



# Influence of wind conditions under icing conditions on the result of a risk assessment

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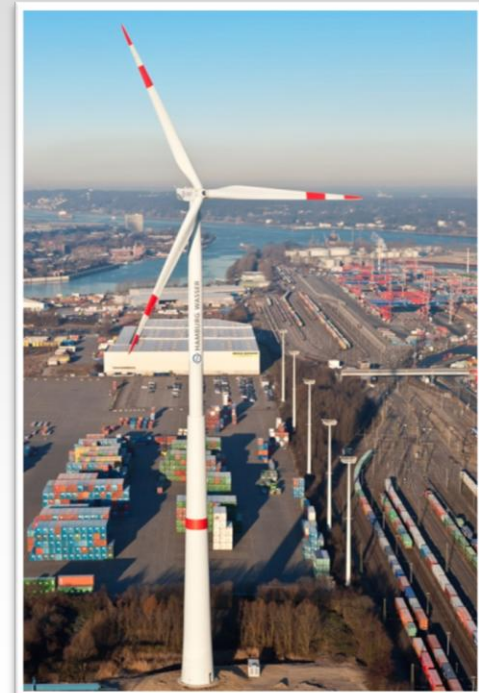
Piteå, February 2015

## Agenda

- Risk assessment in general
- Risks due to icing of wind turbines
- Analysis of the meteorological data
- Analysis of the influence of the meteorological data under icing conditions on a risk assessment
- Results of our analysis
- Further research and analysis

## Risk Assessment

- The operation of wind turbines may cause hazards, that should be assessed especially if the wind turbines are very close to residential areas or traffic infrastructure. Risks could be the consequence if the wind turbines are very close to:
  - Traffic infrastructure (road / railway / airports / shipping)
  - Residential areas
  - Industrial areas or Chemical plants
  - Pipelines or Power lines
- A Risk Assessment contains:
  - Hazard analysis
  - Risk analysis und -illustration
  - Risk assessment
  - Concepts for risk reduction



Source: Nordex SE

## Methods for Risk Reduction in case of icing

- Avoid ice throw:
  - Ice Detection System
  - Inform about icing, reduce the risk of ice fall → close of hazard area
- Reduce the risk due to ice fall e.g.:
  - Protection Roof
  - Close of hazard area
  - Parking position of WEA
  - Safety Rules



Source: TÜV NORD

### Influencing factors on the risk of iced wind turbines

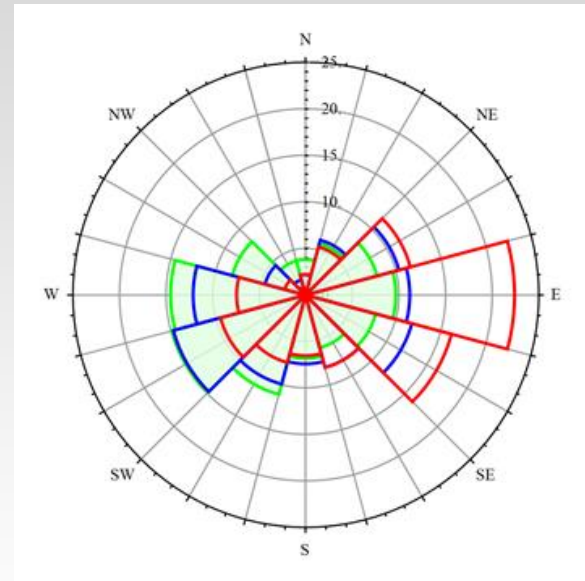
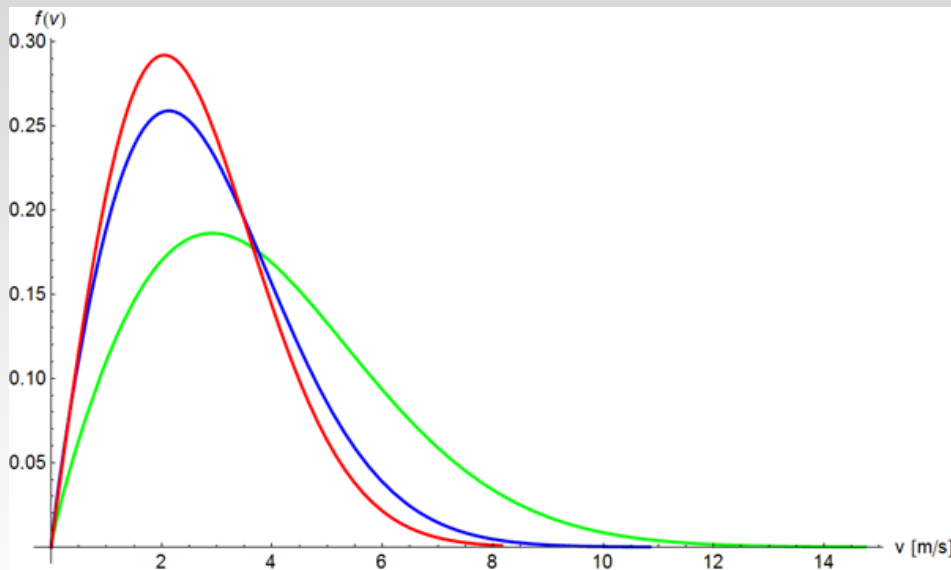
- The risks for persons and protection objects and the radius of falling ice depends on the site-specific wind conditions and the distance of the objects to the wind turbine.
- Therefore it is necessary to determine the wind conditions under icing conditions as accurately as possible to identify the risk as precisely as possible.




