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# State of the art risk reduction of wind power facilities

Daniel Swart, Lloyd's Register

Ane Kristiansen, Lloyd's Register

Rolv E. Bredesen, Kjeller Vindteknikk

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Umeå, Sweden



Working together  
for a safer world



# Content

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- Lloyd's Register (LR) in brief
- What is risk
- Case study: Tryvann broadcasting tower
- Transfer case study to wind farms
- Summary



# Lloyd's Register (LR)

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- Established in 1760 by Edward Lloyd
- LR acquired Scandpower in 2010, fully integrated in LR in 2014
- 195 offices worldwide
- Approx. 7500 employees worldwide
- 60 000 clients, from small-medium enterprise to «Fortune 500» companies

## Consulting

Risk management and asset integrity solutions.

## Assurance

Expert independent assurance services.

## Compliance

Supporting safe and reliable operations.

# Risk management throughout the lifecycle



## 1. Design / Project development

### • Reference projects:

#### • **Equinor**

- Field development, Hywind Scotland

#### • **Statnett**

- Development of HSE risk analysis methodology in project planning phase
- Development of HSE-method for power grid routing selection
- Technical safety course for project management lifecycle

# Risk management throughout the lifecycle



## 2. Construction / Installation

### • Reference projects:

#### • **Statnett**

- HSE-advisory service during construction and installation of
  - North Sea Link (Subsea power cable between UK and Norway) (ongoing)
  - NorNed HVDC cable link (Subsea power cable between Norway and the Netherlands)
- Technical safety for cable installation and power grid

# Risk management throughout the lifecycle



## 3. Operation and maintenance

### • Reference projects:

#### • **Statnett**

Emergency preparedness analysis and plans for local distribution grid

#### • **Statkraft**

Emergency preparedness analysis for on-shore wind farm

#### • **Equinor**

Emergency preparedness analysis for off-shore wind farm

# Risk management throughout the lifecycle



## 4. Decommissioning / Phase-out

- Reference projects:
- **Statnett**  
HSE advisory service related to decommissioning of coupling stations and removal & recycling of old subsea cables

# Risk management throughout the lifecycle



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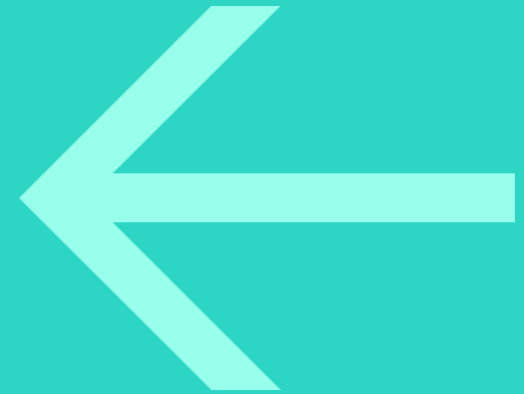
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# What is risk?



# What is risk?

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## General definition of risk

