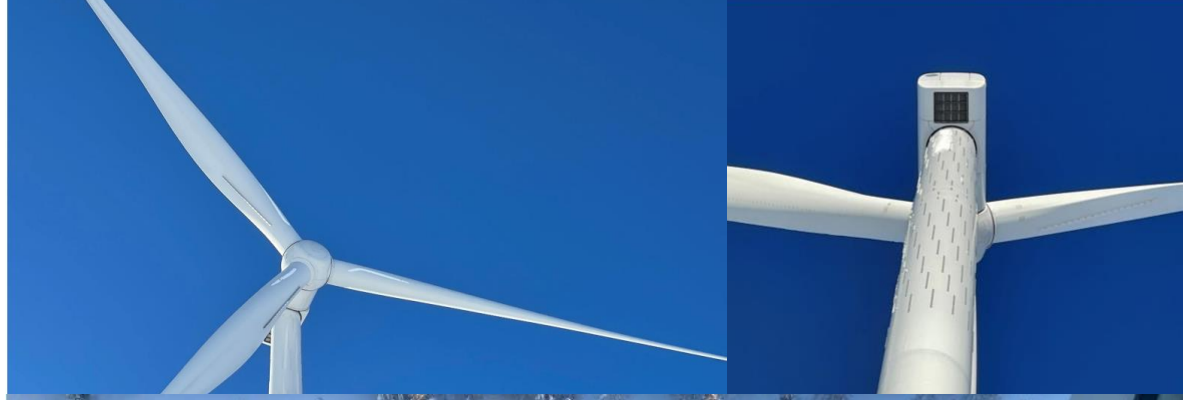
IceRisk tool for Safe Operation of Wind Power in Winter Climate

2024-03-19 Rolv Erlend Bredesen

WinterWind 2024

Real life problems that service personell are facing

- Quick introduction of icethrow and different kind of risks
  - Ice throw from the blade of a wind turbine is already well understood
  - (wet) snow and ice on nacelle
  - (wet) snow and ice on tower



Hydro

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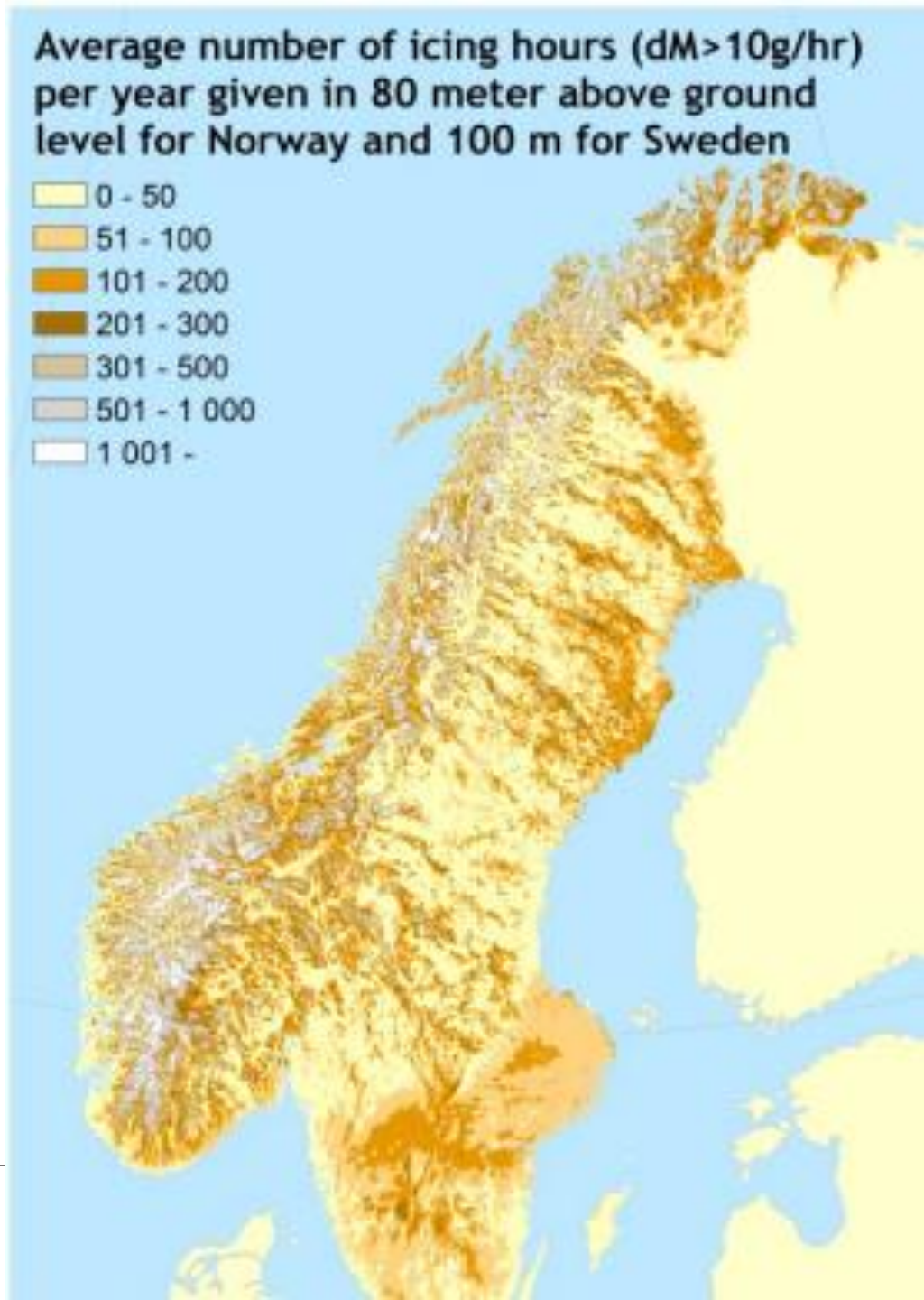
Pictures from Wind Farm in Southern Norway (Hydro Energy)

- real life problems that service personell are facing.



How to enter area?

