On the Nordic Capacity Calculation Methodology and the Flow-Based capacity calculation

Pieter Schavemaker – Managing Director of E-Bridge Consulting BV,
PM of the Nordic CCM project

NordREG meeting on Cross Border Capacities, June 12 2019, Copenhagen

Agenda

1 Background

2 The status in Europe and the Nordics

3 Capacity calculation: FB and NTC

4 Nordic capacity calculation methodology: where are we now?

5 Example results

6 Questions

Agenda

1 Background

2 The status in Europe and the Nordics

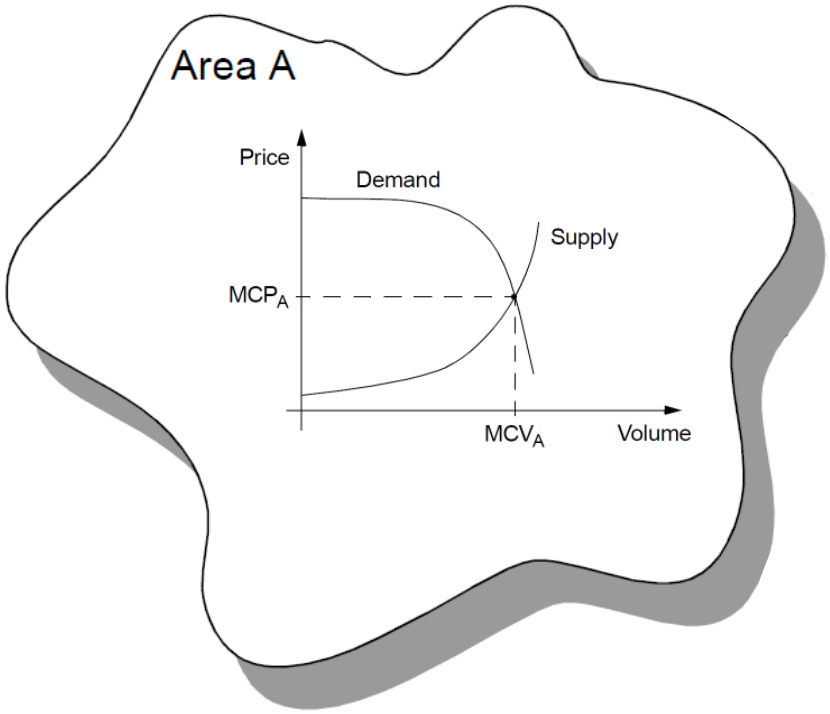
3 Capacity calculation: FB and NTC

4 Nordic capacity calculation methodology: where are we now?

5 Example results

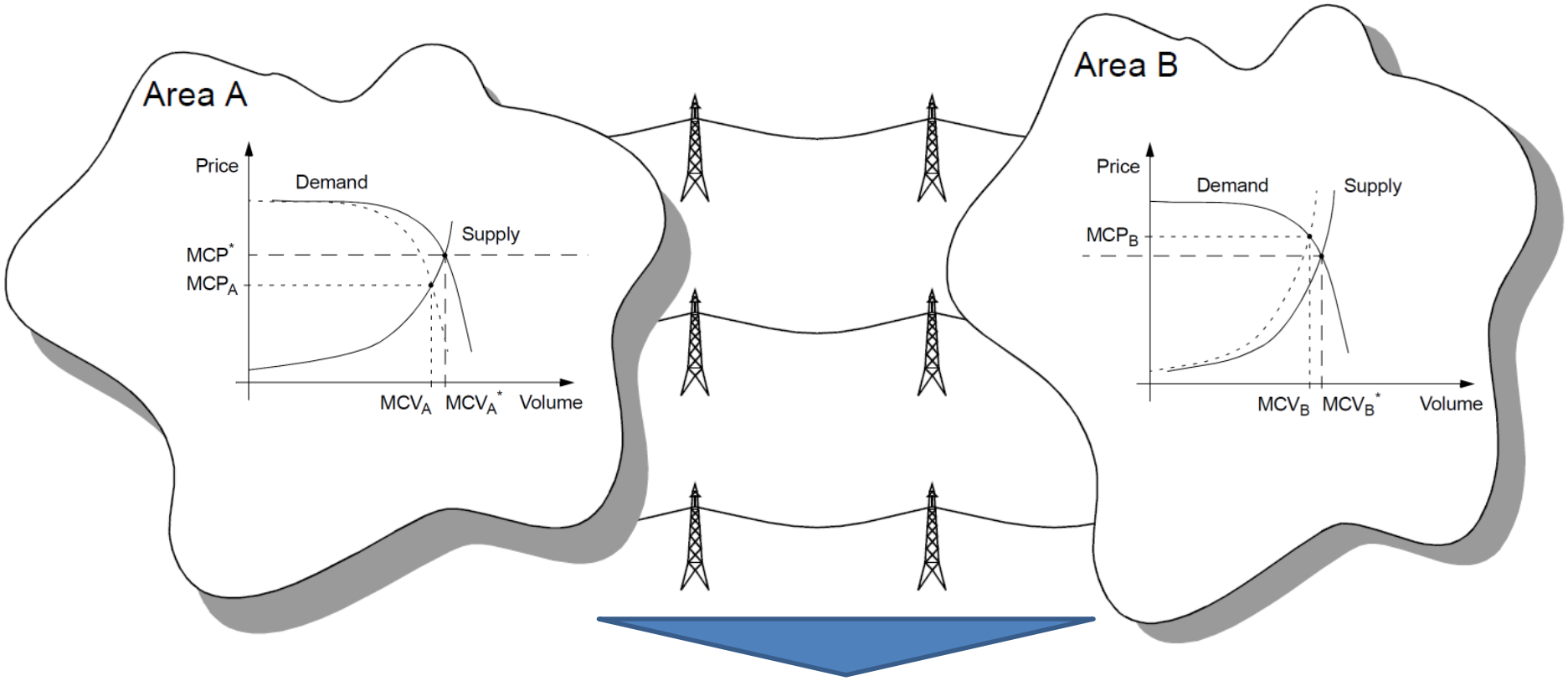
6 Questions

Market



Source: Electrical Power System Essentials (2nd edition), Pieter Schavemaker, Lou van der Sluis, Wiley, 2017.

Market coupling



Capacity calculation

Source: Electrical Power System Essentials (2nd edition), Pieter Schavemaker, Lou van der Sluis, Wiley, 2017.

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Capacity calculation
From complexity to simplicity

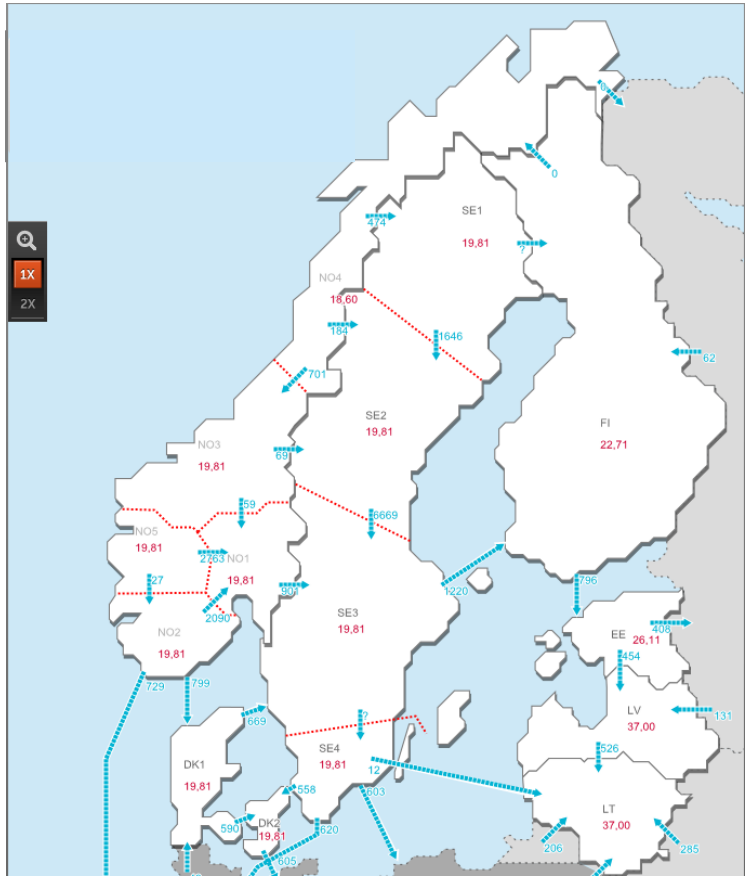
The physical world

Complexity → Simplicity

Detailed grid model → Flow Based (FB) → Net Transmission Capacity (NTC)

Capacity calculation is the process of translating the complex physical grid into a simplified form that can be understood and applied by the power exchange

