Fire safety of wind turbines: fire scenarios

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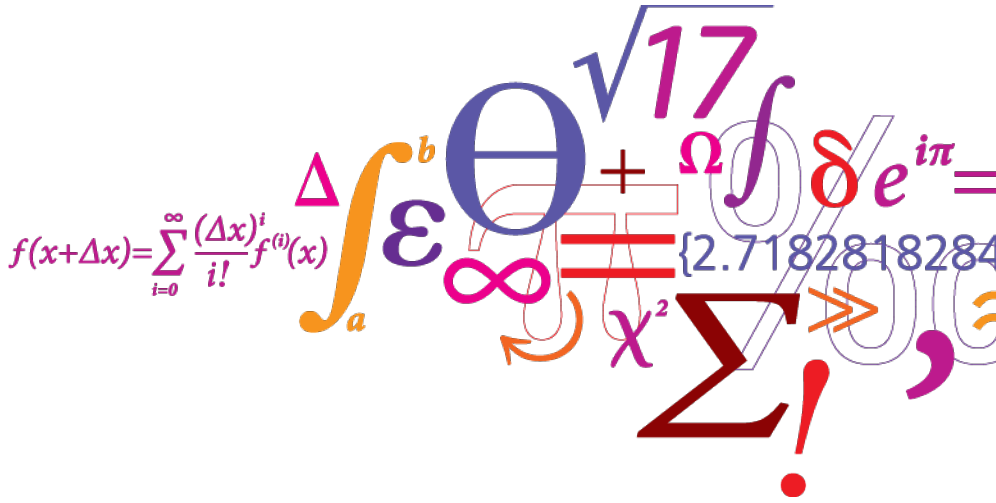


Workshop Fire Safety for Wind Turbines

20-Sep-2016 09:00 - 17:30

Location: Hilton Copenhagen Airport

Organiser SP Sweden www.sp.se;

DTU Management Engineering
Department of Management Engineering

Windmill accidents

Fires are not a common occurrence for wind turbines – but when they do strike, they can be very costly.

Prevention and protection are therefore Essential

(Nancy Smith and Eize de Vries in September–October 2004 RENEWABLE ENERGY WORLD)

But fires may occur

Lit:
http://www.ifv.nl/kennisplein/Documents/2013_04_16_lste.pdf

Fire scenario: summer thunderstorm

- The wing of a 2 MW-Windmill was stroked by lightning. The Windmill stopped automatically, the burning wing stopped vertically to the top and burned totally down. Falling burning debris led to a following fire of the nascelle.

- Failure: faulty connection (screw contact) in the lightning protection sytem caused the fire → total loss
- Top of tower was also destroyed because of high temperatures

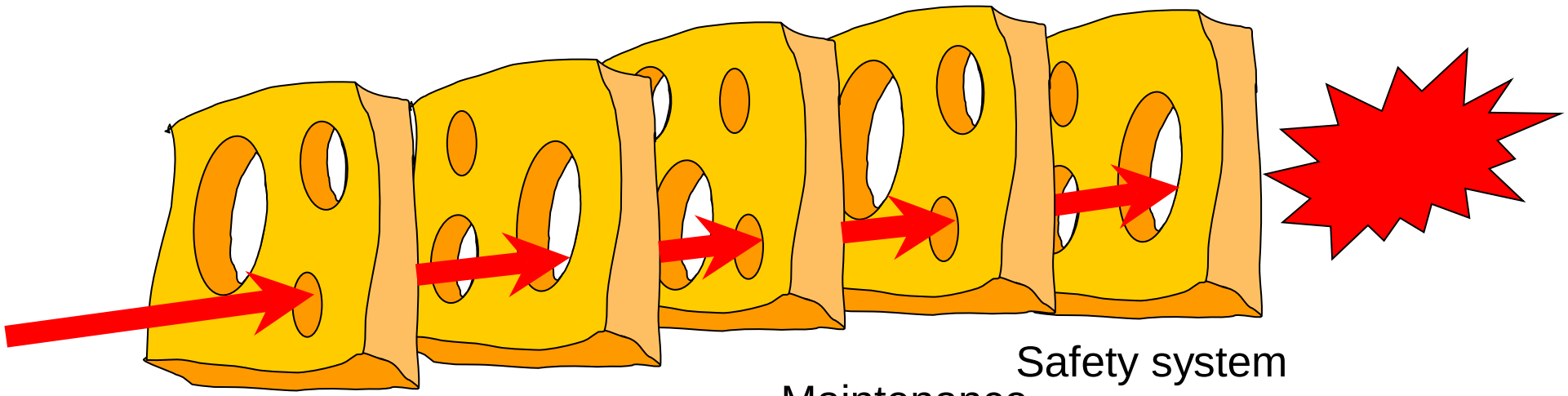
Fire scenario: windmill fire with fatality

