5 | > 10 | > 20 | > 20 | > 3200 | > 8800 | > 9600 | > 8000 |
| 4 | 5 – 10 | 10 – 30 | 10 – 25 | 1600 | 4400 | 4800 | 4000 |
| 3 | 3 – 5 | 6 – 15 | 3 – 12 | 800 | 2200 | 2400 | 2000 |
| 2 | 0.5 – 3 | 1 – 9 | 0.5 – 5 | 400 | 1100 | 1200 | 1000 |
| 1 | 0 – 0.5 | 0 – 1.5 | 0 – 0.5 | 80 | 220 | 240 | 200 |

*Table 2: IEA icing class and corresponding yearly number of ice pieces per wind turbine, based on manual site measurements of ENERCON E-82 turbines (78 m HH) with and without active IPS, respectively in anti- or de-icing operational mode (column (a), (b) and (d)), and an extrapolation from the values of column (a) to the operational state without active IPS (column (c), see paragraph below).*

# Risk acceptance with respect to background risk levels

- Risk acceptance criteria are deduced from MEM principle (Minimum Endogenous Mortality):

  *The risk posed by a given technology may not increase the MEM by a significant amount (<5%).*

  - Max. limit of $10^{-6}$ fatalities per year for the individual risk
- Additional risk aversion factor for larger groups of people
  - Max. limit of $10^{-4}$ fatalities per year for the collective risk

# Risk acceptance with respect to background risk levels

- Numerous risks in the vicinity of a WTG, even more during daily life in general
- Some risks in daily life are knowingly accepted, e.g. participation in traffic
- Accident rate per km on higher-ranking roads in general much higher than collective risk of icing
  - ➢ Risk from icing does not significantly increase socially accepted risk posed by traffic
  - ➢ Accumulation of risks posed by several turbines along such a road can be neglected

Source: www.stadtwerke-muenster.de

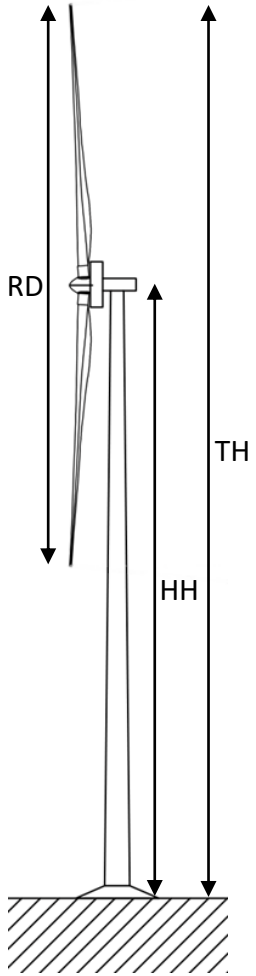
# Risk acceptance with respect to background risk levels

- Accumulation only to take into account when relevant for most exposed (group of) individual(s)
- Reference to background risk level can be transferred to other sectors of civil life, if risk is accepted by public in general (e.g. risk of flooding)
- Can also be adopted to individual risk, e.g. for specific activities (alpine touring, snow shoeing etc.)
- Risk acceptance criteria then again given by insignificance in comparison to background risk level (e.g. <5% as for MEM principle)

Source: www.tourentipp.de

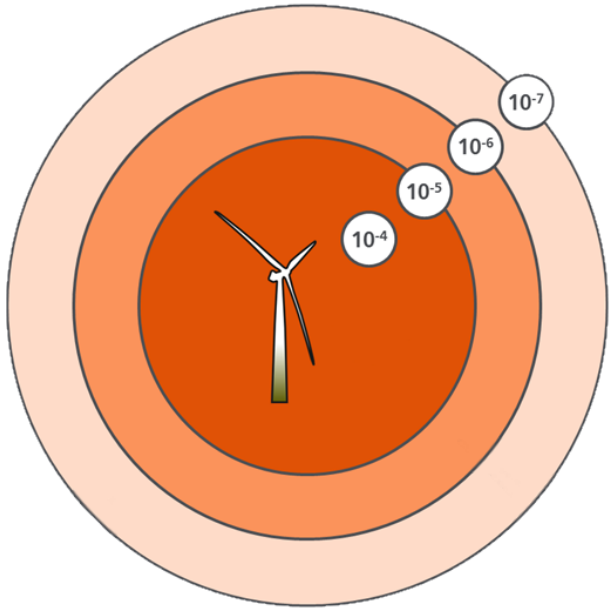
# Placement of warning signs

- Placement of warning signs at all relevant entry points to area around turbine(s) is important for effectivity
- Numerous country-specific rules of thumb in place, e.g.:
  - Norway: HH + RD
  - Austria: 1,2 * TH
  - Germany: 1,5 * (HH + RD)
- Fixed distances represent conservative approach
- Probability for ice pieces falling / being thrown that far only becomes relevant for extreme wind conditions