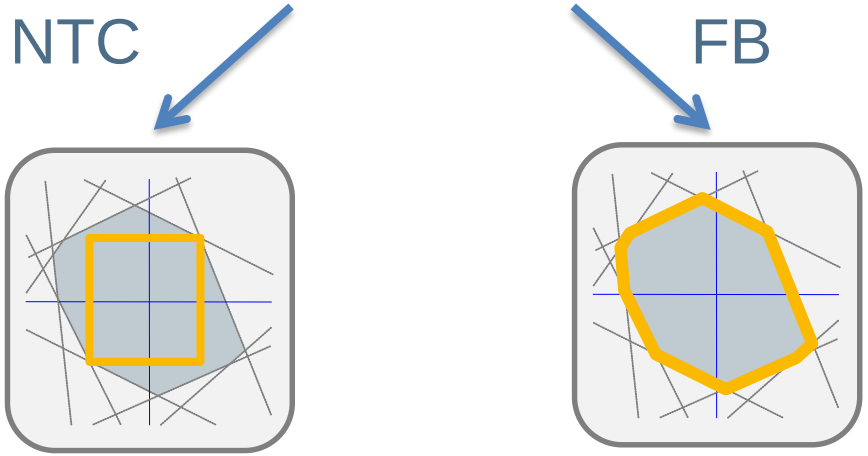
The commercial world

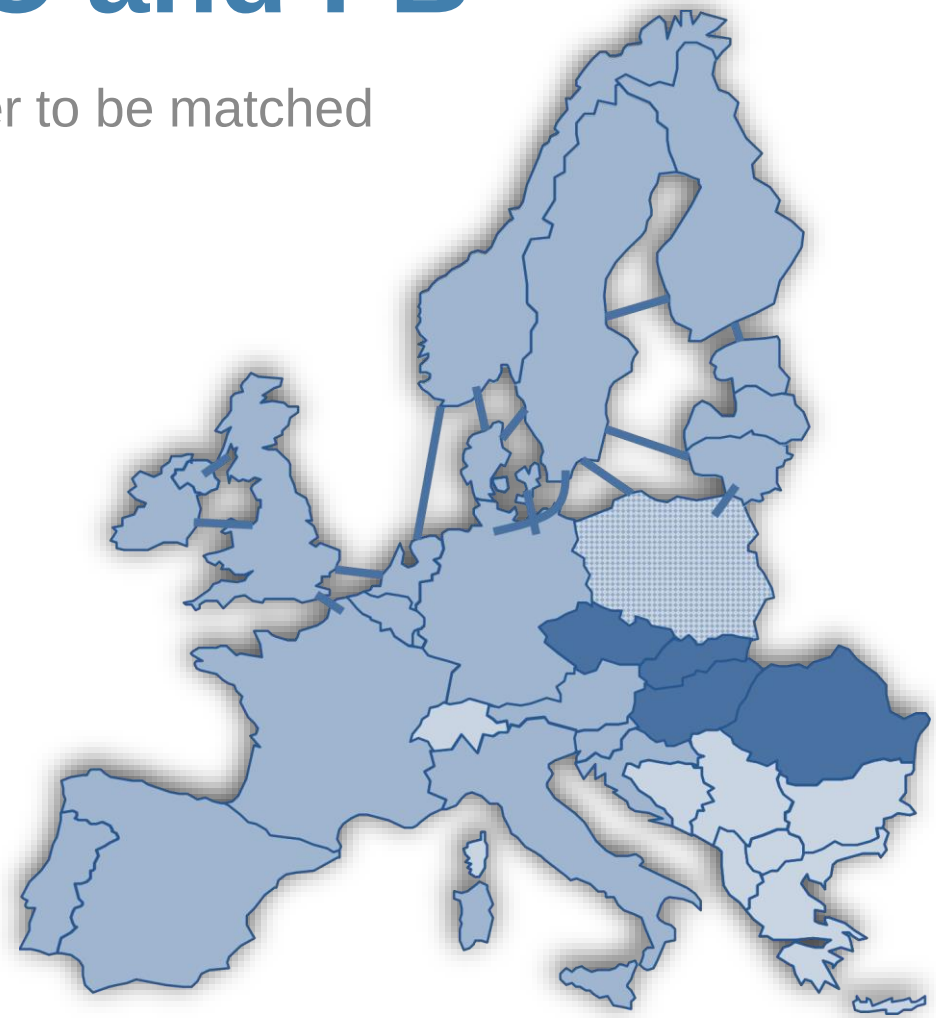


ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Market coupling: NTC and FB

- All the bids of the bidding areas are brought together in order to be matched by a centralized algorithm
- Objective function: Maximize social welfare
- Control variables: Net positions
- Subject to: ∑ net positions = 0
  Grid constraints





ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Agenda

1 Background

2 The status in Europe and the Nordics

3 Capacity calculation: FB and NTC

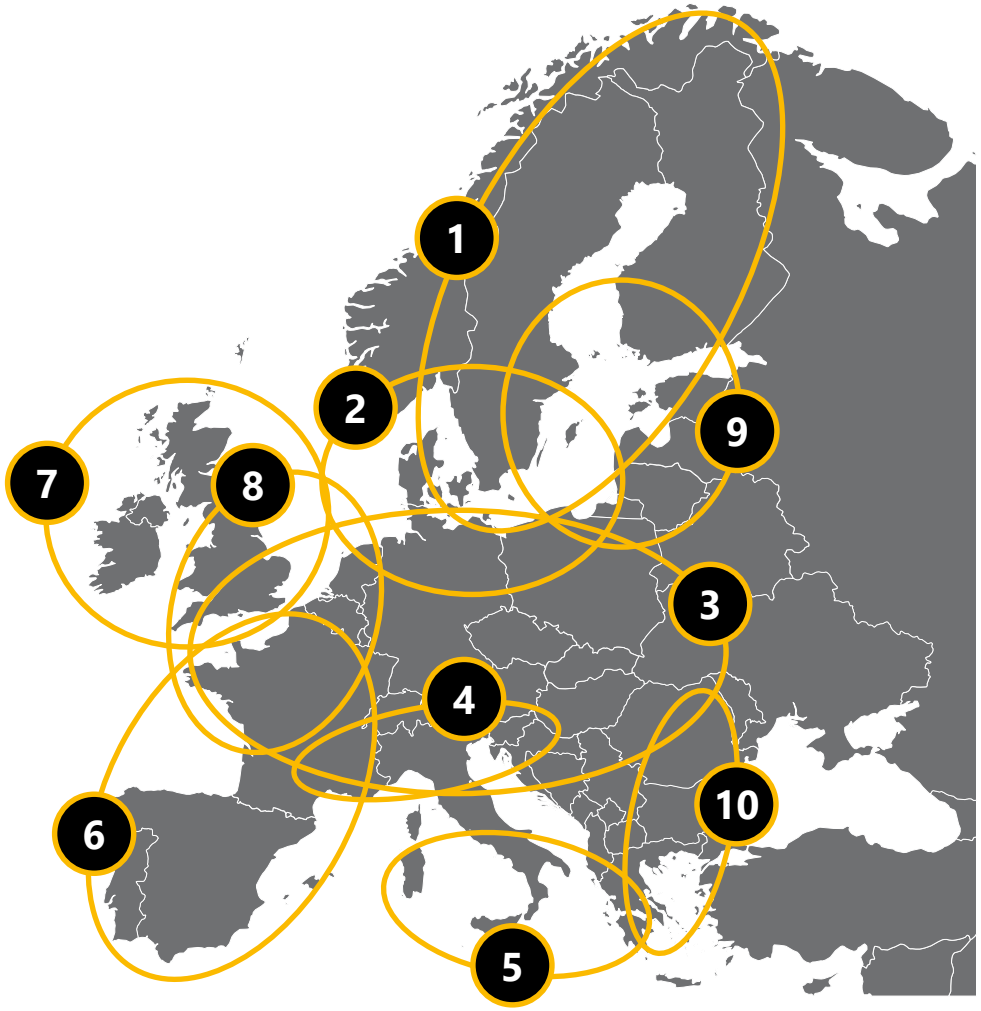
4 Nordic capacity calculation methodology: where are we now?

