Analysis of transmission corridors – and modelling of grid constraints

Hydro Scheduling User Meeting, 28.november

Statnett

ATK 2023 – in short

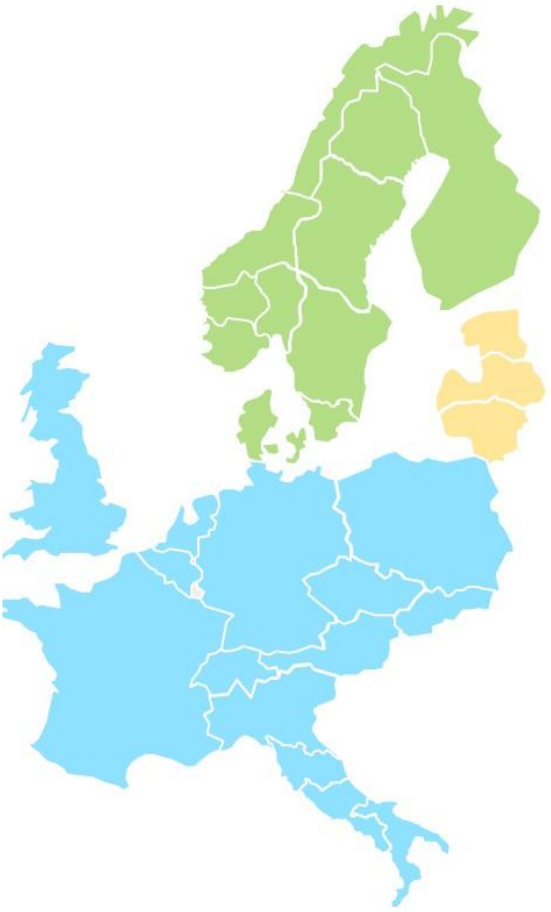
Focus of the analysis:

- Flow, price, bottlenecks in the transport channels towards 2050
- Need for planned measures as described in the regional plans
- Capacity to demand – what does it take to realize the High demand scenario from LMA

Method :

- Calculate transmission capacity in future grid with technical grid model
- Simulate with market-grid model to calculate flow, price and bottlenecks
- Compare a large volume of data years to understand interlinks and illustrate sample space

Starting point: Datasets and scenarios from LMA 2022



PSSE – technical grid model
Samnett – market and grid model
BID 3.0 – market model

ATK is a part of Statnetts System Development Plan 2023

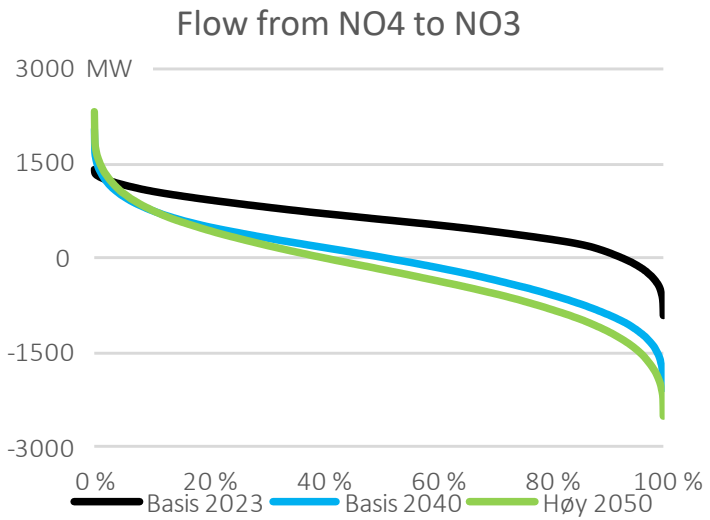
Important focus areas for Statnett:

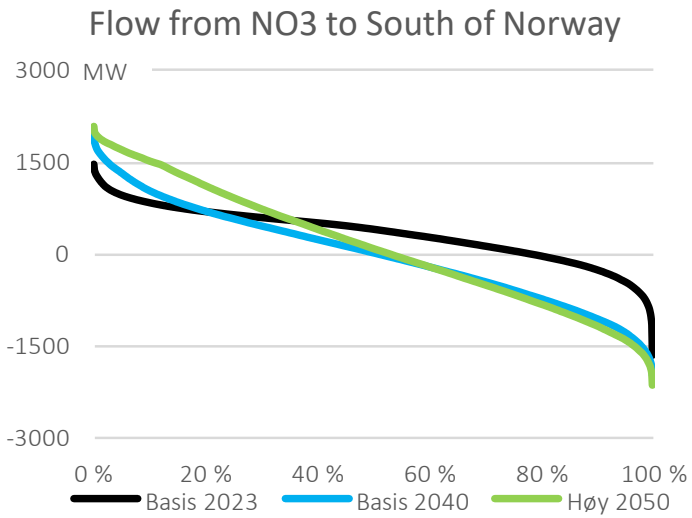
1. More grid faster
2. Increased capacity to the market players
3. Higher utilisation of today's power system
4. Automatized system operation
5. Stability in a changing power system
6. Facilitate development of offshore wind

Government, producers, consumers must contribute:

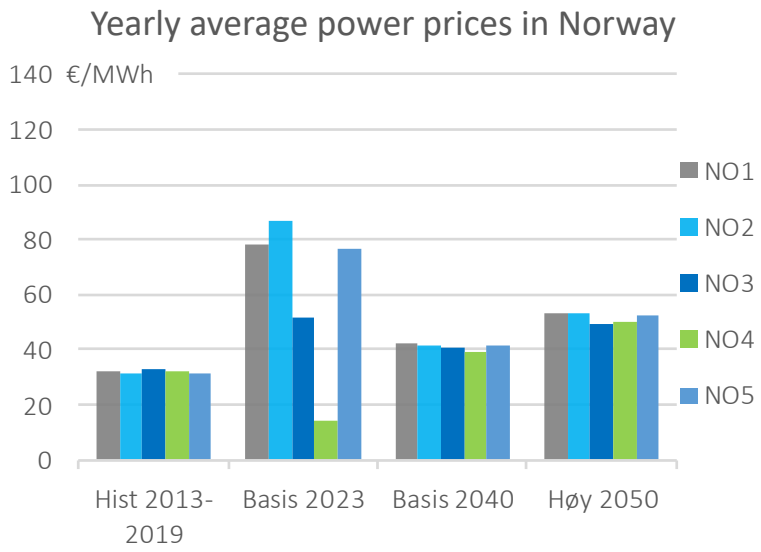
7. Government needs to provide clear direction and regulation
8. Norway needs more power production
9. More of the power demand needs to be price flexible
10. Power market provides important signals

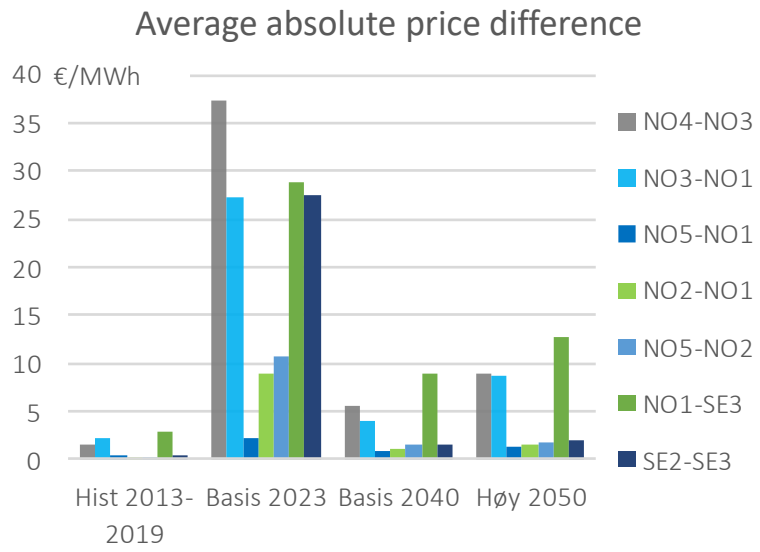
Main trend is more balanced power flow between regions



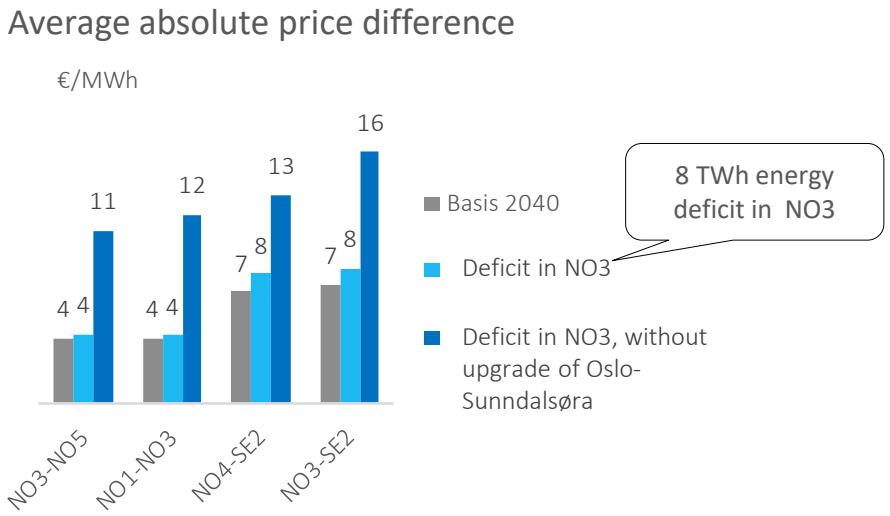


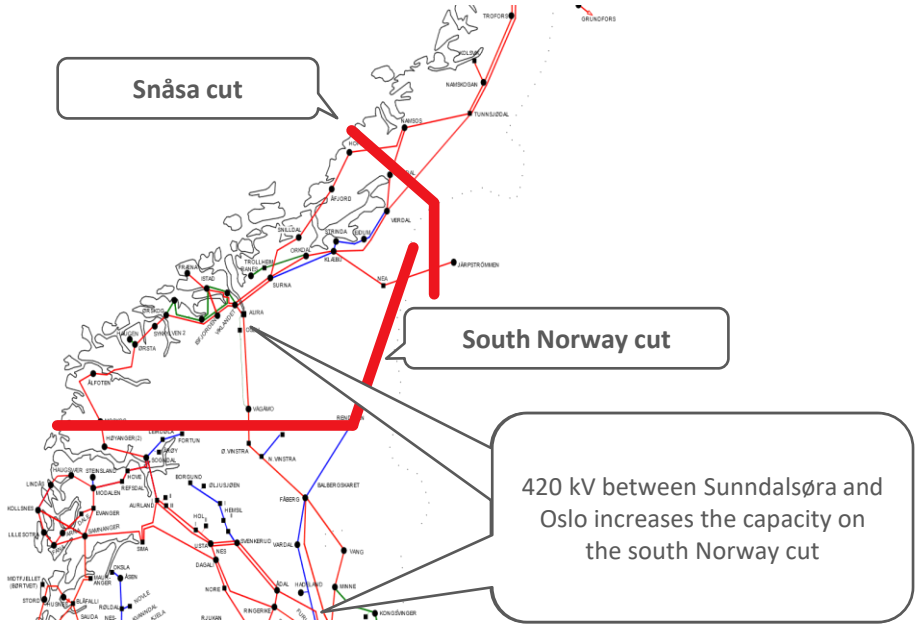
2040-grid results in small price differences – enables 260 TWh demand