- Snow/ice on tower
- Large cratres from snow/ice falling down
  - Also outside hardstand
  - Damaged staircases
- Can't see all sides from entrance road
- Visibility
  - Daylight
  - Fog
  - Night

- Ice/Snow on blades

Craters from ice throw

Ice/Snow from tower falling down

Larger crater

Large craters means large ice piece fell down

Smaller craters

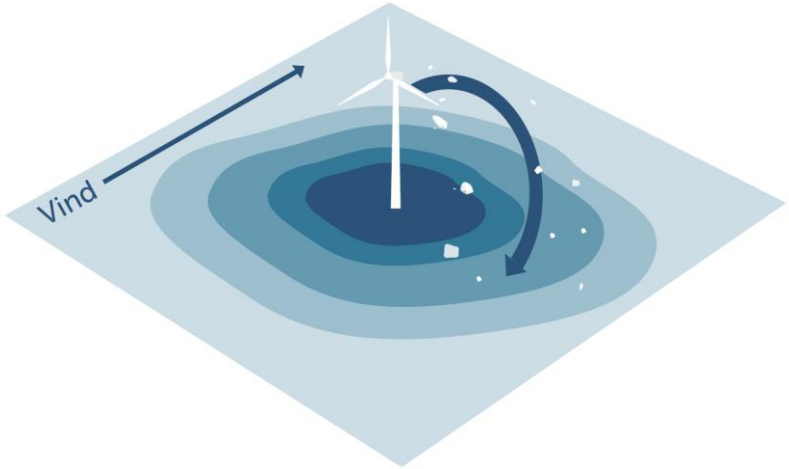
And larger

2024-03-18

2024-03-18

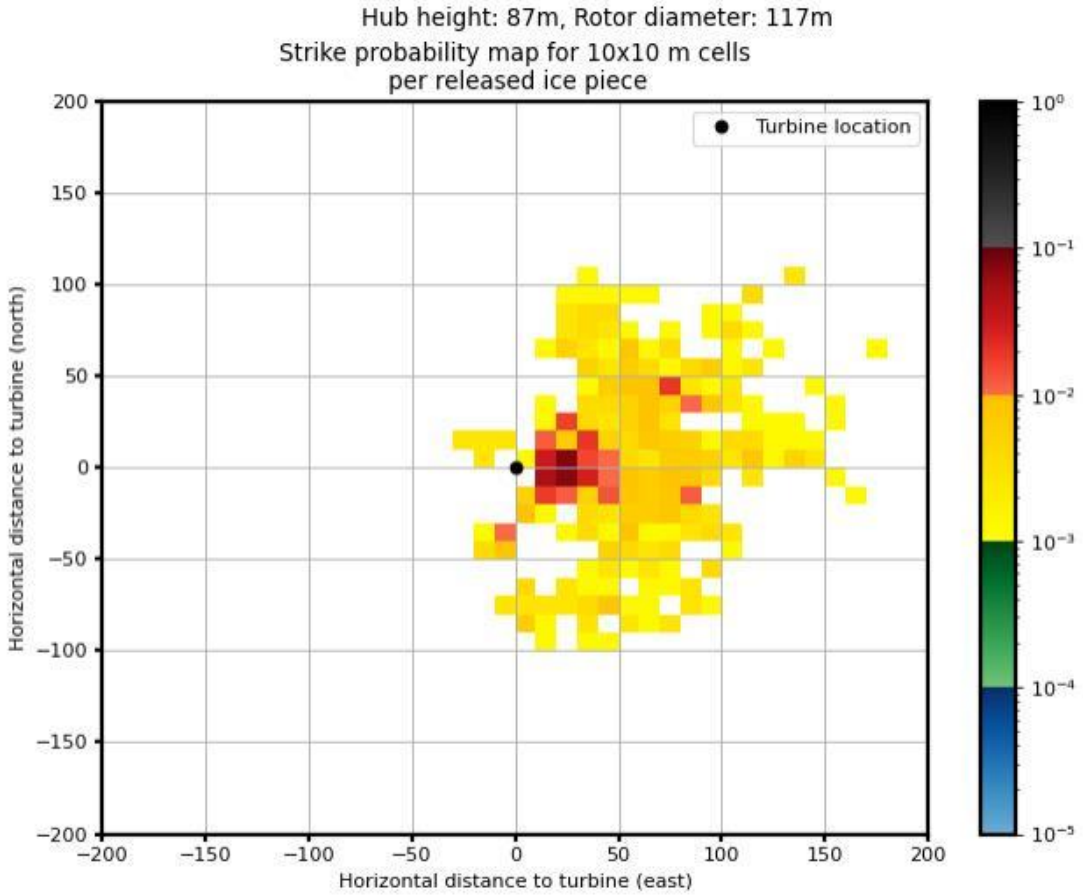