## Process

- Searching and selecting of weather data
- Icing incidents from secured climatic data from weather observation stations
- Set the criteria for icing
- Developing of different scenarios
  - Scenario 1: long-term general climatic data
  - Scenario 2: icing conditions (max. 0.5° and min. 95% relative humidity)
  - Scenario 3: concrete icing (observed)
- Analysis for a sample site
- General analysis for 28 weather observation stations in Germany
- Case study for a risk assessment

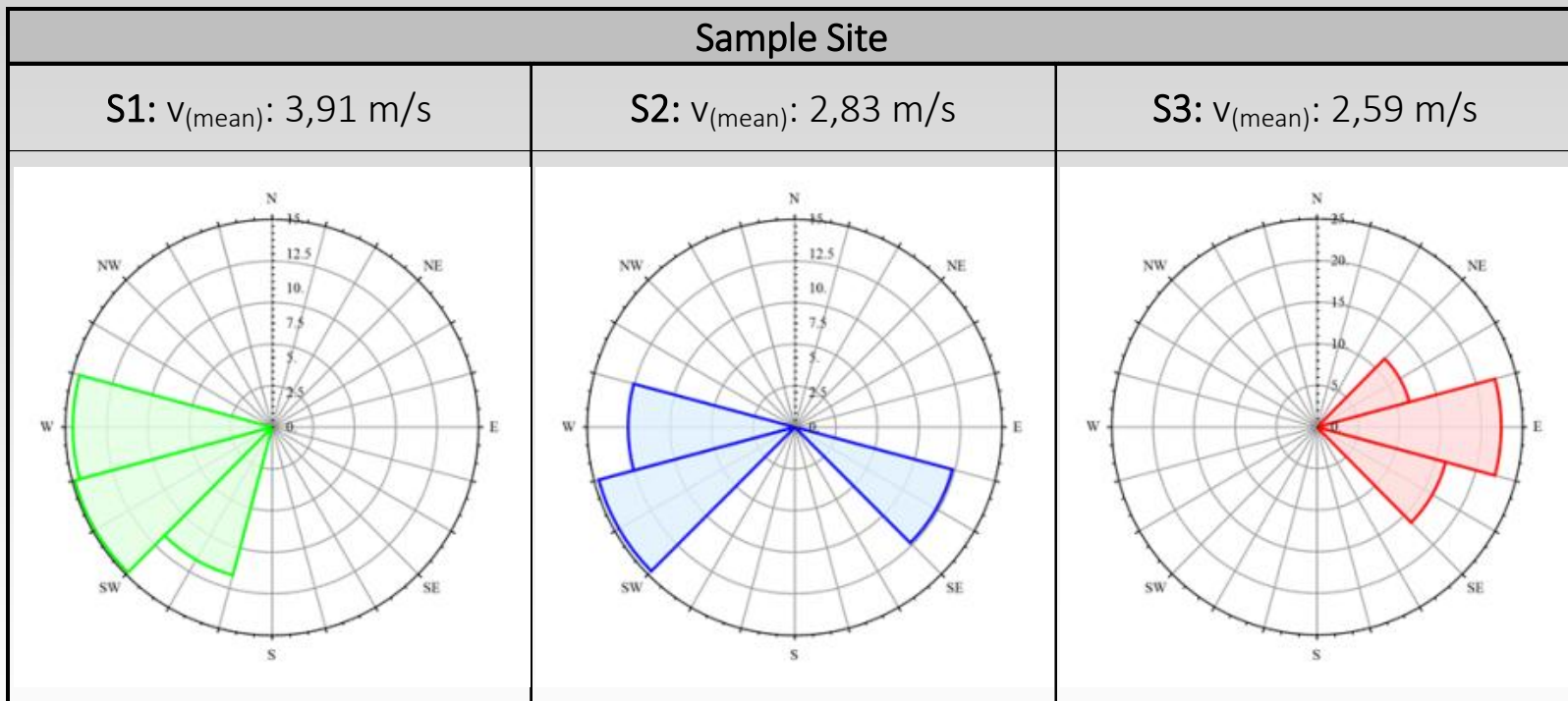
## Influence of meteorological data of icing conditions

