Welcome to

Statnett's R&D Conference 2019

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Sustainable System Development Session

12:05	Introduction to Sustainable System Development	Ingeborg Buchalik, Statnett
12:15	How to reduce our impact on nature?	Ellen Torsæter Hoff, Petter Christian Jonvik, Statnett
12:35	Are there alternatives to grid expansion?	Harris Utne, Statnett
12:55	Should we prepare for high impact events with a low probability?	Eivind Ødegaard Norum, Rolf Korneliussen, Statnett
13:15	Which models are needed for the future grid?	Ivar Husevåg Døskeland, Statnett
13:35	How to dimension our overhead lines for salt-pollution?	Kjell Åge Hansen, Statnett

BærekraftigSystemutvikling
Sustainable System Development

Ingeborg Buchalik, Programme Manager

Statnett

R&D Conference, Oslo, 2 April 2019

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Global and national challenges

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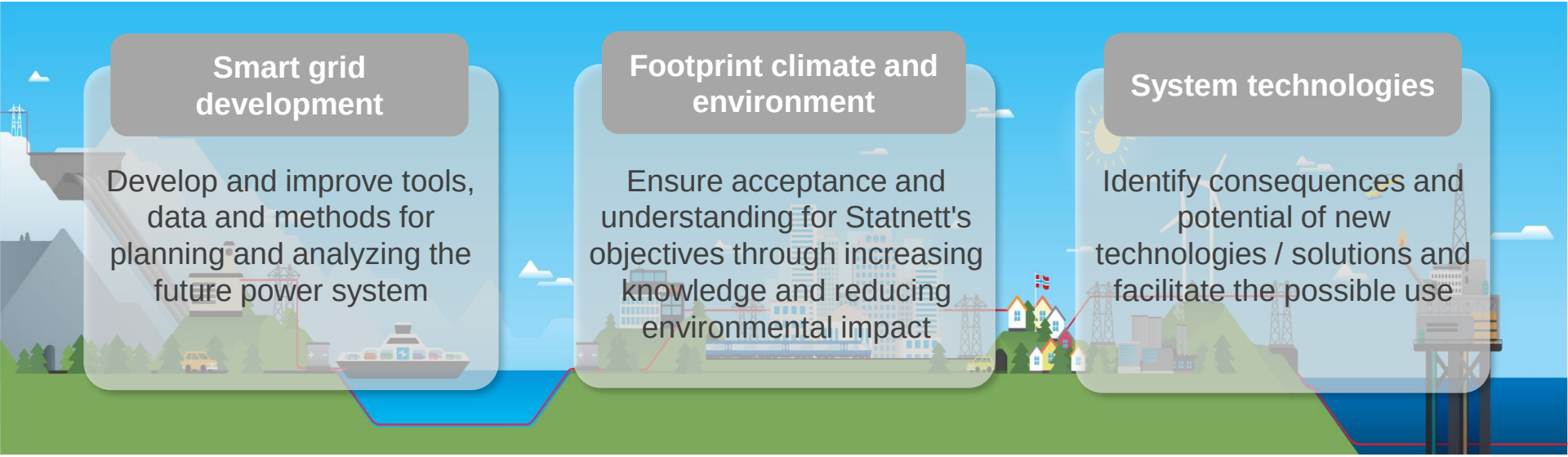
Sustainable System Development – focus areas



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Results snapshots

Climate adaptation

Bio diversity

Smart grid development

Demand side management

Unpredictable fluctuations

Load models

Improved simulation techniques

Extra ordinary event

Security of supply

Norwegian energy system in a European perspective

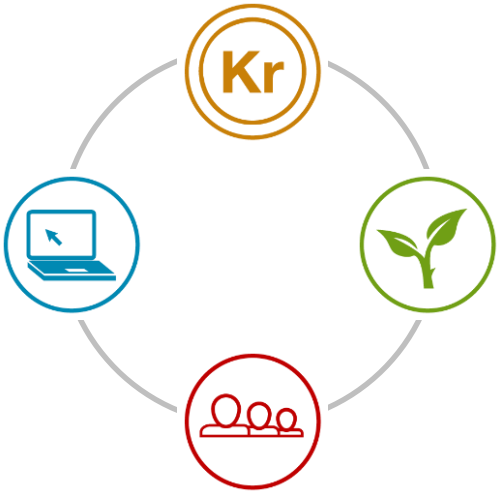
Probabilistic risk assessment

Bird friendly design of power lines

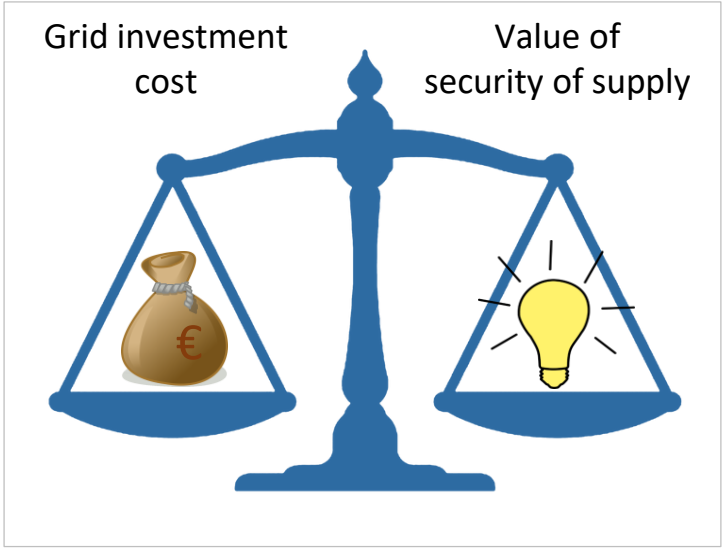
Price balancing

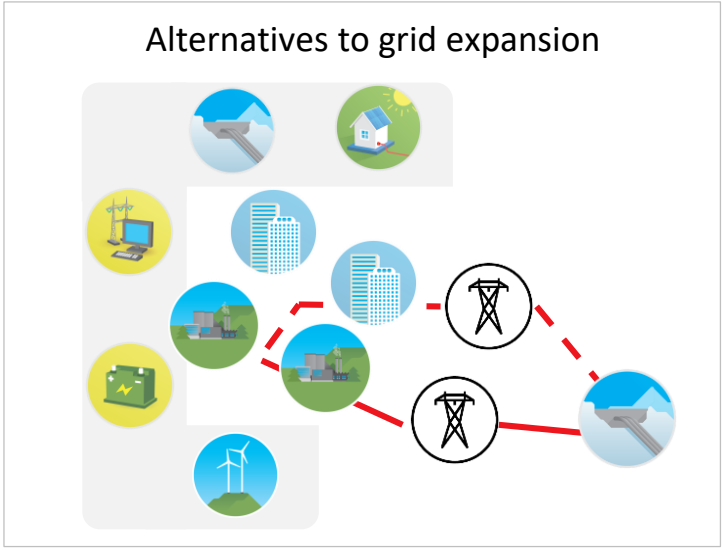
Aggregation and disaggregation

Energy roadmap



Smart grid development





Statnett seeks to utilize the demand side further in our planning and operations.

Climate and environment

R & D are key in reaching our ambition to be a leader in environmental and climate work in our sector.

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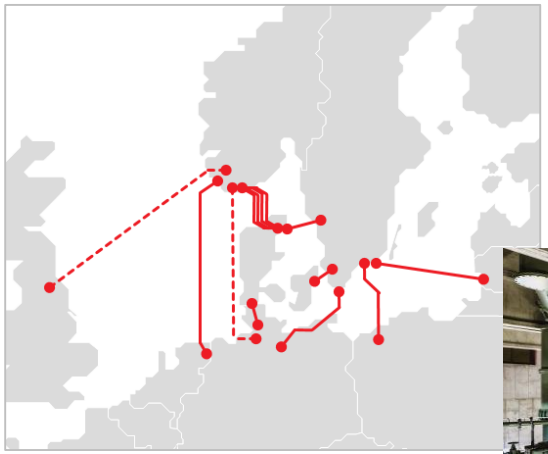
System technologies



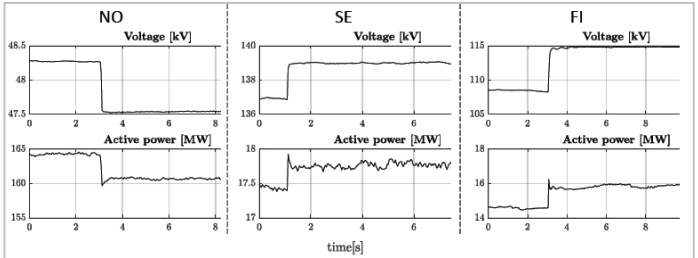


Figure 4: Time plots showing the response in voltage and active power from one staged event at each evaluation point.

$$P_{ZIP} = P_0\left[Z_p\left(\frac{U}{U_0}\right)^2 + I_p\left(\frac{U}{U_0}\right) + P_p\right] \quad Q_{ZIP} = Q_0\left[Z_q\left(\frac{U}{U_0}\right)^2 + I_q\left(\frac{U}{U_0}\right) + P_q\right] \quad (1)$$

How can HVDC provide required system inertia and how can we develop improved aggregated load models?

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Two roads diverged in a wood, and I -
I took the one less traveled by,
And that has made all the difference.

(The Road Not Taken, Robert Frost 1874-1963)

@ ingeborg.buchalik@statnett.no + 47 95 75 16 34

How to reduce our impact on nature?

Petter Christian Jønvik & Ellen Torsæter Hoff

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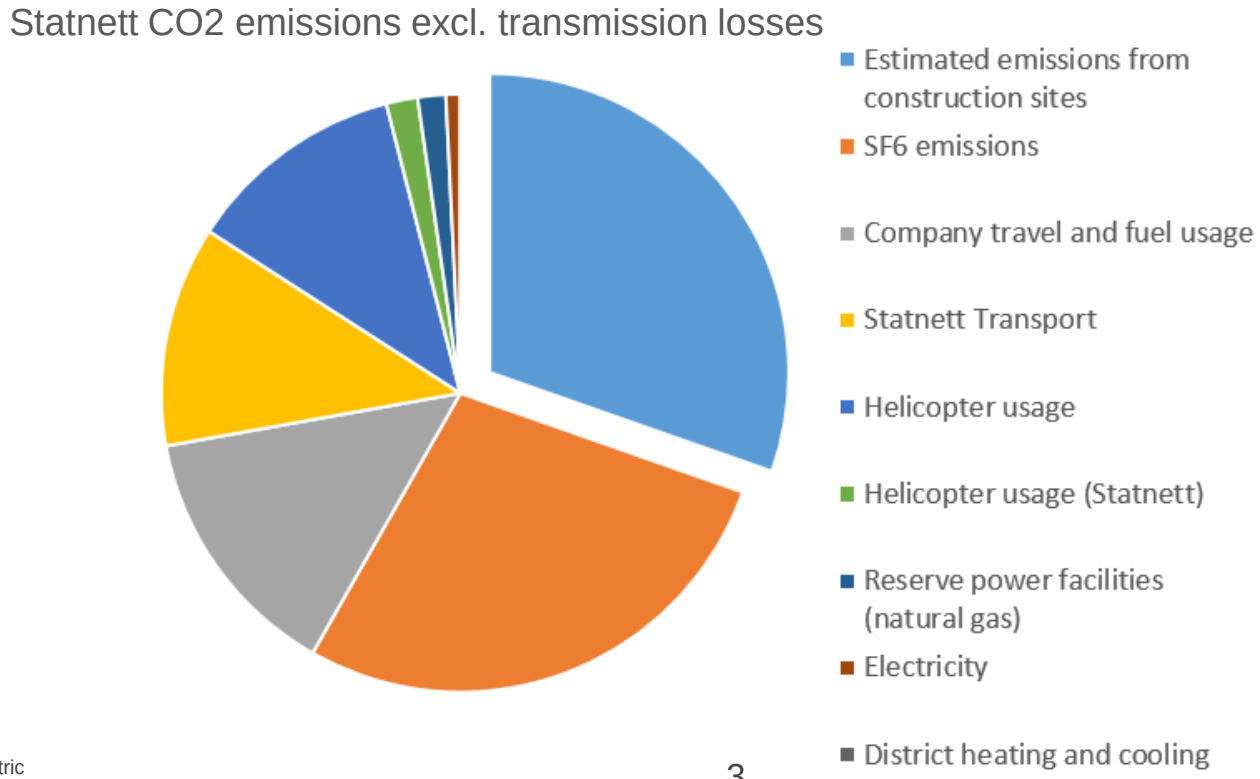
Oslo, April 2nd 2019