- *One person was found dead immediately, and two other mechanics survived the incident. In the turbine there were four mechanics when the fire broke out. The fourth mechanic had been missing. The fire rescue team conducted an inspection from the outside of the wind turbine and searched the whole evening. He was eventually found at the top of the tower. The fire started in the top of the 67 meter high wind. It is a cooperative Delta Wind turbine in the wind farm Piet de Wit at Ooltgensplaat (Holland). The police have just announced that the two men are fatalities." Source*

- https://youtu.be/2hJeaPzDnOE

dinsdagmiddag **29 oktober 2013** rond 15:45 uur ontstond in een windturbine op Windpark Piet de Wit van Cooperatie Deltawind aan de Mariadijk te Ooltgensplaat brand terwijl vier monteurs

The Swiss cheese model (James Reason)



e.g.: User interface

Latent failure ←→ active failure

Fire safety issues-what does we know?

- Generic causes of wind turbine fires
  - Lightning strike
  - Technical fault

Windenergieanlagen-Leitfaden für den Brandschutz VdS 3523: 2008-07 (01)

Why- to write the guidelines for fire protection?

- The increasing demands on the availability of wind energy and the experiences of damages over the years

- The Authors:
  - GDV der gesamtverband der Deutschen Versicherungswirtschaft e.V.
  - Die Germanischer Lloyd Industrial Services GmbH, Geschäftsbereich Windenrgie

Background:

- Windmills are different from common power stations :
  - risk of total damage of the Nacelle.

Main risk parameters from insurer view

- high concnentration of values in the nacelle
- Concentration of potential ignition sources in the nacelle and increased lightning strike
- Unmanned production
- No possibility for firefighting by emergency services because of the great heights
- Remote, partly difficult reachable locations, in particular for off.shore windmills

Lightning damages to windmills

Susceptibility to lightning damage is heavily dependent on a wind turbine's location – and its size.

Examples on location:

- relatively high frequency of lightning in the north of Germany and the Alps
- Denmark is rarely affected.

- Lightning strike is significantly more common in the US than in Europe. (windpro insurer)

- Parts of Japan have experienced severe lightning losses:
  - During one winter season in Japan.
  - Alone the area of Honshu, at least 55 machines had blades destroyed by lightning.
    - **The total estimates [that] one year loss for those machines exceeded $5.5 million, and the cost of prevention is approximately one half that value'.**

Technical ignition scenarios

- The other main cause of fire is technical fault.
- technical reasons
  - Overheating, or sparking, in combination with flammable fluid or vapour.
- Human error can also play a part.
  - fires caused by loose or broken electrical connections
- Fires can also occur as a result of component failure.
  - 2003 the nacelle of the German 1.2 MW Vensys 62 prototype burned down, cause:
  - short circuit in a fail-safe battery pack of the pitch control system.
- Other causes, e.g. a bearing starts failing and runs dry leading to hot surface

Hot surfaces

- Mechanical brakes can lead to ignition temperatures
- Emergency brake without cover can lead to sparks → long distance ignition
- Faulty equipment as leaking oil pipes or dirt increases the fire risk
- Generator: over power , lacking unsatisfactoring lubrication hot lager

Hot work- in connetction with repair, and other work is often a fire cause
(welding , grinding, cutting sparks may reach a distance of 10m)

Fires may first develop many hours after the hot work finished

Costs of windmills and accidents

- The costs of establishing the windmills as well as reestablishing costs are proportional with the installet effect