Summary of identified hazardous events

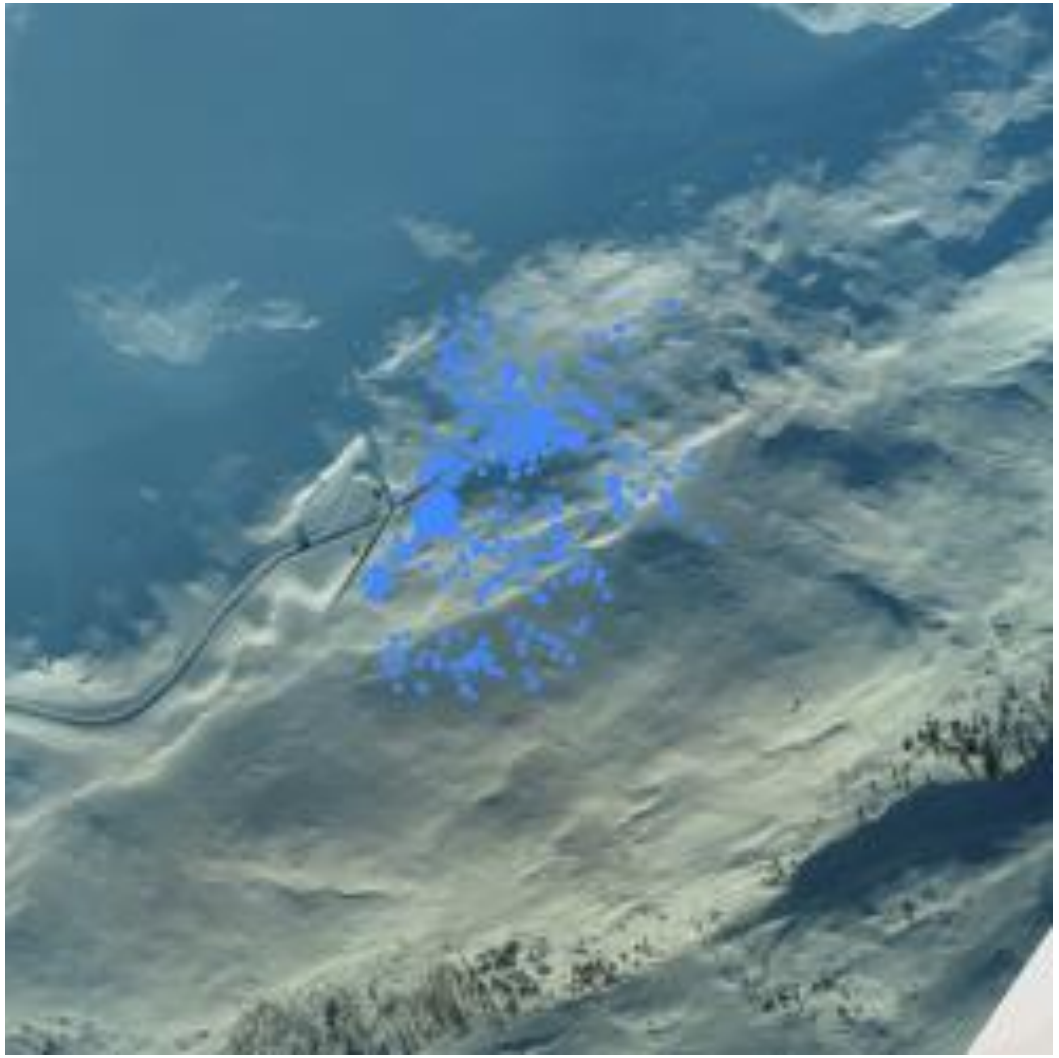
- i) Ice throw or fall from blade,
- ii) wetsnow can also accumulate on inner parts of blade
- iii) ice fall from tower (can be frozen wetsnow)
- iv) Rooftop avalanche of ice/snow or icicles falling from nacelle or heat exchanger



Ice throw example: One episode in Norway Winter 2022

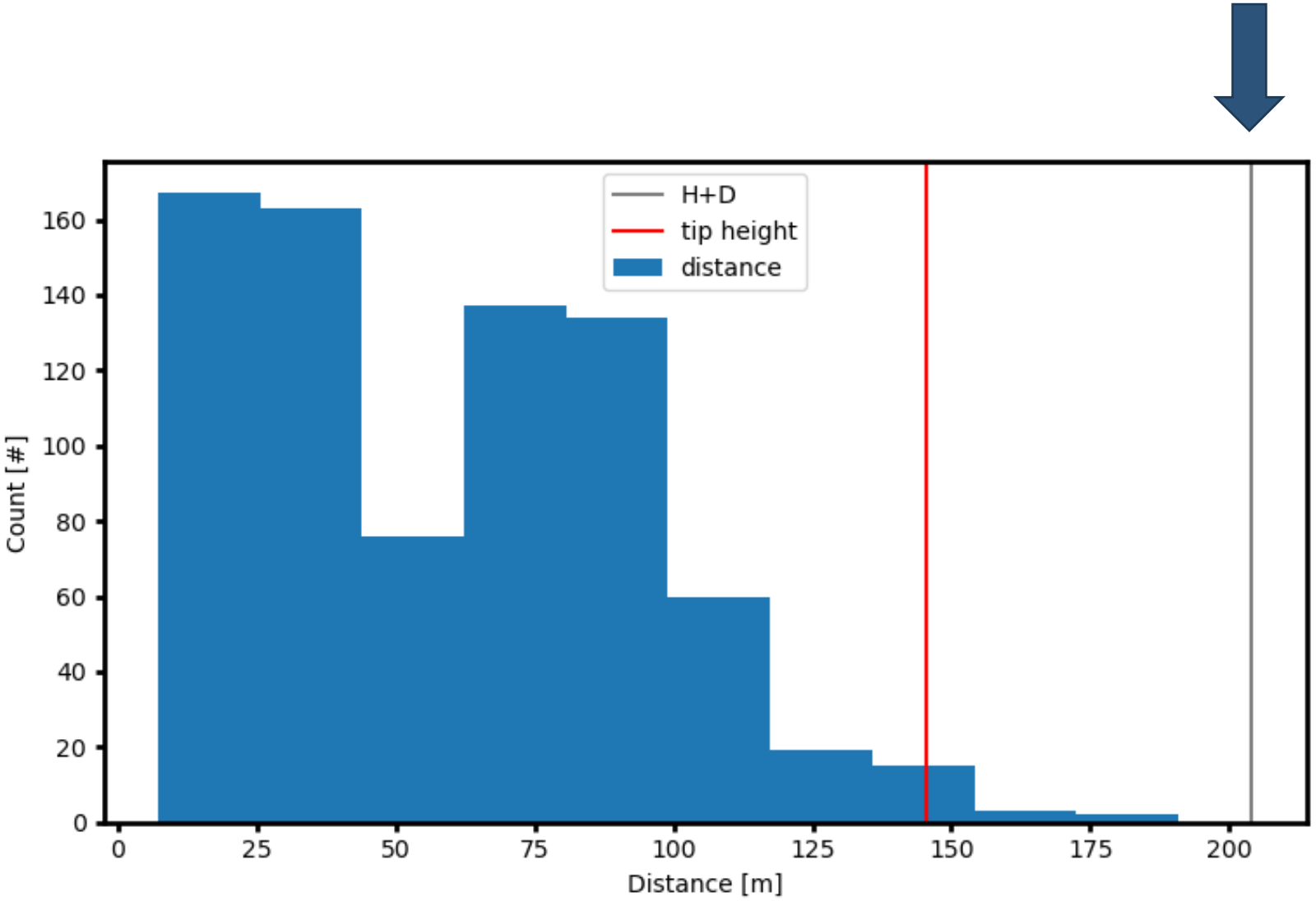
- Map show impact locations of ice pieces, (below map from 3 turbines)