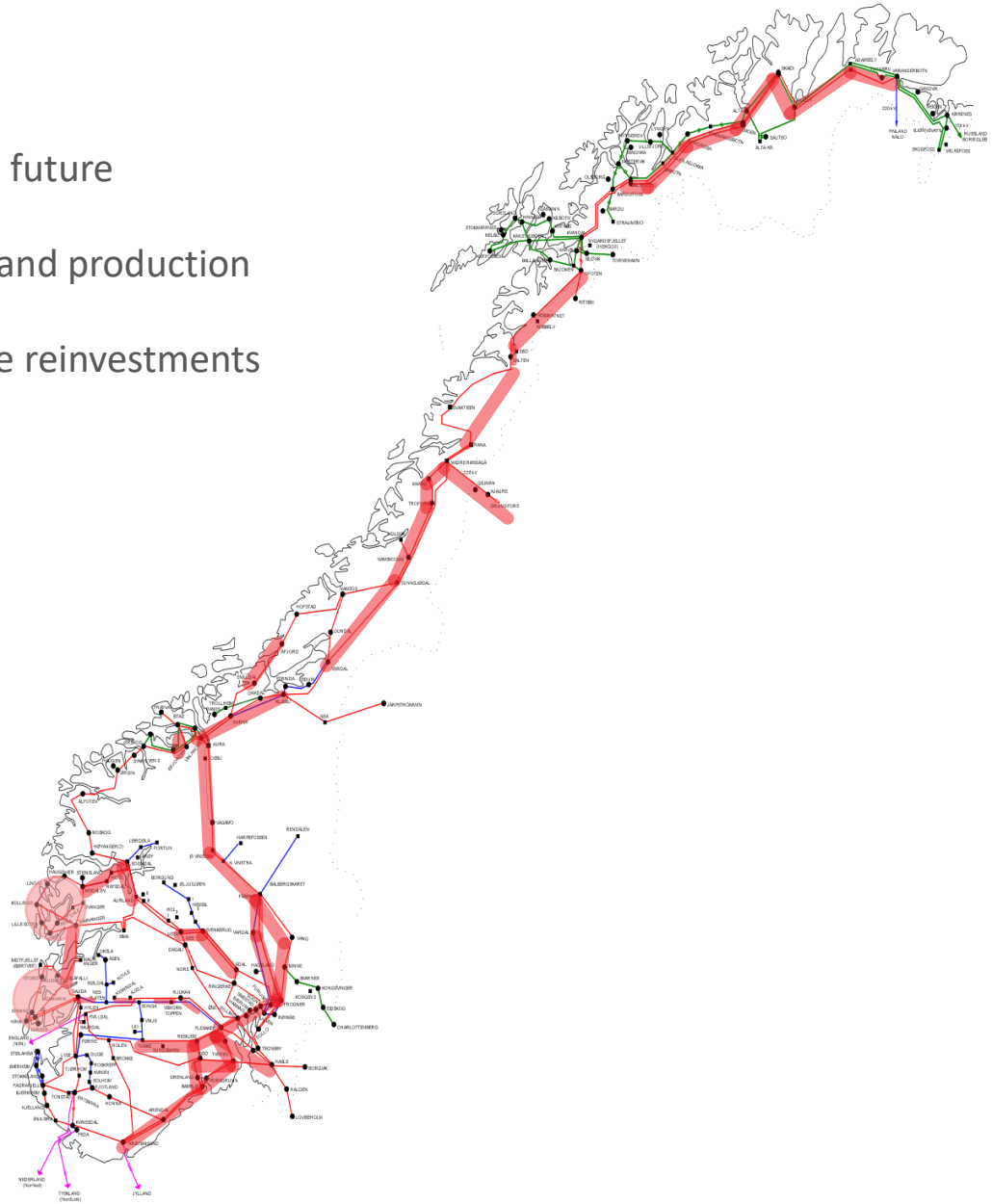
Without the planned grid measures – larger price differences





Summary

- There is a large need for increased transmission capacity today and in the future
- The transport channels in the planned grid can handle 260 TWh demand and production
- The socio-economic cost is moderate as most of the grid investements are reinvestments



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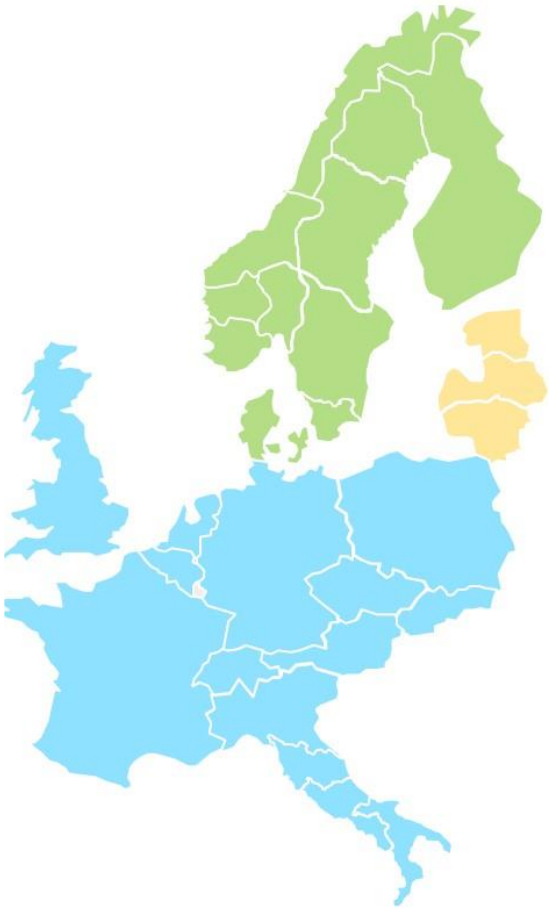
Grid constraints in Samnett Flowbased algorithm

Iterative analysis with three fundamental models

BID 3.0: Market model that, with optimization algorithms, minimizes the ongoing operating costs to meet demand hour by hour over various analysis years, based on detailed data descriptions of the entire market. Used at Statnett to represent the British and continental markets – and provides price series for the countries bordering the Nordic region as input data for Samnett.