- Comparison of general climatic data (green) and the wind data under icing conditions (blue) and concrete icing (red).



	S1: General climatic data
	S2: Icing conditions
	S3: Concrete icing

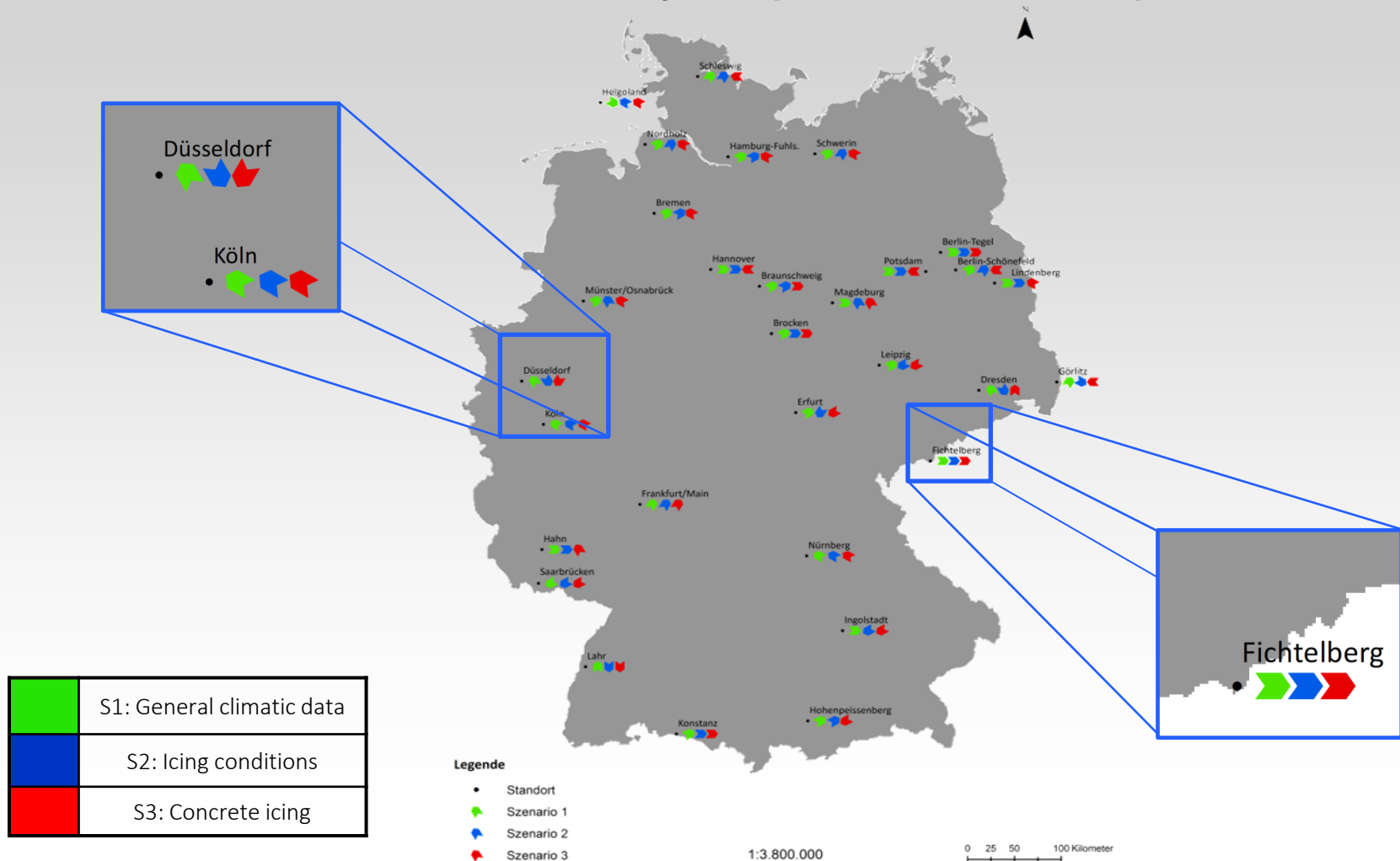
## Results of the wind data analysis



	S1: General climatic data
	S2: Icing conditions
	S3: Concrete icing



## Results of the wind data analysis (Wind directions)



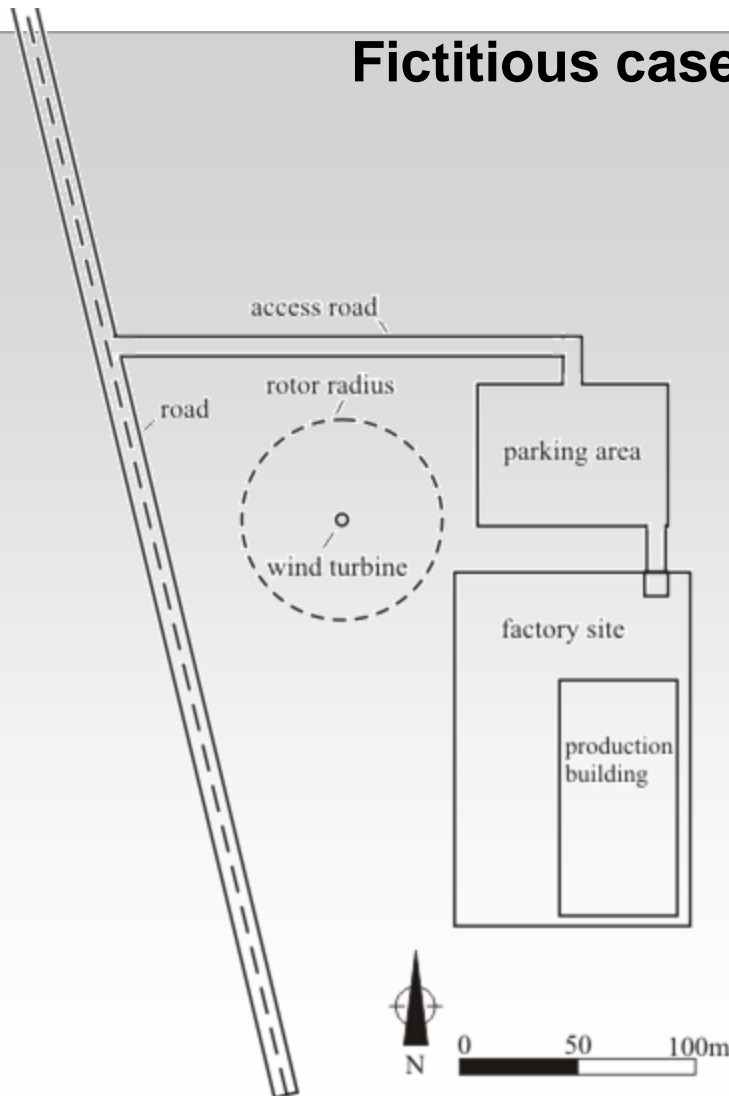
## Results of the wind data analysis

- Average wind speed in both icing scenarios lower than the long-term mean wind speed.
- In many cases there is a change in the main wind direction in some cases up to 180°.
- Huge differences between different sites causes a need for a site-specific analysis.

## From risk assessment to energy losses

- Wind conditions under icing conditions have to be stated as clearly as possible.
- Wind conditions under icing conditions deviating from annual mean wind conditions lead to different losses.
- Definition how often icing does occur.