Statnett environmental and climate strategy

- Our ambition is to be among the leaders in climate and environmental work.
- Focus areas in the strategy period
  - Keep our strong environmental position in construction projects
  - Strenghten focus on climate gas emissions from our activities
- 25 % climate gas reduction within 2025

Statnett contribution to climate gas emissions

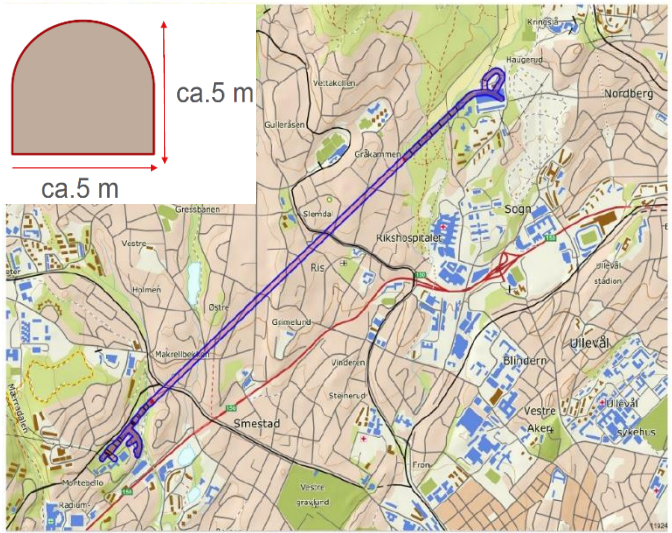


Low emission construction site pilot in Oslo

Approx. 90% CO2 reduction compared to using conventional fuel

Biofuel

Electricity



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Towards emission free construction sites

2019

2020

2024

The future is electric



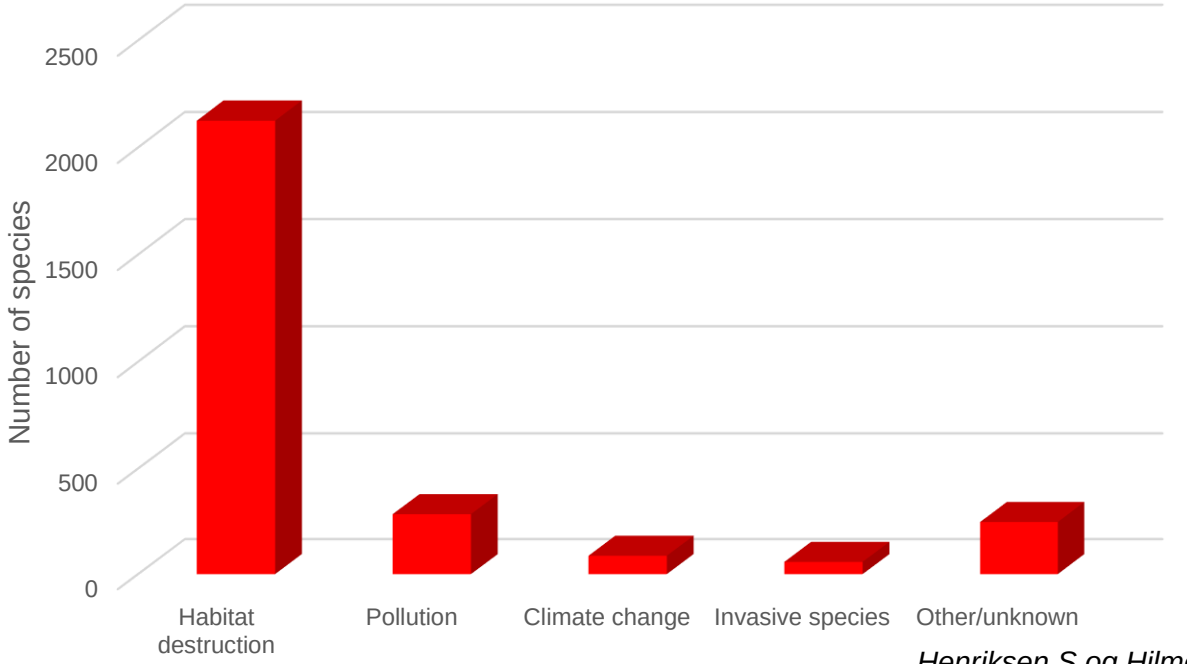








Why do species go extinct?



Henriksen S og Hilmo O (2015) Påvirkningsfaktorer. Norsk rødliste for arter 2015. Artsdatabanken

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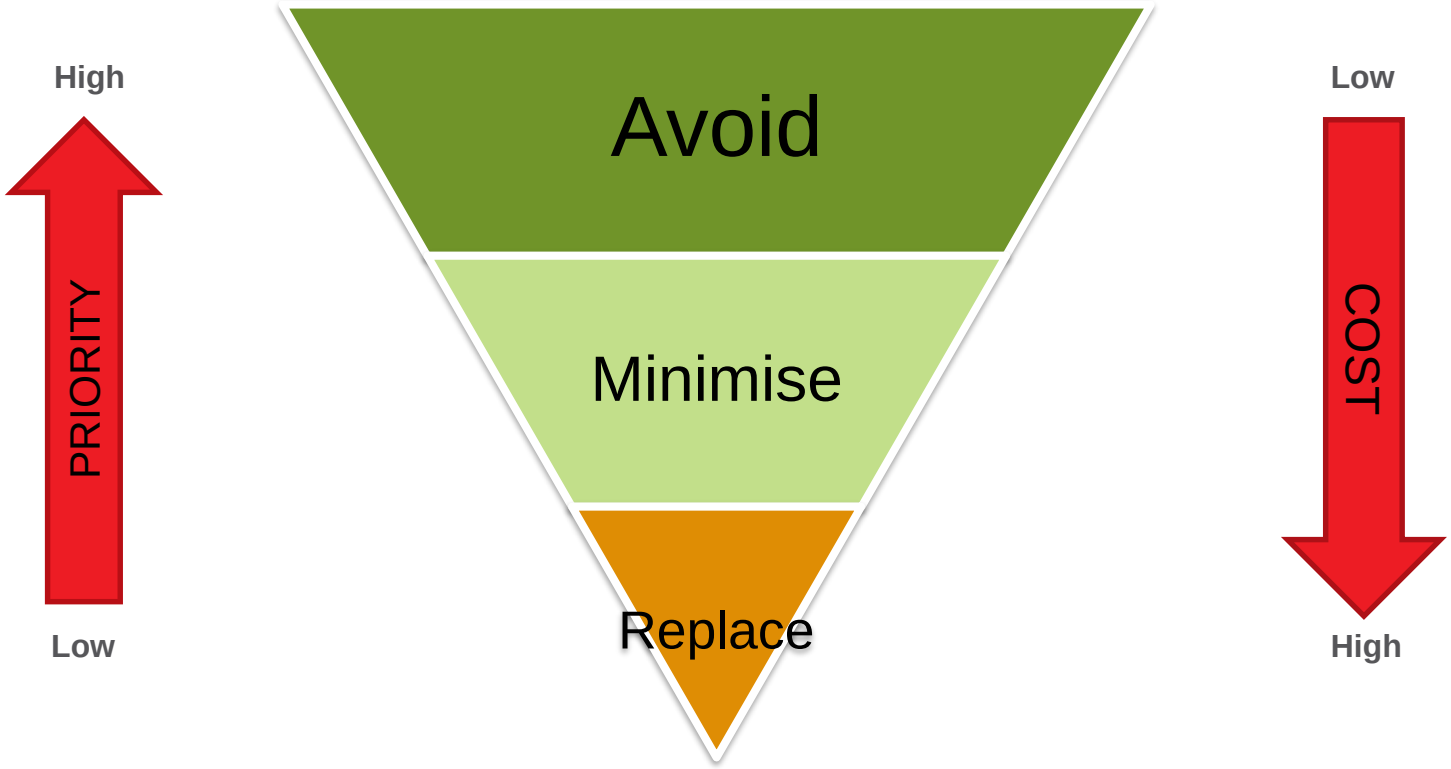
Mitigation hierarchy



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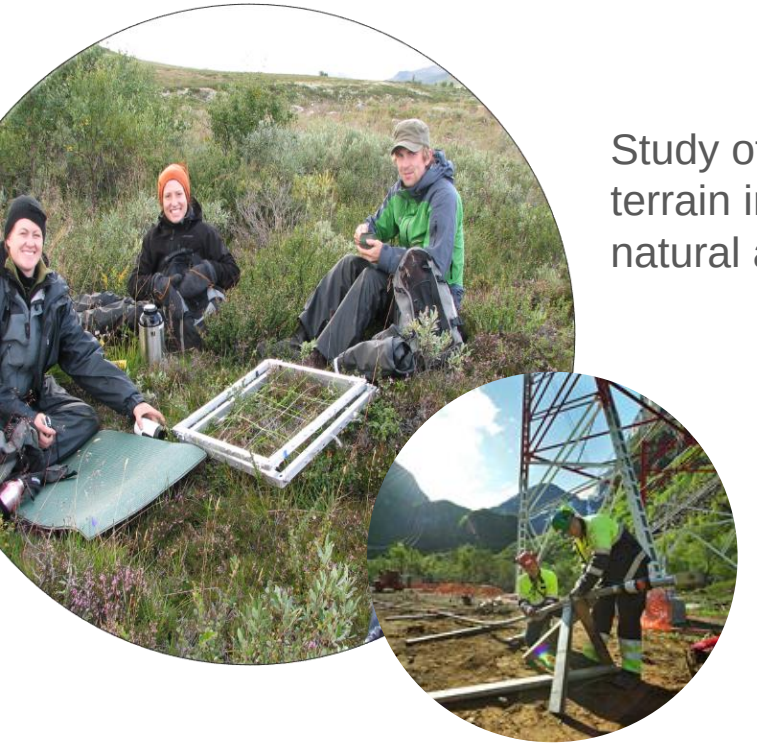
GRAN

Increase environmental responsibility and reduce greenhouse gas emissions during construction work



Study of vegetation and terrain in previously restored natural areas

How to state environmental requirements in tender descriptions and contracts

NINA

NTNU

NVE

Statens vegvesen

Forskningsrådet

Statnett

Analyze CO2 emissions for different vegetation types, compare alternative use of area

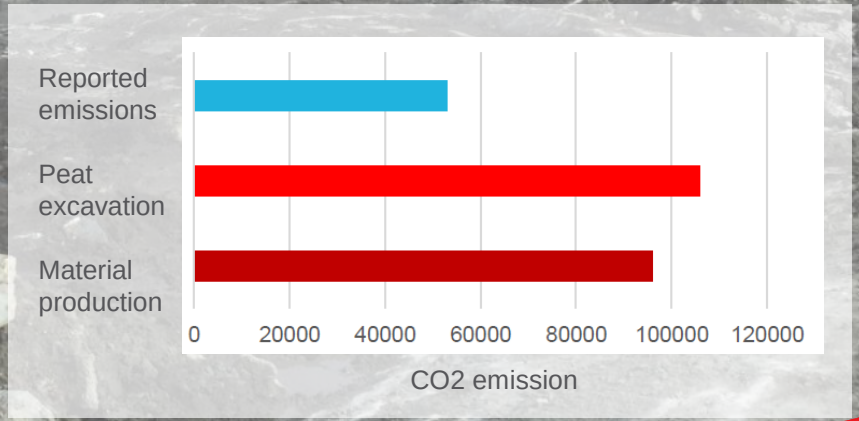


Photo: Magnus Gabrielsen

Illustration from Parker-project DK.

