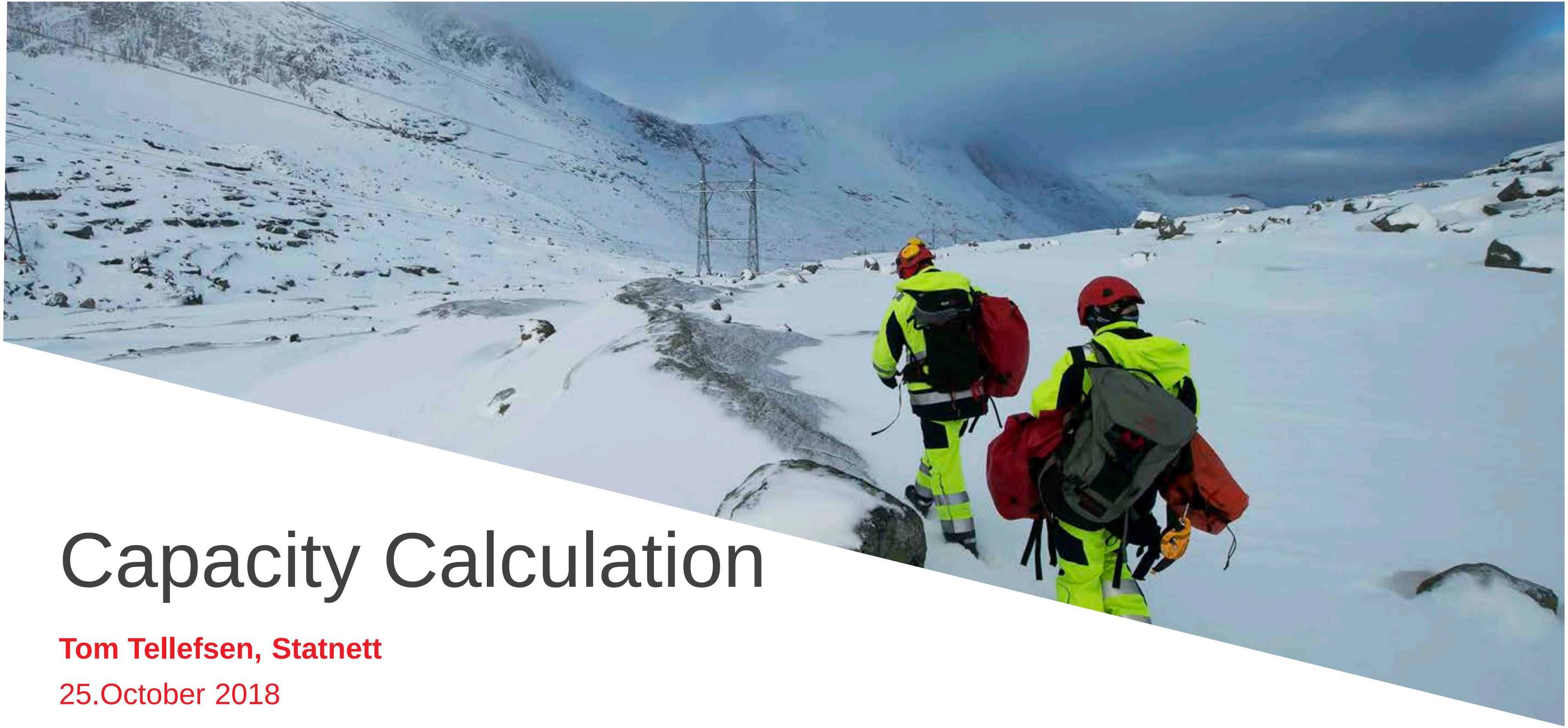

Capacity Calculation

Tom Tellefsen, Statnett

25.October 2018

Statnett

Capacity calculation

1. **Provide the market with as high market capacities as possible, given the constraints in the grid.**
   - N-1 principle
   - No planned countertrade

2. **Achieve a market clearance adaptable to the physical reality.**
   - The exchange in the DA-result (elspot flow) should be close to the physical flow.