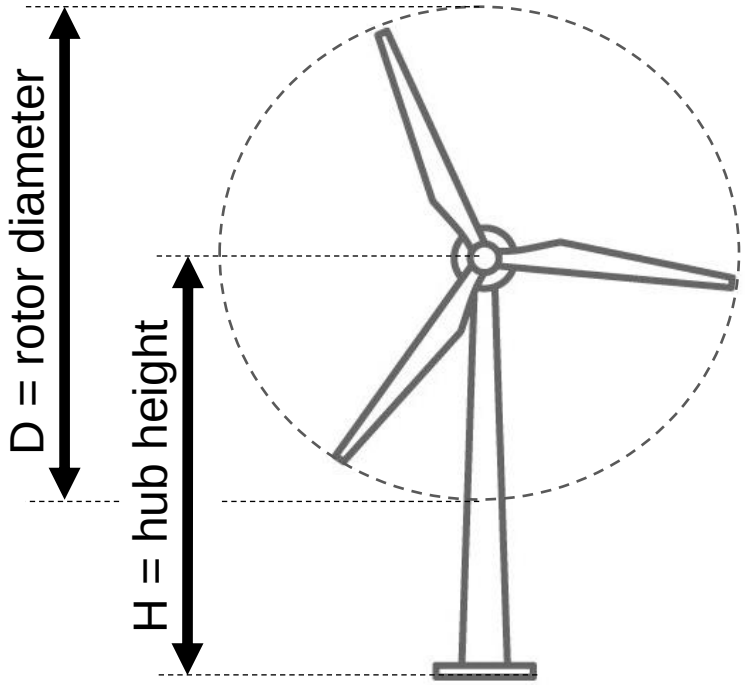




https://windren.se/WW2022/08_3_06_Nodeland_Using_drones_for_an_ice_piece_collection_campaign_Pub_v1.pdf

Observed throw distances within H + D





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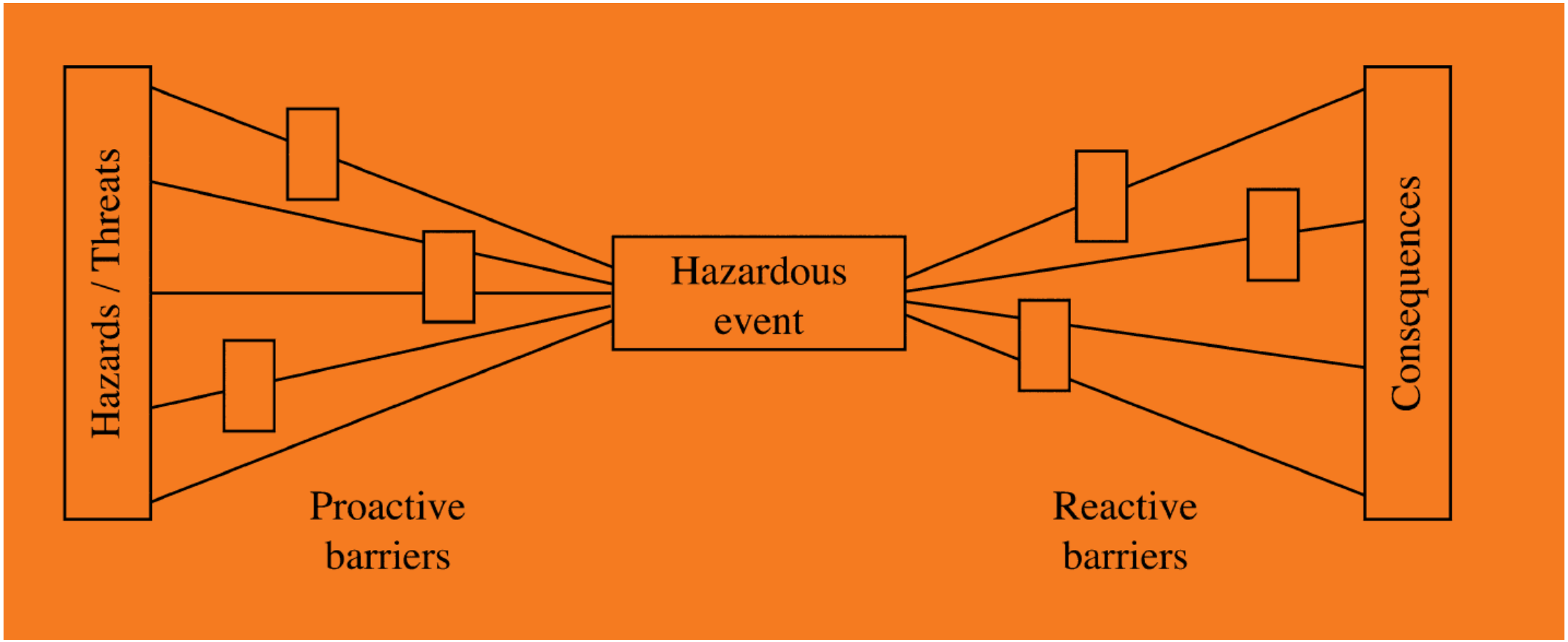
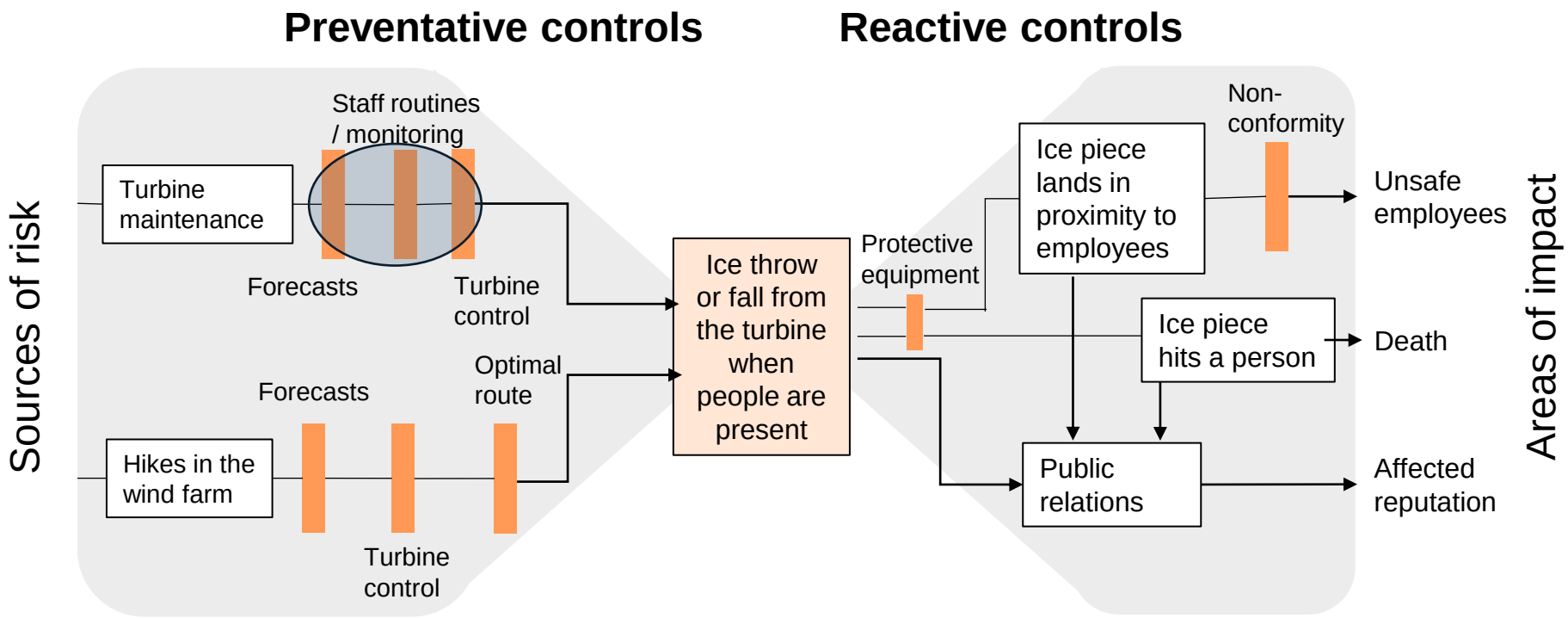
Description on causal and consequence picture of risk using a bow-tie diagram