Are there alternatives to grid expansion?

Harris Utne, R&D Statnett

Statnett

Oslo, April 2, 2019

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Agenda

What do we mean by "alternatives to grid"?

Flexibility grid operations and long term capacity

Case: Electric vehicles

Flexibility for new connections **(new, significant demand/production)**

Way forward

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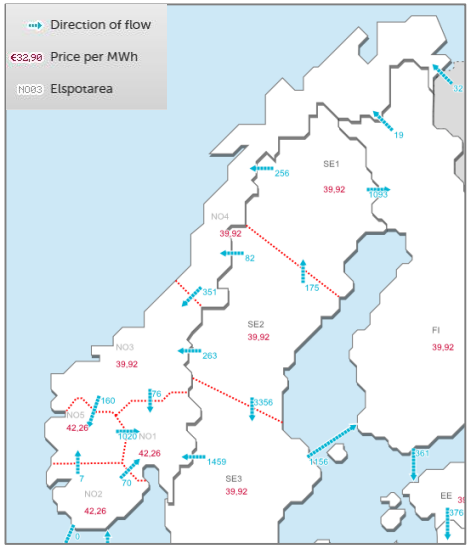
Are there alternatives to grid?

- Yes, already in use
- Why alternatives-to-grid?

  To reduce grid investment
- So what is new?

  A great belief in new technology
- Revolution or long term goal?

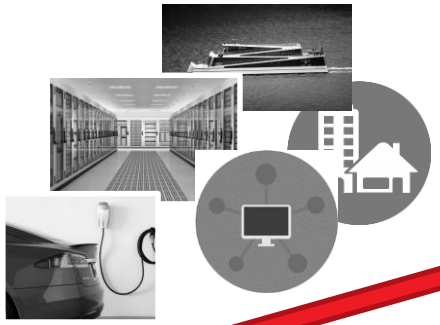


Feb 15, 2019, 23:59

What is new?

Technology in place? ✓
Volume (MW) in place? ✗
Easy to get paid for flex? ✗

Flexibility from large scale production and consumption



Today

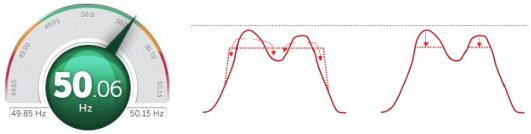
Future

- *More demand side flexibility*
- *New types of consumption*
- *More efficient control systems*

- ***Distribution grid (DSOs) play an even more important role***

Two perspectives to avoid grid expansions

1. Flexibility in operations lower the long term need for grid



2. Flexibility for new connections (data parks, wind power, harbours) lower the immediate need for grid

Ladepunkter på havna kan forsyne både båter og kjøretøy med strøm.
Credit: Illustrasjon : Siemens / Bellona

Agenda

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Flexibility for new connections (new, significant demand/production)

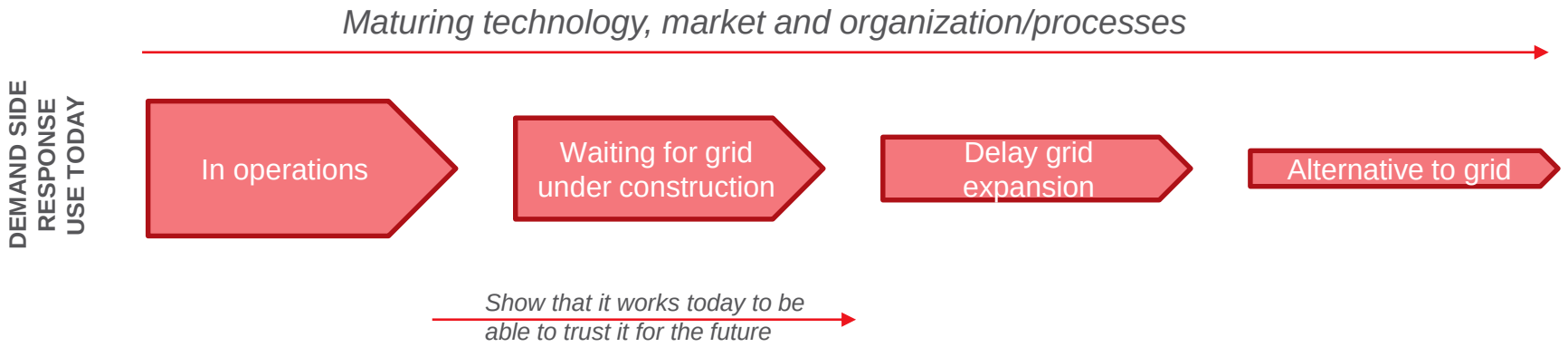
Way forward

Statnett

Flexibility versus alternative to grid

Demand side response (DSR), or flexibility

– how mature is this for grid investment decisions?



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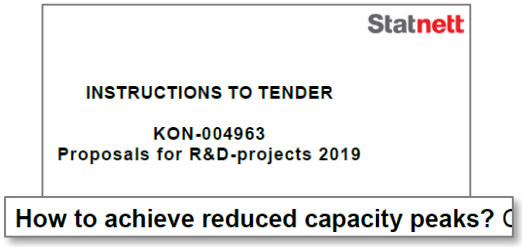
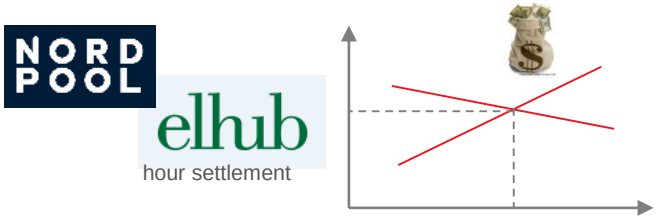
The main solution is the market

1. Most important is the market mechanisms
   How to get the most out of price signals in the market (*implicit flexibility*).

Ongoing Statnett PhD price on elasticity and consumer behavior with Matthias Hofmann.





System operator may also buy flexibility

2. Flexibility as ancillary services (*explicit flexibility*).
   Reserves market. Testing/pilots.

Agder Energi – Fleksibilitet

ENOVA

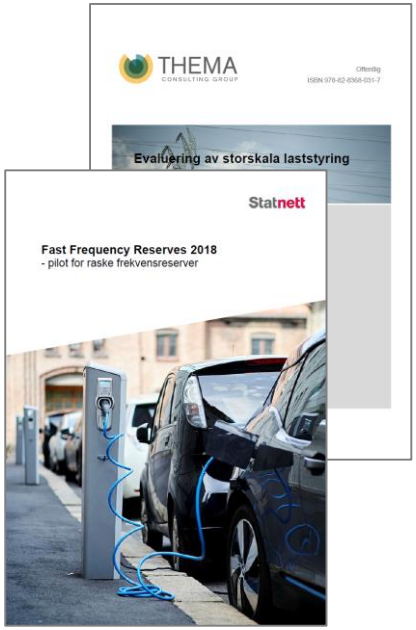
Agder Energi Fleksibilitet vil på vegne av Statnett og tre nettselskap gjennomføre prosjektet Norflex som består av

Statnett

INSTRUCTIONS TO TENDER

KON-004963
Proposals for R&D-projects 2019

Collaboration for a fully electrified society:



Agenda

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Flexibility for new connections (new, significant demand/production)

Way forward

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Flex from EVs can be simple or advanced

1 Delay charging for lower electricity prices

2 Delay (or start) charging for ancillary services*

3 Vehicle to grid (V2G)

parker

High attention and pilots (outside Norway)

Statnett pilot 2018 for fast frequency reserves

Already happening

tibber

*Delivering services to system operator, like for balancing

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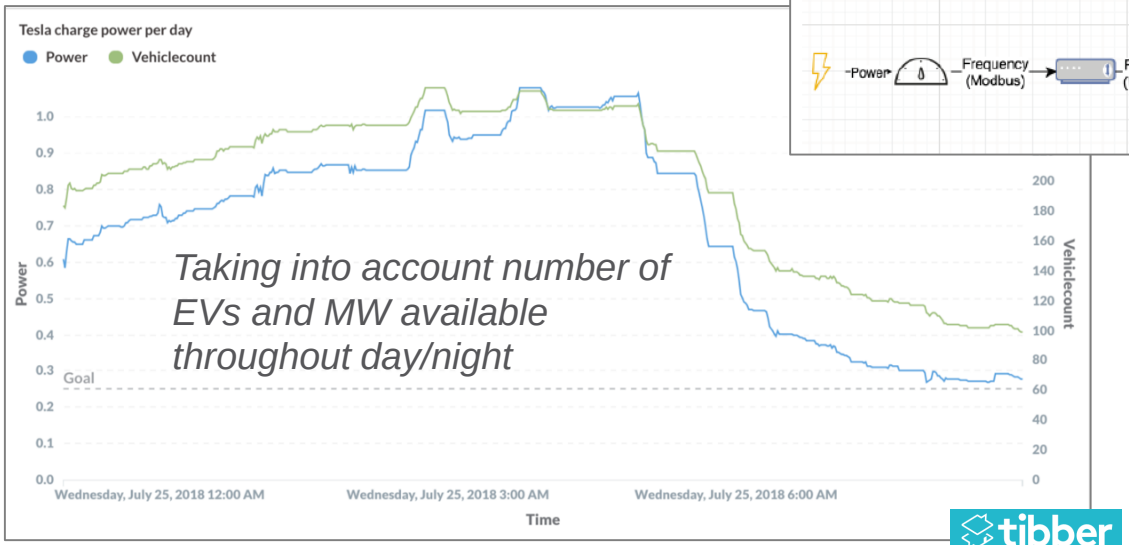
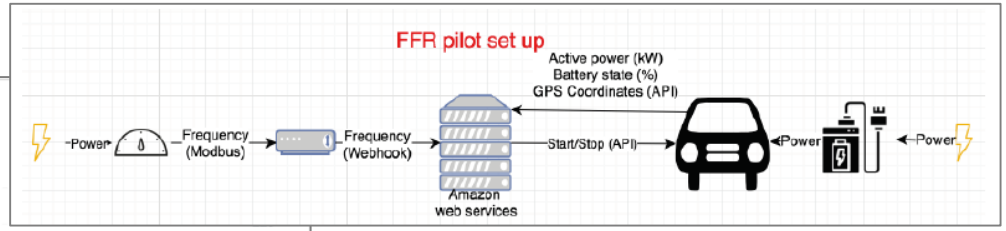
Fast frequency pilot 2018 with EVs