3. **Uncertainties in the capacity calculation must be taken into account to reduce the risk of an unacceptable situation in the operational phase.**
   - All capacity calculations involve a degree of uncertainty.
   - Uncertainty and risk will vary between the cross-zonal corridors.

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Elspot bidding zones

- Norway is divided into 5 bidding zones based on "structural congestions"
- 624 capacities are given every day to the DA-market.
  - Ca 228 000 individual capacities determined in 2017.
- The bidding zones are essential in order to ensure that the planned Elspot flow is within the physical limits between the bidding zones.

Current bidding zones

- The current bidding zones in Norway (and Sweden) are functioning well.
- More bidding zones would result in:
  - Small market areas (market power)
  - The process of capacity calculation would be too complex, given todays NTC-model.
- Fewer bidding zones would result in:
  - Lower cross-zonal capacities
  - Unnecessary restrictions on a larger number of market players
  - More large bottlenecks would potentially have to be handled in the operational phase.
- NTC calculations are difficult to communicate!

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From physical capacity to trading capacity

- Certain adaptations must be done in order to handle physical constraints in an NTC-model (without a grid model)

- Three main groups of capacities:
  1. Strictly based on physical capacity, including system protection
  2. Based on physical capacity, but adjusted due to:
     - Max import/export capacity to one or a group of elspot areas.
     - Load, production or exchange forecast, power flow in neighboring areas and available reserves.
  3. Strictly based on a prognosis of load flow

Considerations in the capacity determination process

- Which bottlenecks should be included in the capacity calculation?
  - Will a reduction in trading capacity contribute to solving the problem?
  - Can the problem be solved using other actions?
- Which cuts will be fully loaded first?
- What is the physical flow on other transmission lines in the corridor when the first cut reaches its limit?
- The availability of system protection
- Availability of reserves
- Grid configuration

NTCs cannot be set individually.

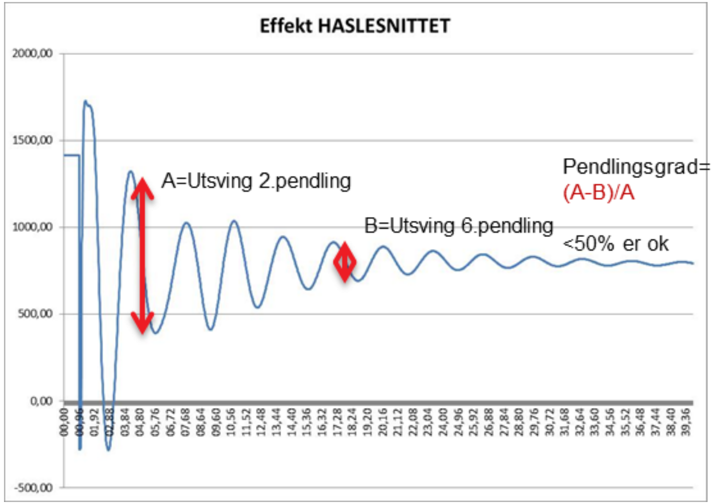
- Many NTCs are summarized to give the max exchange to the area (or sum of many areas).
- Higher capacity on one corridor, gives lower on other corridors.
- Outages in one area can couse congestions in other areas.
- Dimentioning cuts can include lines from different areas.

Risk management and efficiency

- If the capacity is set too high; is the security of supply at risk, or is it easy to handle it in operation by special regulation?
- If capacity reduction will not solve the problem, or be an inefficient measure, the capacity will not be reduced.