$$\text{Risk} = \text{Probability} \times \text{Consequence}$$

### **Probability or frequency:**

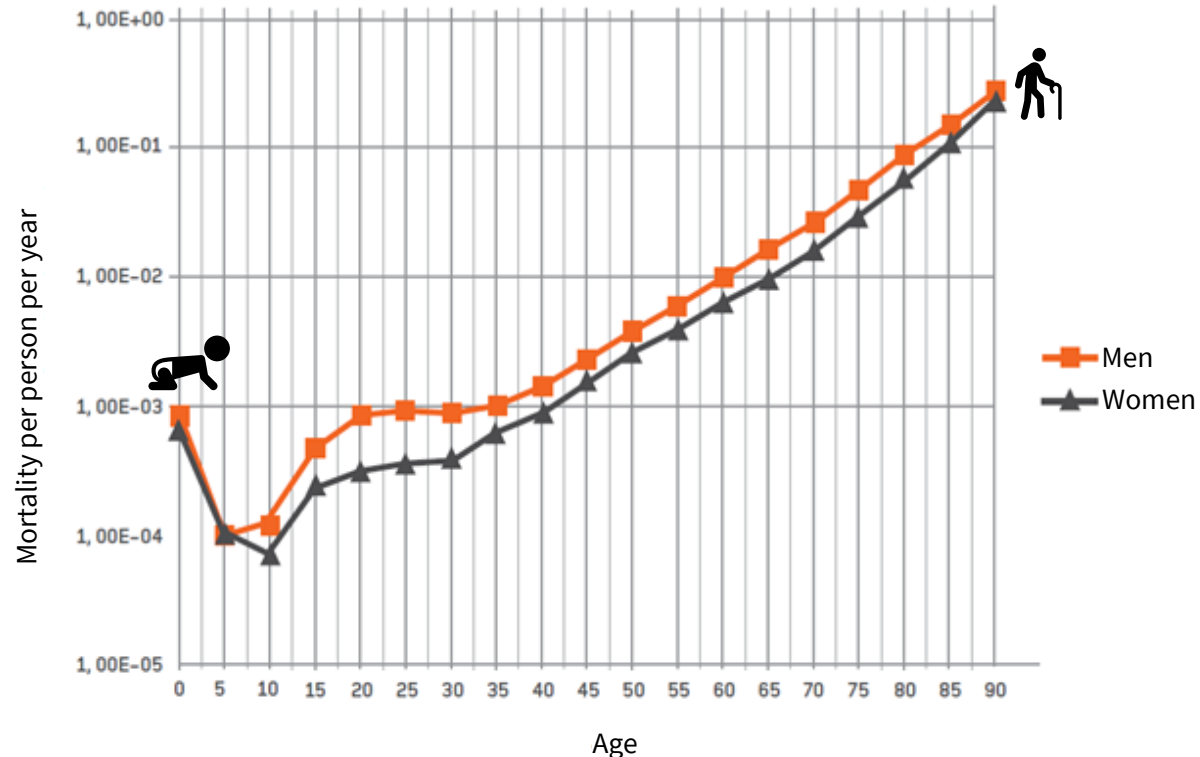
How often can it happen or what is the frequency (e.g. how many times does it occur per year)

### **Consequence or effect:**

What is the effect of an event (e.g a leak leads to a fire or ice accumulation leads to ice throw which in turn causes someone to be injured)

# What is individual risk?

- Probability of dying per year for men and women in different age groups



**1E-3/10<sup>-3</sup> equivalent to 1/1 000 or 0,001(one per thousand)**

**1E-4/10<sup>-4</sup> equivalent to 1/10 000 eller 0,0001**

Ref. The Norwegian Directorate for Civil Protection

# Who are the 1st, 2nd & 3rd parties?

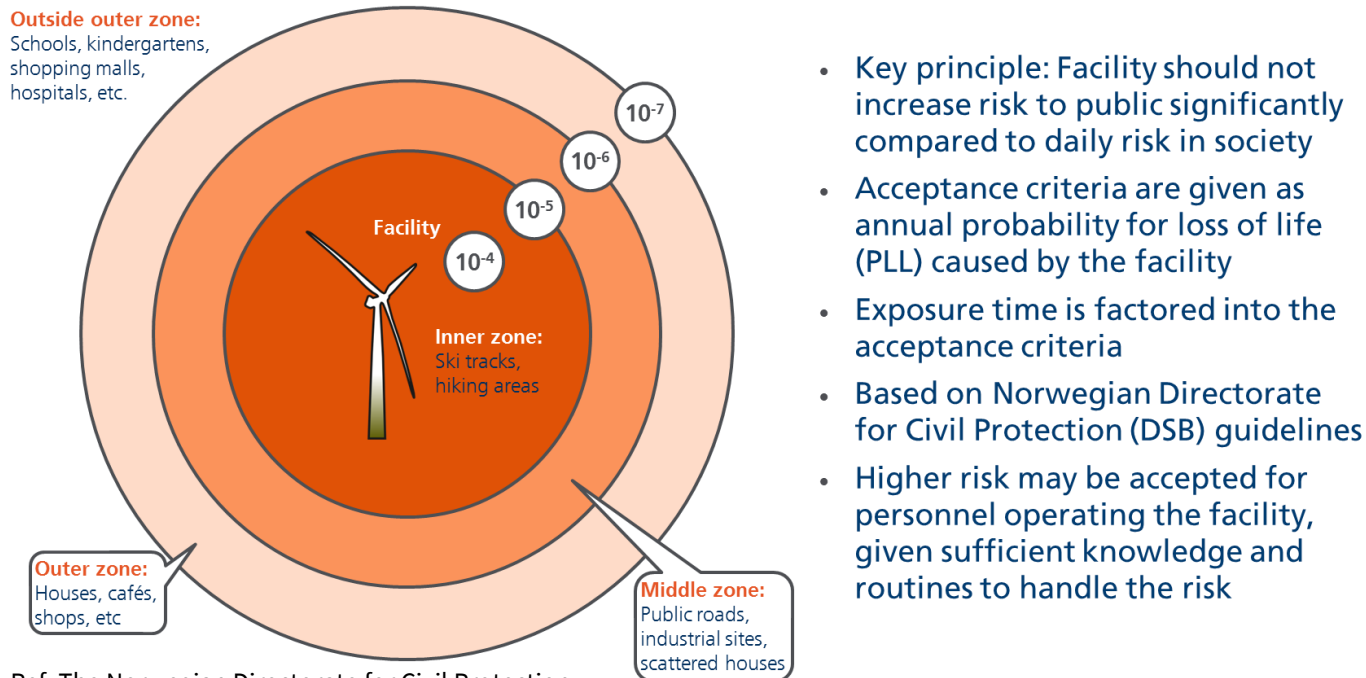
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- 1st party
  - Persons directly involved in your business activity, e.g. your employees
  - Have the full understanding of the risks associated with their activity (procedures, PPE, training etc.)
- 2nd party
  - Persons that benefits your business, e.g. suppliers, goods delivery personnel
  - Have somewhat understanding of the risks associated with your activity
- 3rd party
  - Persons that does not relate to your business, e.g. people who may be affected by your activity, but does only enjoy the environment surrounding your business
  - No requirements for 3rd party to understand the risks associated with your activity