- Additional increasing stand-still costs with increaing effect

Costs

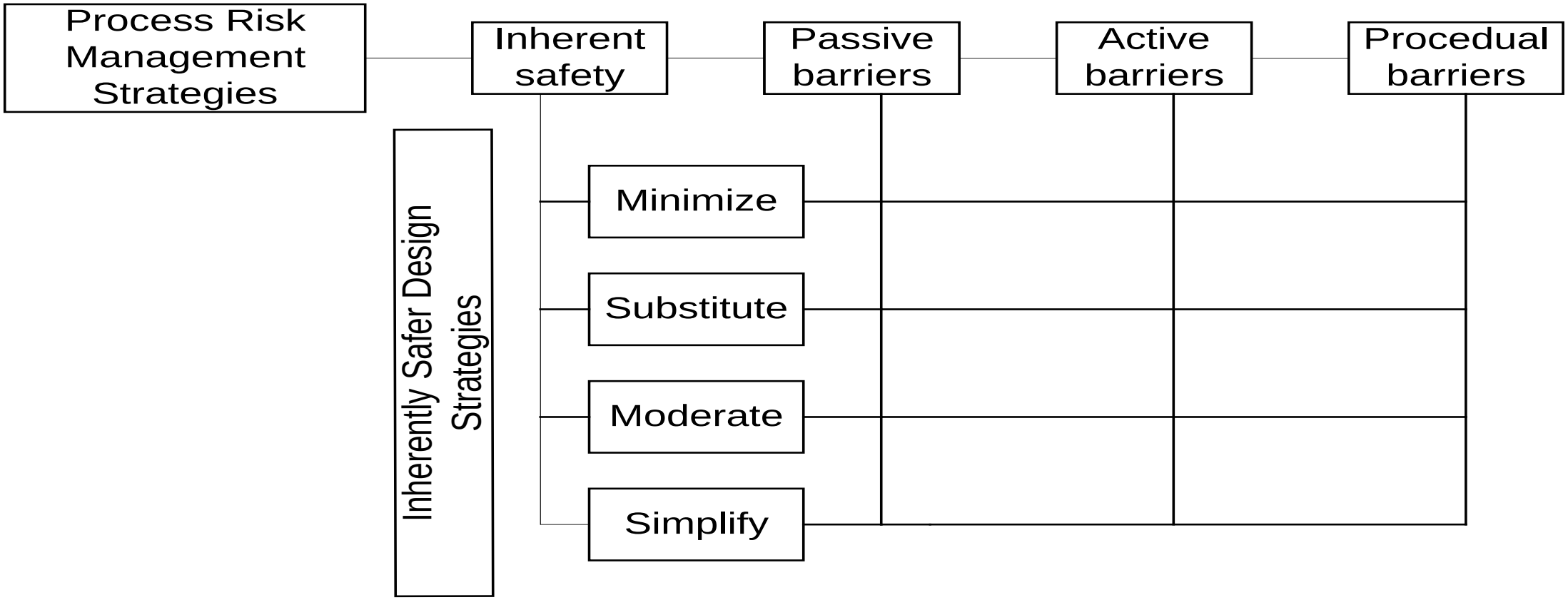
Estimates from 2004

- Once a wind turbine has burned down, it can lead to between **nine and twelve months of down time,**
- a considerable loss of income for a wind farm operator,
- according to insurers WindPro.:
  - Figures suggest that **fire damage accounts for between 9 % and 20 %**
  - (Umweltkontor, WindPro, resp.) **of the value of wind power insurance claims**.

Off-shore windmills

- Off-shore windmills have in principle the same fire damage causes as land windmills
  - But due to adverse environmental conditions and the reduced knowledge (stand 2008) the **likelihood of technical defects is increased and with it the risk of fires**

Fire safety strategies by Inherent safety



Minimize other Fire load

- Foam for noise reduction in the gonde partly contaminated with oil
- The polymer of the gondel
- Oils inthe hydraulicsystems (pitch regulation, braking systems)
  - High pressure sprays the oil out that may lead to explosion like fire spread
- Gear oil and other lubricants (e.g in generators)
- Transformer oil
- Electrical installation, cabels aso.

- Unnecessary stored oils and not removed oily wastes contribute to the genral fire risk and fire spread

Substitute combustible materials

- Hydraulic oils and lubricants should be non-combustible or have a high ignition point
  - much above the drifts temperatures of the windmill
- Combustible materials in installation should be avoided (foams PU, glasfiber polymers) for covers and building materials
- If not possible
  - Use less igniteable materials
- Materials should be smooth (no pores) that make them cleanable from contamination and spills by oils a.o.