PSS/E: Technical grid model that, with detailed data and the mathematical equations of electrical power, reproduces snapshots of the electrical part of the power system in the Nordic region. Used to calculate capacity limits in the grid with outage analyses, for use in Samnett.

Samnett: Integrated market and grid model. Mimics the market bottom-up by minimizing the ongoing operating costs for the entire market hour by hour, within the limits set by, among other things, all power plants and the grid. This includes detailed optimization of hydropower. It has an integrated grid model similar to the one in PSSE and calculates physical load flow hour by hour. Ensures that the flow stays within the limits calculated in PSSE with price areas and flow-based market coupling. In Statnett's setup, the model covers the Nordic region and retrieves market prices for the continent and the UK from simulations with the BID model



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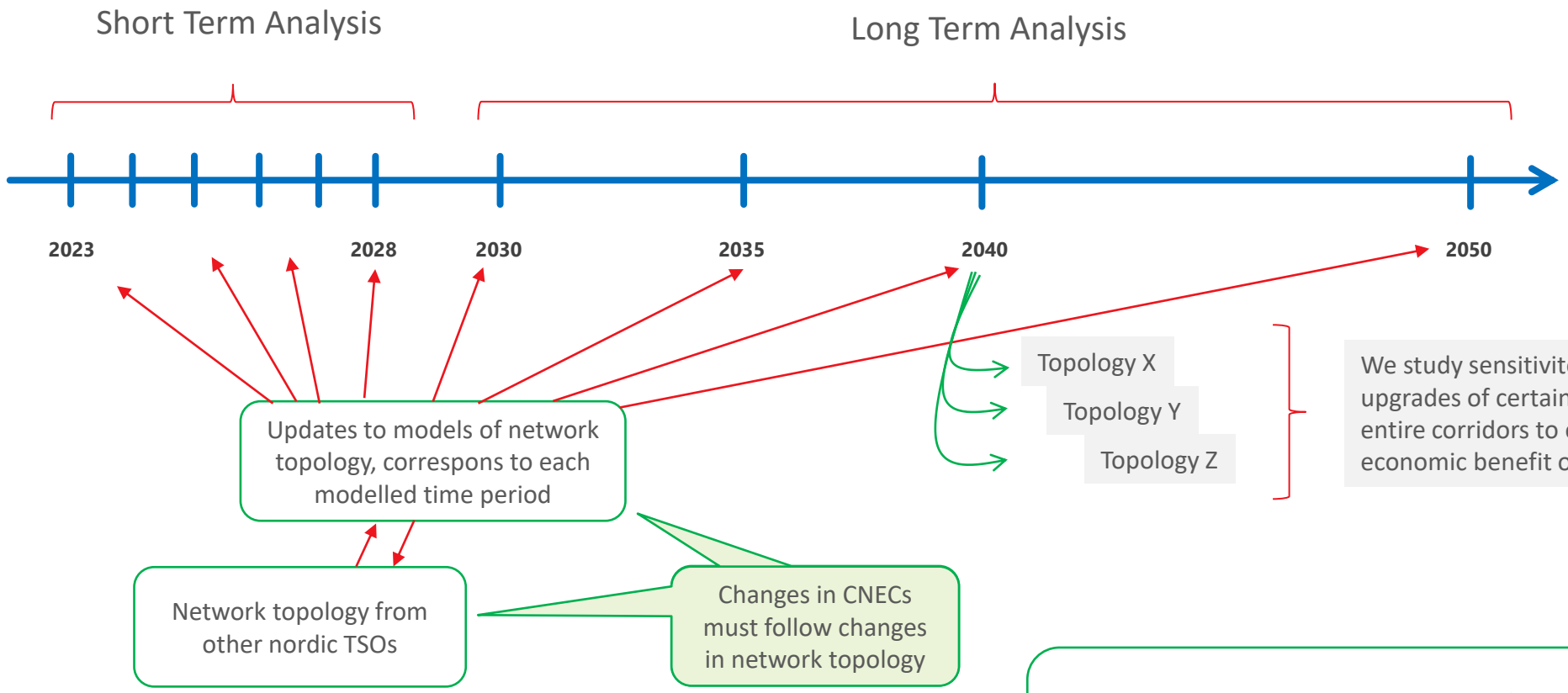
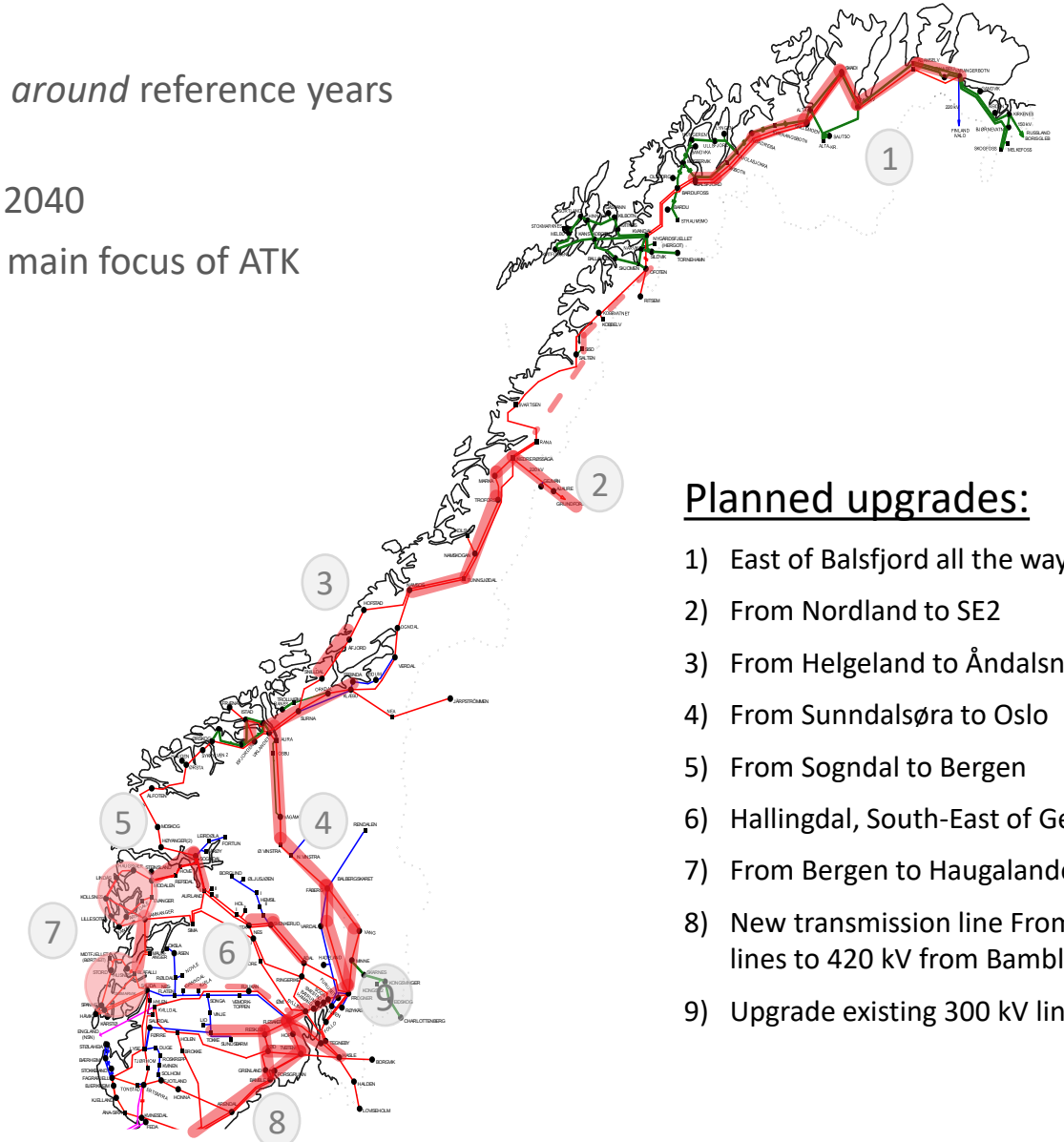
CNECs and network topology for all time horizons