Relevant initiating events, causes and **consequences**
barriers mitigating the risk, barrier failure



How “barriers” are used to control the risk of ice throw



Research project SVIV (fall 2023 + 3 years)
Safe operations of windpower plants in winter climate

IceRisk in the time domain – How to increase safety for working personell

- H1 Monitoring of risk (e.g. cameras on nacelle roofs)
- H2 Risk reducing measures
- H3 Icing forecast
- **H4 Modelling - assessment of risk for service personell**
- H5 Communication and risk management
- **H6 International collaboration - Task 54 participation**

Feedback from group:

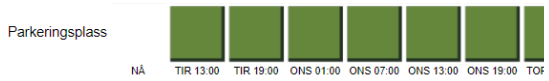
- We need to increase awareness and demand proper design early on (wind turbine manufactures and early project developers)
- Emphasis on safe design of wind turbines wrt to rooftop avalanches/ wetsnow from tower | inner part of blade, icicles/chunks from cooling system | nacelle
- Availability analysis for safe servicing conditions

What tools give the most benefit for service personell?

3 large risks they manage every day: electricity, falling, and ice falling/thrown
Mapping of risk in space and time for all relevant scenarios, risk sources, protection and patterns of movement

- Simplified and standardized data format of risk as mapped per hour and scenario (e.g. unprotected person / car, dangerous icethrow on road / area)
  - Ice and rooftop avalances from nacelle.
  - Wetsnow icing from tower and inner part of rotor,
  - Icethrow from turbine in predefined operational modes (full production, idling, heating modes, yaw e.g.)
- Mapping of movement patterns in time and space (scenarios)
- Rank risk in order to make informed decision on recommended movement pattern and operation on both short and long time horizon.
- Simplify user interface and data pipelines (overview over whole parks, mapping for each scenario and datasource)

	hit per m^2	0	22.5	
2	0.0-5.0	2.67E-01	6.17E-01	3.6
3	5.0-10.0	9.38E-02	4.38E-01	1.9
4	10.0-15.0	7.74E-03	1.39E-01	8.0
5	15.0-20.0	1.93E-03	5.20E-02	3.1
6	20.0-25.0	2.29E-03	3.26E-02	1.9
7	25.0-30.0	2.85E-03	2.11E-02	1.3
8	30.0-35.0	2.88E-03	1.13E-02	8.9
9	35.0-40.0	2.14E-03	4.87E-03	6.3
10	40.0-45.0	1.35E-03	1.76E-03	4.1
11	45.0-50.0	8.80E-04	4.55E-04	2.1
12	50.0-55.0	5.93E-04	8.43E-05	1.0
13	55.0-60.0	4.18E-04	1.50E-05	3.5
14	60.0-65.0	2.70E-04	8.64E-07	1.1
15	65.0-70.0	1.67E-04	########	2.7
16	70.0-75.0	7.60E-05	########	5.2
17	75.0-80.0	3.62E-05	########	2.7
18	80.0-85.0	1.57E-05	########	###
19	85.0-90.0	4.94E-06	########	###
20	90.0-95.0	2.33E-06	########	###
21	95.0-100.0	5.54E-07	########	###



