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# Onshore Wind Turbine Risk Assessments

DNV Energy Systems Germany, DE (35)

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# Agenda

Wind turbine risks

Ice throw and fall

Regulation in Germany

Task 19

Ice throw risk assessment

Short example

Outlook – integrated risk management

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# Wind turbine (WT) risks

## Tower collapse

## Blade Failure



https://images.app.goo.gl/LCAnRXvpzJHas1n5A

## Ice throw



https://images.app.goo.gl/q7bBhQshppgver5Z6



https://images.app.goo.gl/JPzzcZ1zwii5TyBX7



! Warning !
Ice Fall Zone

https://images.app.goo.gl/yNgpSLHZkk14jXUb9

## Nacelle breakage

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# Ice Throw / Ice Fall

- WT in operation (often near nominal rotor speed) → Ice throw

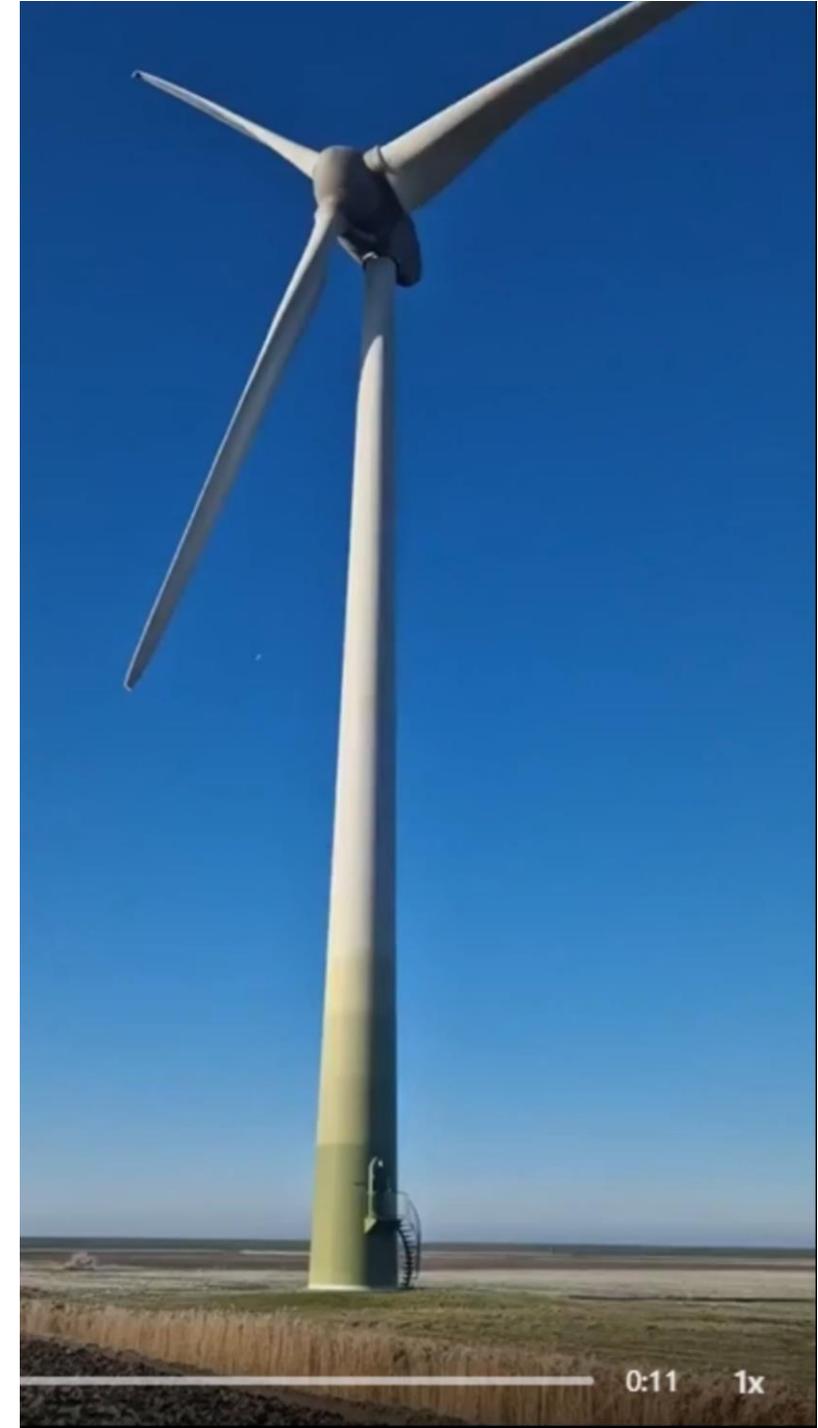- WT out of operation / shut down / idle mode → Ice Fall

