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# Climate change and power systems

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# Outline

- Introduction and background
- Climatic vulnerability today
- Climate prognoses
- Impact of climate changes on power systems
- Adaptation to climate change

# Introduction

- Infrastructure for production and supply of electric power is a **critical infrastructure**
- Society is totally dependent on a steady power supply
- Major interruptions may result in extensive societal consequences and threaten life and health
- Climate is expected to change…

# Background

- Norwegian power supply is mainly based on hydro power
  –› climate changes will directly influence the generation potential

- An expected increase in temperatures will decrease the need for heating during the winter, but increase the need for cooling during the summer

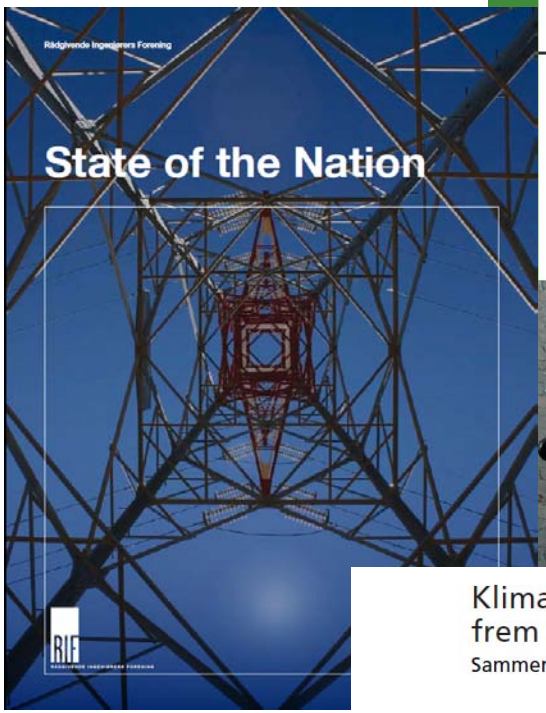
- Power supply is required to operate during extreme weather conditions and therefore dimensioned accordingly

- At the same time: Weather related events are an important cause for faults and interruptions at all power system levels

- An expected increase in extreme events will increase the risk of damage, unless actions are taken

# Sources of information

- NVE: Klimautfordringer i kraftsektoren frem mot 2100
- NOU 2010:10, Tilpasning til eit klima i endring
- RIF: State of the Nation
- Vestlandsforskning: Klimaendringenes konsekvenser for kommunal og fylkeskommunal infrastruktur