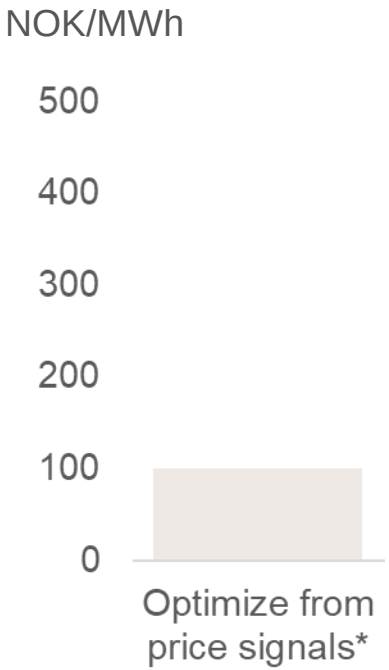


- 2 seconds response time
- Activation if frequency < 49,6 Hz
- 30 seconds duration

Source: https://www.statnett.no/contentassets/250c2da4dd564f269ac0679424fdfcfc/evaluering-av-raske-frekvensreserver.pdf

Is there any money in delivering EV flex…?

…yes, but more outside Norway.



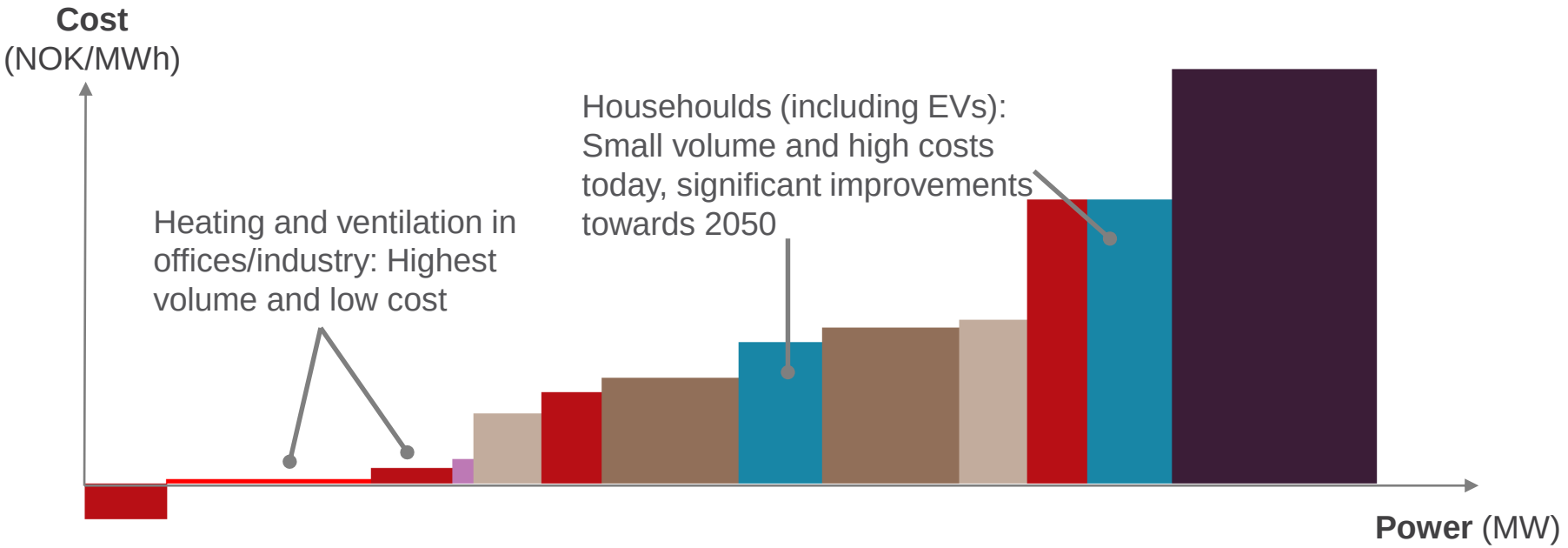
Assuming

- 9 kW EV
- 6000 hours per year
- 350 kr/MWh

➢ Denmark: 17000 kr/yr
➢ Norway: 3000 kr/yr

*Assuming 10% of 1 NOK/kWh
**DK2 FCR as communicated in the Parker V2G project

High flexibility potential at moderate cost…



Calculations based on report VistaAnalyse 2017/30, R&D project Statnett and Enova

Agenda

What do we mean by "alternatives to grid"?

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Flexibility for new connections (new, significant demand/production)

Way forward

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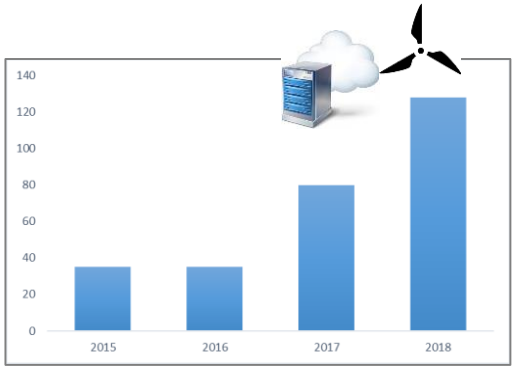
New customers on the grid at low cost

A lot of new customers ask to be connected

- Data parks
- Wind power
- Electrification (like electric ferries)



How can this be done in an efficient manner?

- Can connect with no reinforcements
- Grid expansion is undoubtedly needed
- **Other alternatives more rational**

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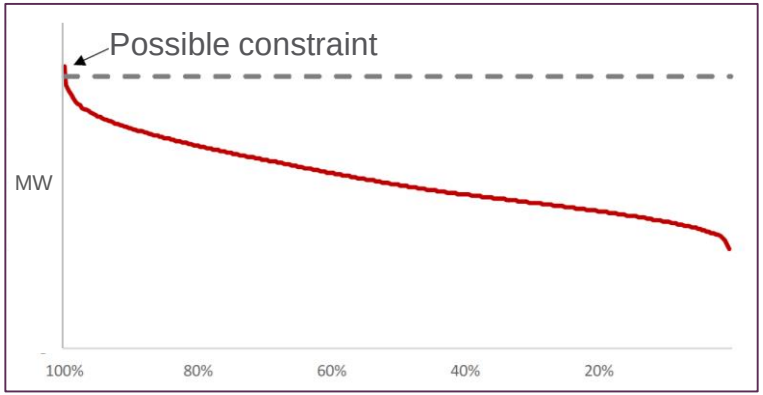
There are ways to do it

1. Grid system operator toolbox
   - Ancillary services; protection
   - In use today, but there are some (regulation) limitations on how to use this

2. "Flexible" connection by agreement
   - Case: The customer is better off risking some hours disconnected than investing in grid expansion.
   - Limitations on how this can be done and what is permitted today



Do we make sufficent use of today's opportunites?
Should we aim for changes?

Agenda

What do we mean by "alternatives to grid"?

Flexibility grid operations and long term capacity

Case: Electric vehicles

Flexibility for new connections (new, significant demand/production)

Way forward

Continious steps in the right direction

1 More flex from **price signals**

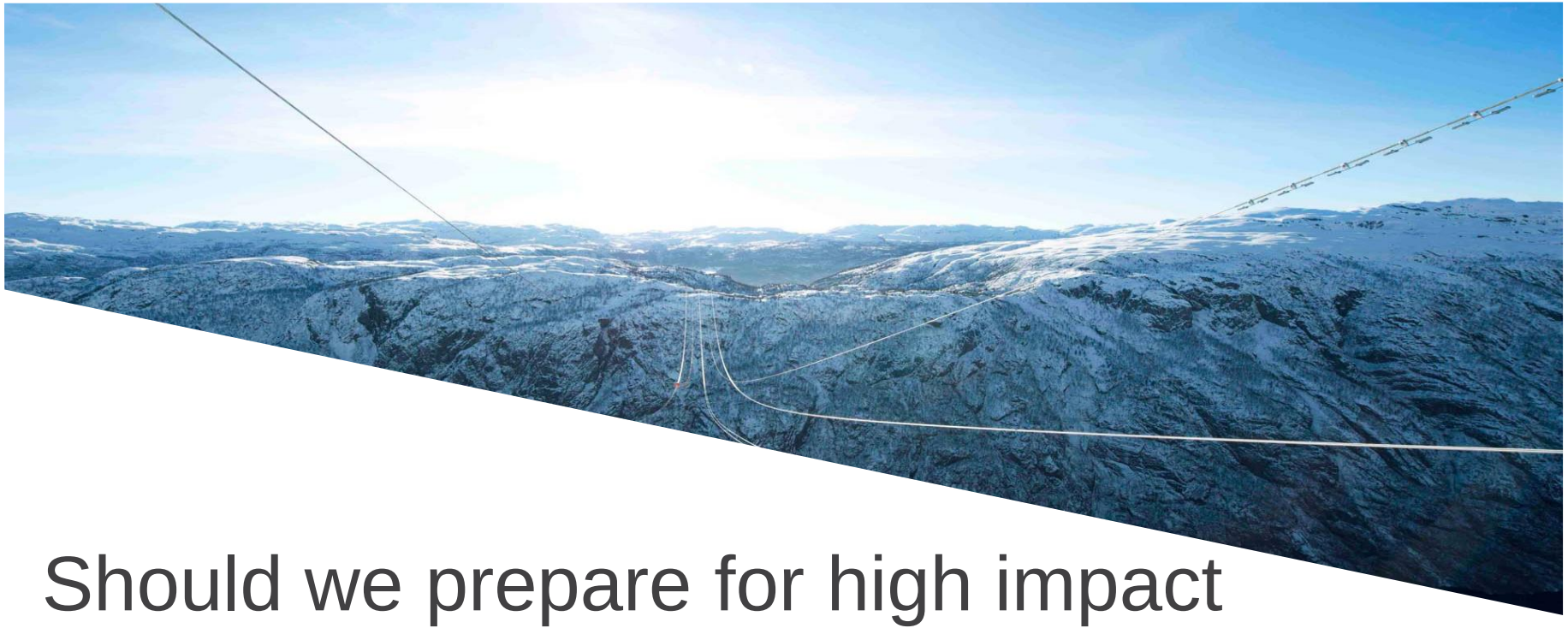
2 More use of flex in **grid operations**