- **Ice fragments:**



Eiswurf in Lankern, Lammersstiege, 17.12.05

https://www.pro-landschaft-arai.ch/wp-content/
uploads/2016/09/Eis_Windrad.jpg
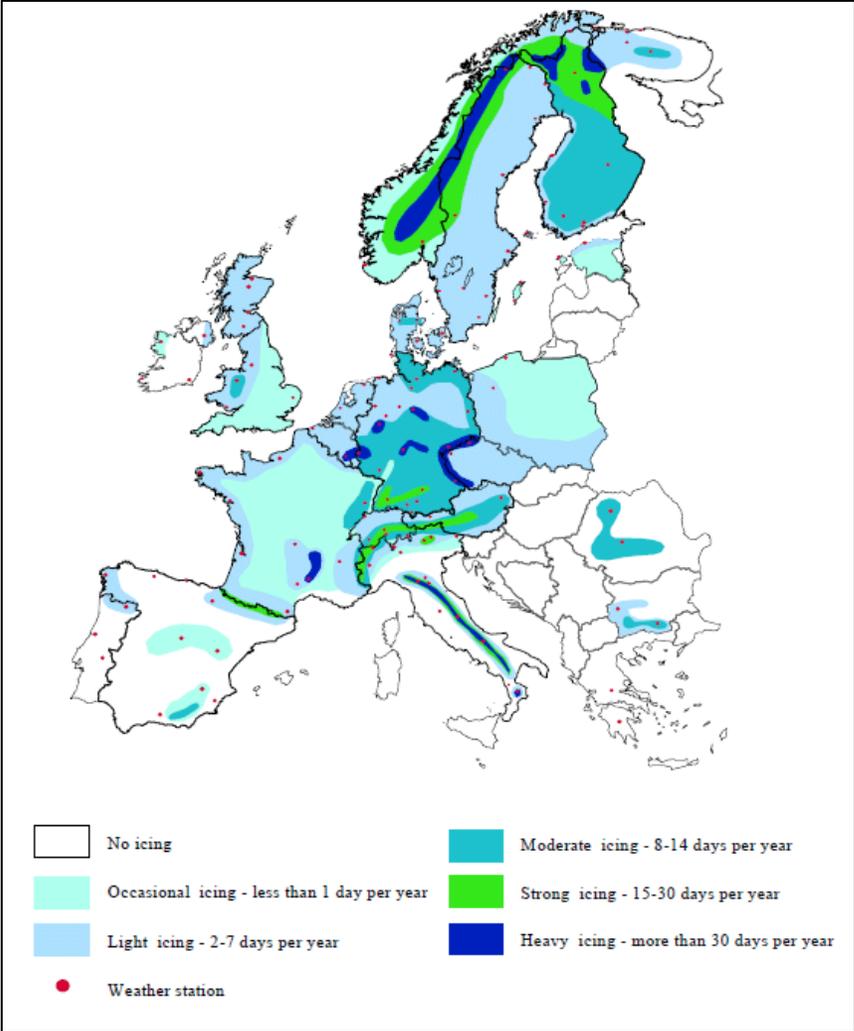


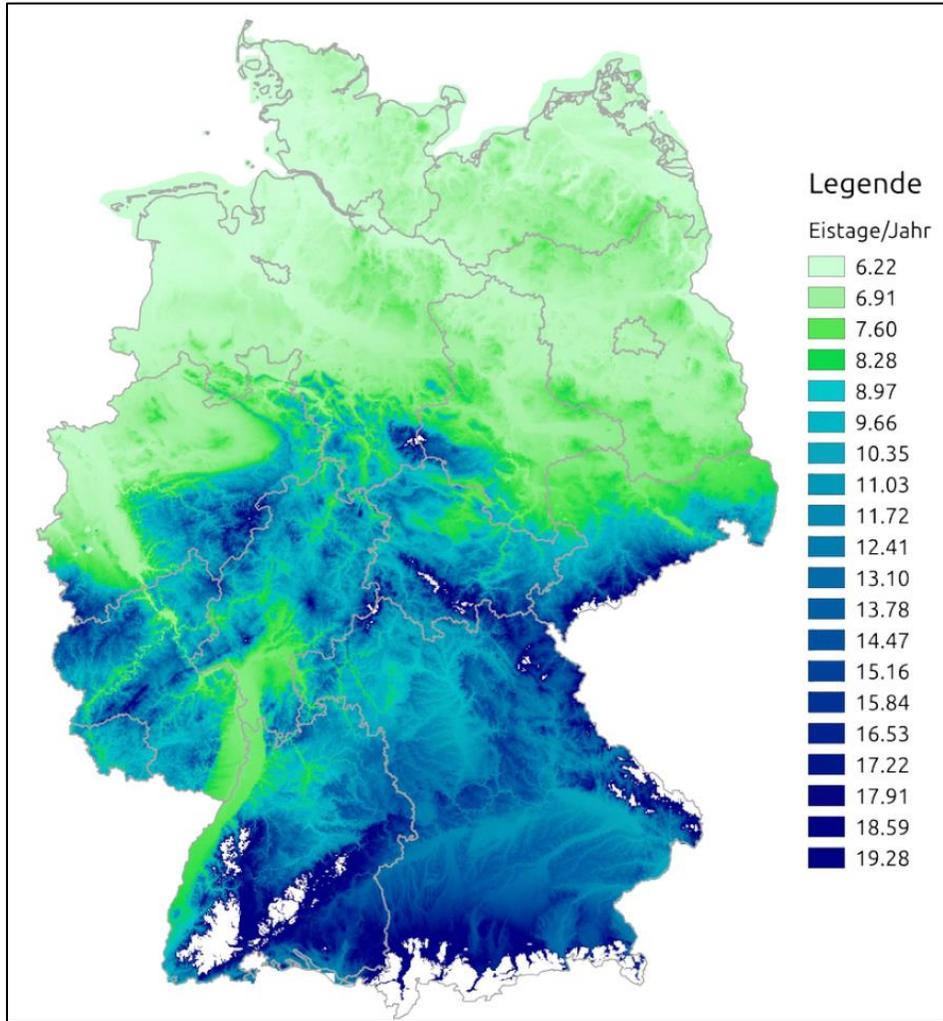http://ww-vb.de/media//Eiswurf/Eiswurf_20141129_Helpershain.jpg