5 Example results

6 Questions

Capacity Calculation Regions

1. Nordic
2. Hansa
3. Core
4. Italy North
5. Greece-Italy (GRIT)
6. South-West Europe (SWE)
7. Ireland and United Kingdom (IU)
8. Channel
9. Baltic
10. South-East Europe (SEE)



ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Guideline on Capacity Allocation and Congestion Management (CACM GL)

L 197/24 EN Official Journal of the European Union 25.7.2015

COMMISSION REGULATION (EU) 2015/1222

of 24 July 2015

establishing a guideline on capacity allocation and congestion management

(Text with EEA relevance)

- Article 20.2:
  '*No later than 10 months after the approval of the proposal for a capacity calculation region in accordance with Article 15(1), all TSOs in each capacity calculation region shall submit a proposal for a common coordinated capacity calculation methodology within the respective region.'*

- The ACER decision on the TSO's proposal for the determination of Capacity Calculation Regions dates November 17, 2016

Source: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R1222&from=EN

Guideline on Capacity Allocation and Congestion Management (CACM GL)

L 197/24 EN Official Journal of the European Union 25.7.2015

COMMISSION REGULATION (EU) 2015/1222

of 24 July 2015

establishing a guideline on capacity allocation and congestion management

(Text with EEA relevance)

'There are two permissible approaches when calculating cross-zonal capacity: flow-based or based on coordinated net transmission capacity. The flow-based approach should be used as a primary approach for day-ahead and intraday capacity calculation where cross-zonal capacity between bidding zones is highly interdependent.'

…

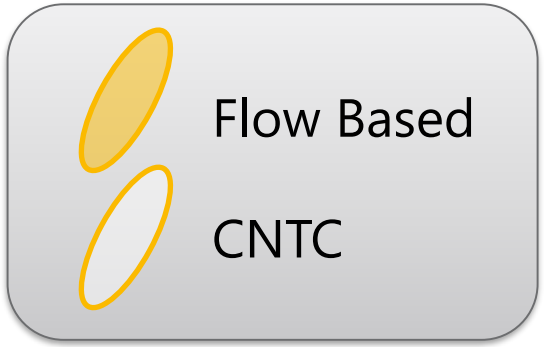
'The coordinated net transmission capacity approach should only be applied in regions where cross-zonal capacity is less interdependent and it can be shown that the flow-based approach would not bring added value.'

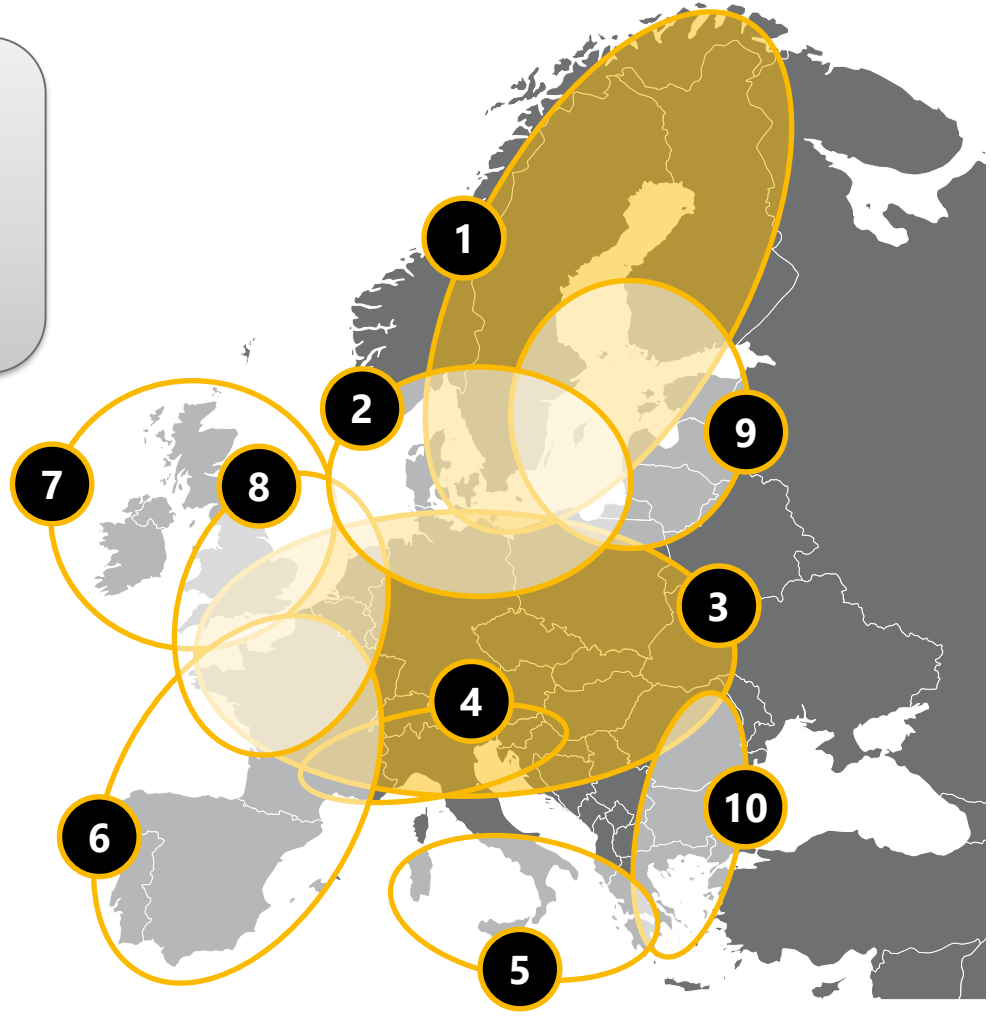
Source: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32015R1222&from=EN

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Capacity Calculation Regions

1. Nordic
2. Hansa
3. Core
4. Italy North
5. Greece-Italy (GRIT)
6. South-West Europe (SWE)
7. Ireland and United Kingdom (IU)
8. Channel
9. Baltic
10. South-East Europe (SEE)





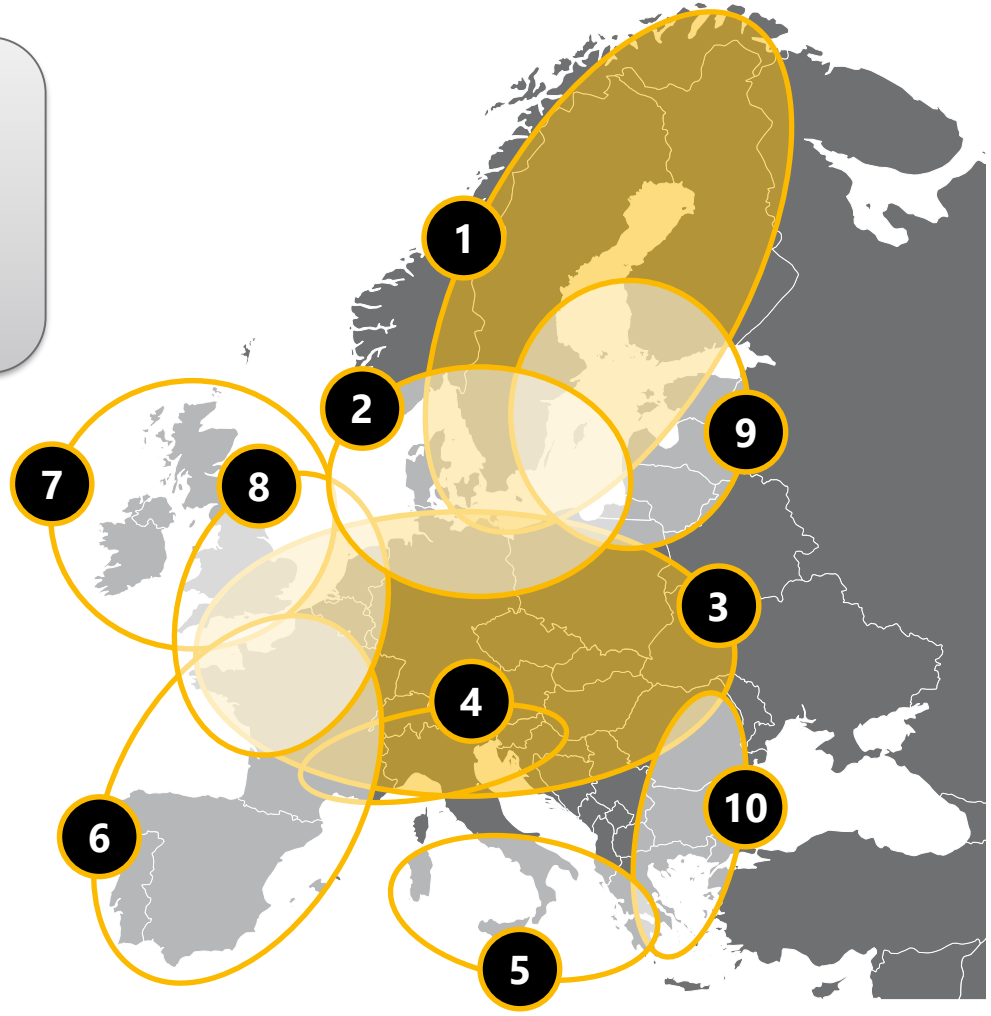
ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Capacity Calculation Regions