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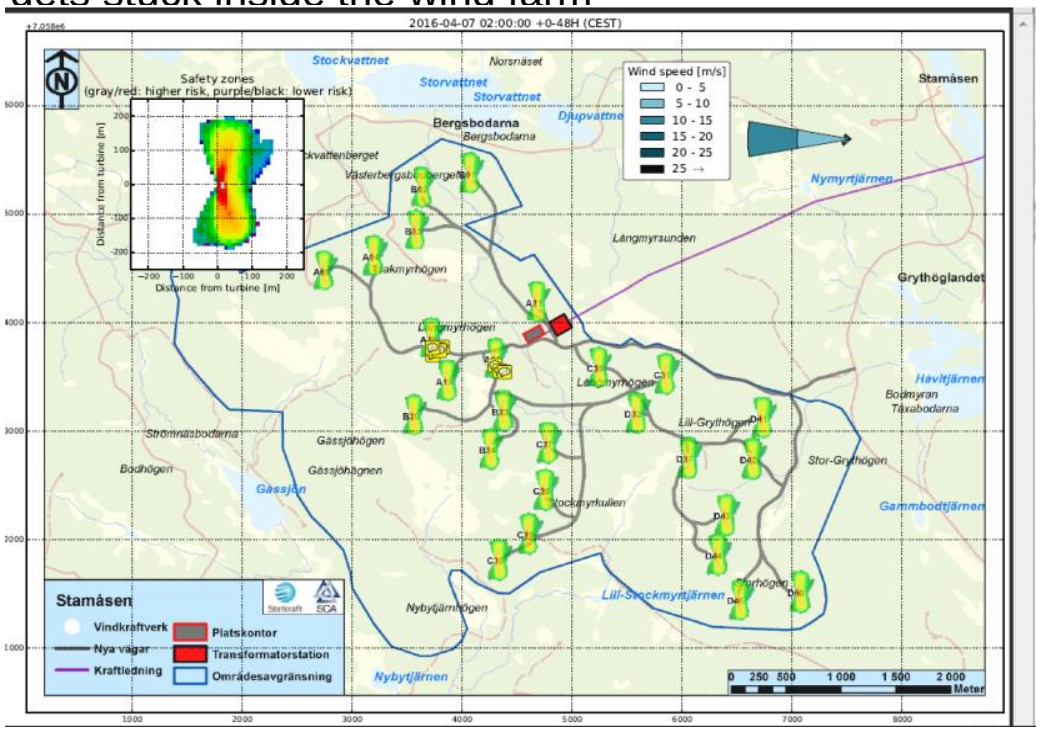
Tools should answer day to day questions like

- a) Allow access
- b) Allow drive-by with vehicle for service of other turbines or to enter a service building located inside the wind farm.
- c) Which turbines are available for service/visit e.g. today. Should service be delayed?
- d) Is it safe to perform snow clearance?
- e) What is the risk associated with an evacuation or rescue from a turbine (or area) if an accident occurs or a vehicle gets stuck inside the wind farm



Overall objective: Develop methods to increase safety

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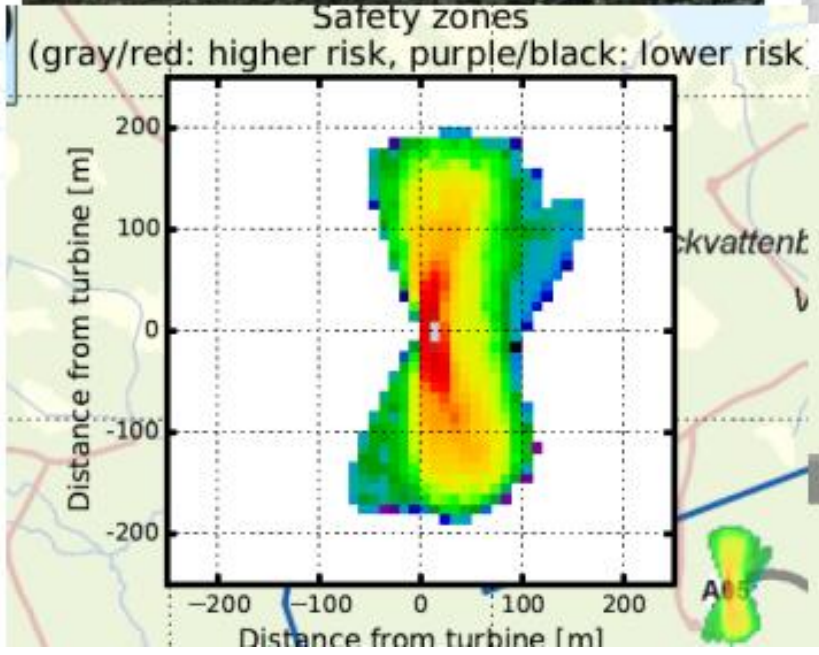

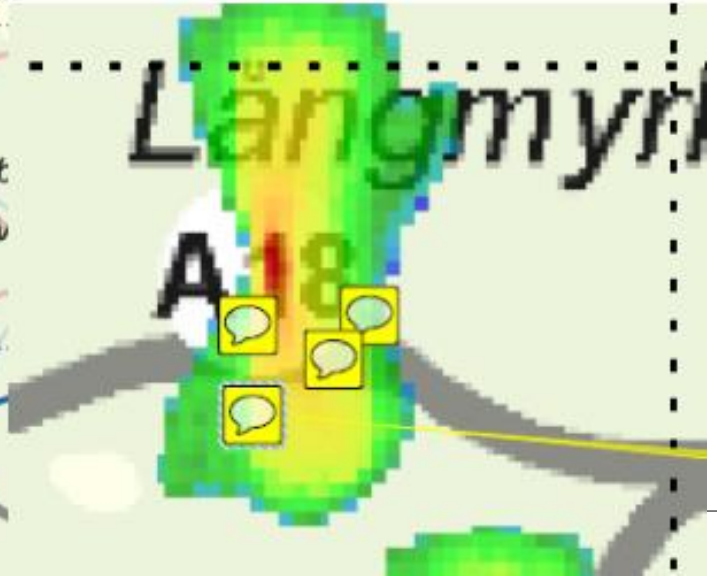

https://winterwind.se/wp-content/uploads/2015/08/3_3_28_Bredesen_IEA_Task_19_-_IceRisk_Review_of_current_knowledge_and_the_way_forward_in_risk_assessments_associated_with_ice_throw_from_wind_turbine_blades_Pub_v1.pdf