Seifert, Risikoabschätzung des Eisabwurfs von Windenergieanlagen, 2007

https://www.linkedin.com/posts/vivekktrivedi_windturbines-icing-safety-ugcPost-7287355760030724096-L-jX?utm_source=share&utm_medium=member_desktop

# In Germany icing between 6 and 20 days per year



Effect of atmospheric ice accretion on the dynamic performance of wind turbine blades by Abdel Salam Alsabagh
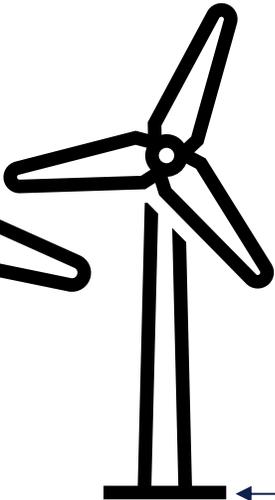
**No icing**

**Occasional icing** - less than 1 day per year

**Light icing** - 2-7 days per year

• **Weather station**

**Moderate icing** - 8-14 days per year

**Strong icing** - 15-30 days per year

**Heavy icing** - more than 30 days per year



DWD, Wichura, 2023

**Legende**

Eistage/Jahr

6.22
6.91
7.60
8.28
8.97
9.66
10.35
11.03
11.72
12.41
13.10
13.78
14.47
15.16
15.84
16.53
17.22
17.91
18.59
19.28

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# Ice Throw risk regulation in Germany

**Model Administrative regulation - Technical Building Regulation**

- Appendix A 1.2.8/6 "Guideline for wind turbines"

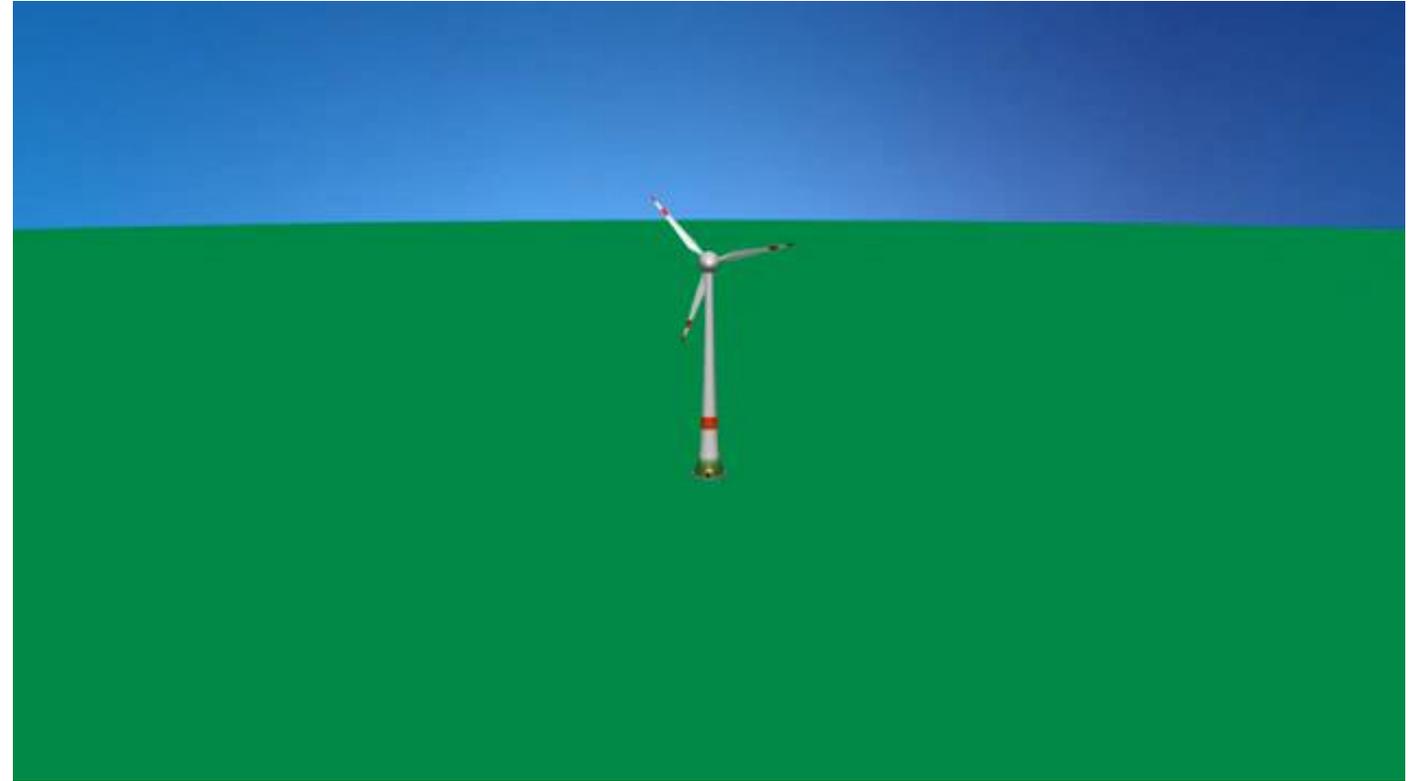- Screening zone SZ = (Hub height + Rotor diameter) x 1,5