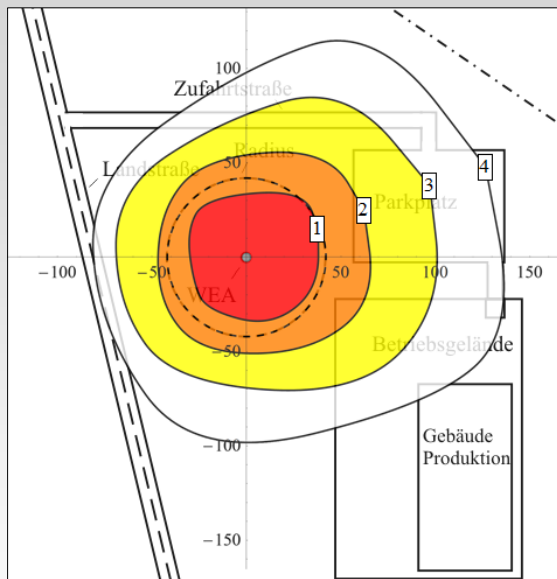
## Fictitious case study



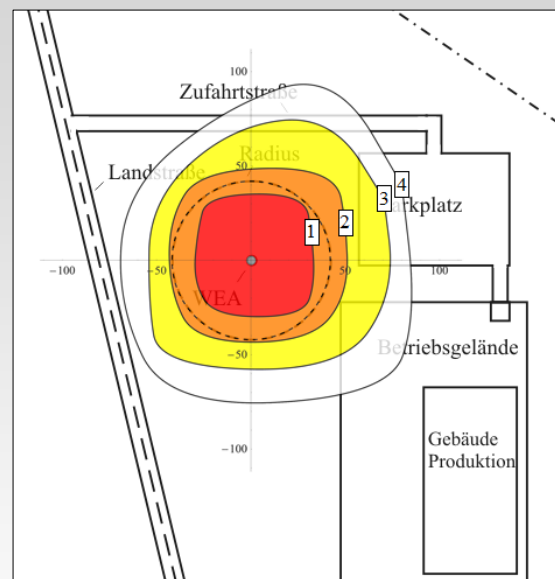
### relevant parameters

hub height	100m
rotor diameter	84m
distance to road	74m
distance to access road	68m
distance to parking area	57m
distance to factory site	50m

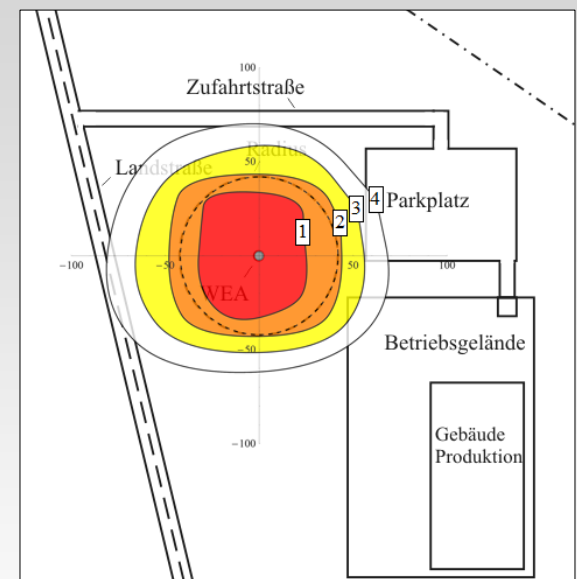
## Influence to the risk assessment



**S1: general climatic data**



**S2: icing conditions**



**S3: concrete icing**

Zone	Hit frequency [1/m <sup>2</sup> ]
1	> 1,0E-04
2	≤ 1,0E-04
3	≤ 1,0E-05
4	≤ 1,0E-06

## Results of the Risk assessment

- Due to the higher mean wind speeds of the general climatic data (long-term evaluation), the simulated icefalls achieves greater length / range so the risk areas are larger.
  - Higher risks for the protection objects are determined (more strikes).
  - Decreasing wind speed (under icing conditions) affects a smaller risk area.
  - The frequency distribution of the wind direction can change significantly under icing conditions (different mean wind directions affects different shapes of the risk area).
  - Expansion of risk areas depending on the frequency distribution of wind direction and the mean wind speed.
  
- With the help of the wind conditions under icing conditions, a more precise delimitation of the risk areas is possible.

### Forecasting of icing and icing conditions is

- Not only important for the evaluation of the possible risk.
- Important for a more accurate prognosis of the annual energy yield.
- Crucial for the economic feasibility of a wind farm planned at a exposed “icing-risk” site (losses due to operational restrictions, site specific power curves, energy usage for heating and detection devices).

## Further analysis

- Is it possible to transfer data from a weather station (temperature, humidity, whether phenomena like icing) to a distant location?
- Synthesized data / reanalysis data?
- Mesoscale models?
- How can the transfer be done? Which models do get reliable results? How to validate?

**Thank you for your attention!**



Please contact me in case of questions

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Expert Risk Assessment

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