Grid analyzes

- Three different restriction could occur:
  - Thermal (dependent on outdoor temperature)
  - Dynamic instability
  - Voltage



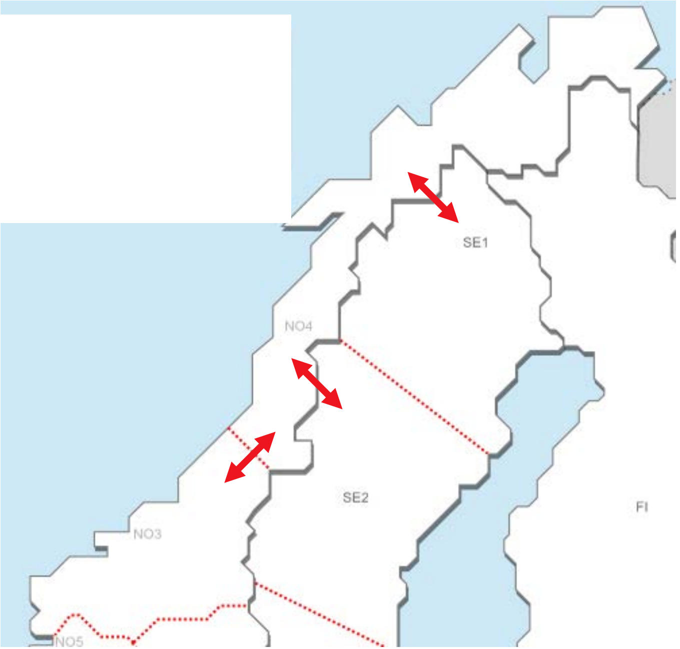
Measures to increase capacity

- System protection
  - Generator tripping
  - Load shedding
  - Grid splitting (Automatic disconnection of a line or transformer when an outage occurs on another line, to avoid instability)
- Change the grid configuration to increase capacity, often at the expence of security of supply.

Capacity calculation NO4

NO4

NO4 ←→ SE1
NO4 ←→ SE2
NO4 ←→ NO3



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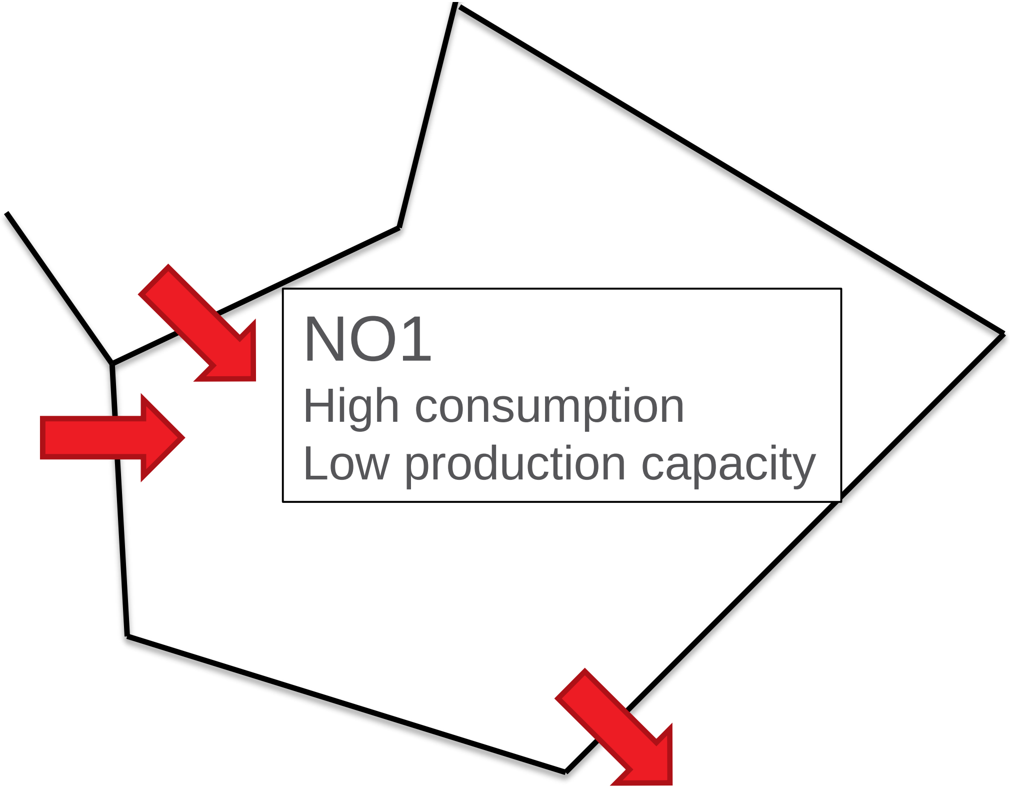
- The capacities could not be set individually. The physical congestions relate to the sum of capacity on all three corridors.
- The share on each corridor is based on flow forecast.