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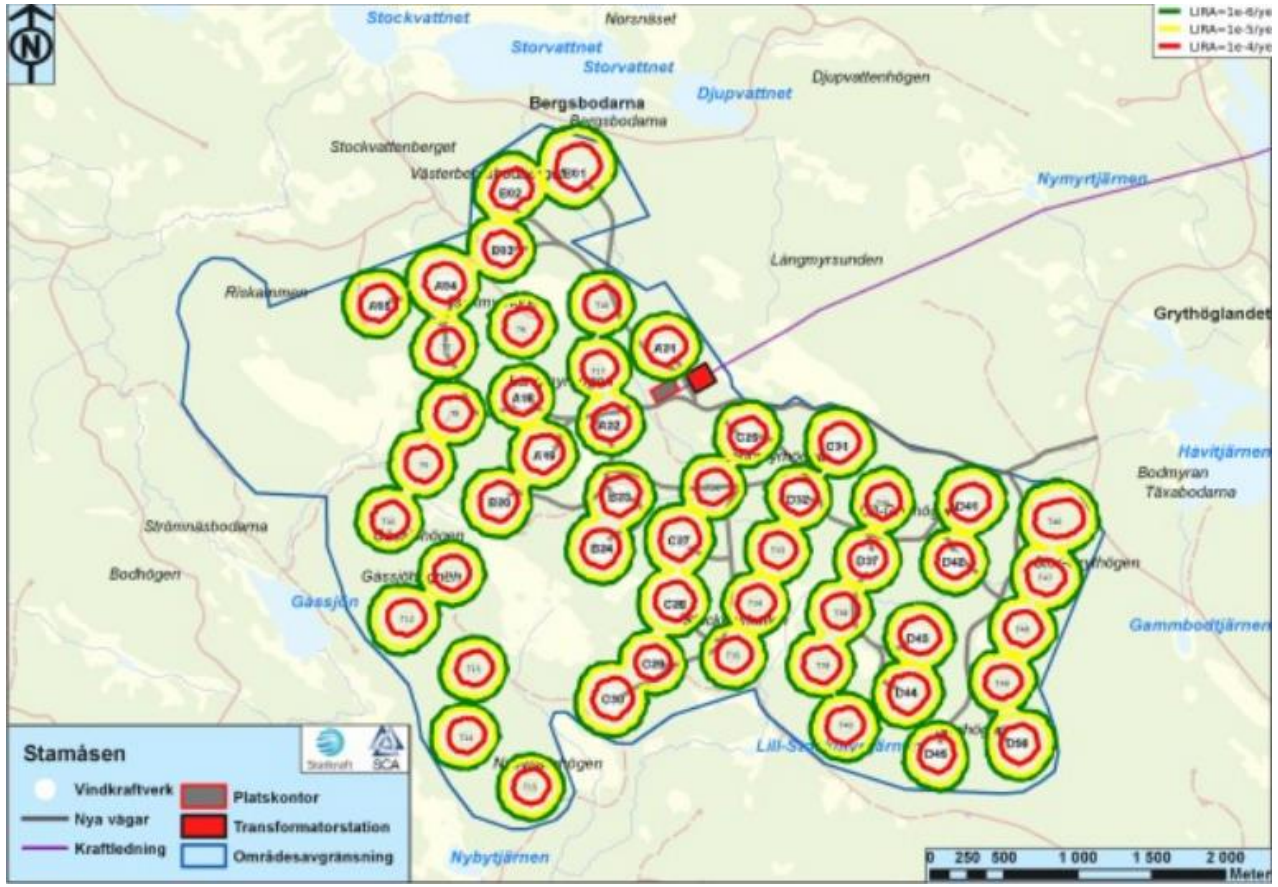
Consider service availability already at project development stage

Cost/risk-effective design early on

- How often will the turbines be approachable/accessible by service personell in a safe way.
  - Where are service buildings located
  - Relative placement of roads wrt to turbine and hazard zones
  - What is the running cost of wtg's being isaccessible for weeks during winter?
- Require safer designs of nacelle roofs / heat exchanger.
- Safety at entrance of tower
- What are the design implications in cold climates?



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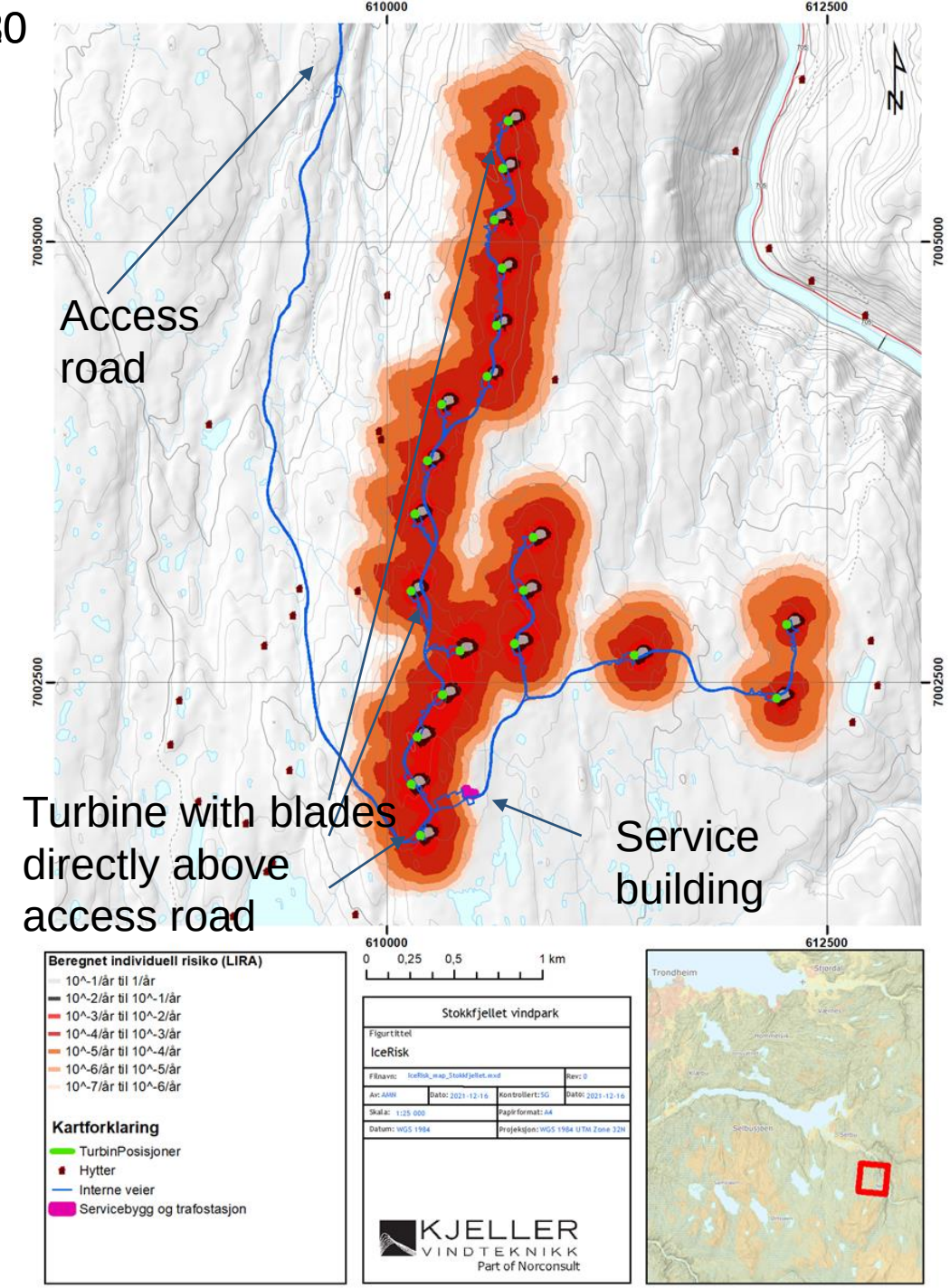