Nordic grid model with CNECs for each time period

Planned upgrades in the Norwegian transmission corridors

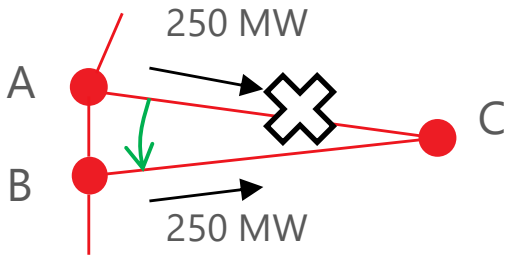
- Stepwise modelling of the grid *around* reference years 2030, 2035, 2040 and 2050
- "Målnettet" - finalised around 2040
- Transmission corridors are the main focus of ATK

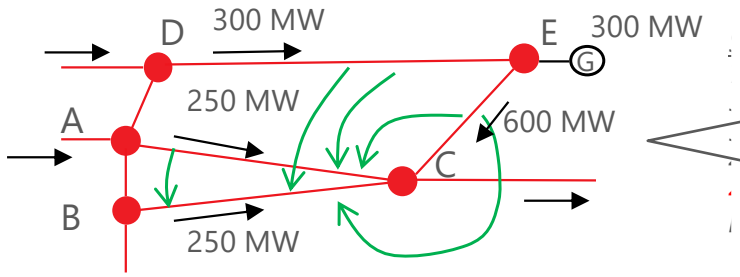


Planned upgrades:

1) East of Balsfjord all the way to Varanger. Back-to-back towards Finland.
2) From Nordland to SE2
3) From Helgeland to Åndalsnes
4) From Sunndalsøra to Oslo
5) From Sogndal to Bergen
6) Hallingdal, South-East of Geilo
7) From Bergen to Haugalandet, including local upgrades in these areas
8) New transmission line From Kristiansand to Bamle, and upgrade of existing lines to 420 kV from Bamble to Oslo
9) Upgrade existing 300 kV lines to 420kV through Oslo

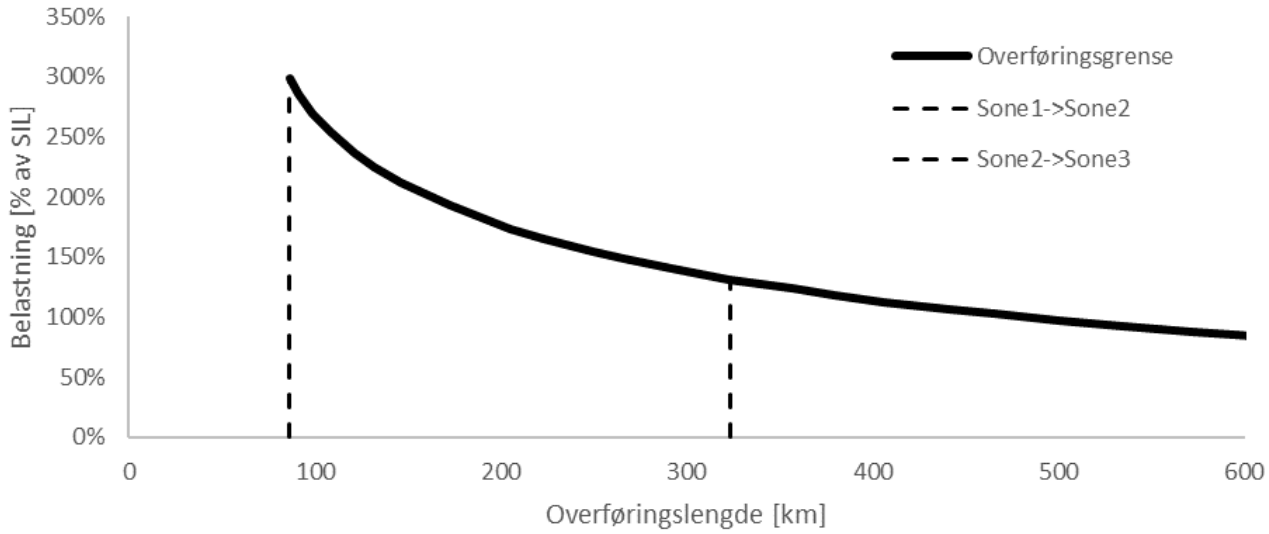
The allowed transfer capacity must ensure operational security