# Risk and acceptance criteria's

## Additional individual risk



Ref. The Norwegian Directorate for Civil Protection, adapted from major accidents from land based industry

- Key principle: Facility should not increase risk to public significantly compared to daily risk in society
- Acceptance criteria are given as annual probability for loss of life (PLL) caused by the facility
- Exposure time is factored into the acceptance criteria
- Based on Norwegian Directorate for Civil Protection (DSB) guidelines
- Higher risk may be accepted for personnel operating the facility, given sufficient knowledge and routines to handle the risk

# Major accidents

Murdock, Illinois, US, 1983, LPG, Train accident, (BLEVE)



Hindenburg, US, 1937, Hydrogen, airship, (explosion and fire)



Mexichem, Mexico, 2016, petrochemical plant, Vinyl chloride, (explosion and fire)



Imperial sugar, Georgia, US, 2008, Sugar refinery, (Dust explosion)



Lloyd's Register

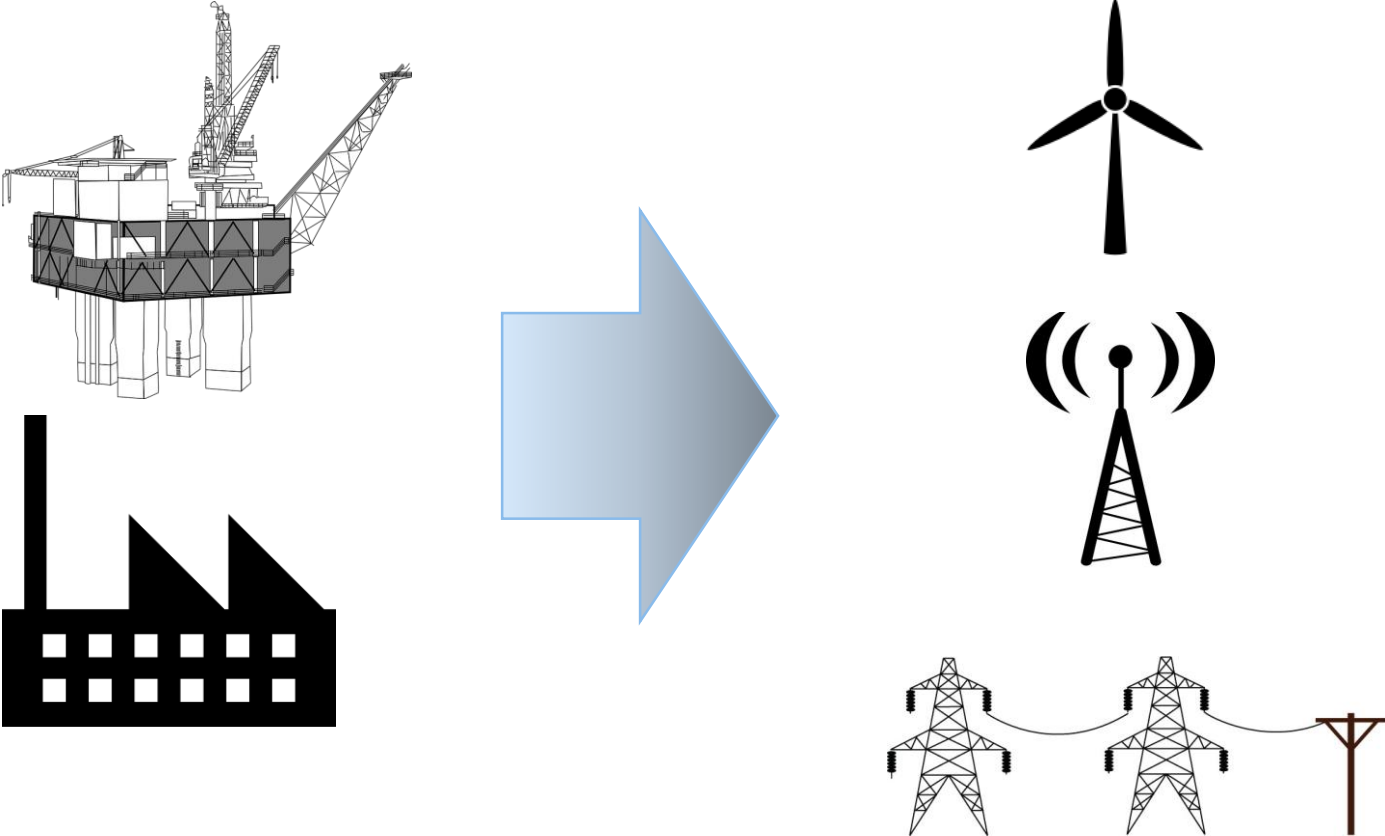
Events must be avoided !  
Risk management throughout  
the lifecycle; everyone, everyday !