Capacity calculation NO1-SE3



Potential internal bottlenecks that must be handled by capacity reduction (NO5-NO1, NO2-NO1 and NO1A-NO1)

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Capacity NO1-SE3

- Consist of:
  - 420 kV Hasle-Borgvik
  - 420 kV Halden-Loviseholm
  - 132 kV Eidskog-Charlottenberg
- Maximum capacity: 2145 MW (included system protection)
- Lower capacity during wintertime.
- TSO responsibility to be able to deliver spot result to neighbouring countries, despite BRP imbalances.

Consequences of not taking these congestions into account in capacity calculation

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- Planned export to Sweden is not delivered in operation.
- The export to Sweden is already sold to Poland, Lithuania, Germany and Denmark.
- Use of Swedish disturbance reserves to cover the imbalance.
- Imbalanced system:
  - Need for a lot of activation, even if the BRPs are balanced.
  - Loop flows will cause congestions on many corridors.
  - Need for more TSO reserves to handle the imbalance and the loop flows.

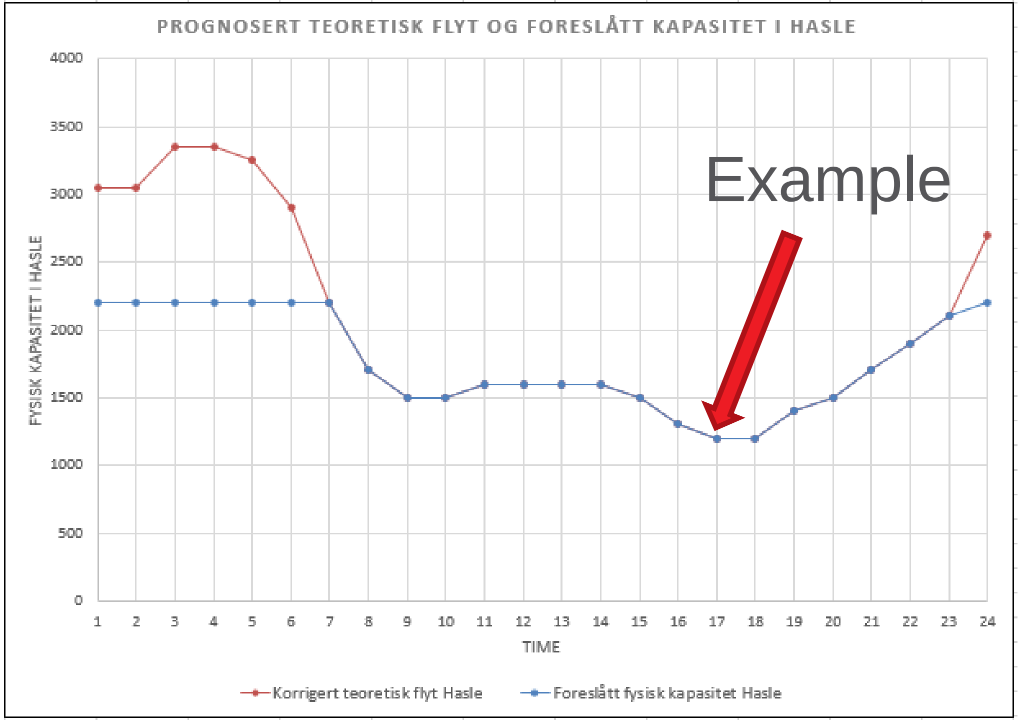
Example Capacity Calculation NO1-SE3

- Production forecast NO1: 2100 MW
- Import capacity (NO5-NO1+NO2-NO1): 6000 MW
- Reserves NO1: 200 MW
- Concumption forecast NO1: 7000 MW (normal winterday)
- TRM: 150 MW

- Capacity NO1-SE3= P + I + R – C - T = 1150 MW

Project to get more reserves (demand side response)!