The power system must be redundant to avoid blackouts in case of network faults anywhere in the grid.

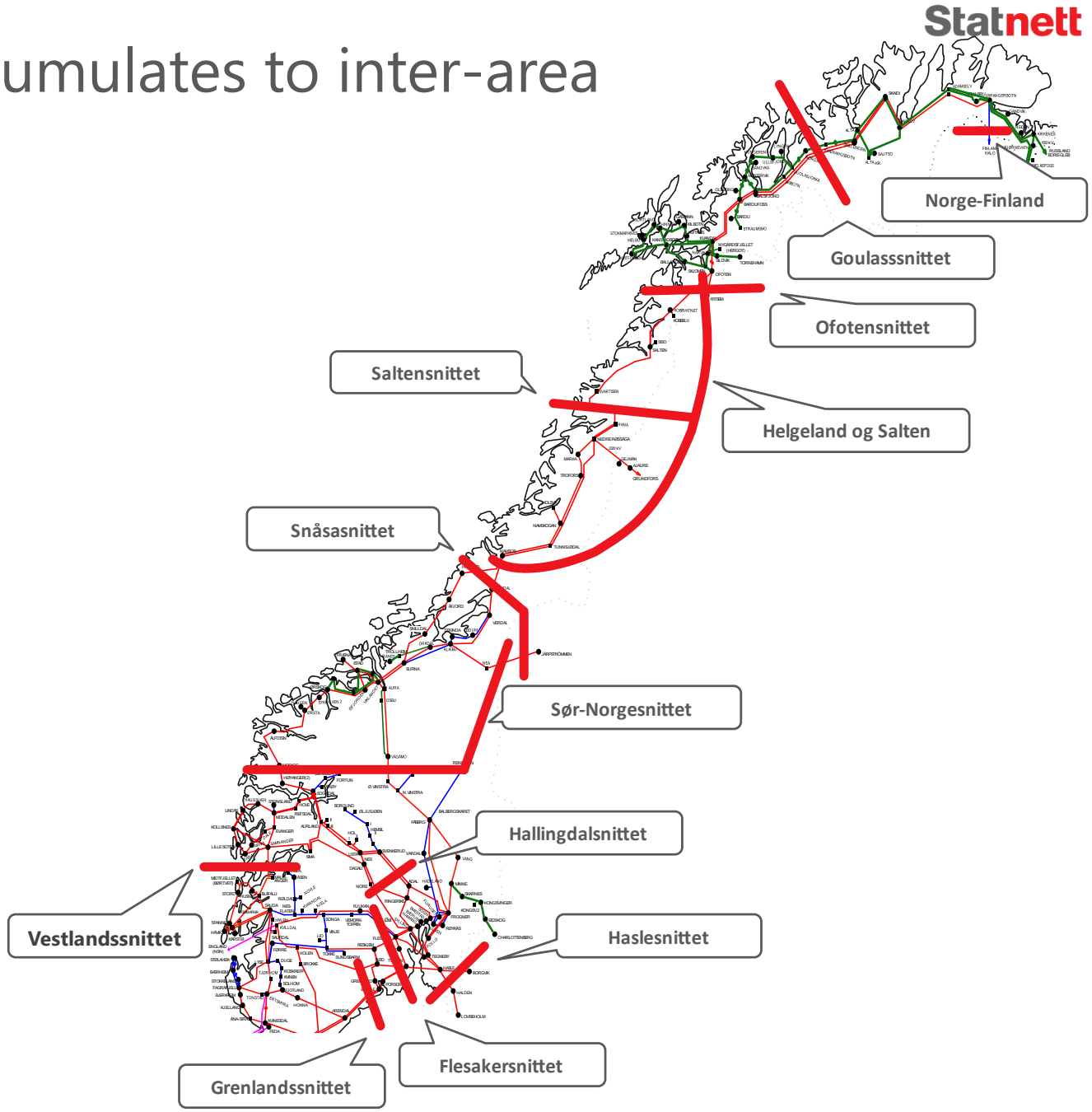
Transfer capacity is defined by the distribution factor and the capacity of the remaining component.