Buncefield, UK, 2005, petrol, storage facility, (explosion and fire)



# Transferring knowledge and expertise

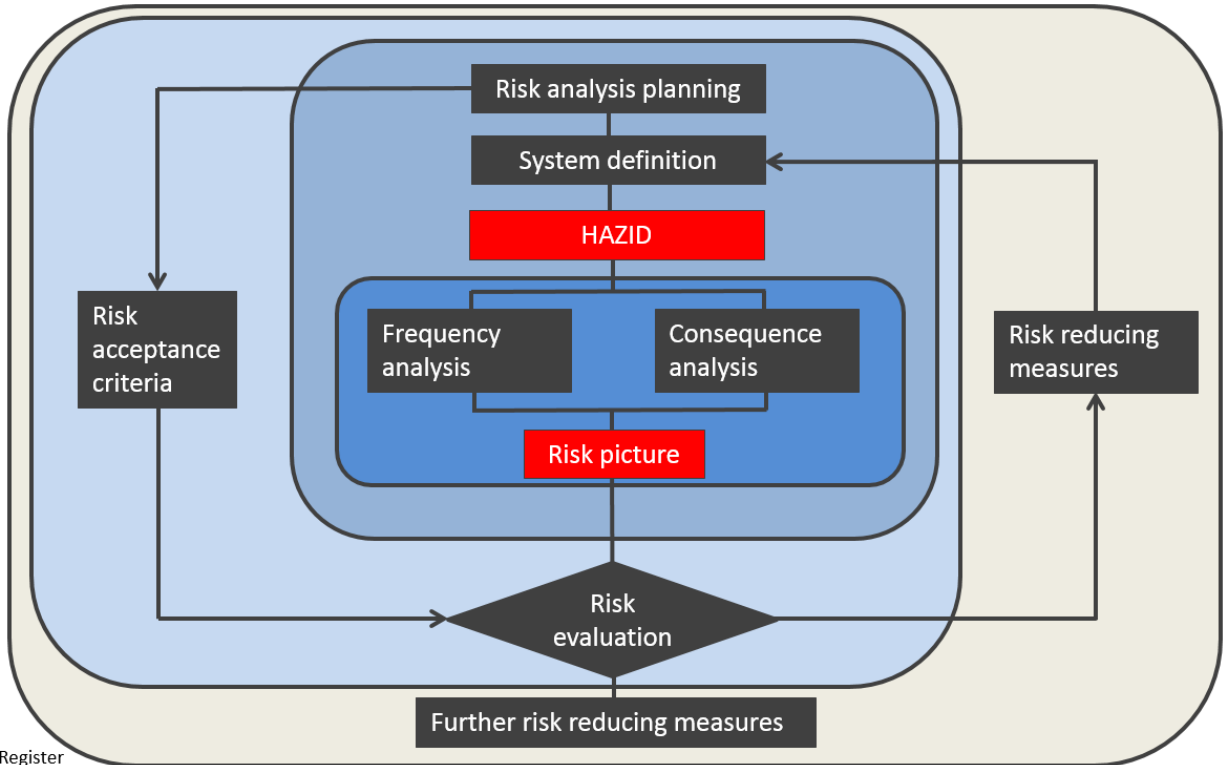
Technical and operational safety



# Risk management process

## Overall methodology for safety studies

- Risk assessments are included as one of the elements of systematic risk management in an enterprise or for an activity, and can provide support for security-related decisions



Lloyd's Register



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# Case study: Tryvann broadcasting tower

Located in Oslo, capital of Norway

Tower owner: Norkring, Norkring owned  
by Telenor



# Case study presentation

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- Presented previously in Piteå, 2015
- 4 years with practical experiences and continuously improving barriers



# Case study presentation

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- Board and management responsibility to have control on the risk picture associated with the business activity
- Discrepancy in risk perception
  - Board
  - Management team
  - Operations and maintenance
  - Other interested parties
    - Hikers and cross-country skiers
    - Alpine ski centre
    - Kindergarten



Ref. picture: google maps

Lloyd's Register



# Establishing the risk picture





# SMS notifications – risk of ice fall from Tryvannsmasta



- Number of notifications per season
  - Winter 2015/16 – 2 notifications – duration 25+34 days
  - Winter 2016/17 – 3 notifications – duration 2+2+15 days
  - Winter 2017/18 – 3 notifications – duration 1+1+1 days



# Risk matrix

<b>Consequence</b>	Fatality	4	MED					
	Permanent injury / disability							
	Temporary injury							
	First aid injury							
	<b>Safety</b>							
			Negligible	Unlikely	Occasional	Likely	Frequent	
<b>Probability</b>								

# Bow-tie and barrier management

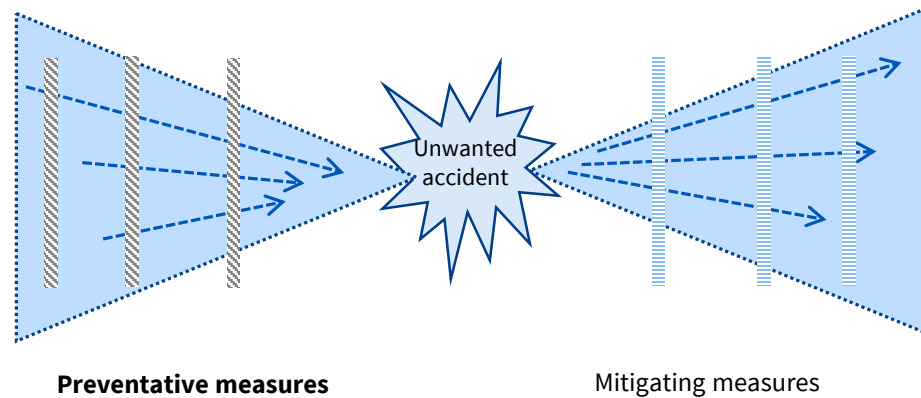
## Barrier management:

How **mature** / **vulnerable** / **effective** is it?

Can we optimise it?