1. ✓ Nordic
2. ✓ Hansa
3. ✓ Core
4. Italy North
5. ✓ Greece-Italy (GRIT)
6. ✓ South-West Europe (SWE)
7. ✓ Ireland and United Kingdom (IU)
8. ✓ Channel
9. Baltic
10. South-East Europe (SEE)

Flow Based

CNTC



✓ : approved by NRAs ✓ : ACER decision

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Agenda

1 Background

2 The status in Europe and the Nordics

3 Capacity calculation: FB and NTC

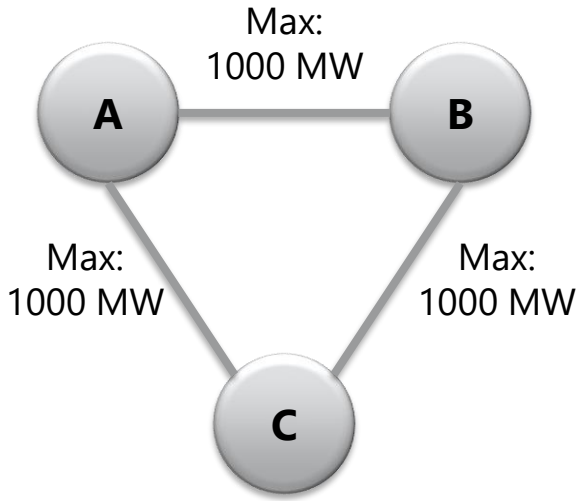
4 Nordic capacity calculation methodology: where are we now?

5 Example results

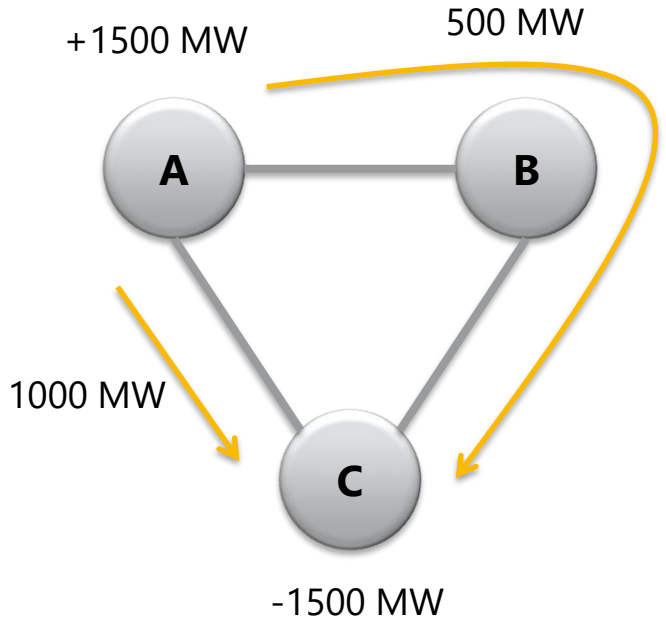
6 Questions

An example three-node network

- Let's consider a three-node network
  - Equal impedances
  - Max flow on the branches: 1000 MW



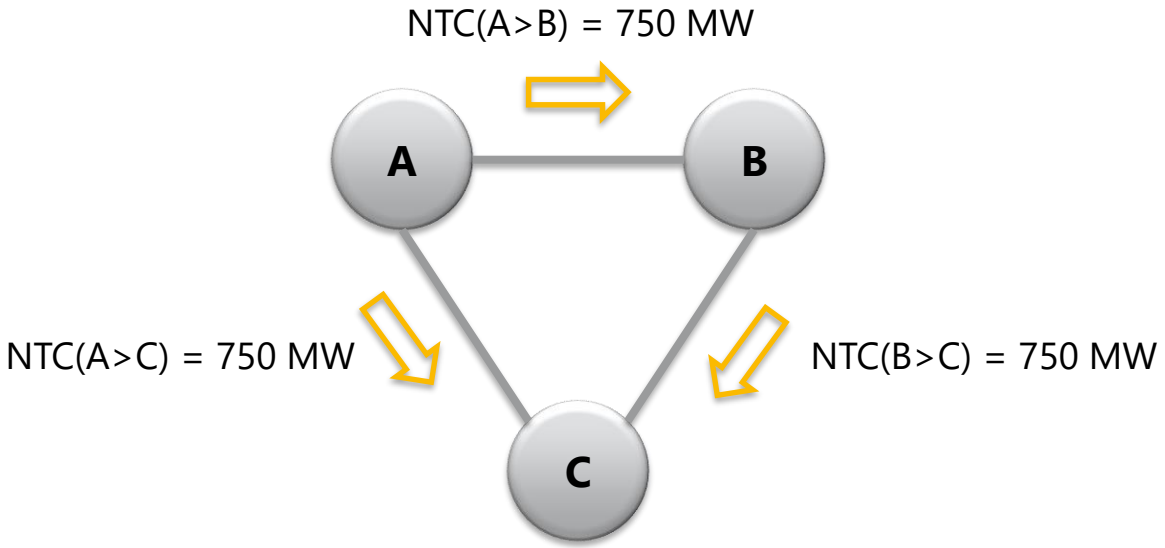
- The maximum export from A to another bidding area amounts 1500 MW:



An example three-node network: NTCs

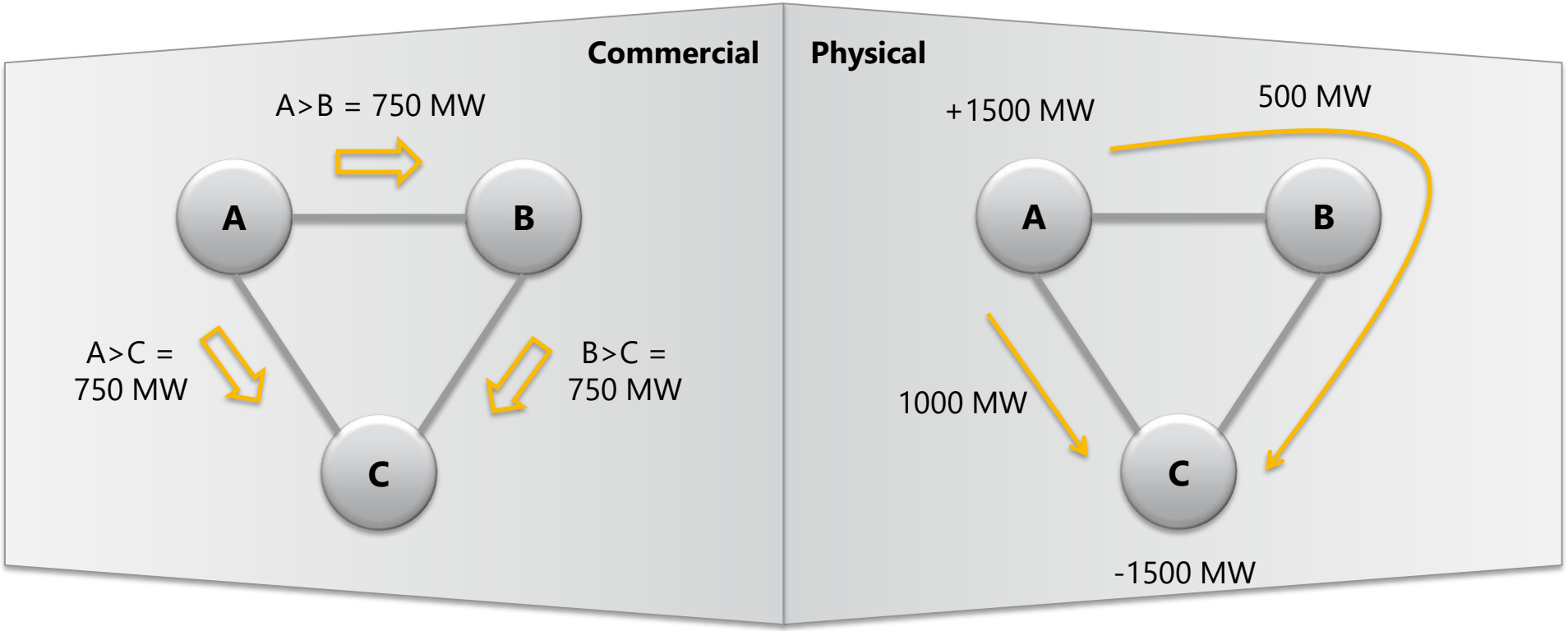
- NTCs are determined by the TSOs to facilitate the market while safeguarding the grid
  - A NTC limits a commercial exchange between two bidding areas
  - NTCs are simultaneously feasible

- Given the maximum export of bidding area A, the TSO needs to split the 1500 MW export capability into two bilateral exchanges, for example:
  - NTC(A>B) = 750 MW
  - NTC(A>C) = 750 MW
- There are in principle an infinite number of NTC solutions; it is a choice which one to select