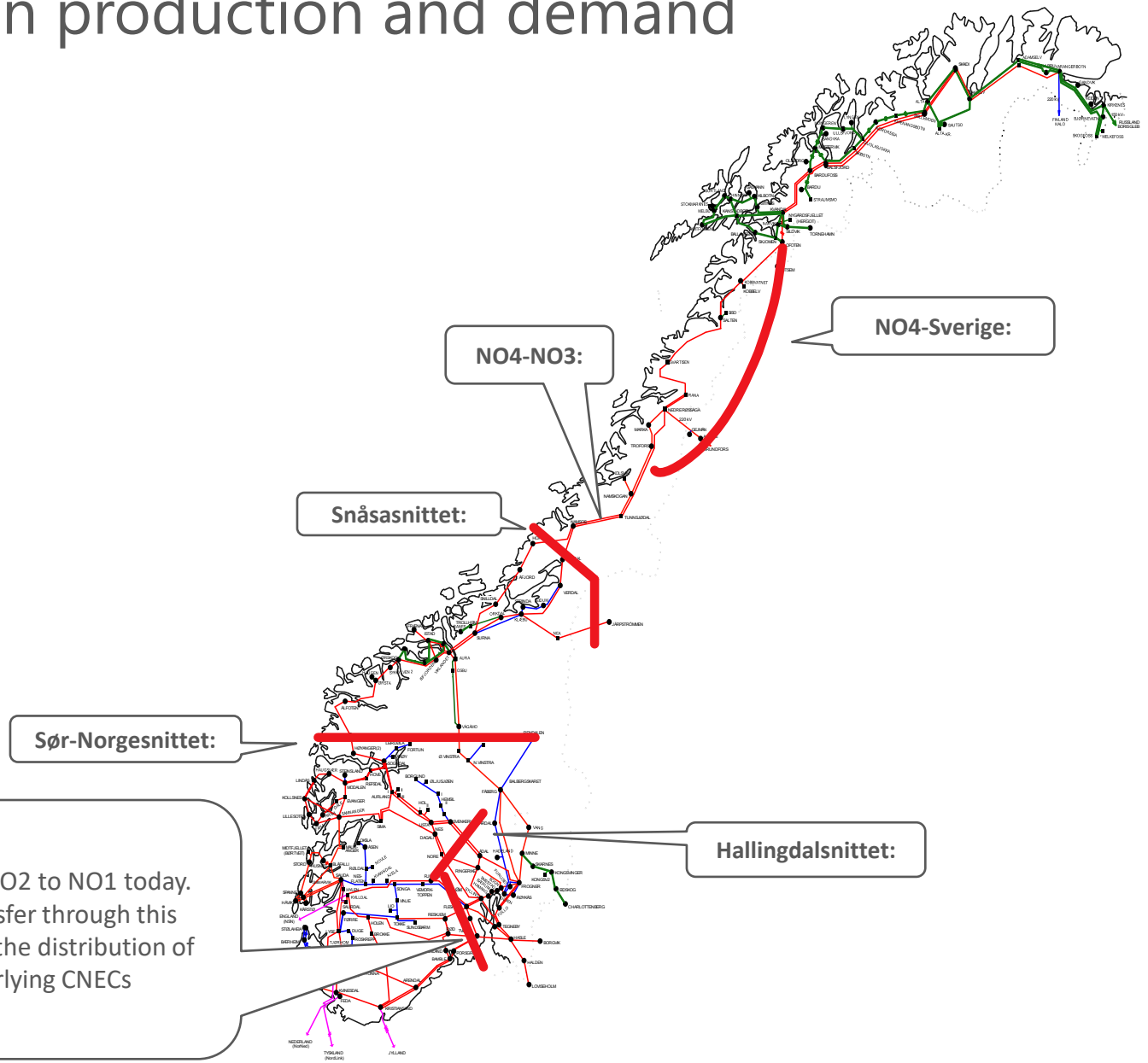
Limits to avoid voltage collaps might be more restrictive than thermal capacity

St.Clairs kurve: Overføringsgrense som funksjon av overføringslengde.
SIL ≈600MW ved 420 kV og ≈300MW ved 300 kV