Mitigation of fires

Cables and wires in a fire situation should give less:

- Toxic and corrosive degradation products
- Emission of smoke
- contamination of the spaces and the equipment
- Not support fire spread
- Maintenance with flammable liquids and oils care is tto be taken to collect spilled liquids , leakages need to be closed immediately

Procedural measure: emergency training

- Education
- Service personal and contarcted companies need to be instructed on the fire risks on a regular basis:
  - Avoidance of fire risks
  - Function of the installed fire saftey installations as well as operating them
  - Right reaction in case of a fire insident, e.g. alarming of third parties
  - Right handling of fire extinguishers

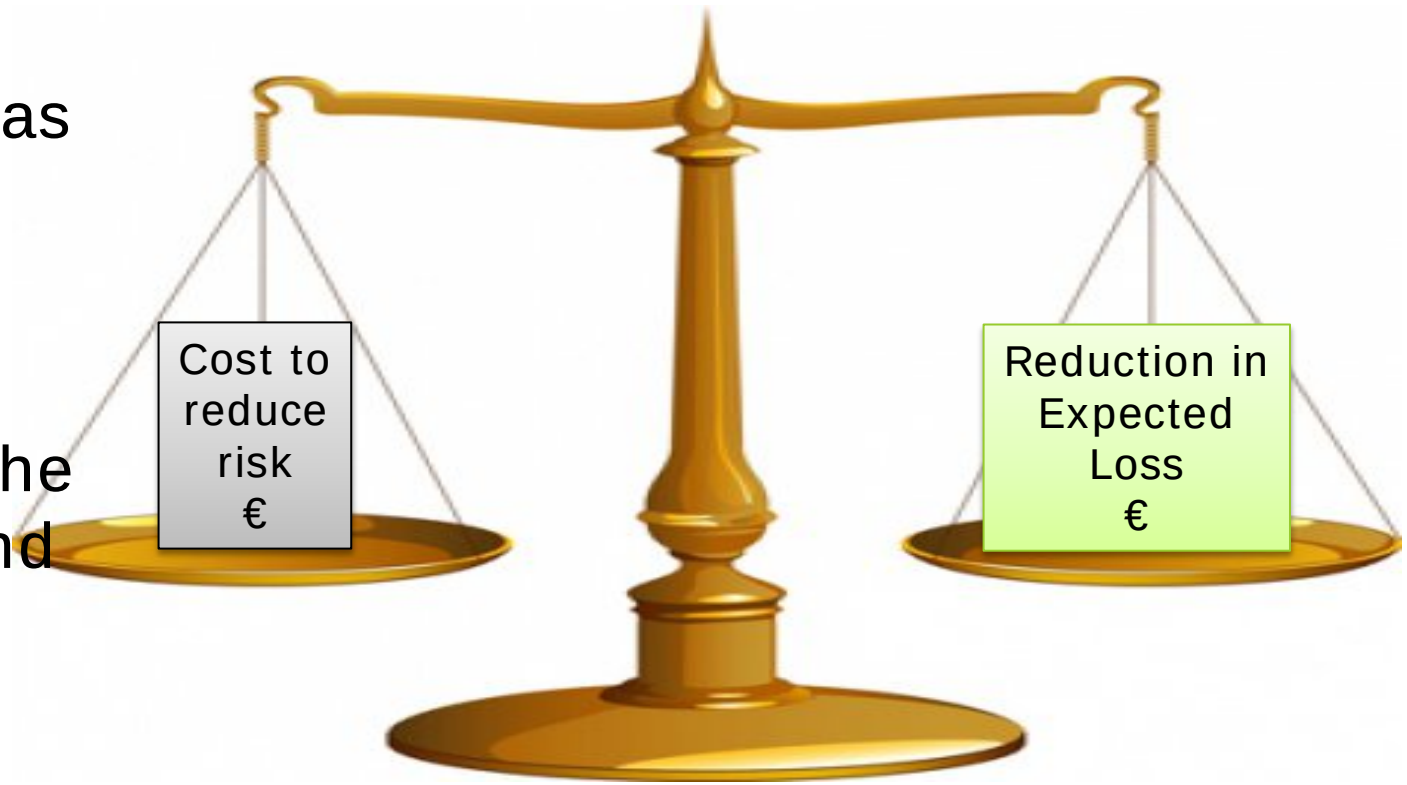
  - It is recommended to conduct regular fire rescue training togtehr with the local fire department:
    - Test alarms
    - Training on the emergency plan
    - Evacuation of the gondel

Cost benefit assessment

When:

- If damage can be expressed as costs
- If there are no ethical issues

- Rational decision: minimize the nett sum of Expected Loss and cost to reduce risk



Now we consider *life*

- the risk of loss of life should be reduced ***As Low As Reasonably Practicable (ALARP)***

- We may still consider the costs of risk reduction, but we only may reject further risk reduction if the costs are **grossly disproportionate** with the value of the risk reduction

Thank you for listening