

Statnett

GIC in Norway – Past, Present and Future

We are building the
next generation main grid

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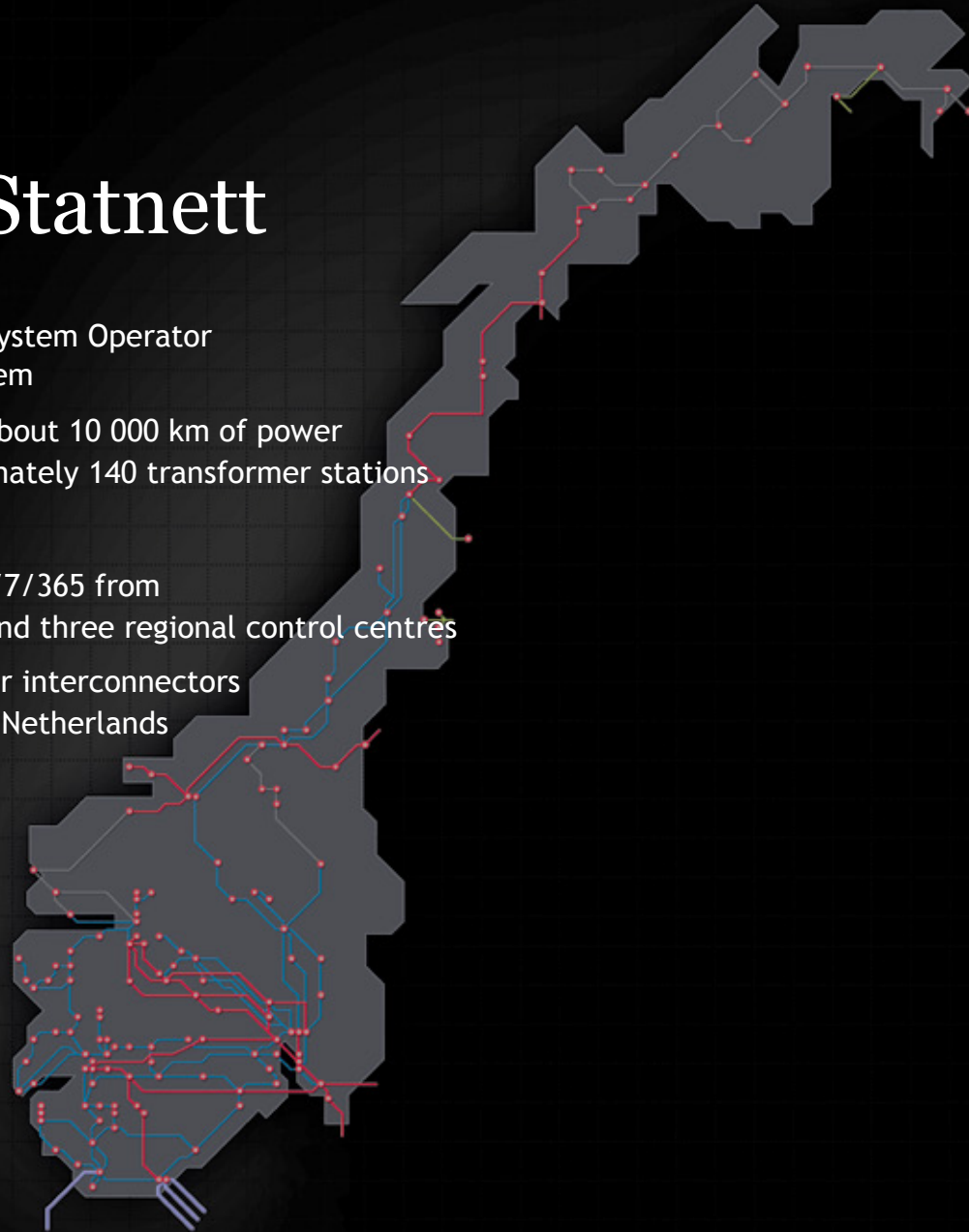
This is Statnett



Facts about Statnett

- Statnett is the Transmission System Operator in the Norwegian energy system
- Statnett operates and owns about 10 000 km of power lines and cables and approximately 140 transformer stations throughout Norway
- Operations are monitored 24/7/365 from one national control centre and three regional control centres
- Statnett is also responsible for interconnectors to Sweden, Denmark and the Netherlands

- 420 kV
- 300 kV
- 220 kV
- 132-150 kV
- HVDC interconnector



In short



Everything is dependent on electricity

Our society is already electrified. Electricity is perhaps our most important infrastructure.