- Example

**Amtliche Mitteilungen**

Ausgabe 2 | 17. April 2023

Veröffentlichung der
Muster-Verwaltungsvorschrift
Technische Baubestimmungen
2023/1

(MVV TB 2023/1)

mit Druckfehlerberichtigung
vom 10. Mai 2023

DIBt  Amtliche Mitteilungen des
Deutschen Instituts für Bautechnik (DIBt)
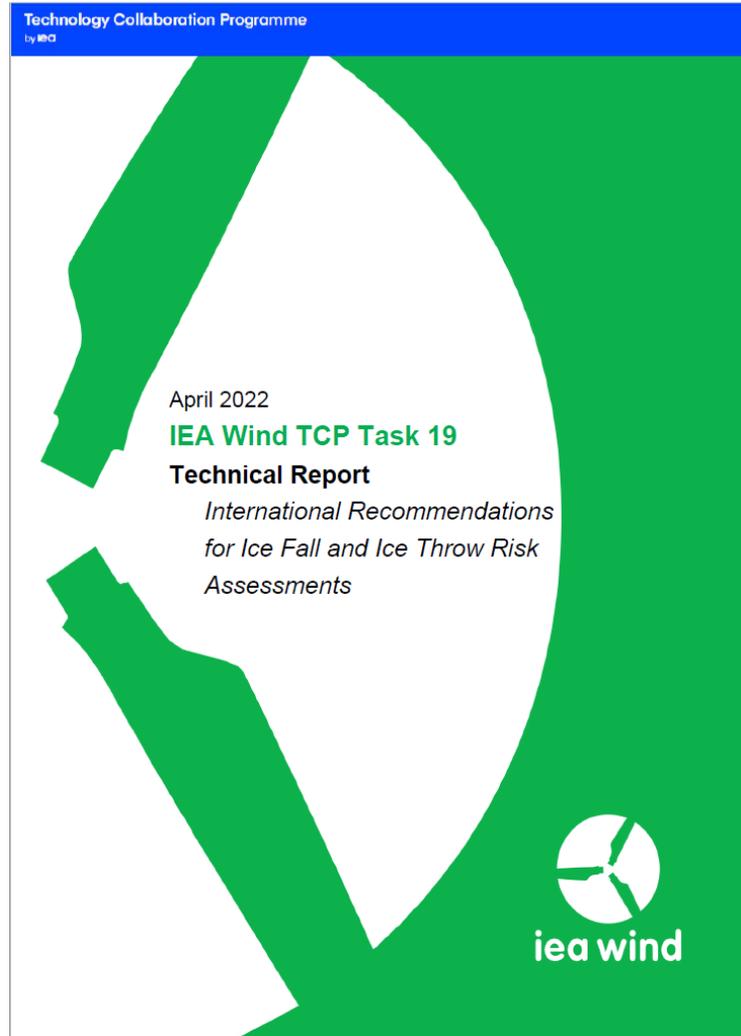
Distance from WT to public < SZ

Distance from WT to public > SZ

…

Expert statement needed
from independent advisor to demonstrate safety

Considered to be safe

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# Ice throw risk assessment according to IEA Task 19



April 2022
**IEA Wind TCP Task 19**
**Technical Report**
*International Recommendations for Ice Fall and Ice Throw Risk Assessments*