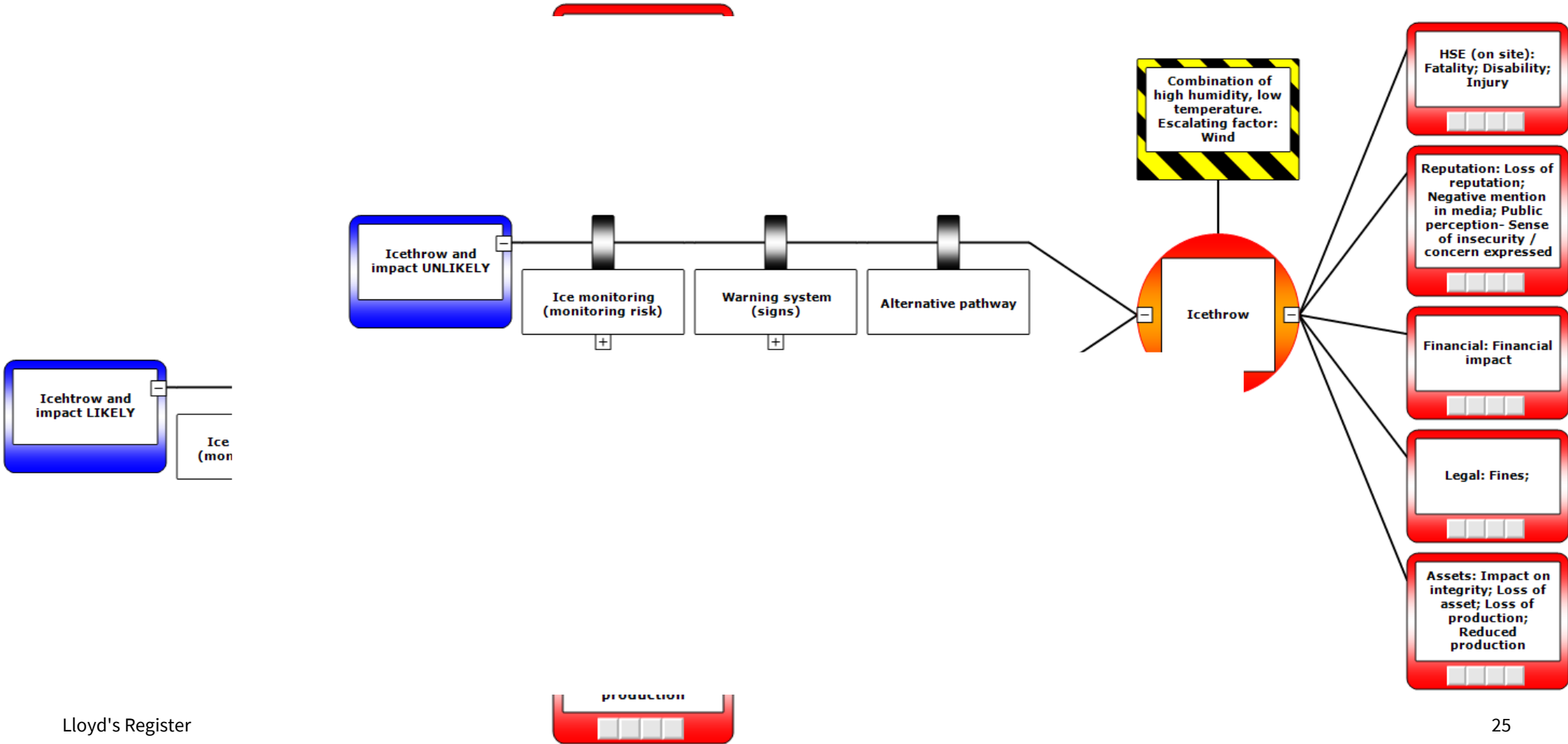
Who is responsible for follow-up and maintaining the barrier?

Are there any measures to monitor or to control the risk?