The future is electric

Electricity is the energy carrier of the future - it is both climate and user friendly.



The power system – a balancing act

The power system is constantly put to the test. Operational reliability is our number one priority.

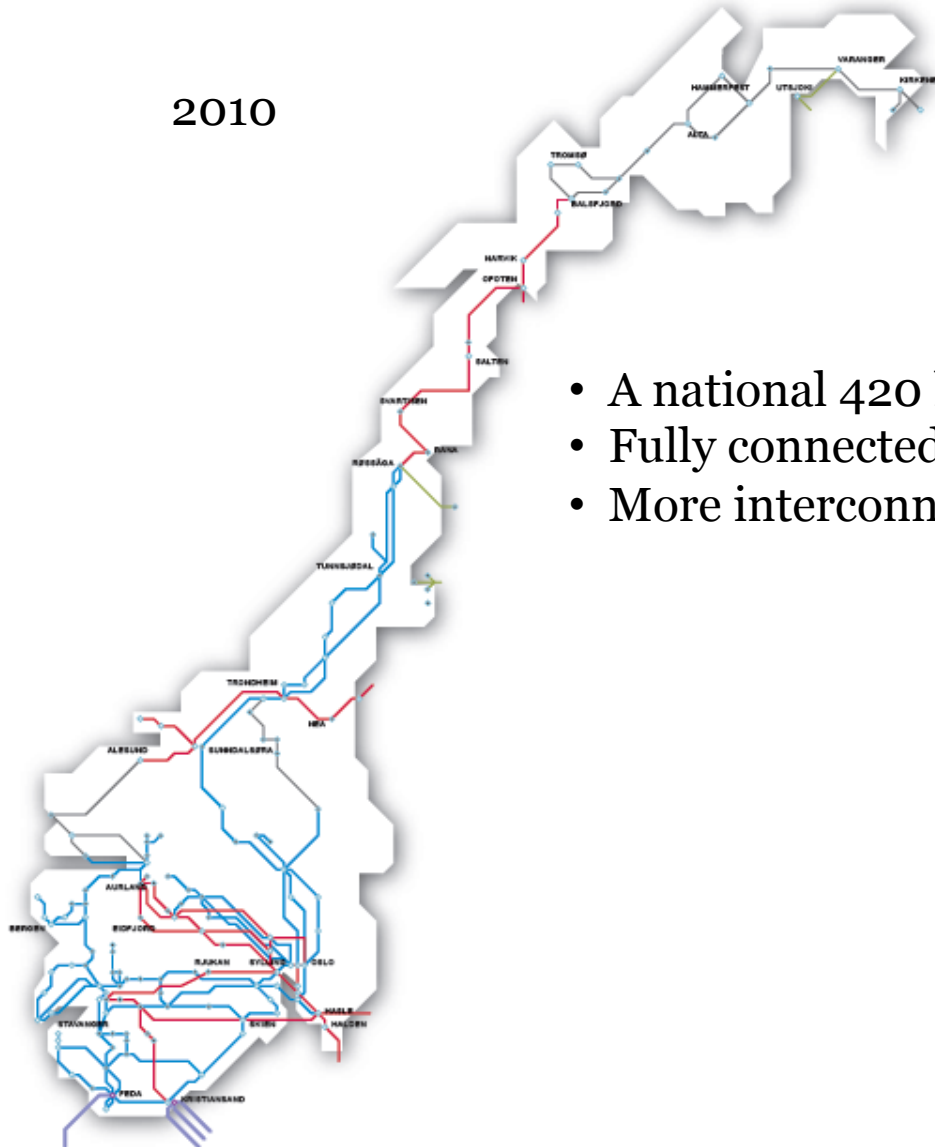


Next generation main grid

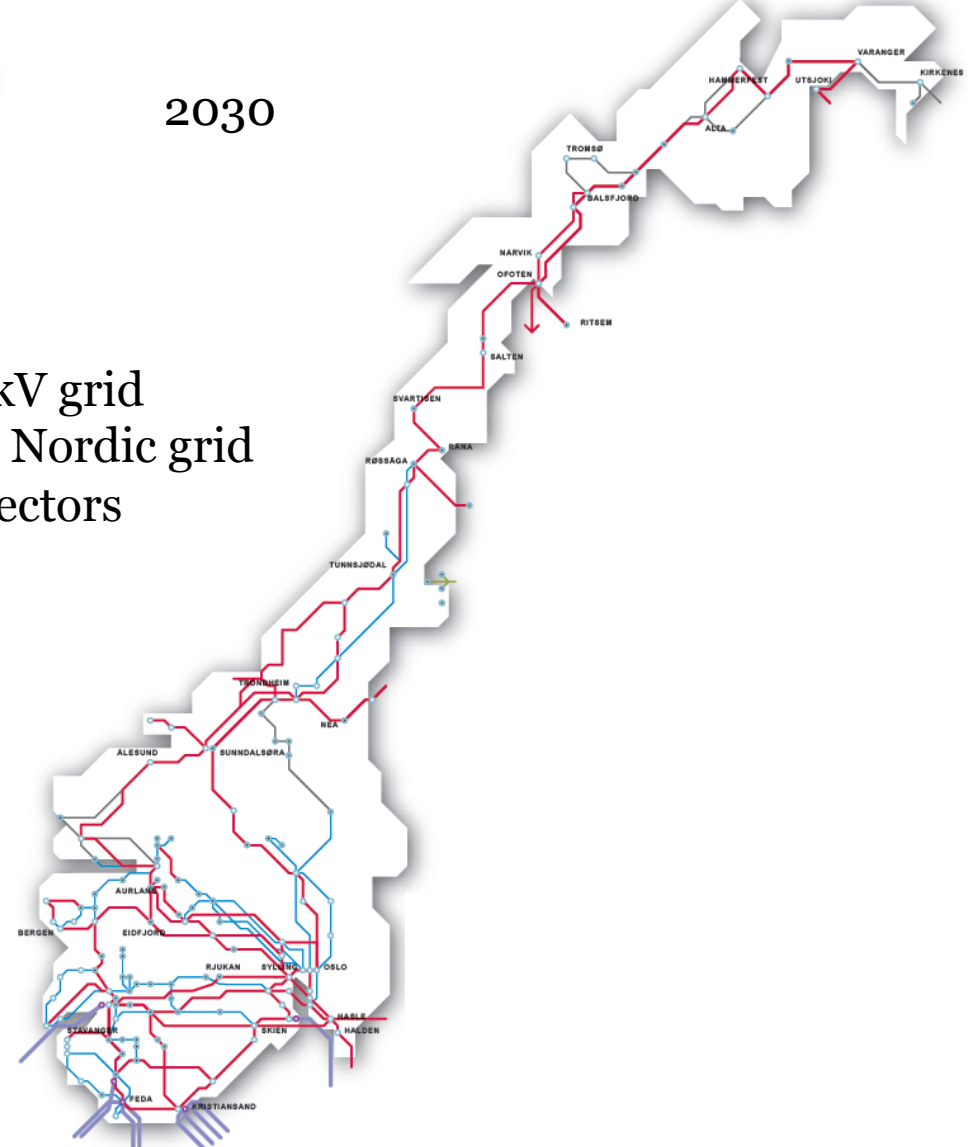
The grid needs updating and developing. We are building the main grid of the future.