Many smaller restrictions accumulates to inter-area restrictions

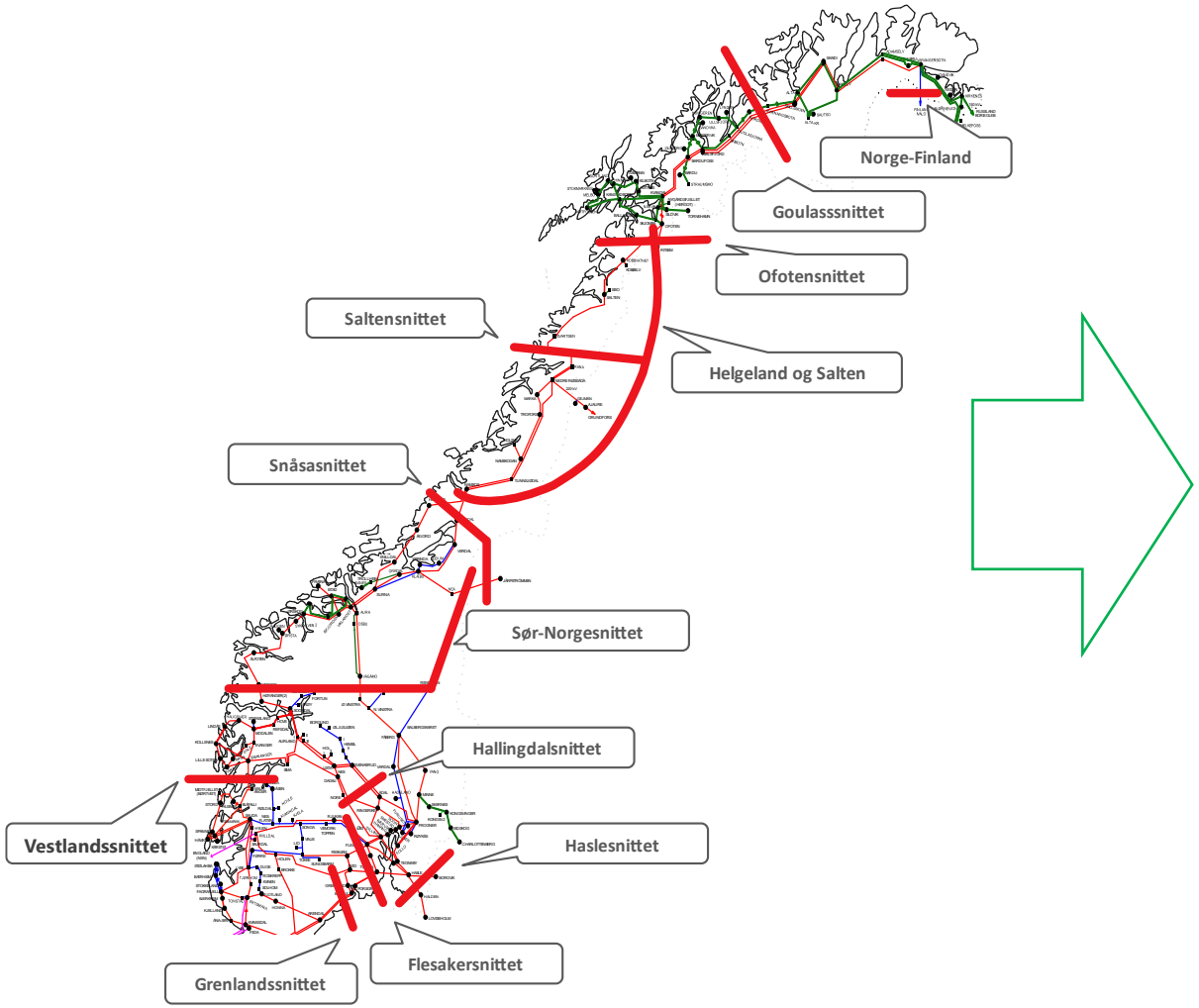


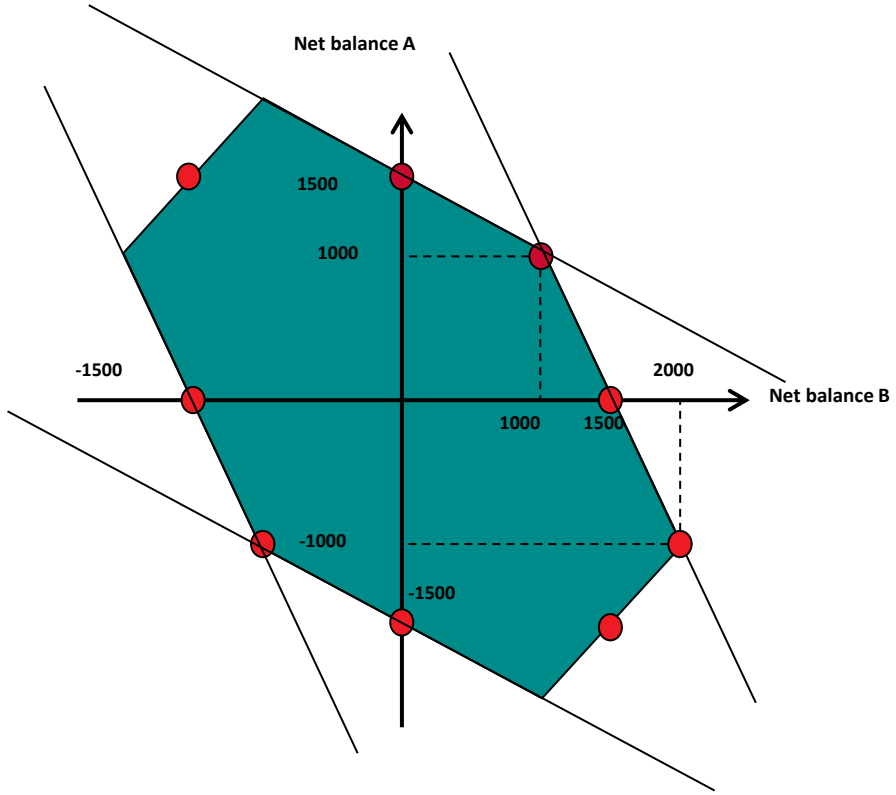
Transfer capacities depend on production and demand



Flesakersnittet: Maximum NTC-capacity is 3600 MW from NO2 to NO1 today. With the grid updates in 2040, the maximum possible transfer through this corridor varies between 4700 and 5100 MW, dependent on the distribution of production, demand and the resulting loading of underlying CNECs

Built-in flowbased algorithm in Samnett



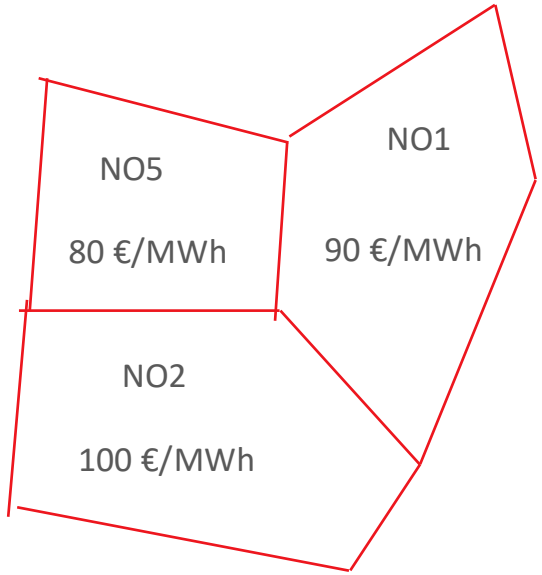


Flowbased market mechanism allows for better utilisation of the grid

- Actual transfer capacity depend on many factors that vary over time
- Flowbased allows for more precise adjustment to these factors
- Sometimes this will lead to price differences between areas where there are no congestions

Example from our Basis 2023. Simulated price and flow in an hour with different price in NO5 and NO1, although the flow between the areas is far below the allowed capacity

Price



Physical flow	Capacity
NO5-NO2 860 MW	NO5-NO2 860 MW
NO1-NO2 1050 MW	NO1-NO2 2200 MW
NO5-NO1 800 MW	NO5-NO1 3800 MW

- Full report avaliable at statnett.no
- Webinar (recording) avaliable till the 29th november