# Climatic vulnerability today

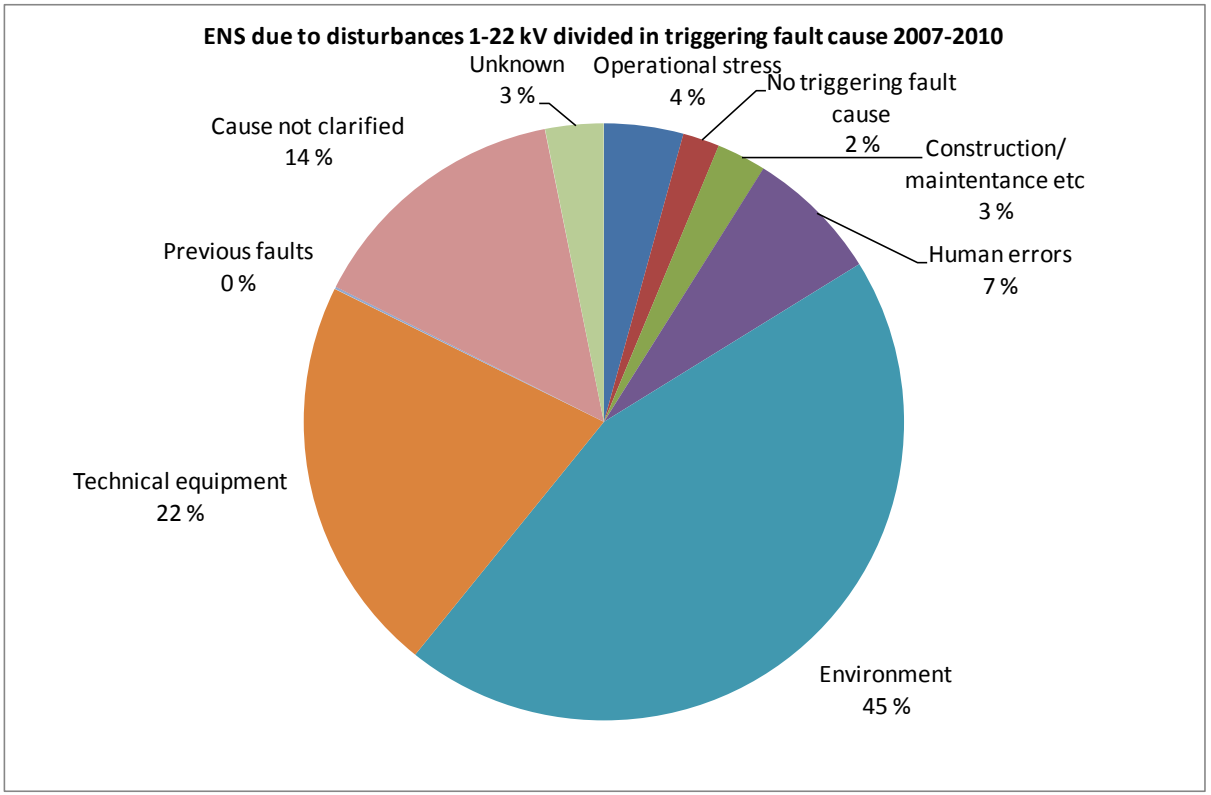
- About 50% of faults and outages in the distribution system are weather related
  - Lightning is the main cause
  - Vegetation, wind, snow and ice

- Infrastructure is well adapted to today's climate
- Preparedness towards weather related events is good

- Large parts of the power supply system were built during the 60- 70- and 80-ies., thus an increasing need for reinvestments and renovation
- Vulnerability due to long delivery times for power system components

# Many interruptions and a large amount of ENS is weather related – example 1 – 22 kV

- Weather related stress:
  - **Wind**
  - **Snow and ice**
  - Salt/pollution
  - **Lightning**
  - Precipitation
  - Temperature
  - **Vegetation**



# Climate prognoses

- Results from analyses carried out by Bjerknessenteret for year 2050, and compared with "Klima i Norge 2100" for NOU klimatilpasning.

- The following parameters are calculated:
  - Precipitation
  - Temperature
  - Freezing/ melting cycles
  - Wind
  - Icing
  - Change in sea level

- National and regional calculations
- Local calculations

# Climate prognoses 2050 1:2

- Precipitation: Increasing all over Norway
  - Largest increase in Mid- and West-Norway, precipitation during winter may increase by 40%
  - Least increase in Northern-Norway
  - Number of days with extreme precipitation is expected to increase

- Temperature: Increasing all over Norway,
  - Largest increase in North, particularly in winter
  - Least increase in South

# Climate prognoses 2050 2:2

- Freezing/melting cycles:
  - Increasing in Finnmark and high-lying areas
  - Reduction near the coast