3 More use of flex in **grid planning**

Technology in place? ✓
Volume (MW) in place? ✗
Easy to get paid for flex? ✗

Thank you

Harris Utne, April 2, 2019



Should we prepare for high impact events with low probability

Eivind Norum & Rolf Korneliussen

Statnett

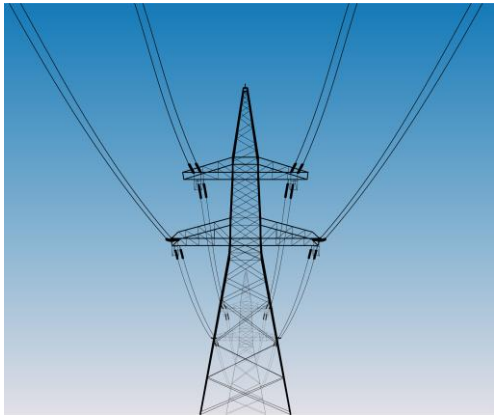
Oslo, 2.4.19

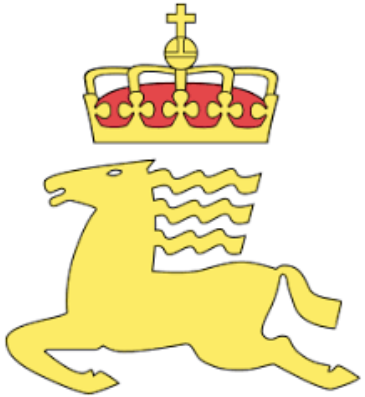
Pick up your mobile and go to:

MENTI.COM

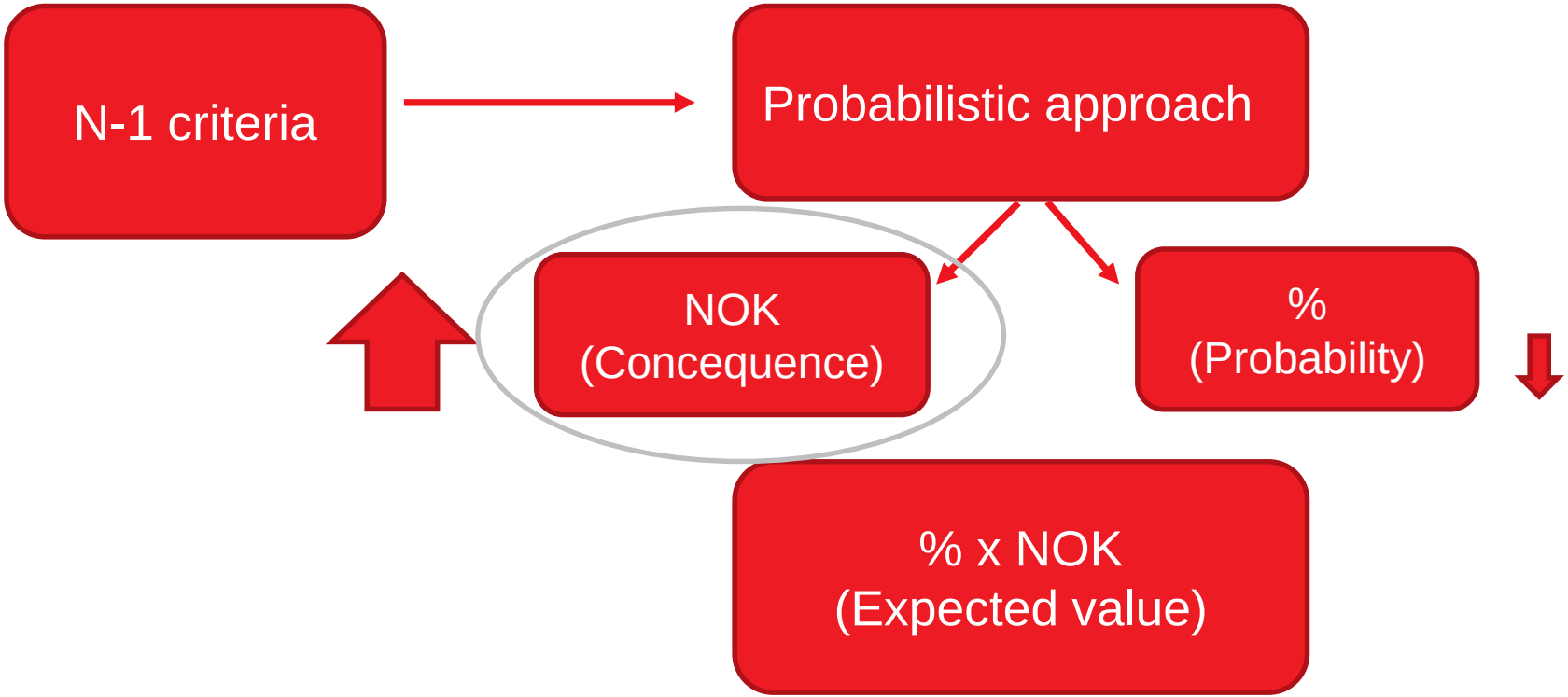
Enter code: 116683

Power system planning – why?

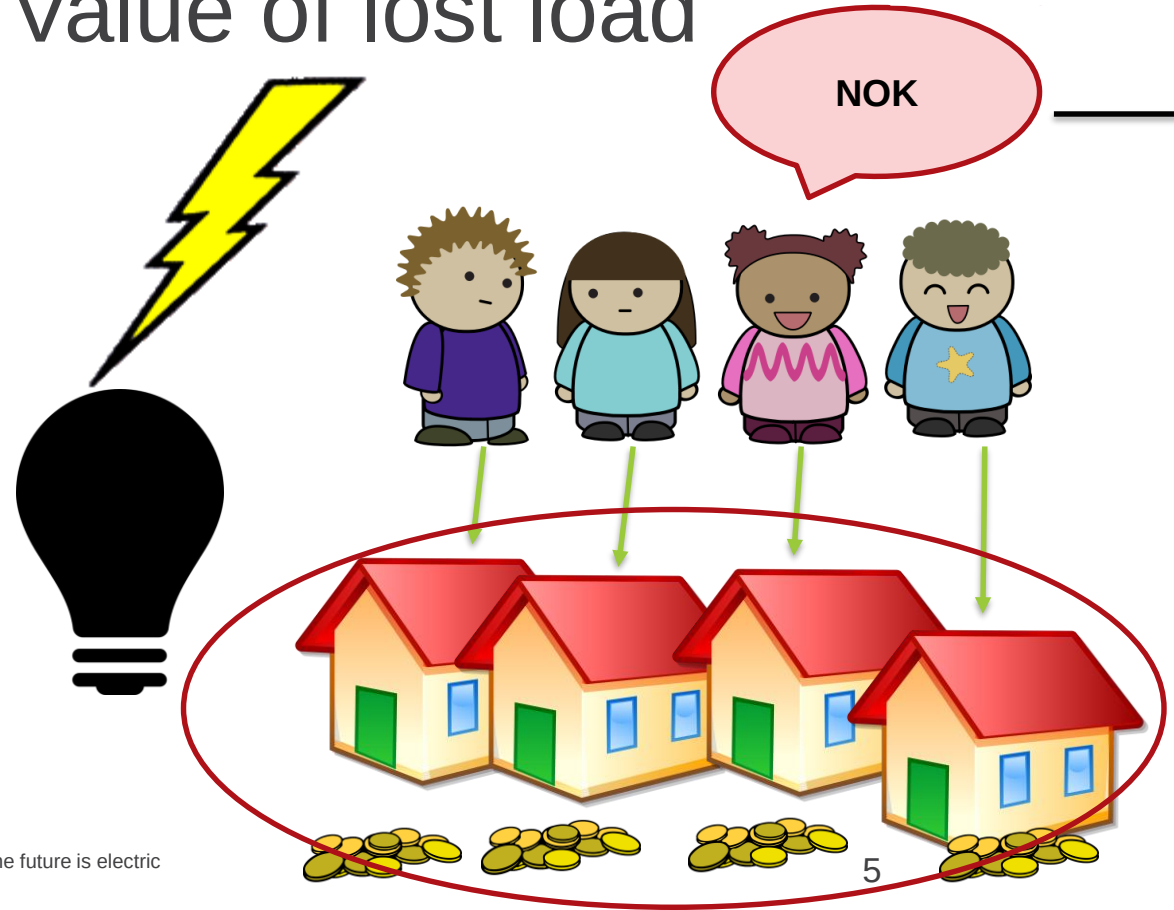




Is there a lower bound of security of powersupply?

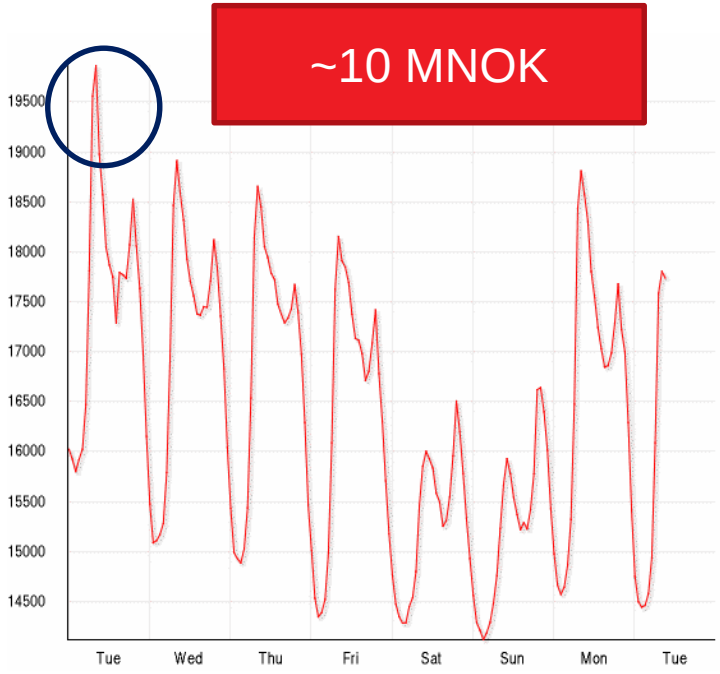


Value of lost load



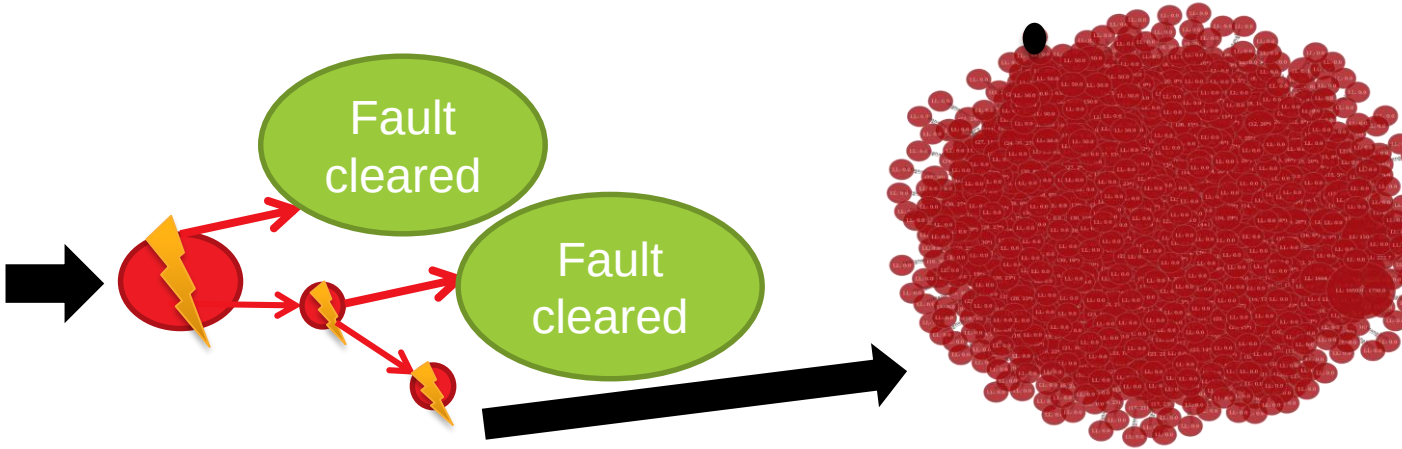
kWh x NOK/kWh
= NOK

Then it looks like this for households



The future value of lost load?