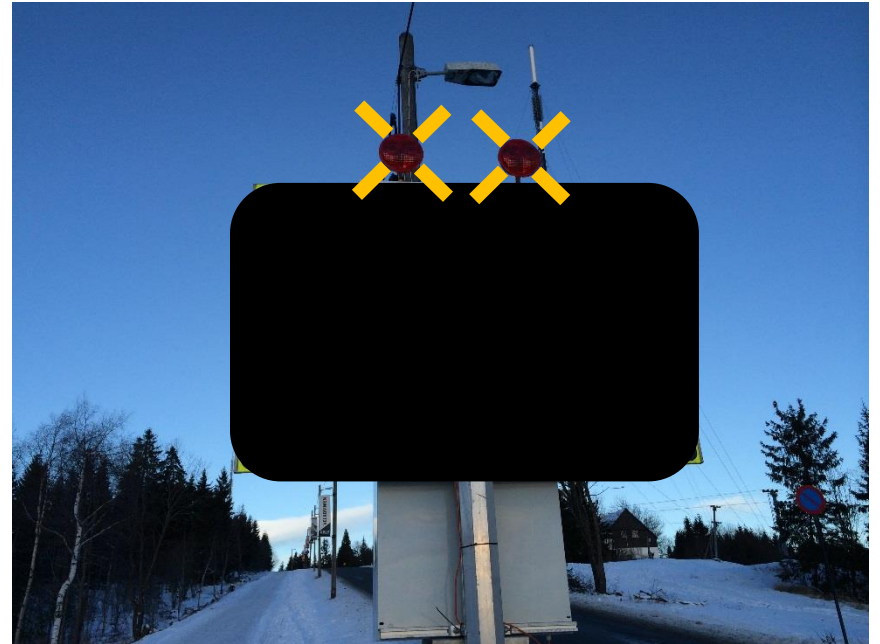
# Bow-tie



# Barrier effectiveness

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- Human factors- an important factor for design of barrier
  - How effective is the design/barrier?
  - You don't want 3rd parties to ignore your signs, lights or other messages
    - How to enhance the design of these solutions?
    - When and how to communicate to 3rd parties?



# Tryvann broadcasting tower

## Investing in public safety



**SMS message to interested parties**  
Hi,  
It is from <date and time> danger of ice fall from our tower on Tryvasshøgda.  
Kind regards,  
NORKRING



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- Norkring invests heavily in safety and continuously maintain the barriers to safeguard the public