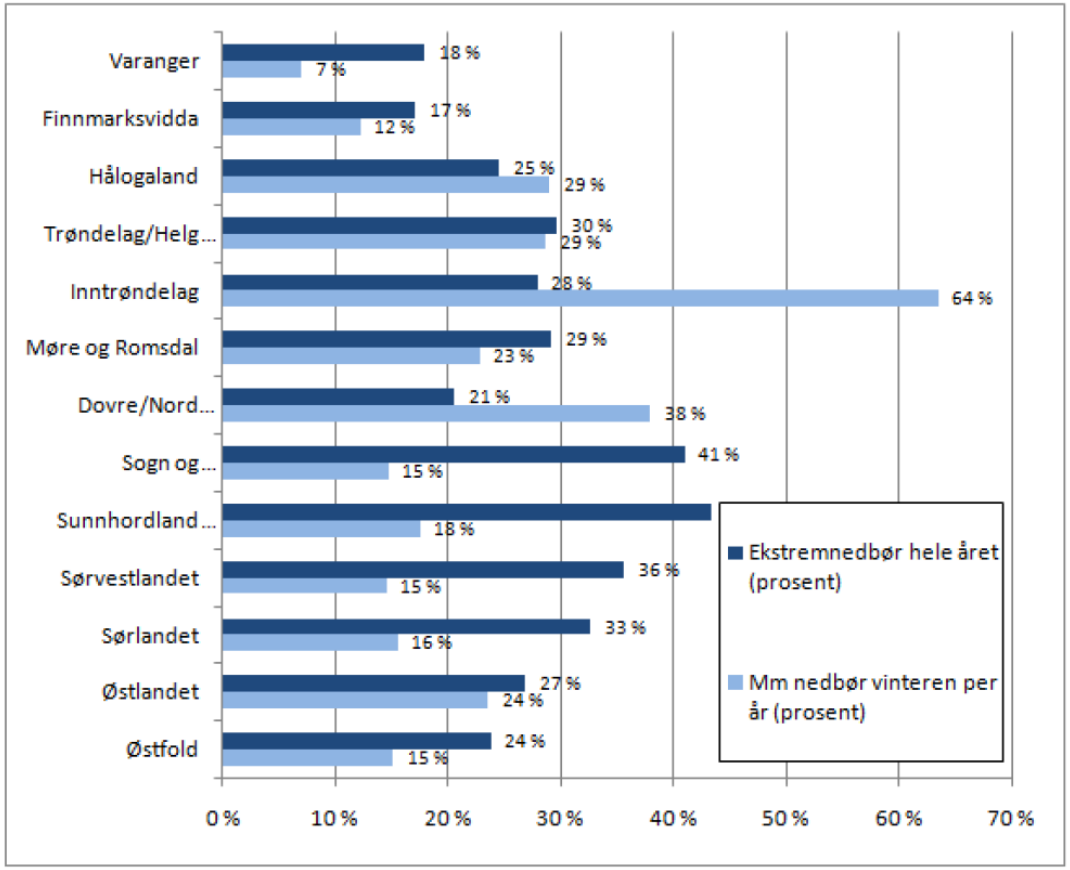
- Drought periods: Uncertain results

- Wind: Large uncertainties and small effects makes it difficult to draw any conclusions