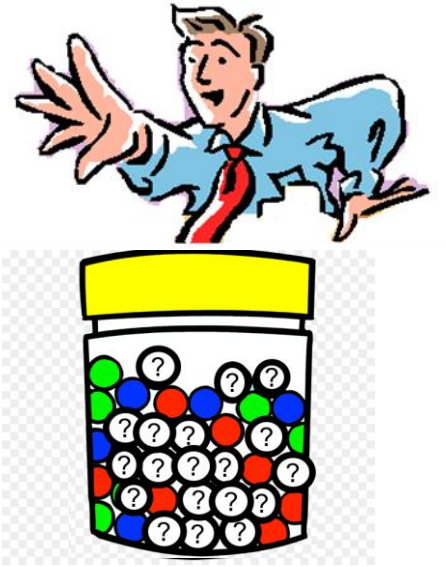
A single failure may lead to something bigger and lead to something even bigger…



Eventually….

Eventually….

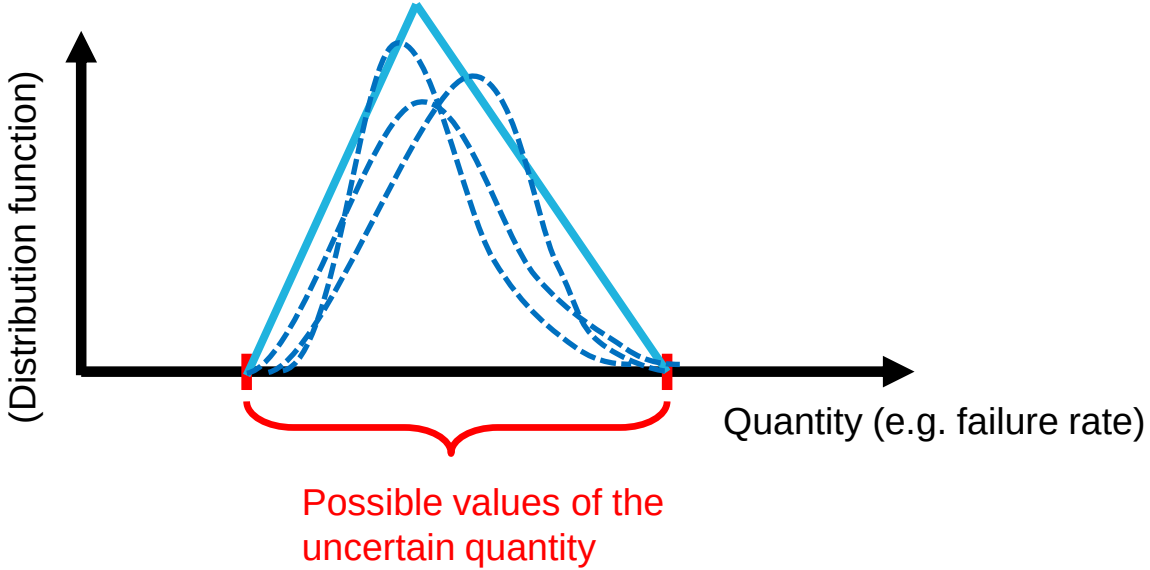
Reliability data is essential in power system planning



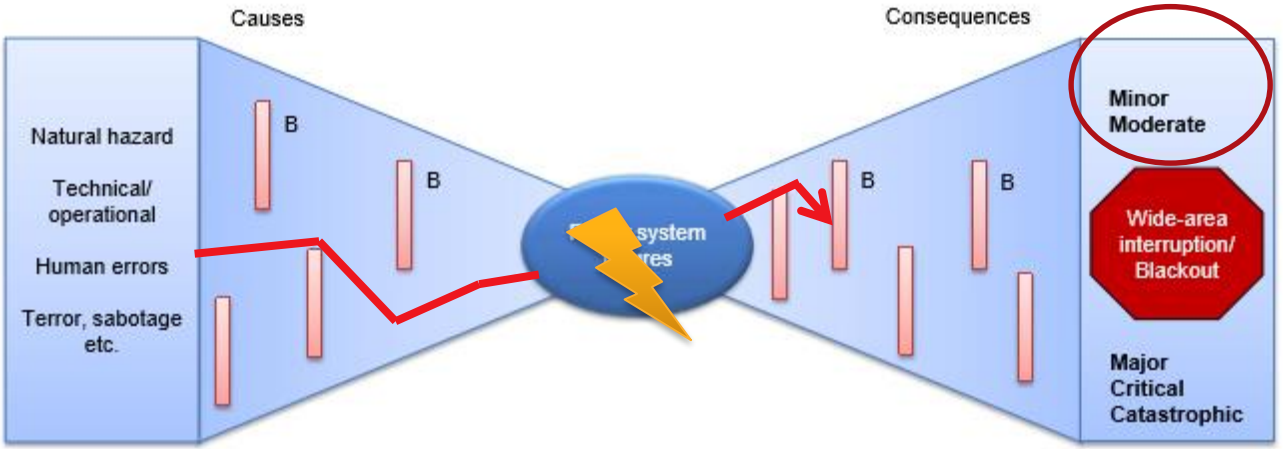
The probability is small, but uncertain for such events

- Uncertainty – statistics, natural uncertainty
- Uncertainty – lack of knowledge

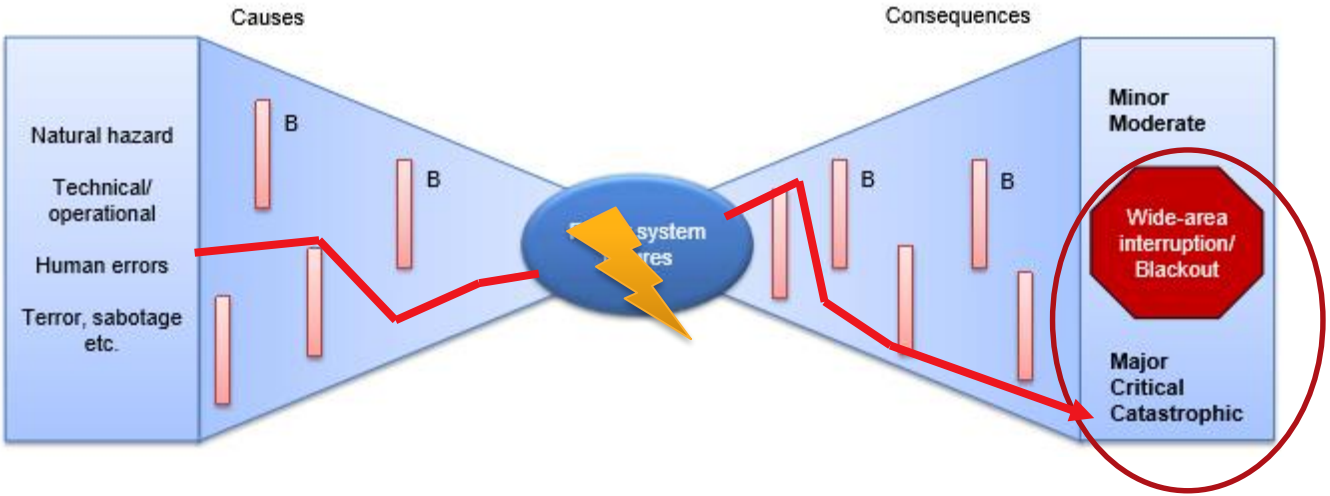
Framework for analysing HILP events



Framework for analysing HILP events



Framework for analysing HILP events



Impacts

- Better tools to asses the security of supply
- More precise cost/benefit analysis in power system planning
- We reduce the cost and time used on power system planning

Which models are needed for the future grid?

Presentation for Statnetts R&D conference

Oslo, 3 April 2019

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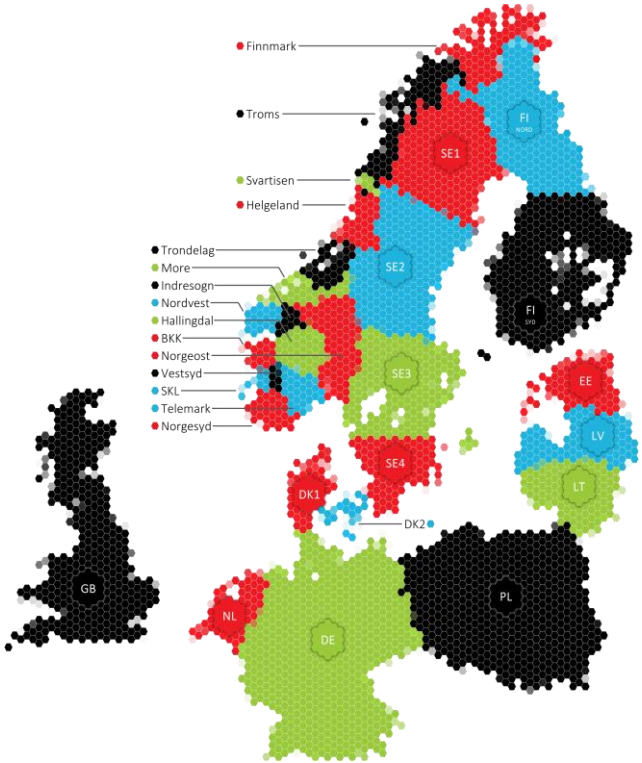
Market analysis in Statnett



- Nordic and European analysis
- Use of power system models, we don't make them
- The power market is both economic and physical – so we must be both

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The dataset

882 reservoirs,
796 hydro plants

2948 power lines,
2665 nodes

120 000 000 000 kWh industry,
26 472 866 persons,
14 309 657 coffee brewers?

Optimized over 262 080 hours of varying weather

While keeping the power system in secure operation

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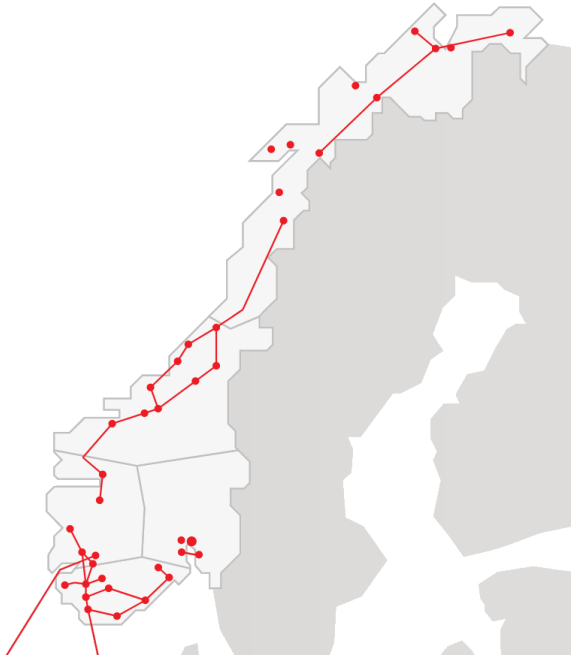
We have the world at our fingertips

- "What happens if…?"
- Important tool to find the right project and at the right time
- Less useful if the models don't behave like real world



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What do we use models for?