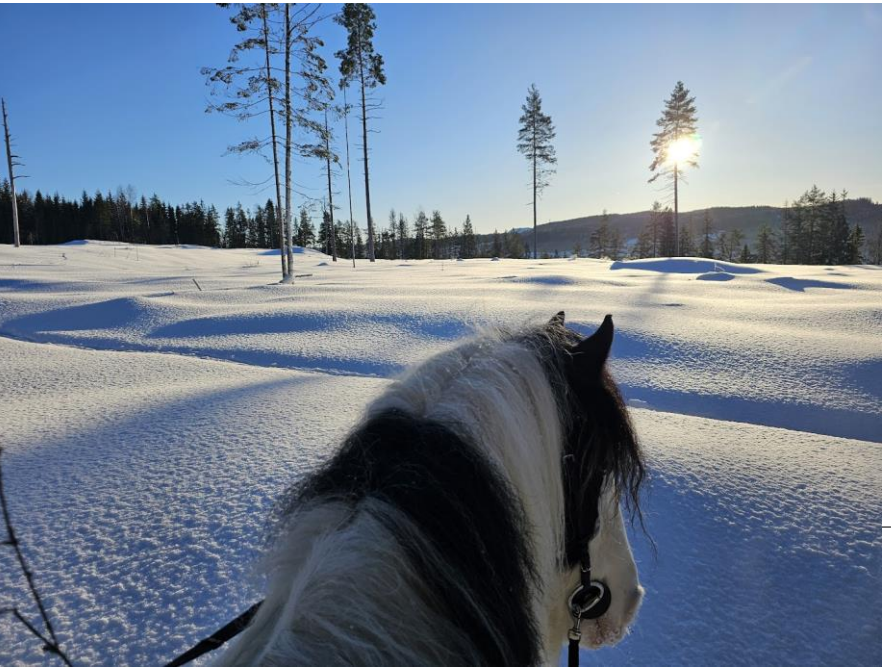
Missed opportunities for inherently safe design

- Risk zones shown for <u>permanent</u> exposure
- 40 J limit
- Includes wet-snow and icicles
- Each zone = factor of 10x

- Safe access to service building?
- Maintenance road directly underneath rotor-plane
- What is the service availability for the northernmost turbine?

Choosing suitable and sufficiently risk reducing measures by ranking choices

- State-of-the-art **forecast system coupled with SCADA** data: **RRF=20**, because informed individuals avoids the area when there is a danger.
- **Personal protective equipment** (e.g. helmet, eyeprotection, winterboots).
- **Switching operational mode**: **RRF between 1 to 4** for a given path, risk depend on the number of risk relevant ice pieces landing on it.



Mode	Risk reduction factor relative normal operation
Normal operation	1
Heating under idling	1.5
Heating under operation	1.6
Idling when ice is detected	4.2

Swedish site where area is used for horseriding (Råmmarehemmet, EnBW)

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Effect of risk reducing measures from international guideline on icethrow hazard, only reduction on likelihood of presence

Category	Safety measures	Risk reduction (RRF)	Appropriate for
Reduction of likelihood of presence	Warning signs of ice fall conditions	1 to 10	Minor roads and paths
	Warning light connected to the ice detection system on the turbine in combination with warning signs	10 to 100	Minor roads and paths
	Rerouting supervised by security guard for high risk events	10 to 100[13]	Minor roads and paths
	Physical barrier (official road closure) and signs	10 to 100	Roads and official frequently used hiking paths

- I would like to see statements on risk reducing effect of other measures.

IEA Wind TCP

- https://iea-wind.org/task54/
- Continuation of Task 19
- I have been the Norwegian participant since 2016

Task 54: Cold climate wind

Cold climate conditions present challenges to wind power projects that requires specific solutions to maximize production and minimize risks and uncertainties.

Cold climate sites are defined as those that experience either icing events or temperatures lower than the operational limits of standard wind turbines. Low temperature sites require special solutions to keep turbines operating. In icing conditions, a combination of low temperatures and liquid water in the atmosphere results in ice accretion on surfaces, such as wind turbine blades, towers and nacelle. Blade icing results in loss of lift and increase in drag, resulting in reduced energy production. Icing can increase mechanical loads on the turbine, vibrations in structures and noise. In addition, ice on the blades, nacelles and towers can present a health and safety risk, due to ice falling off or being thrown from the blades.

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IEC 61400-31 TS Wind Turbines Siting Risk Assessment

International Electrotechnical Commission

PT 61400-31

Wind energy generation systems - Part 31: Siting Risk Assessment

The Technical Specification will lay out the process and methods for the creation of a turbine siting risk assessment and will address:

- Glossary of terms and definitions
- Aims of a risk assessment
- Types of risk events
- Values under risk
- Risk criteria
- Risk assessment
- Risk evaluation
- Risk management
- References

Worked on this together with Karl Ove as Norwegian members of IEC technical comittee nr 88. Financed by WEIC project (Wind Energy in Cold Climates

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Thank you!

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Questions

- Q: What is the best solution for controlling the risk of icethrow
- A:
  - I think it is about knowing when there is a danger or at least when to be vigilant.
  - Avoiding, moving fast and not stopping or get stuck in a hazardous area is a good way of reducing exposure.

- Q: How to we build trust in risk reducing systems
- A: Share knowledge, show track record and issue warranties/statements on the risk reducing effectiveness of different systems.