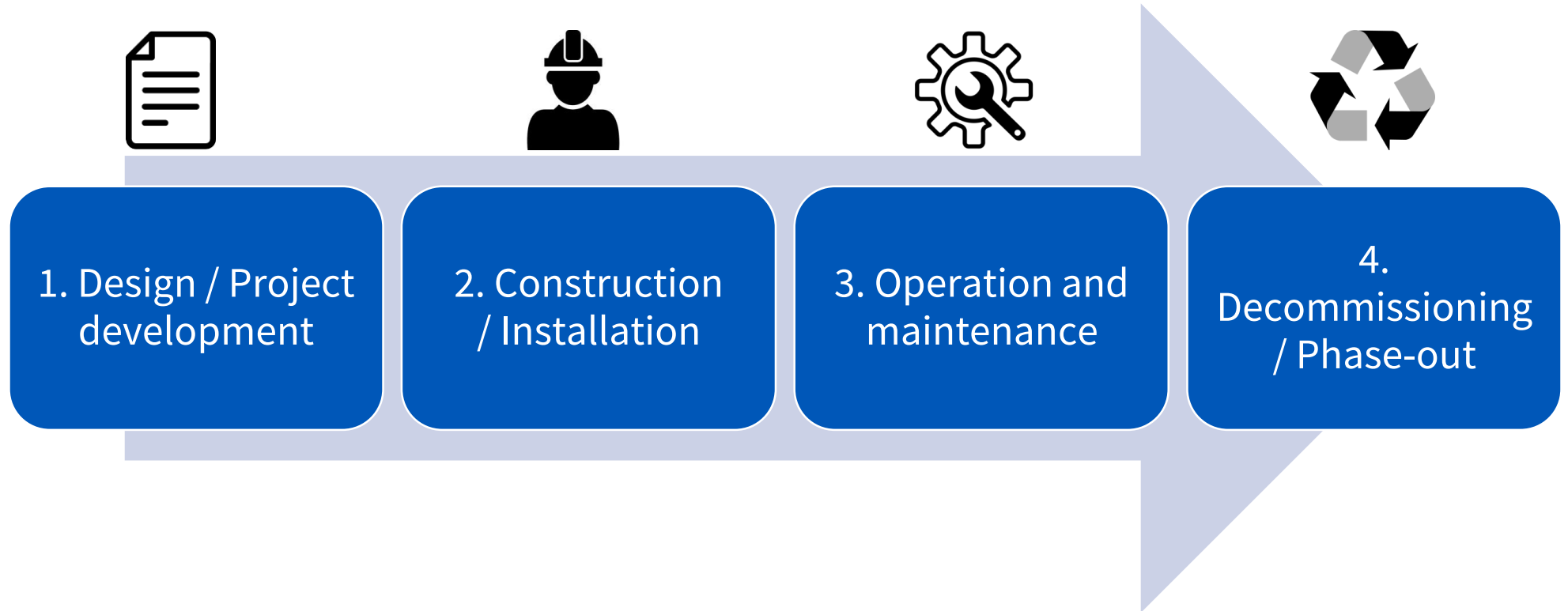


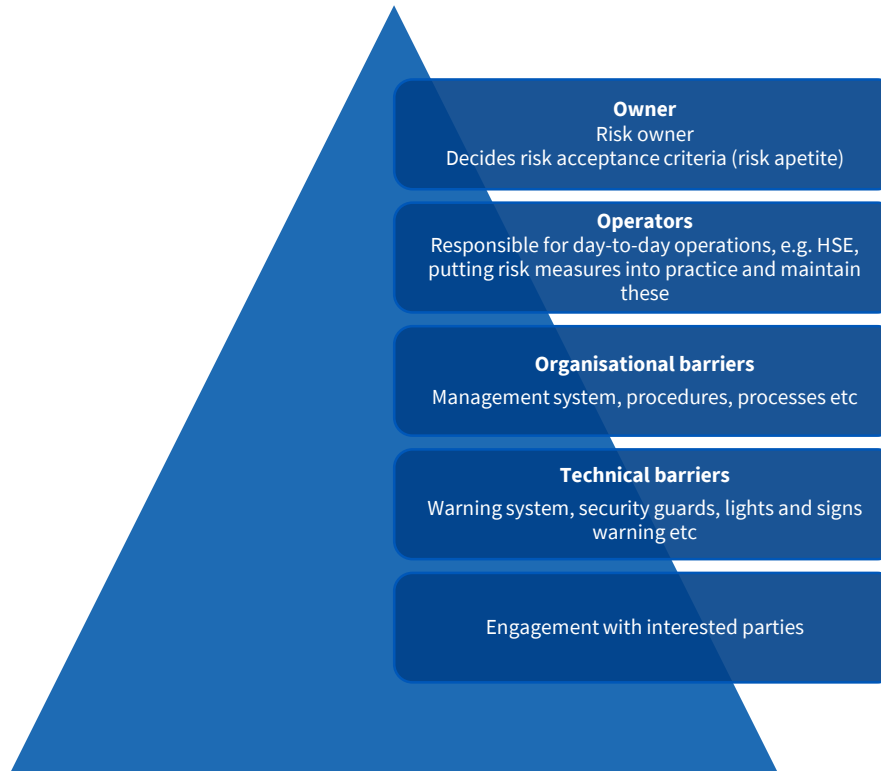
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# Transfer case to wind farms



# Risk management throughout the lifecycle

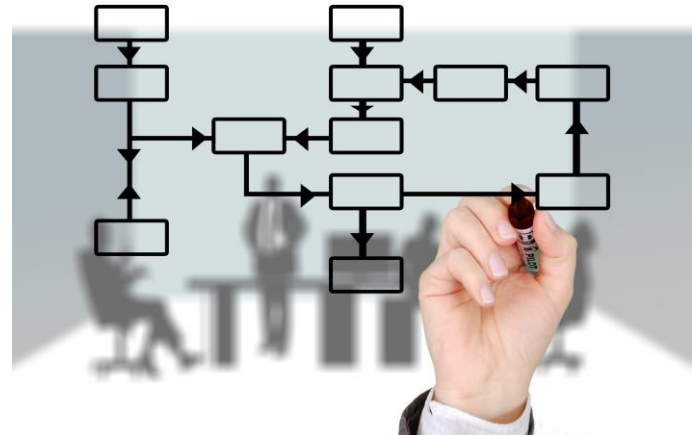






# Communication

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# Support material

## The Norwegian Water Resources and Energy Directorate

- The guideline for **Ice throw from windmills** gives recommendations on how to manage the risk of ice throws from wind turbines and to avoid 3rd party injuries resulting from ice throws



## IEA Wind TCP Task 19: Wind energy in cold climates

- International recommendations for **Ice fall and ice throw risk assessments** provides best available recommendations for assessing the risk of ice fall/throw as well as reducing the uncertainties in such assessments



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# Summary



# Summary

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- Use best practice for the industry as guidance
- Develop risk acceptance criterias
- Identify unwanted incidents, the related frequencies and potential consequences
- Identify the current preventative and mitigating barriers, and if needed, identify new barriers
  - Investigate the effectiveness, vulnerability and the maturity of the barriers
  - Opportunity to optimise?
- Develop lean response plans for the most critical incidents, with clearly defined responsibilities and tasks
- Ensure that you are not dependent on one person to be able to have an effective barrier
- Maintain communication with interested parties

## Get in touch

- Daniel Swart
- [daniel.swart@lr.org](mailto:daniel.swart@lr.org)
- +47 986 48 723