Statnett is building the next generation grid

2010



2030



- A national 420 kV grid
- Fully connected Nordic grid
- More interconnectors

Grid development strategy for Northern Norway

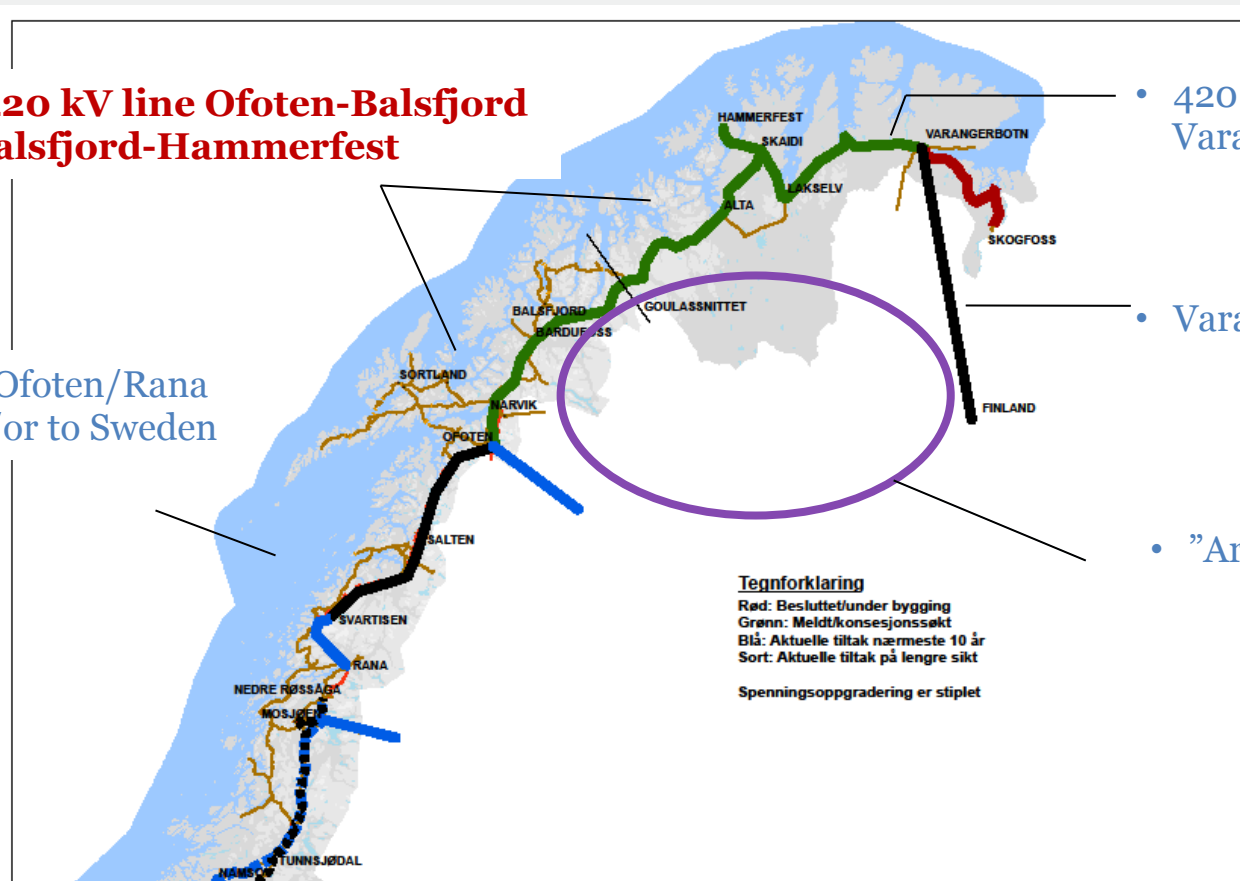
- **New 420 kV line Ofoten-Balsfjord and Balsfjord-Hammerfest**

- 420 kV line Skaidi-Varangerbotn

- Reinforce Ofoten/Rana south and/or to Sweden

- Varangerbotn-Finland

- "Arctic Circle"



1. Experiences with GIC in the Norwegian Main Grid

2. What do we do to protect against GIC?

In short:

- 1. No serious malfunctions or incidents caused by GIC so far**
- 2. No physical protection measures implemented – R&D programmes including GIC-measurements**

Why Worry ?

- Future "superstorms" – to little knowledge of consequences
- Increasing demand for reactive power (in case of high GIC-levels)
- Increased extent of interconnected 420 kV network towards 2030
- Aging power transformers

Past

R&D project in 1999 og 2000.

- Cooperation with SvK (Swedish TSO), OKG AB og Metatech

Background.

- Increased concern about *solar cycle 23* (1999 - 2001)
- Effect on the transmission grid ?
- Is GIC a real threat for the electrical power system ?

Past

Activities 1999 - 2000

Measurements in the transmission network

- Voltage and transformer zero current in 4 substations

GIC study of the Swedish and Norwegian power system

- Performed by Metatech Corporation USA.
- Established a "GIC model" of the Swedish (132kV - 400kV) and Norwegian (300kV - 420kV) network.
- Worst case studies and benchmarking against previous (registered) solar storms.

Participation in Nordic GIC cooperation

- Established a network with among others SvK, Fingrid, OKG, Stakraft, Vattenfall, Eltra and Elkraft.
- Annually "Nordic GIC meeting".

Litterature studies

- Update on international activities (regarding GIC)

Present

- On-going monitoring of current in transformer neutrals at selected substations, situated North, South, East, West and Central in the power grid.
- Performing new system studies regarding GIC in the Norwegian power grid. -
- Models for present power grid, and for the power grid of 2030.
- Review of technical specifications for power transformers, to make the transformers less vulnerable to GIC.
- Review of trip settings of relay protection for shunt capacitors, to avoid unwanted de-energising during a GIC incident.
- Involvement and contact with international organisations, projects and working groups, like EurisGic, NERC, Entso-E, Cigre and Doble.

Future

- Continue monitoring of current in transformer neutrals.
- Improved GIC forecast services, a reliable early warning system will be available.
- Emergency plan and procedures regarding extreme magnetic storms are established.
- Training of the personnel at the control centres