Quelle: Scientific Computing and Simulation Lab, Aschaffenburg University of Applied Sciences
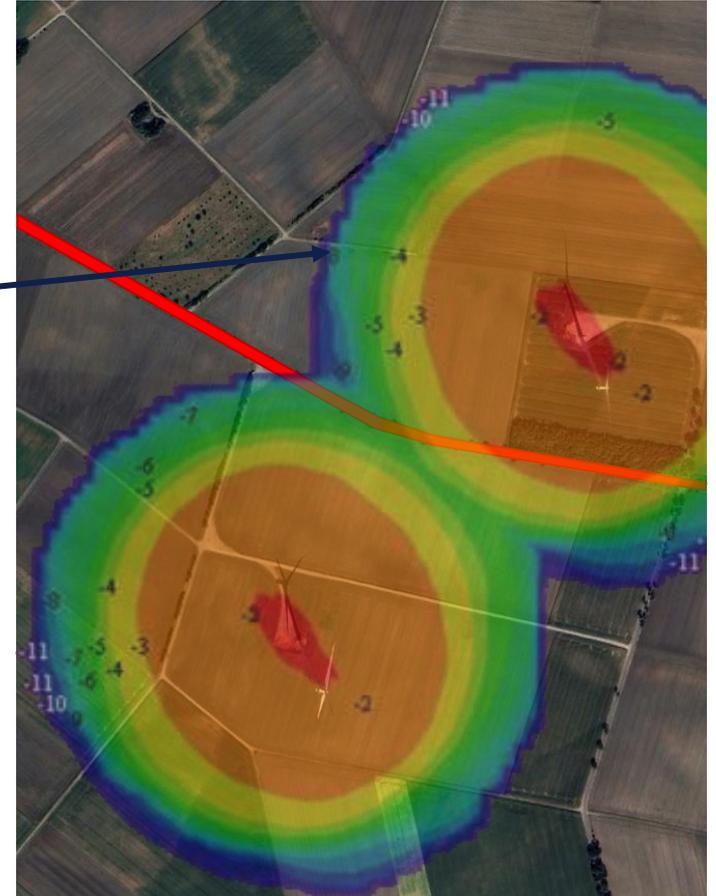
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# Risk Assessment

- Risk = Frequency x Consequence

**Individual Risk measures**

- LSIR (Localized Individual Risk) as contours
  Assumption: 24 h x 365 days per year unprotected

- IRPA (Individual Risk Per Annum) for vulnerable objects
  = LSIR x Probablity of Occupancy

**Societal Risk measures**

- FN Curve (Frequency Number Curve)

- PLL (Potential Loss of Life)
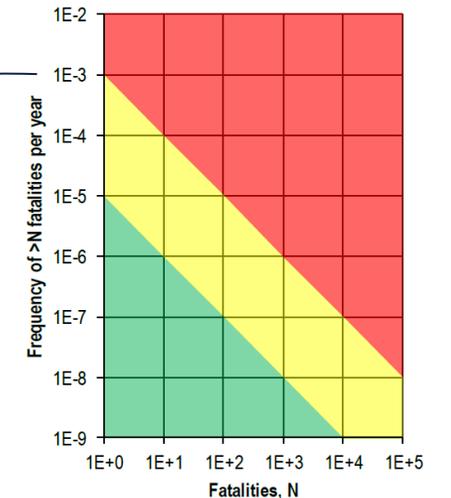  = IRPA x N (Number of people)

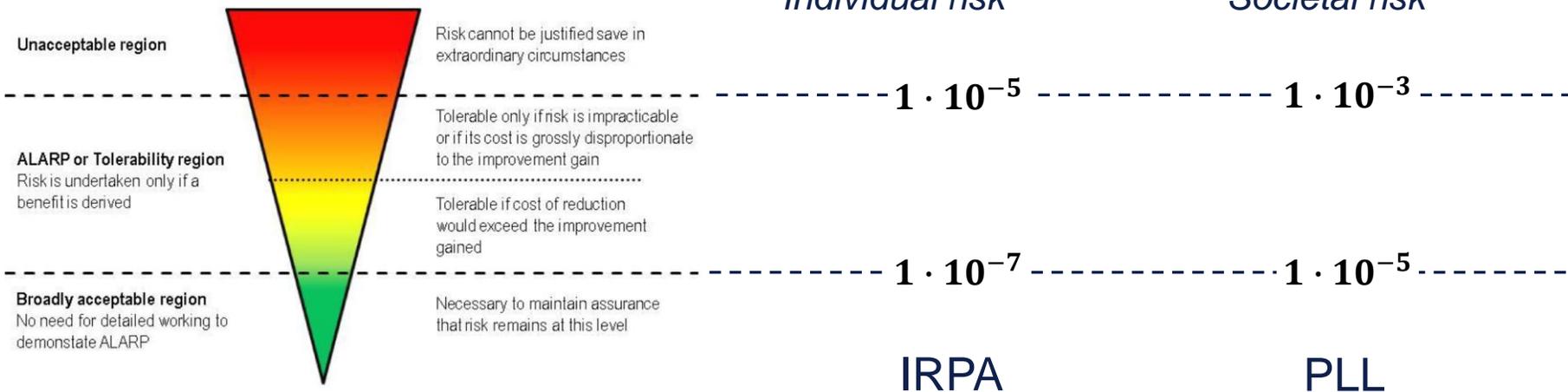# Risk Acceptance Criteria

Basis: Endogenous Mortality Rate (EMR) of an individual, EN 50126: <u>2 x 10<sup>-4</sup> per year</u>

- A new technology should not increase the EMR significantly (5%).