Long term Market Analysis from 2018 to 2040

https://www.statnett.no/for-aktorer-i-kraftbransjen/planer-og-analyser/langsiktig-markedsanalyse/

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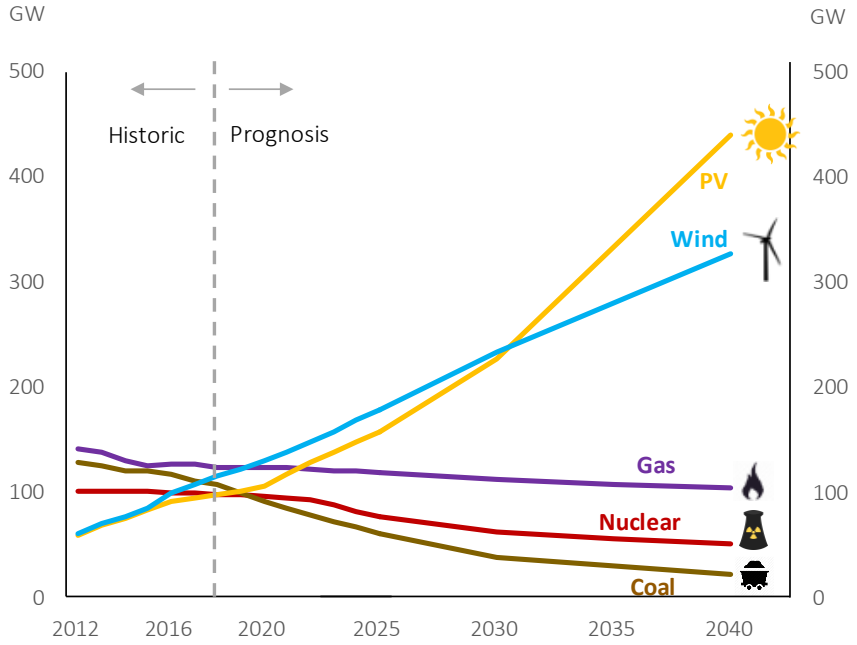
How does models help us with analysis?



- Wind and PV
  - 40% of energy by 2030
  - 56% of energy by 2040
- Flexibility of all types are very important for price and security of supply

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Answering questions and hypotheses

How often is there no solar and no wind production in all of Europe in 2040?

What happens then? Price? Is all demand met?

What is the profit of wind power in 2040 – if any?

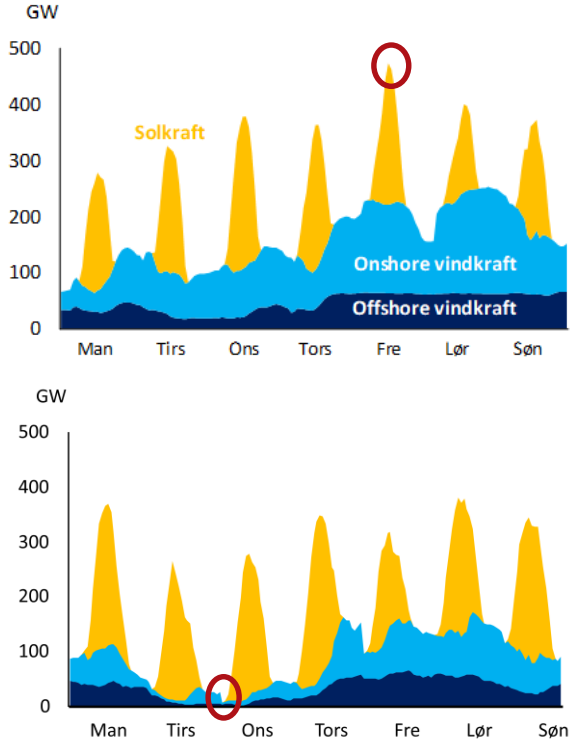
Should we have more price areas?

Can Norway be a "battery" for Europe?

Will the price become zero with enough wind and solar?

How fast will the emissions from the power sector drop?

Will EVs accelerate the building of new renewables?



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Characteristics of current models

- Strengths
  - Very fast
  - Good results for the system as it is today
  - Built over many years based on extensive experience
- Weaknesses
  - Only part of the problem is optimized
  - Short term storage (e.g. batteries) does not work well
  - User calibration required to get the best results

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Do we make new models or fix our old?

- We're exploring multiple possibilities
- Expensive to switch models
  - Lose methods, tools and experience built over time
  - Models must be operative at all times
- Research and thorough testing is slow but important
  - Provides learning on it's own
- We only switch when the gain exceeds the cost

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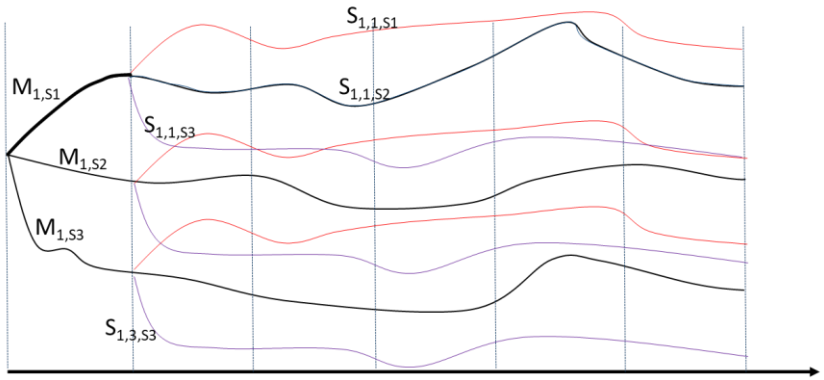
FanSi gives great answers – if you can wait



- Completely new technique
- Optimizes production of every individual power plant under uncertainty
- Perfect for research
- Very long simulation time

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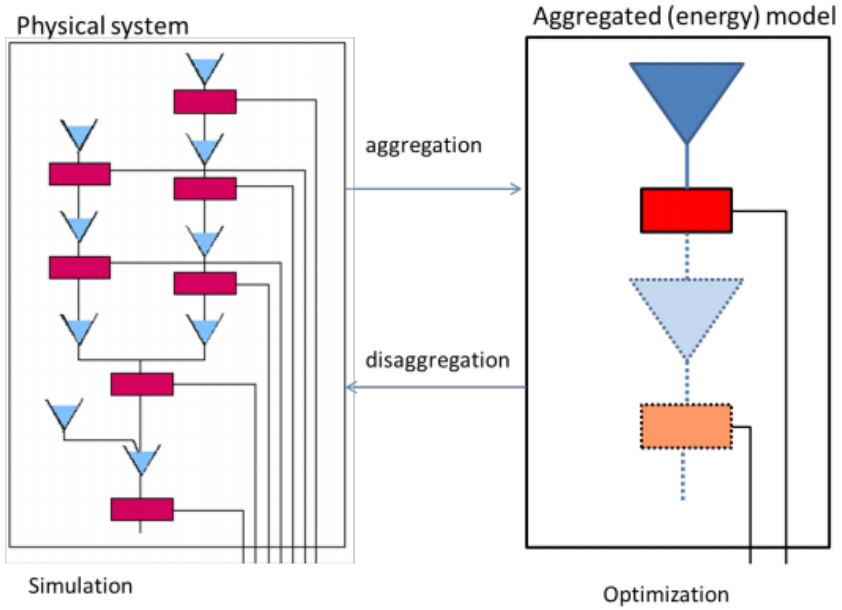
MAD – or not?

- Can we improve the methods we use now?
- Without increasing simulation time?
- No, but we'll compromise



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Is it just research, or can we use it?

- Yes, we are standing on top of years of research
- Important to be ahead
  - Not only to be prepared for the future, but because we are in a position where we help find the "right" future
- Finally, how we use our models is equally important
  - We need a good model, good data and users that understand how the power system works

How to dimension overhead line insulators for pollution

Use of new technology – satellite and weather data

Kjell Halsan, Section Manager,Transmission Line Department
Oslo, 2.04.2019

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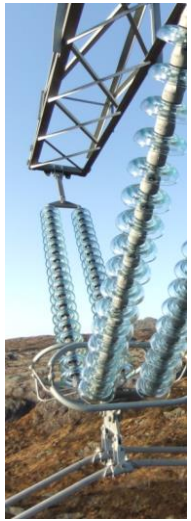
Background 1

- Air pollution have negative effect on insulation performance of electrical equipment
- Worst case scenario is flashover leading to outage
- High level of pollution requires longer insulators



Background 2

- Results from local pollution measurements are used as input at dimensioning of insulation
- Measurements requires resources and a minimum period of 12 months

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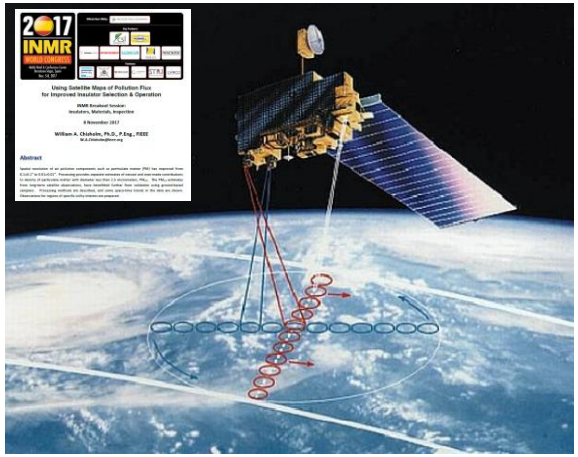
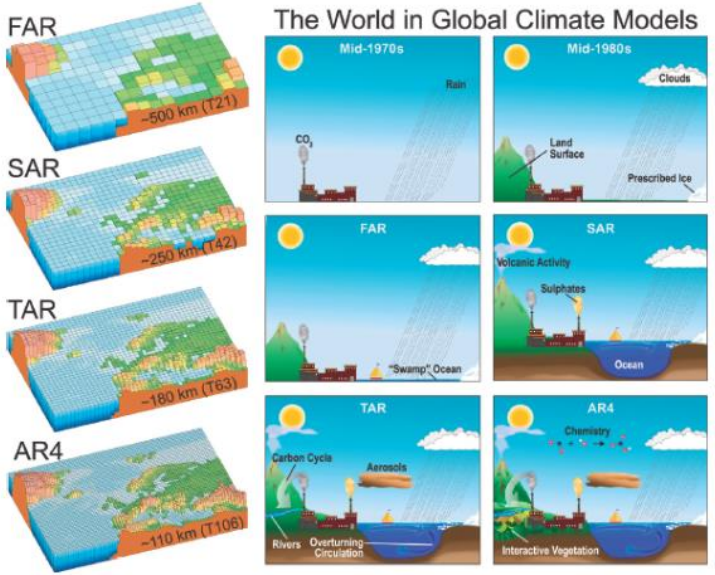
Project scope

Feasibility study on estimation of insulator pollution from:

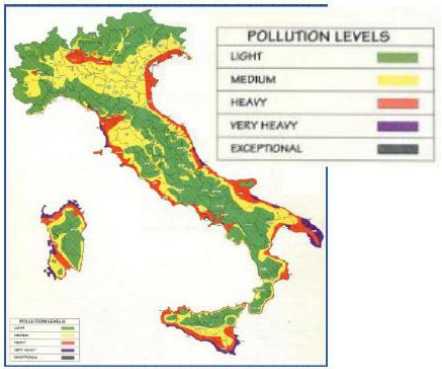
- satellite based data
- weather data with high spatial resolution





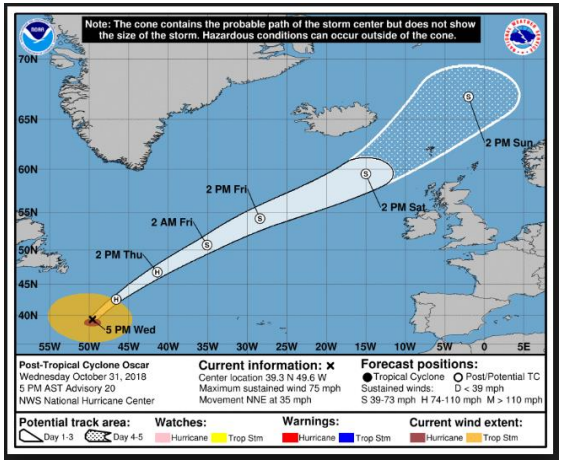
Benefits 1

- Avoid costly and time consuming measurement
- Creation of pollution maps to be used directly for dimensioning



Benefits 2

- Improved fault analysis
- Forecasts of pollution level, estimation of risk of outage



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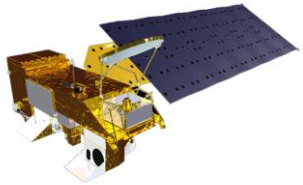
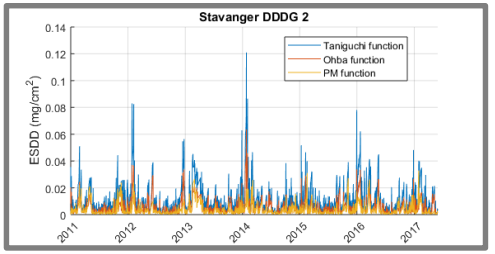
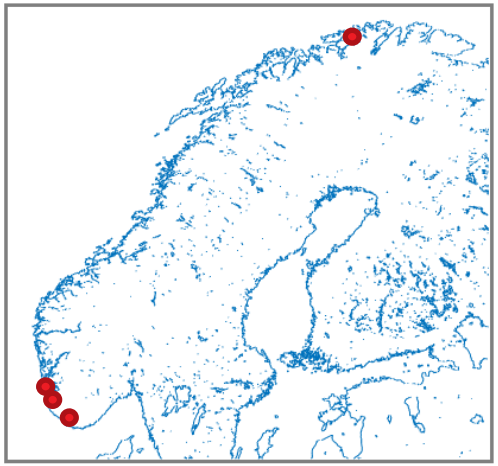
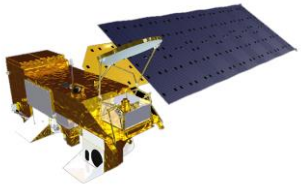
Methodology



- Review of available data from satellites
- Modelling of insulator pollution based on high spatial resolution weather data
  - Calculation of time-series of pollution on insulators.
  - Comparison with earlier measurement in Hammerfest and Stavanger, at Nord.link, etc

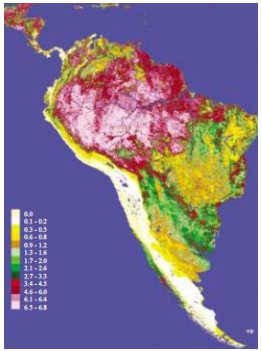


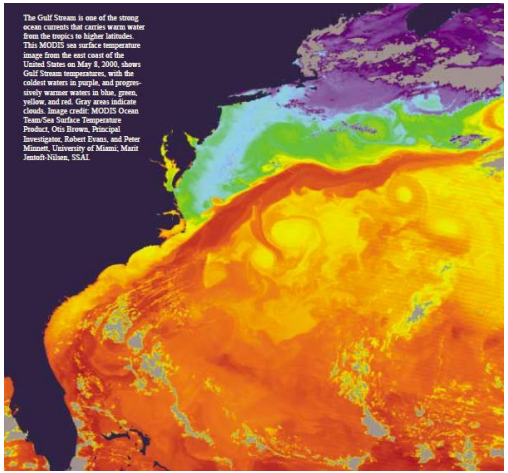




Monitoring by satellites

- Satellites measures a lot of parameters for scientist
  - Sea temperature
  - Algae blooming
  - Leaf area index
  - Aerosols…





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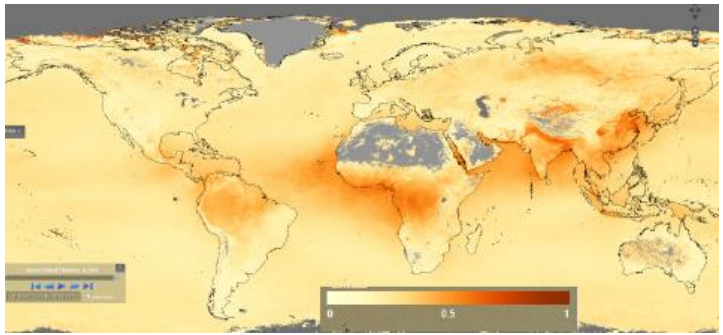
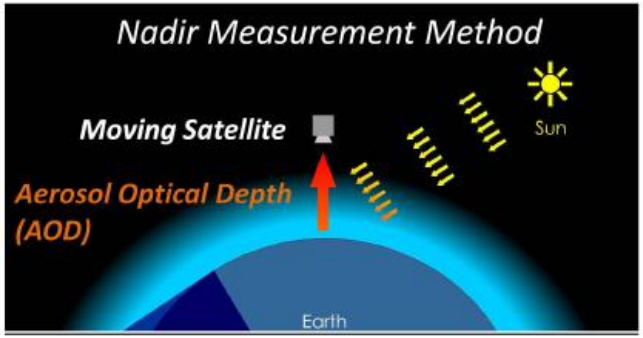
Aerosol monitoring by satellites

- NASA satellite Aqua and Terra has been monitoring air pollution with AOD measurement since beginning of 2000.





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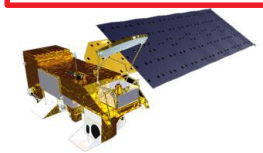
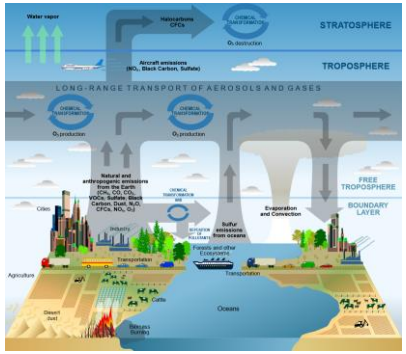
Aerosol monitoring by satellites

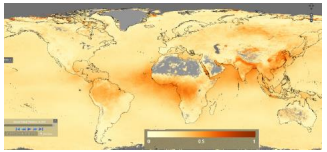
Satellite measurement



Chemical transport model



Aerosol optical dept



Improved model accuracy of dispersion and deposition of pollution

Ground based measurement

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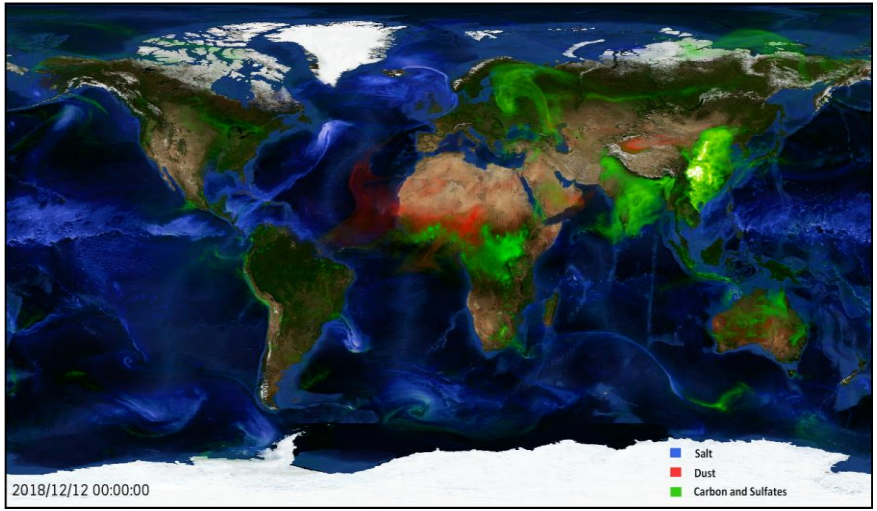
Aerosol monitoring by satellites

Chemical transport model



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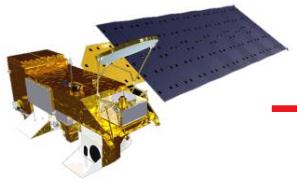

- For Statnett mainly marine aerosol/pollution is of interest

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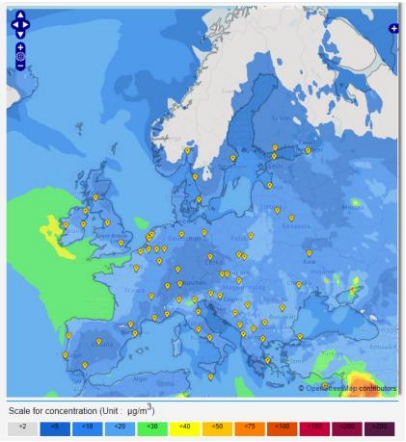
Modelling of pollution on insulators

- Models utilising high spatial resolution weather data
  1. Simple empirical model based on pollution measurements in Norway
  2. Semi-empirical model based on downwind distance to ocean
  3. Semi-empirical model based on Particulate matter estimates from chemicals transport models

Particulate matter

Particles that are suspended in the air. Sea salt, black carbon, dust and condensed particles from certain chemicals can be classed as a OM pollutant.



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Modelling of pollution on insulator

- Models utilising high spatial resolution weather data
  1. Simple empirical model based on pollution measurements in Norway
  2. Semi-empirical model based on downwind distance to ocean
  3. Semi-empirical model based on Particulate matter estimates from chemicals transport models

    - The comparison with **measurements** shows that sufficient accuracy can be achieved by Modell 2 and 3
    - Modell 2 and 3 provides equivalent results

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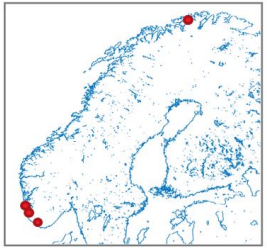
Summary

- The methodology used shows good results for specific sites.
- We’re now one step closer to an insulator pollution map of Norway, providing the following benefits:
  - Reduced risk of outages related to pollution by reliable dimensioning
  - Avoiding costly and time consuming measurements
  - Cost effective dimensioning



- Possibly similar methodology could be used for corrosion.