Sustainable Energy Systems 2050 NORDIC ENERGY RESEARCH PROGRAMME



# Nordic Energy Road Map 2050 Strategic Choices towards Carbon Neutrality (NORSTRAT)

Final conference

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## NORSTRAT partners and stakeholders



## Reference group

- Fingrid
- Energinet.dk
- Svenska Kraftnet
- (Stanett)
- Enova
- Energi Norway
- Vattenfall
- Dong Energy
- Danish Energy Association
- Vestas
- Fortum





## NORSTRAT scenarios 2050



in the Nordic region 200 - 250 TWh/y Volume of new RES 100 - 150 TWh/y

### **Purely RES**

200-250 TWh/y of new RES based production. Nuclear decommissioned. Connection to Europe mainly as today.

#### European Hub

200-250 TWh/y of new RES. 11 GW increased capacity in the Norwegian hydro power. Increased integration with Europe

### Carbon Neutral

100-150 TWh/y of new RES based production. Connection to Europe mainly as today.

#### **European Battery**

100-150 TWh/y of new RES. 11 GW increased capacity in the Norwegian hydro power. Increased integration with Europe

Transmission integration between the Nordic region and the rest of Europe

# Some results power system analysis



- The Nordic region has sufficient renewable resources to develop a power system without greenhouse gas emissions
- Simulations indicate that it is possible to obtain a power system in balance with some upgrades of the transmission grids (local grids not studied)
- For a Nordic power system based on only renewables and nuclear in Finland, large expansions of transmissions grids may eliminate rationing of demand
- Norwegian hydro power balance variable wind system production in a future without nuclear in Sweden.



## 100 % Electrification of private passenger transport



- Present system: 20-30% of GHG emissions because of transport
- Study based on present driving pattern
- Scaled up according to expected demographic changes
- Increase the yearly power consumption with ca 7 %



### The weekly power profile in Denmark



## Short term balancing of variable wind power production from Electric Vehicles and Heat Pumps



- Future variable large scale wind production must be balanced in short and long term.
- Flexibility of Electric Vehicle (EV) and Heat Pump (HP) demand may be a big source of short term balancing (frequency-controlled reserves) - 600% and 500% of the requirement at present.





# Governance analysis Electric vehicles and Grid development

## **Electric Vehicles:**

- Showed the fundamental trends in favour of Battery Electric Vehicles, e.g., rapidly falling battery costs
- Apply all policy measures: Critical to combine financial incentives with knowledge generation. Address misconceptions and lack of experience

## Grid development:

- Barriers:1) Where and how much wind power;
  2) Uncertainties in the concession procedure;
  3) Limited cross country planning
- Solutions: Need for clear guidance on eliciting stakeholder interests, clearer policy targets, and long term planning for RES







# Leaflets with results www.sintef.no/norstrat

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Nordic Energy Research

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Strategic choices towards carbon neutrality NORSTRAT - Nordic power road map 2050

#### How can a Nordic power system be carbon neutral?

The Nordic Energy Research project NORSTRAT has studied a future Nordic power system without fossil fuel production. The studies show that Denmark, Finland, Norway and Sweden has more than enough renewable resources to phase out fossil fuel based production and also to cover expected increase in demand. Simulations with high spatial and temporal resolutions indicate that it is possible to obtain a power system without rationing of demand (demand not supplied) based on mainly wind, hydro, bio and nuclear. No flexibility in demand is assumed. Demand flexibility can further improve the security of supply, e.g. within each hour which is not included in these analysis. The Nordic power system is assumed to be totally integrated and some increases in the transmissions grids internally in the region are found profitable. The interconnectors between the Nordic region and its neighbouring countries are kept at present level.

#### Background

All Nordic countries have presented long-term strategies for CO2 emission reduction to be achieved by 2030. Sweden and Norway already have very high share of renewable sources in their power production, and Denmark alims to a have a 100% renewable energy supply by 2030.



Nordic Energy Technology Perspectives (NETP) was released in 2013 and described several scenarios for a carbon neutral energy system in the Nordic region 2030 [1]. The NORSTRAT scenarios are similar to the NETP scenarios, but provide results with a higher spatial resolution than the NETP. Furthermore NORSTRAT has to a larger extent analyzed power flows and impacts on transmission grids.

#### Results

NORSTRAT has analyzed several scenarios for the power system in Denmark, Finland, Norway and Sweden in 2030. This leaftet describes the Carbon Neutral scenario. In 2012 there were approximately 70-100 TWh/y of fossil based power production which had to be substituted in order to develop a power system without emissions of greenhouse gases (GHG) in the Nordic region. In addition studies show that a power demand increase ca be expected in the long term perspective (see section Methodology below). The assumed demand increase results in power consumption of ca 444 TWh/y in 2030 compared to present consumption of 360-400 TWh/y. Thus, cs 130 TWh/y has to be supplied by new power production in order to obtain a power production without GHG emissions in 2030. NORSTRAT analyses how new renewable production can cover decommission of fossil fuel based production and the expected increase in consumption.

This Short Communication is developed in the Nortic Energy Research project NORSTRAY. The overall objective of NORSTRAY is to build knowledge and understanding energy policicians and decision makers about possible carbon neutral failures for an integrated fiordic power system is to the perspective to 2050.