# Placement of warning signs

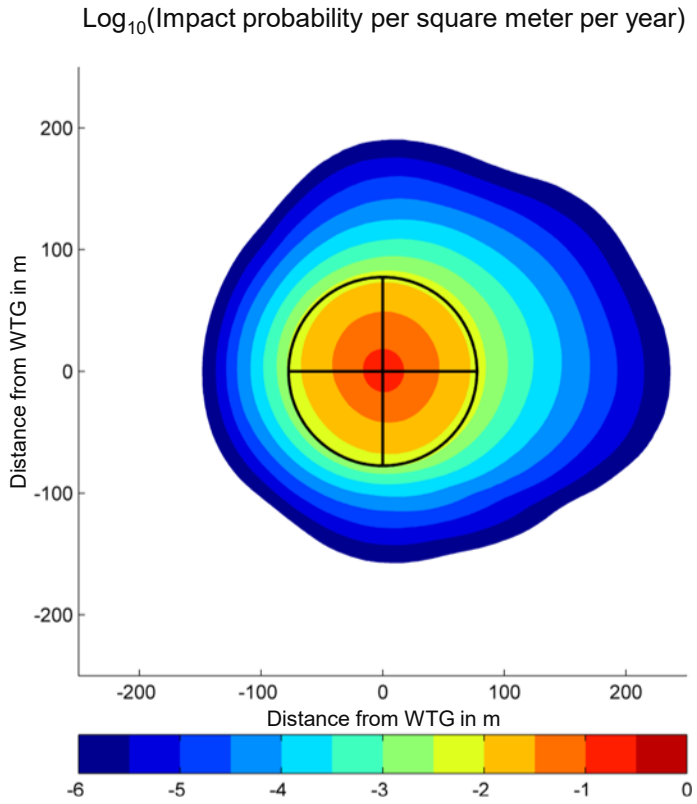
- Warning sign positions can be based on iso-risk contours such as LIRA (Localized Individual Risk per Annum)
- $10^{-6}$ LIRA constitutes threshold from negligible risk to possible risk
  - Further outside no relevant risk to be expected
- $10^{-6}$ LIRA contour corresponds to impact probability contour of roughly $10^{-5}$ per square meter per year




Source: Lloyds Register / Kjeller Vindteknikk

# Placement of warning signs

- Up to $10^{-3}$ impact probability contour no exceedance of risk acceptance criteria for short exposure times per day
  - Pedestrian for ½ h
  - Car passing 2 times per day
    - ➢ $10^{-3}$ impact probability contour is suitable for placement of warning signs
- Site-specific usage scenarios/frequencies can require other limits and distance definitions



# Proposal of a general „Ice Fall Zone“ warning sign

- Wide variety of warning signs for ice fall / ice throw in use
- Some convey nature of possible hazard understandably, many do not
- Often (lengthy) written warnings in absence of standardized template a warning sign
  - Reduced warning effect of text-only signs
  - Possible language barrier for non-native speakers


Source: F2E

# Proposal of a general “Ice Fall Zone“ warning sign

- Warning sign templeate aims to convey risk of ice fall around turbines in a simple but effective way
  - Turbine as source of risk for ice fall
  - Ice fall risk both below and around turbine
  - Icing as icicles & snowflakes to convey nature of risk
  - Risk zone both visually and written
  - 'Warning' preferred over 'Attention' to emphasize possible hazard
  - 'Zone' common in many languages compared to area

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# International Recommendations for Ice Fall and Ice Throw Risk Assessment – Edition 2

- Know and emulate the icing hazard as detailed as possible
- Acknowledge and incorporate background risks to avoid overestimation
- Design risk reducing measures in the easiest and most intuitive manner as possible

# Thanks for your attention!

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