- Tolerability level: $\leq 1 \cdot 10^{-5}$

<u>**ALARP**-Principle,
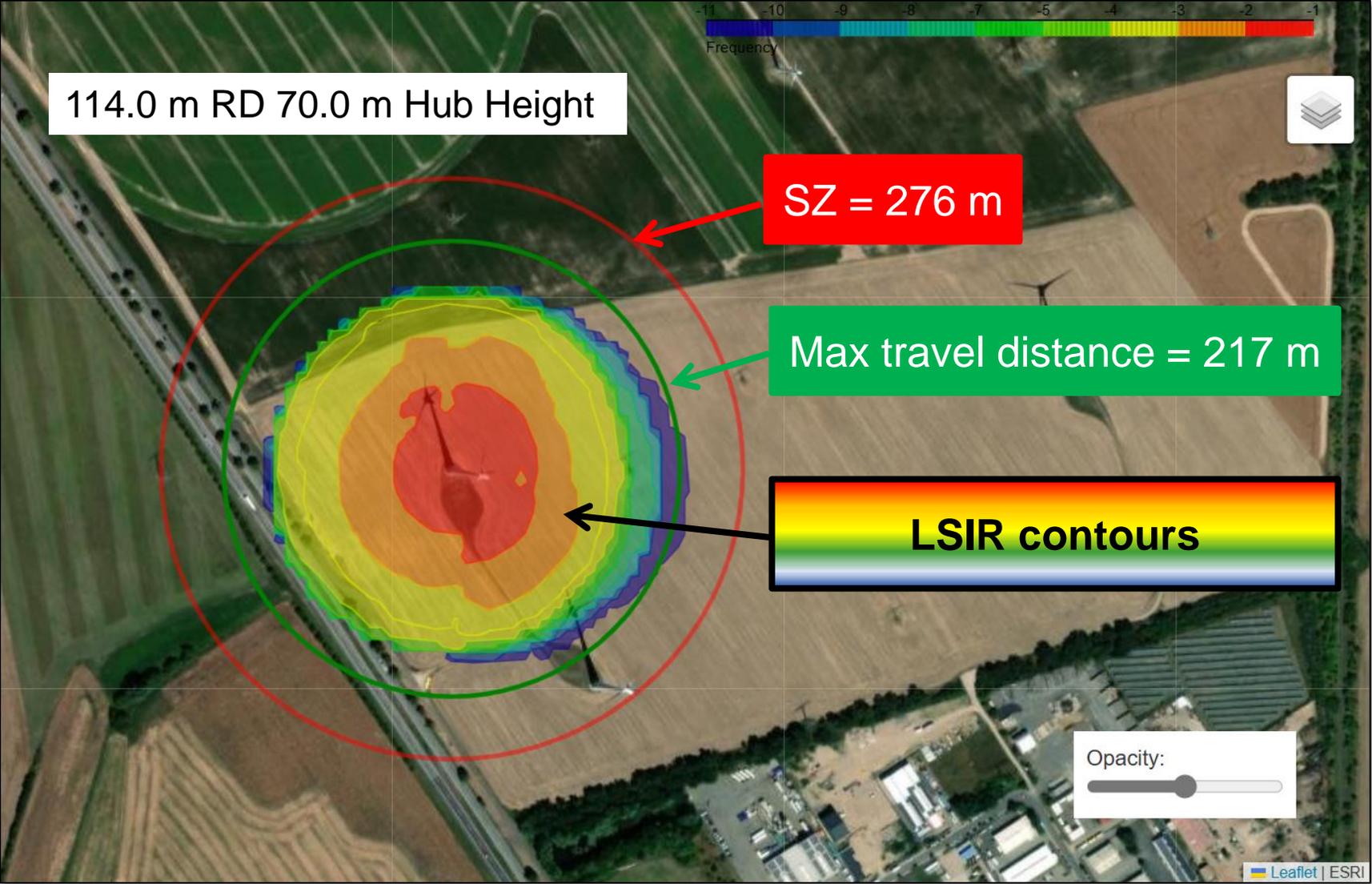UK Health & Safety Executive:</u>



*Individual risk*              *Societal risk*

$1 \cdot 10^{-5}$ ------------------ $1 \cdot 10^{-3}$ -----------

$1 \cdot 10^{-7}$ ------------- $1 \cdot 10^{-5}$ ----------

IRPA                           PLL

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# Example – LSIR contour

Risk scale: $1 \times 10^{-11}$ to $1 \times 10^{-1}$ per year and $1 m^2$



114.0 m RD 70.0 m Hub Height

SZ = 276 m

Max travel distance = 217 m

LSIR contours

Opacity:

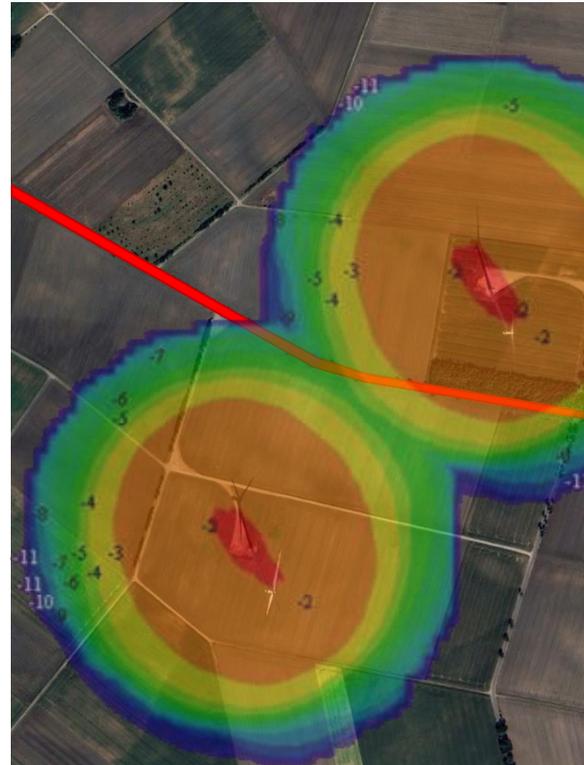Leaflet | ESRI

# Example – IRPA and PLL



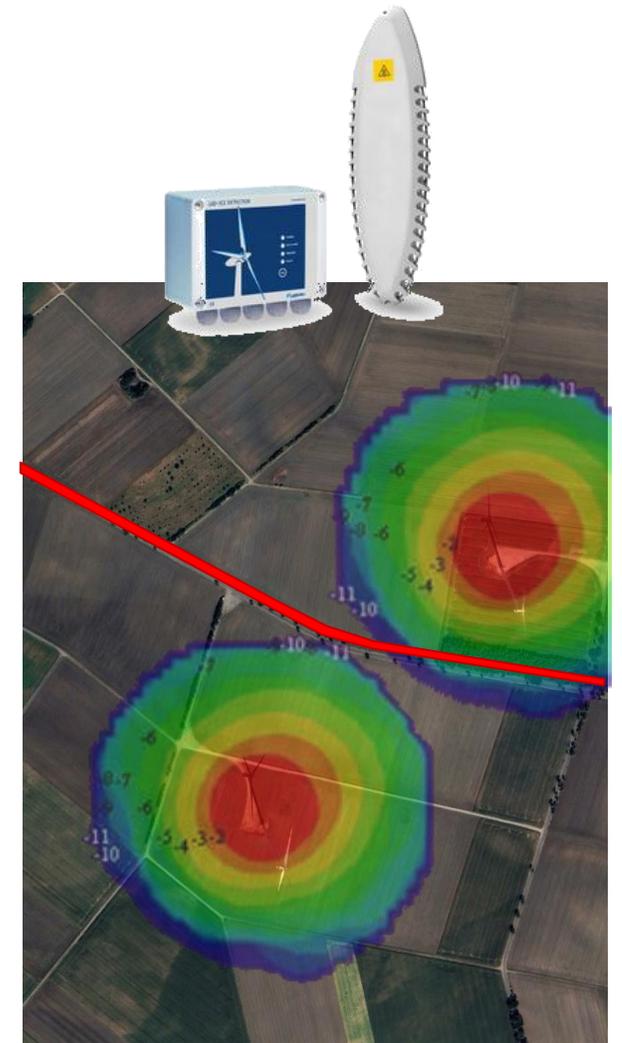per year

# Example - Risk mitigation

- Facility Siting

- Certified ice detection system

- Blade heating

- Fences

- Warning signs

- Warning lights

**Without** ice detection and shut down

**With** ice detection and shut down

Abbildung, Eissensor: https://labkotec.fi/wp-content/uploads/picture1.jpeg

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# Outlook: Integrated approach?



NEK IEC TS 61400-31:2023
Wind energy generation systems
Part 31: Siting risk assessment