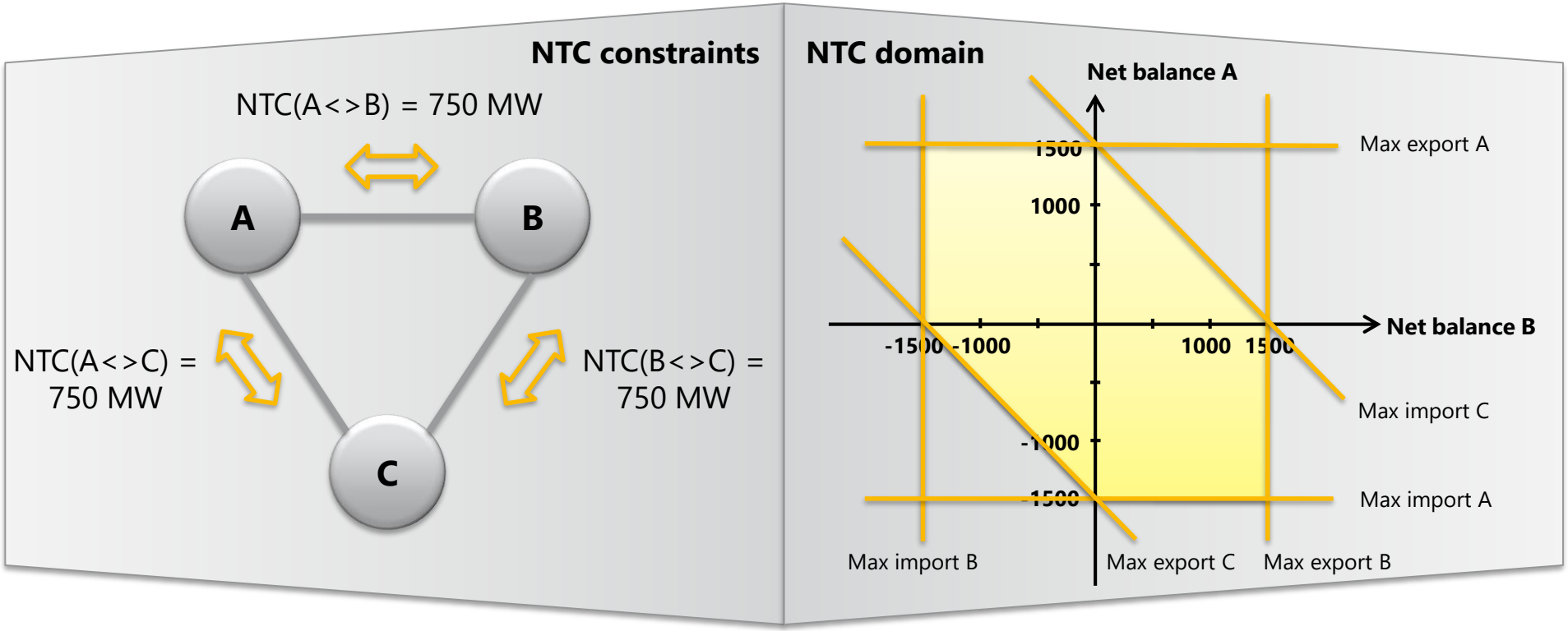
An example three-node network: NTCs and physical flows

- The following commercial exchanges are feasible given the NTCs:
  - A>C = 750 MW
  - A>B = 750 MW
  - B>C = 750 MW



An example three-node network: NTC domain

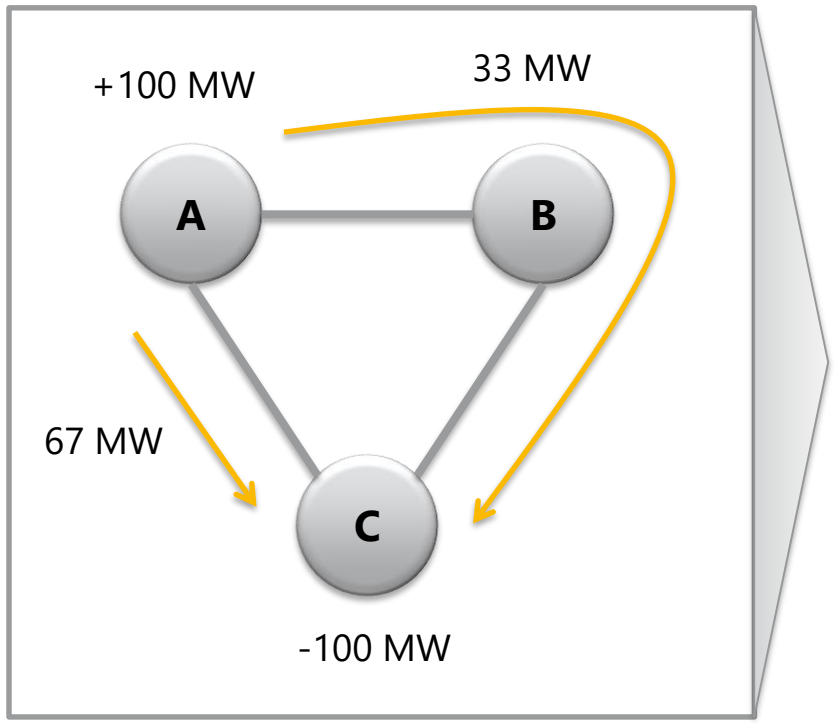
- The NTCs in the three-node system define the NTC domain:
  the import/export positions that the market is allowed to reach under the market coupling while not jeopardizing the grid security



ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

An example three-node network: FB constraints

- FB constraints are a kind of simplified grid model, reflecting the impact of import/export positions on the flows on the grid

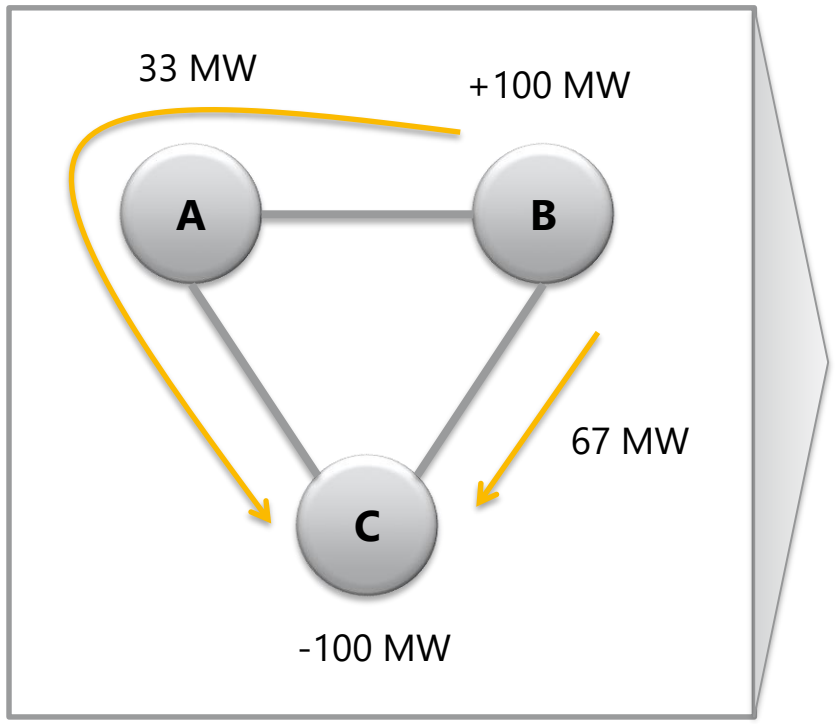


FB constraints ('grid model'):

	Margins	PTDF factors		
Line	**Maximum flow**	**Influence from area A**	**Influence from area B**	**Influence from area C**
A>B	1000 MW	33 %		
B>C	1000 MW	33 %		
A>C	1000 MW	67 %		

An example three-node network: FB constraints

- FB constraints are a kind of simplified grid model, reflecting the impact of import/export positions on the flows on the grid