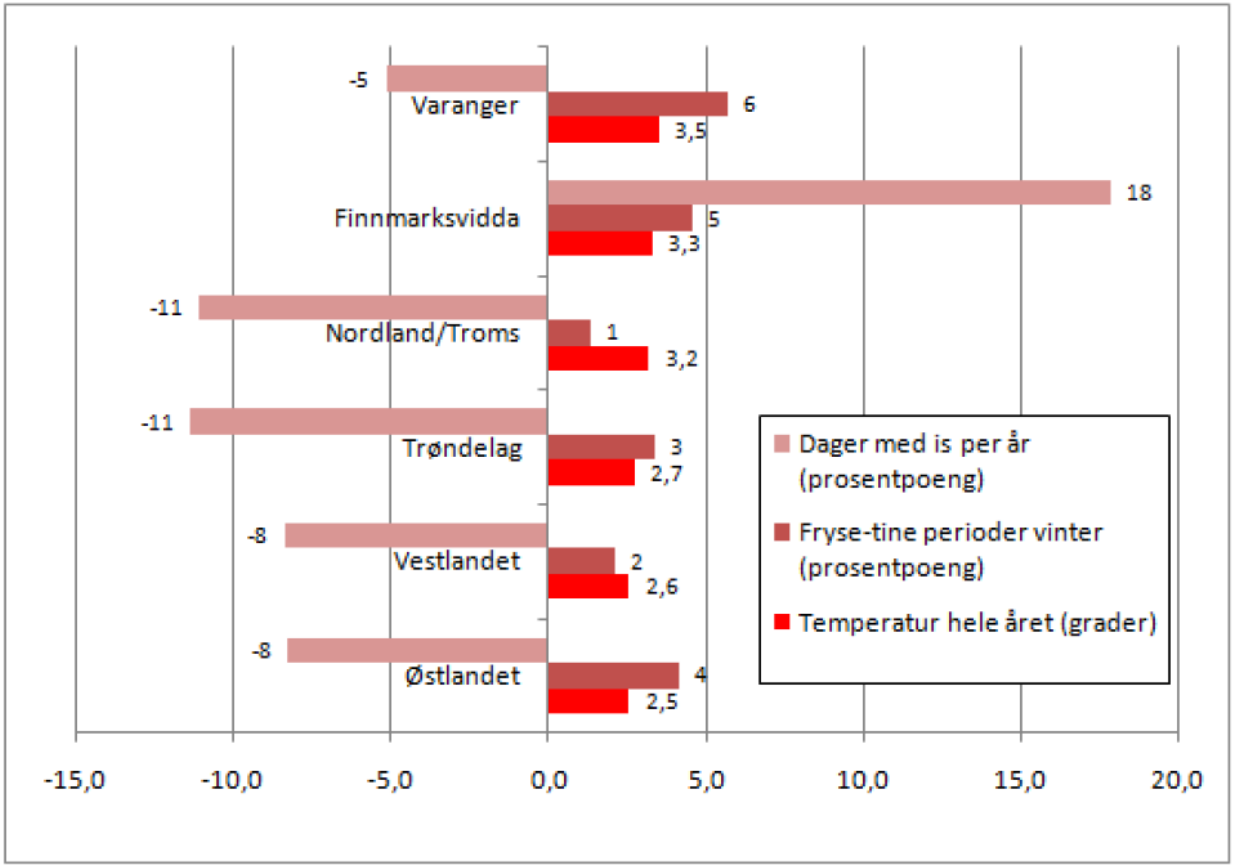
- Icing:
  - Increase in the inland
  - Decrease near the coast

- Sea level rise: From low to high, depending on area. High storm surges may be expected.

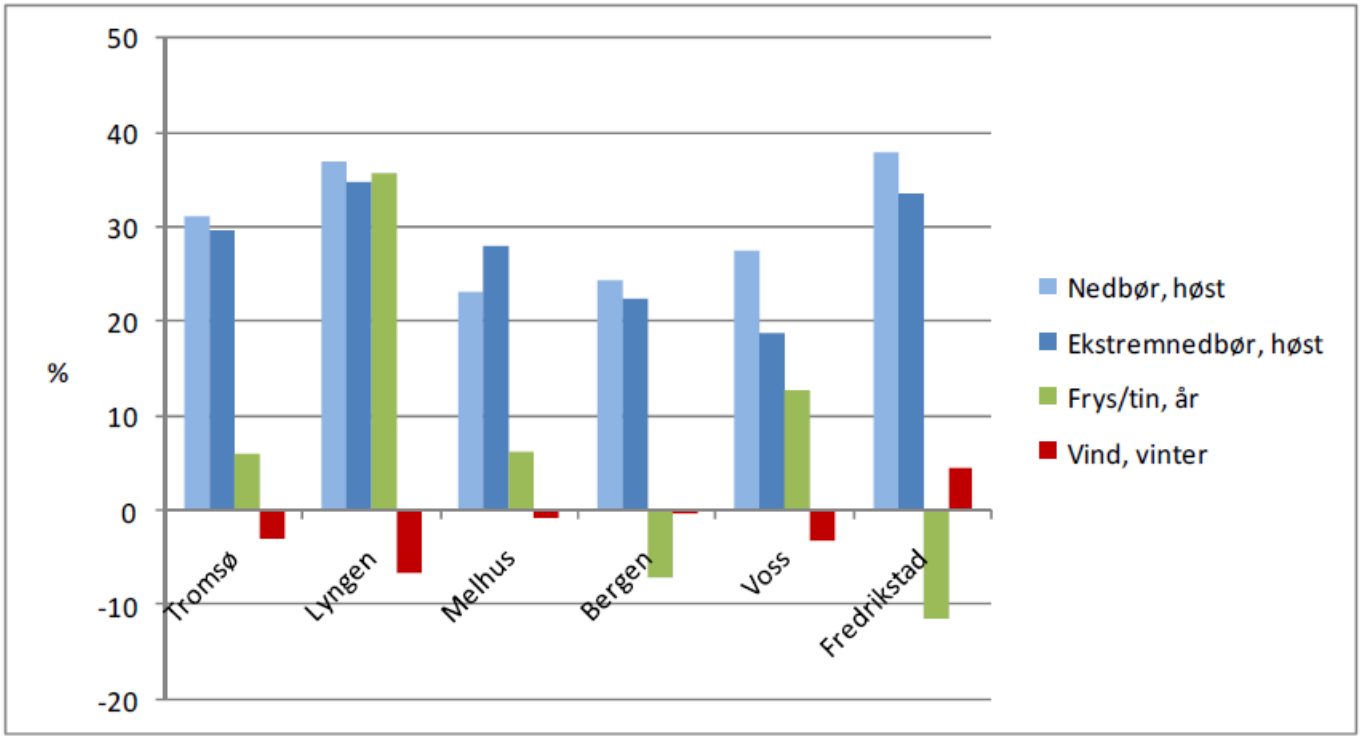
# Precipitation
# (2050 compared with 1960-1991)