Example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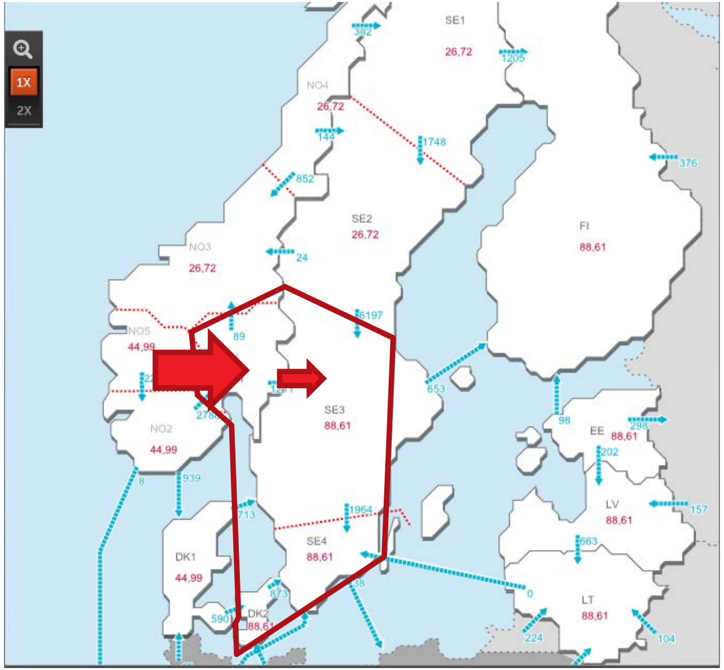
TIME
Example
Korrigert teoretisk flyt Hasle
Foreslått fysisk kapasitet Hasle

Market result



- Common price in NO1, SE3, SE4, DK2
- The reduced capacity NO1-SE3 did not have any consequences on the prices, because of the high deficit in NO1.

Summary

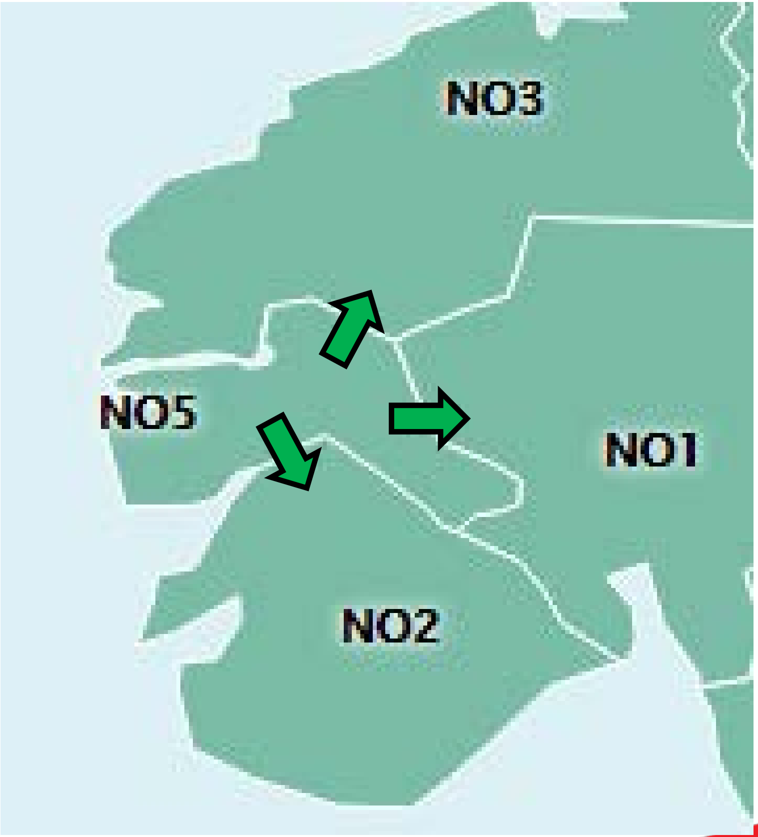
- NTCs today is based on physical congestions, but many more factors are important.
  - Production, load, assumptions on load flow
  - Outages in Norway, and outages in neighbouring countries close to the border.
  - Availability of system protection
  - Available reserves in different areas
- NTCs can not be set individually.
  - Many NTCs are summarized to give the max exchange to the area (or sum of many areas).
  - Higher capacity on one corridor, gives lower on other corridors.
- NTC calculation is complex. We look forward to flowbased