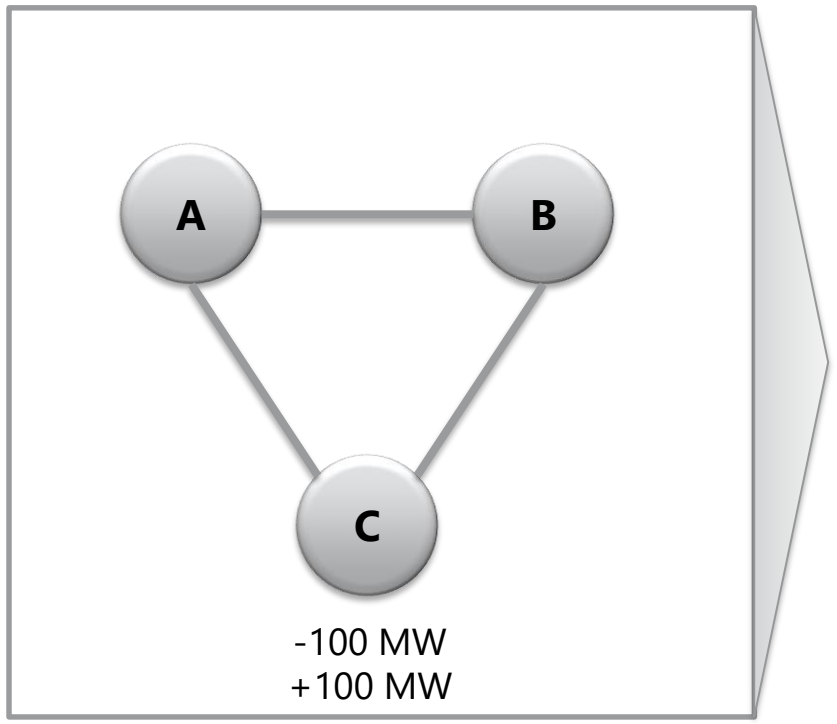
FB constraints ('grid model'):

	Margins	PTDF factors		
Line	**Maximum flow**	**Influence from area A**	**Influence from area B**	**Influence from area C**
A>B	1000 MW	33 %	- 33 %	
B>C	1000 MW	33 %	67 %	
A>C	1000 MW	67 %	33 %	

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

An example three-node network: FB constraints

- FB constraints are a kind of simplified grid model, reflecting the impact of import/export positions on the flows on the grid

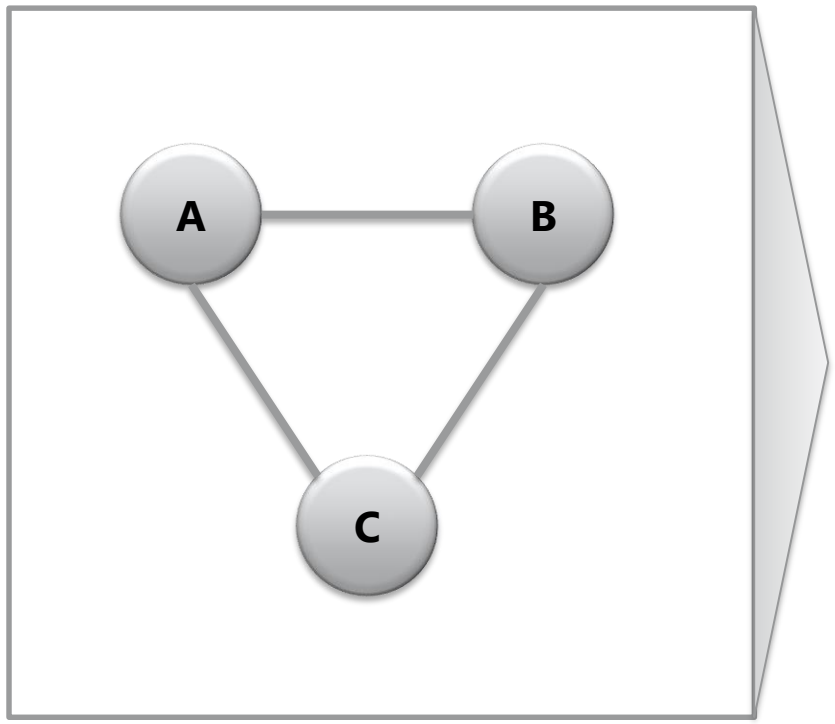


FB constraints ('grid model'):

	Margins	PTDF factors		
Line	**Maximum flow**	**Influence from area A**	**Influence from area B**	**Influence from area C**
A>B	1000 MW	33 %	- 33 %	0
B>C	1000 MW	33 %	67 %	0
A>C	1000 MW	67 %	33 %	0

An example three-node network: FB constraints

- FB constraints are a kind of simplified grid model, reflecting the impact of import/export positions on the flows on the grid



FB constraints ('grid model'):

	Margins	PTDF factors		
Line	**Maximum flow**	**Influence from area A**	**Influence from area B**	**Influence from area C**
A>B	1000 MW	33 %	- 33 %	0
B>C	1000 MW	33 %	67 %	0
A>C	1000 MW	67 %	33 %	0
B>A	1000 MW	-33 %	33 %	0
C>B	1000 MW	- 33 %	- 67 %	0
C>A	1000 MW	- 67 %	- 33 %	0

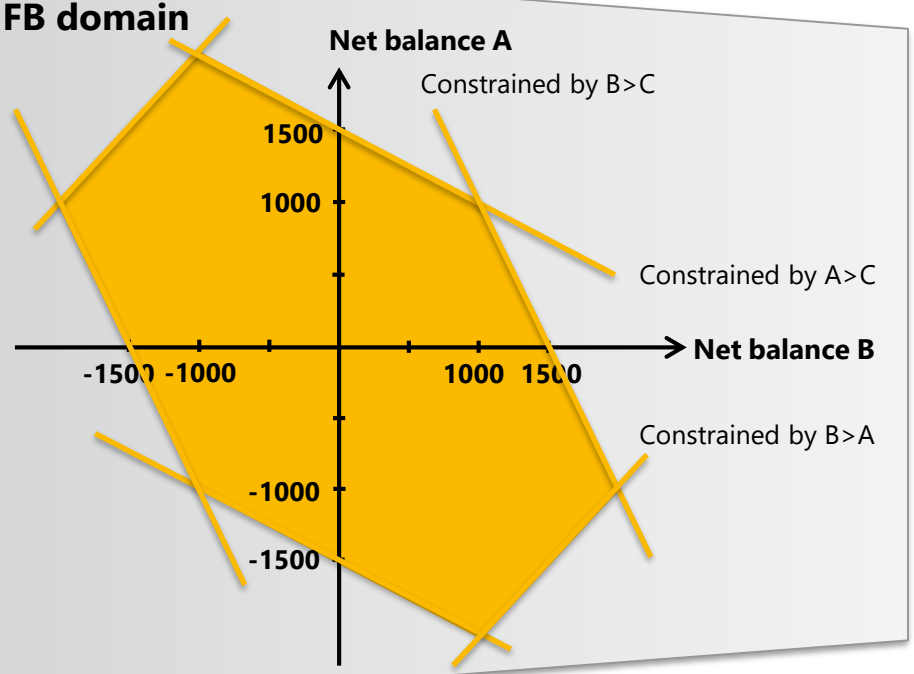
An example three-node network: FB domain

- The FB constraints in the three-node system define the FB domain:
  the import/export positions that the market is allowed to reach under the market coupling while not jeopardizing the grid security

FB constraints

Line	Maximum flow	Influence from area A	Influence from area B	Influence from area C
A>B	1000 MW	33 %	- 33 %	0
B>C	1000 MW	33 %	67 %	0
A>C	1000 MW	67 %	33 %	0
B>A	1000 MW	- 33 %	33 %	0
C>B	1000 MW	- 33 %	- 67 %	0
C>A	1000 MW	- 67 %	- 33 %	0