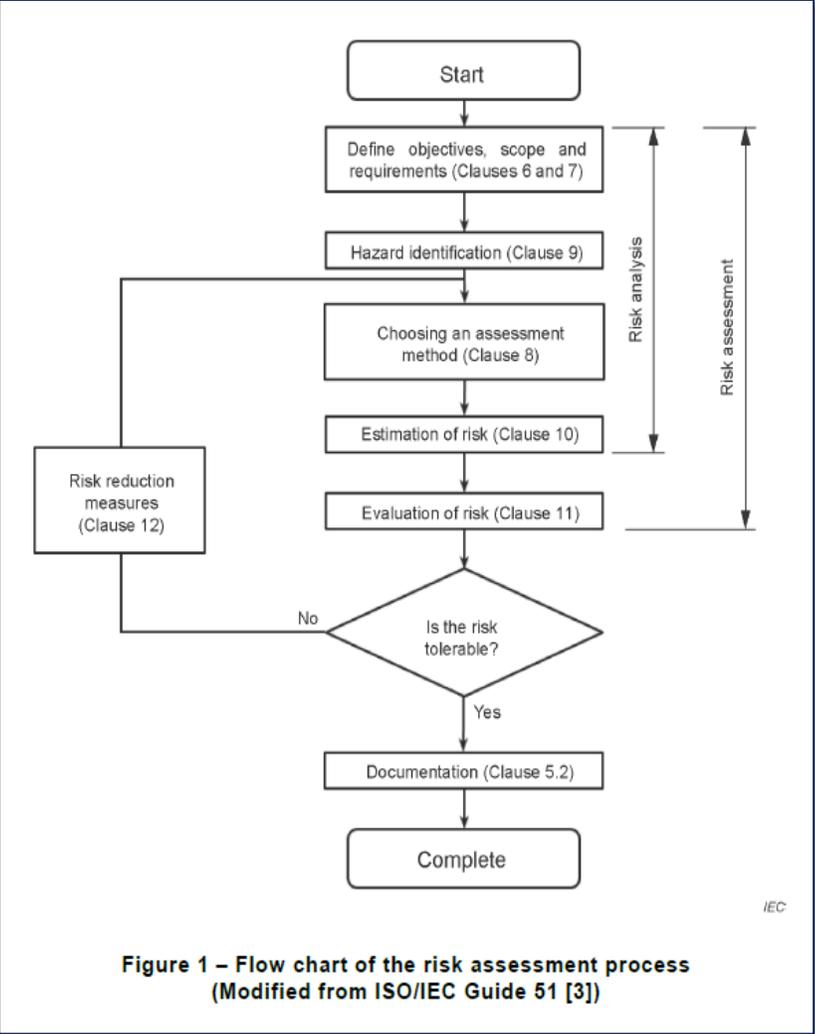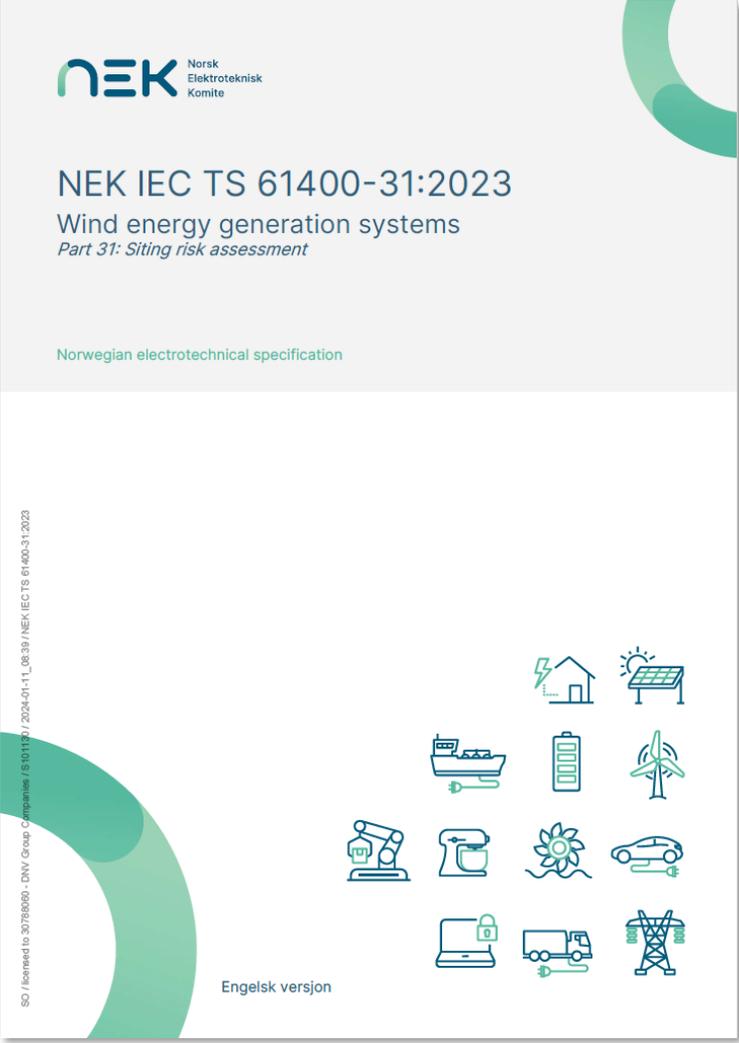Norwegian electrotechnical specification

Engelsk versjon



Figure 1 – Flow chart of the risk assessment process
(Modified from ISO/IEC Guide 51 [3])

**Facility siting
from total risk perspective**

$$R_{total} =$$

$$Risk_{Ice} +$$
$$Risk_{BladeFailure} +$$
$$Risk_{NacelleBreakage} +$$
$$Risk_{TowerCollapse} +$$
$$Risk_{Fire}$$

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# Thank you

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DNV
1864
2024

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Our vision is to be:

**A trusted voice to tackle global transformations.**

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