AVOIDING LOOP FLOWS

- INSTEAD OF HANDLING LOOP FLOWS

Example capacity NO5

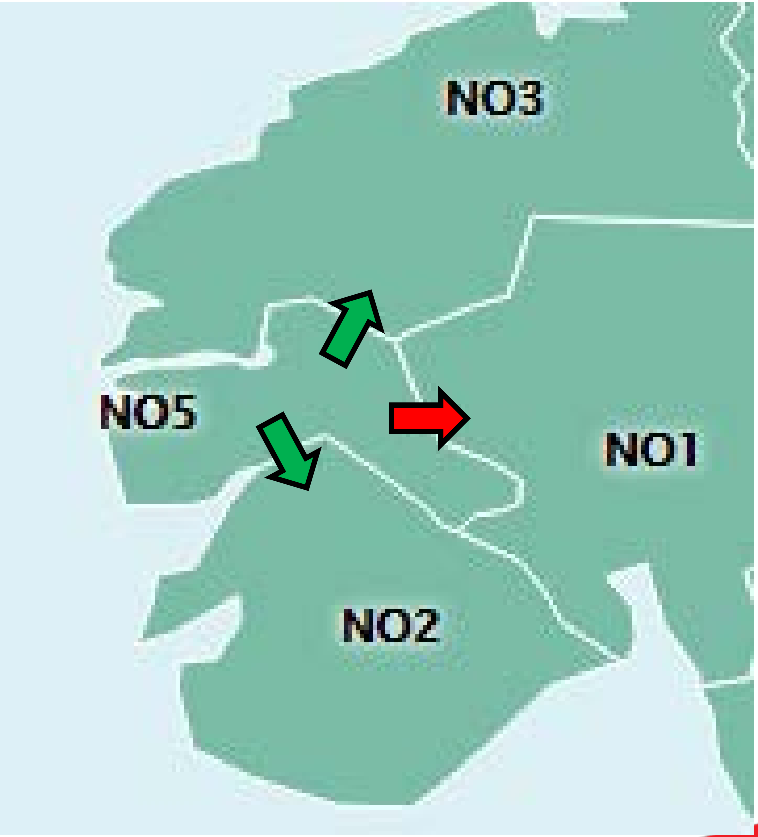
	Capacity	Physical flow
NO5-NO3	500	~500
NO5-NO1	3500	~3500
NO5-NO2	400	~400
Max surplus NO5	4400	4400



Balanced system!

Example capacity NO5

	Capacity	Physical flow
NO5-NO3	1500	700
NO5-NO1	3500	4500
NO5-NO2	800	600
Max surplus NO5	5800	5800



- 1000 MW overload NO5-NO1
- Need for downregulation in NO5

Example capacity NO5

Physical flow after 1400 MW downregulation NO5:

	Capacity	Physical flow
NO5-NO3	1500	500
NO5-NO1	3500	3500
NO5-NO2	800	400
Max surplus NO5	5800	4400

- Lack of 1400 MW in the rest of the system
- Phys. flows not according to planned flows in the whole Nordic region.
- Lack of 1000 MW in NO3!