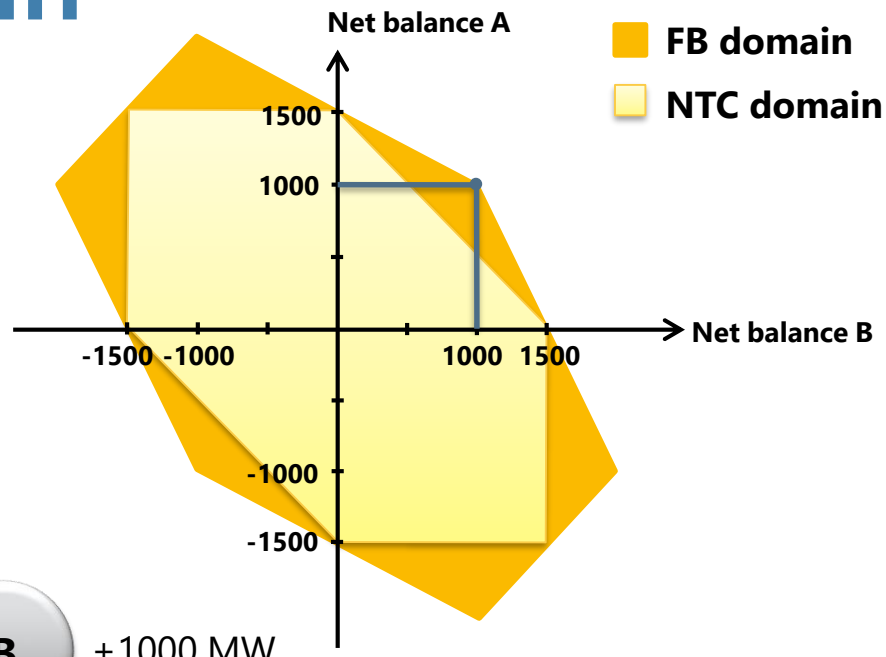
FB domain

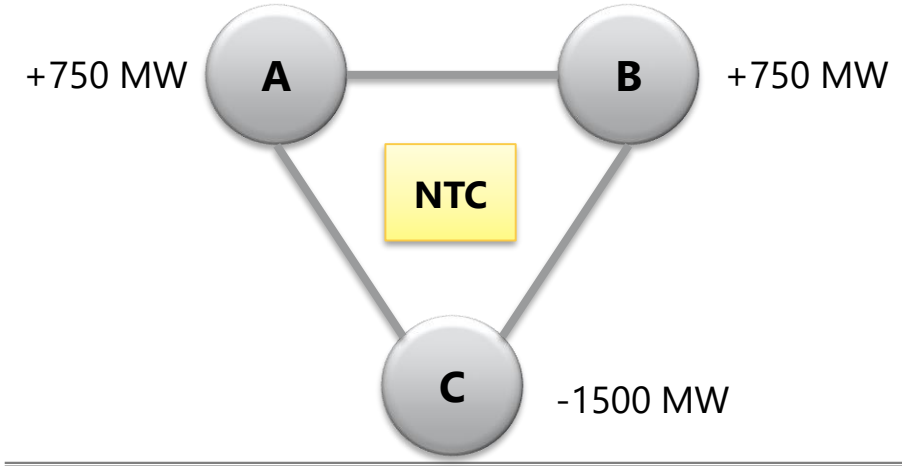


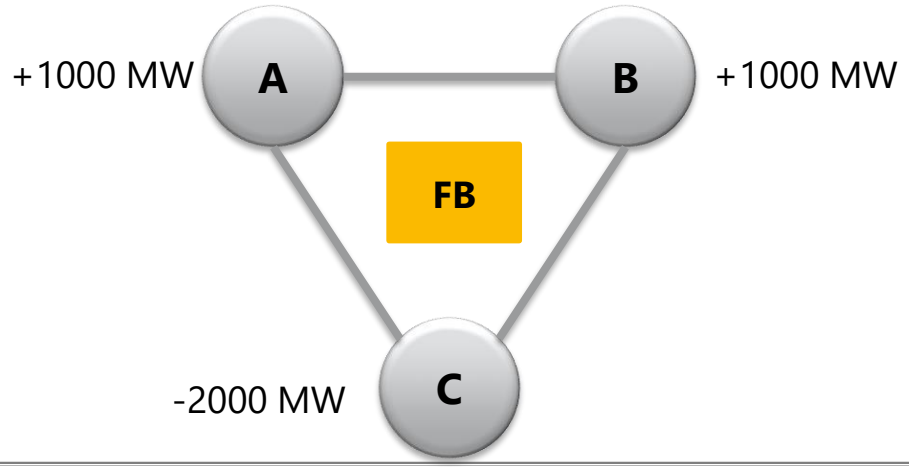
ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

An example three-node network: NTC vs FB domain

- In FB capacity split is not a choice of the TSO, but is market driven (at the time of allocation)
- In principle, FB offers more trading opportunities with the same level of security of supply
- Example:
  - NTC: North-South exchange limited to 1500 MW
  - FB: North-South exchange possible of 2000 MW







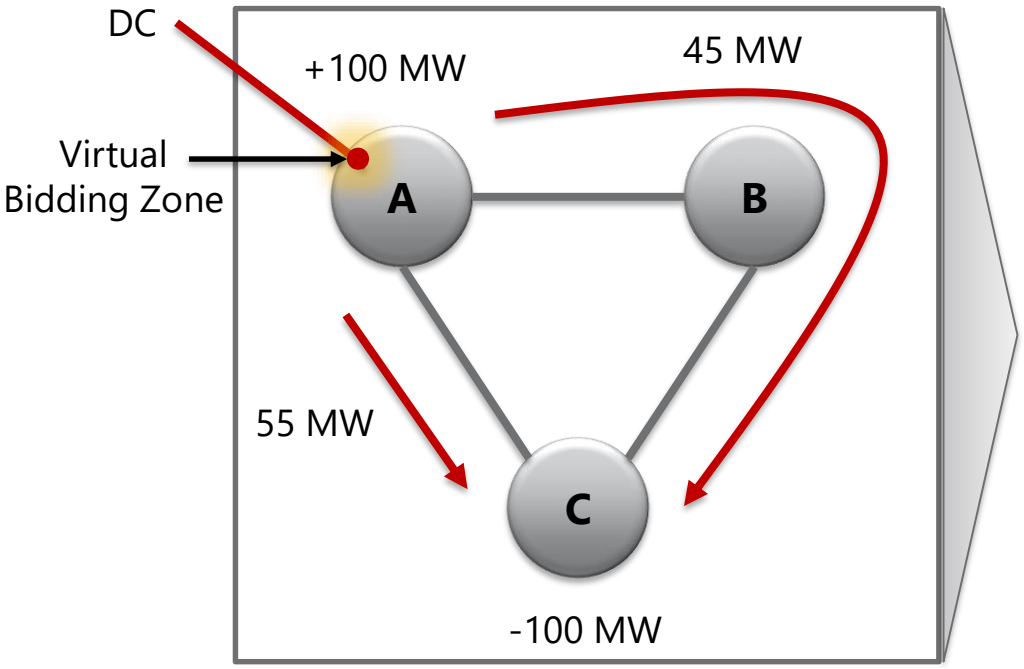
ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Advantages of the FB approach

- In FB capacity split is not a choice of the TSO, but is market driven (at the time of allocation)
  - More efficient and flexible use of the grid
- FB offers more trading opportunities with the same level of security of supply
  - More price convergence / smaller price differences
  - Higher social welfare
  - Income redistribution: Less congestion income and more producer and consumer surplus
- FB offers the possibility to have the DC cables efficiently embedded in the allocation mechanism, by providing a fair competition for the use of the scarce AC capacity
- Flow-based market coupling provides an efficient allocation mechanism in which all exchanges that are subject to the allocation mechanism compete with one another for the use of the scarce capacity

An example three-node network: DC links - Advanced Hybrid Coupling

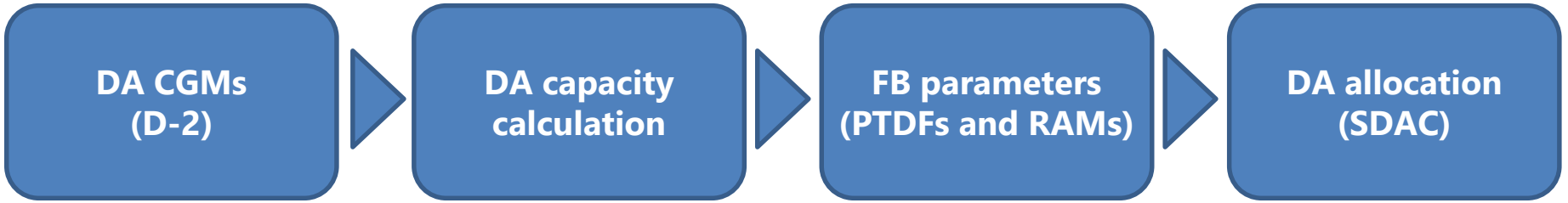
- Advanced Hybrid Coupling is applied on all DC links and AC connections to other CCRs
  - In this way, they compete for the scarce capacity in the AC grid like any other commercial exchange
  - This introduces virtual bidding zones at the converter stations of the DC links in the Nordic area



	Margins	PTDF factors			
Line	**Maximum flow**	**Influence from area A**	**Influence from area B**	**Influence from area C**	**Influence from virtual BZ**
A>B	1000 MW	33 %	…	…	45%
B>C	1000 MW	33 %	…	…	45%
A>C	1000 MW	67 %	…	…	55%
B>A	1000 MW	…	…	…	…
C>B	1000 MW	…	…	…	…
C>A	1000 MW	…	…	…	…

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Nordic DA CCM in a nutshell



Nordic DA CCM in a nutshell

- Advanced Hybrid Coupling is applied on all DC links and AC connections to other CCRs
- Number of Bidding Zones: 27
  - Nordic bidding zones: 12
  - Virtual bidding zones: 15
- Two synchronous areas
  - DK1 is part of the continental European synchronous system

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Nordic DA CCM in a nutshell

- CNEs:
  - Tielines, internal network elements, PTCs
- PTCs (Power Transfer Corridors)
  - multiple lines, modelled as a single CNE, with its own RAM and PTDFs
  - Voltage and dynamic constraints
- Number of presolved FB constraints
  - Around 85
- In order to maximize socio-economic welfare, the FB market coupling could result in “non-intuitive” flows on some borders: flows from a high-price to a low-price area