# Temperature, freeze-melt and days with ice, (2050 compared with 1960-1991)



# Local effects




***Figur 43*** *Endringer for ulike klimaparametre i de utvalgte casekommunene i 2050 ifht perioden 1960-1991, basert på verstefallsscenario*

# Impact of climate changes on power systems 1:4

- Higher frequency and increasing strength or intensity of events
- New geographical areas may experience stresses which they are not exposed to today
- Possibly resulting in
  - Increased need for maintenance
  - Increased damage frequency

# Impact of climate changes on power systems 2:4

| Parameter | Strain | Possible impact |
|---|---|---|
| Wind | Extreme wind force | Damage to power lines and buildings, directly or by falling trees |
| | Catchment of salt | Flashover due to salt coating on insulators and bushings |
| | Storm surge, flooding | Challenging with respect to low-lying installations |
| Precipitation | Flooding | Exposed installations may be damaged |
| | Heavy snowfall | Causes mechanical strain on power lines, directly or because of vegetation/ trees. Snow slides may damage installations and buildings. |
| | Heavy rainfall | Landslides may damage installations and buildings |
| | Drought periods | Increased forest fire hazard, may damage installations and buildings |

# Impact of climate changes on power systems 3:4

| Parameter | Strain | Possible impact |
|---|---|---|
| Temperature | Changes between freezing and melting | Frost weathering on concrete and stone constructions. May damage buildings, foundations, pylons etc. |
| | Higher ambient temperatures | Sagging lines may come in contact with vegetation. |
| | Higher ambient temperatures combined with more rain | Increased growth of vegetation |
| Icing | Icing and snow on power lines | Mechanical stress may cause damage or breakage of power lines |

# Impact of climate changes on power systems 4:3

- Coincidence in changes may  cause additional challenges:
  - High air humidity combined with high temperature may cause rot (pylons, buildings)
  - Combination of high temperature,  humidity and frequency of adverse weather could mean increased problems with lightning
  - Temperature and humidity influence growth of vegetation.
  - Snowfall and wind, or icing temperatures and wind, may lead to increased mechanical stresses

- Extreme weather may delay repair significantly, not at least if other infrastructures are involved

# Adaptation to climate changes - challenges

- Knowledge, competence and training among the involved parties in societal security and preparedness is a good basis for dealing with climate changes
  - Possible lack of equipment and work force to deal with natural incidents
  - Easier to get resources to deal with accidents than for preventive work
  - Improvement potential in utilizing experience in work with societal security
- Need for government supervision of climate adaption
  - 24 % of the power companies have plans for adaptation to climate change. 31 % believe that they will not be affected.
  - NVE and DSB need to get climate changes and vulnerability higher on the agenda and to get resources to follow up
  - The need for a robust power system may require changes in the regulatory regime
- Time perspective for building of new power lines is long – start planning early!
- Need for more research on power systems and climate changes

# Positive proof of global warming