Nordic DA CCM in a nutshell
Internal CNEs and Remedial Actions (RAs)

- Short term: take RA into account in the capacity calculation
- Mid term: bidding zone configuration
- Long term: efficient investment

- Approach: Internal CNEs will (always) be taken into account in capacity allocation, but potentially increasing the available capacity for the market (RAM)
- Available capacity for the market (RAM) will be increased if:
  - Remedial action (RA) resources can be expected to be available and
  - It is economically more efficient to take these RAs into account in CC compared to the alternative; submitting the internal CNEs for capacity allocation based on the "true" RAM

Agenda

1 Background

2 The status in Europe and the Nordics

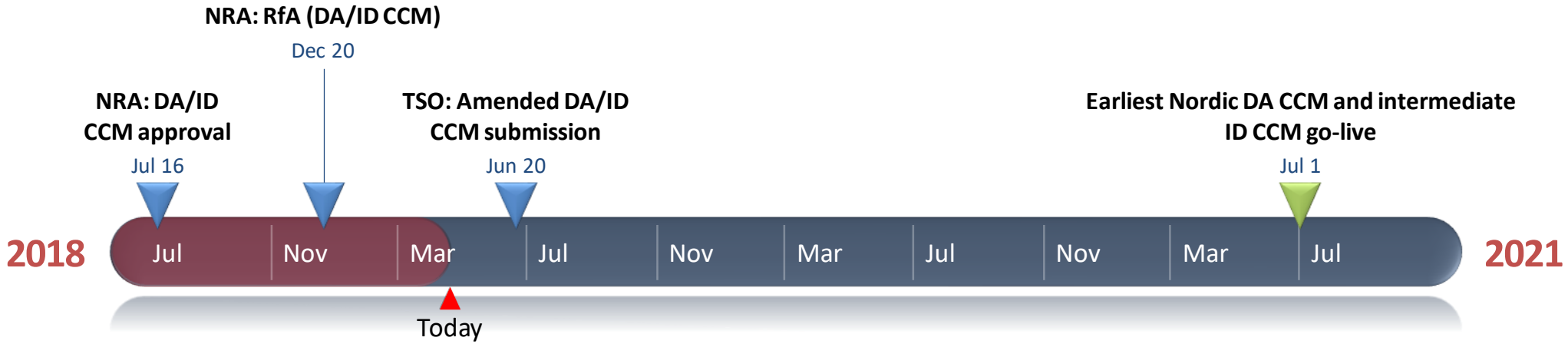
3 Capacity calculation: FB and NTC

4 Nordic capacity calculation methodology: where are we now?

5 Example results

6 Questions

Nordic DA/ID CCM Request for Amendment



- Nordic NRAs approved the Nordic DA/ID CCM in July 2018
- The NRAs of the Nordic CCR issued an RfA in December 2018
  - The amendment applies for Energinet, Fingrid, and Svenska kraftnät
- The TSOs of the Nordic CCR amended the DA/ID CCM; a public consultation has just closed

Nordic DA/ID CCM
Request for Amendment

- "The proposal does not provide sufficient clarity on the roles in capacity calculation, especially regarding dynamic stability calculation"

Therefore:

- "The TSOs should start preparing to refine the now agreed methodology with processes and elements to enable for the CCC to handle dynamic stability in capacity calculation"
- "The CCC shall calculate the capacities using the technical limitations of the system needed to ensure secure system operation i.e. operational security limits".
- "The appropriate format for the operational security limits shall not include any precalculation by the individual TSO where the operational security limits are transposed to flow limits presented with MW values"

CCM project and Nordic RSC

CCM project

-

CCM methodology development

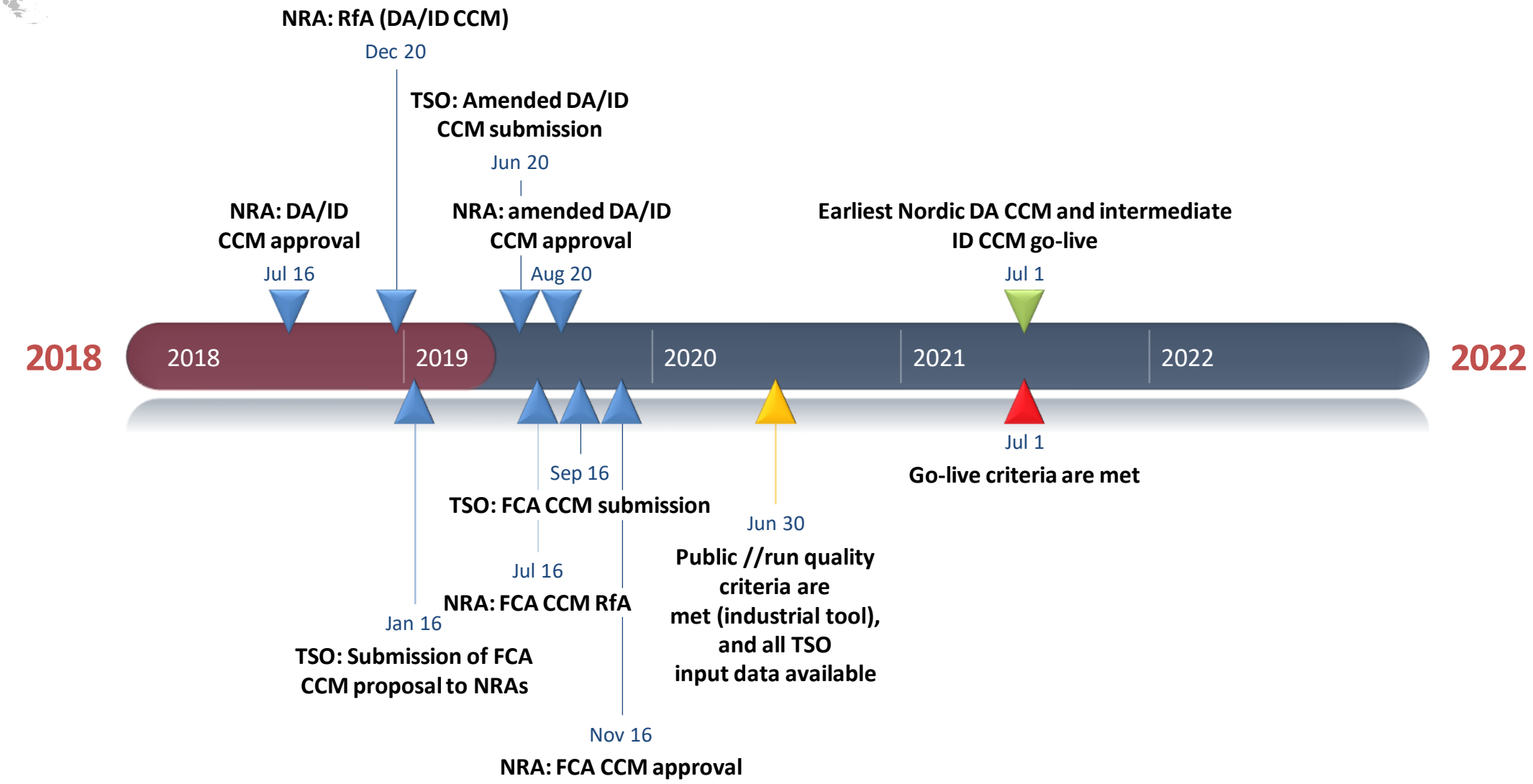
NORDIC RSC

CCM implementation

(amongst others)

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Indicative timeline



ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Agenda

1 Background

2 The status in Europe and the Nordics

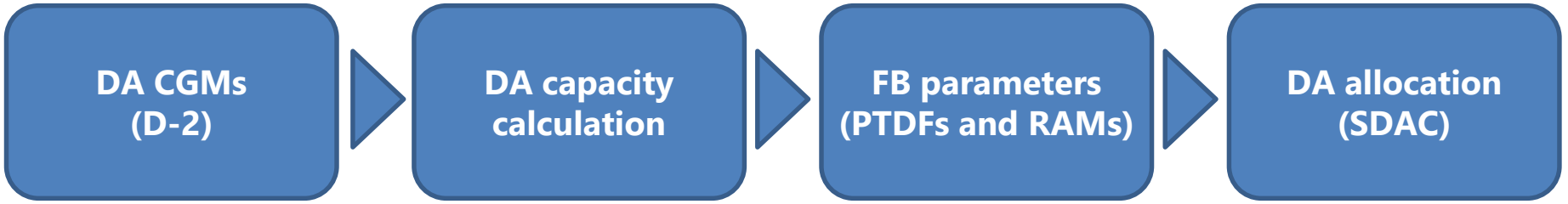
3 Capacity calculation: FB and NTC

4 Nordic capacity calculation methodology: where are we now?

5 Example results

6 Questions

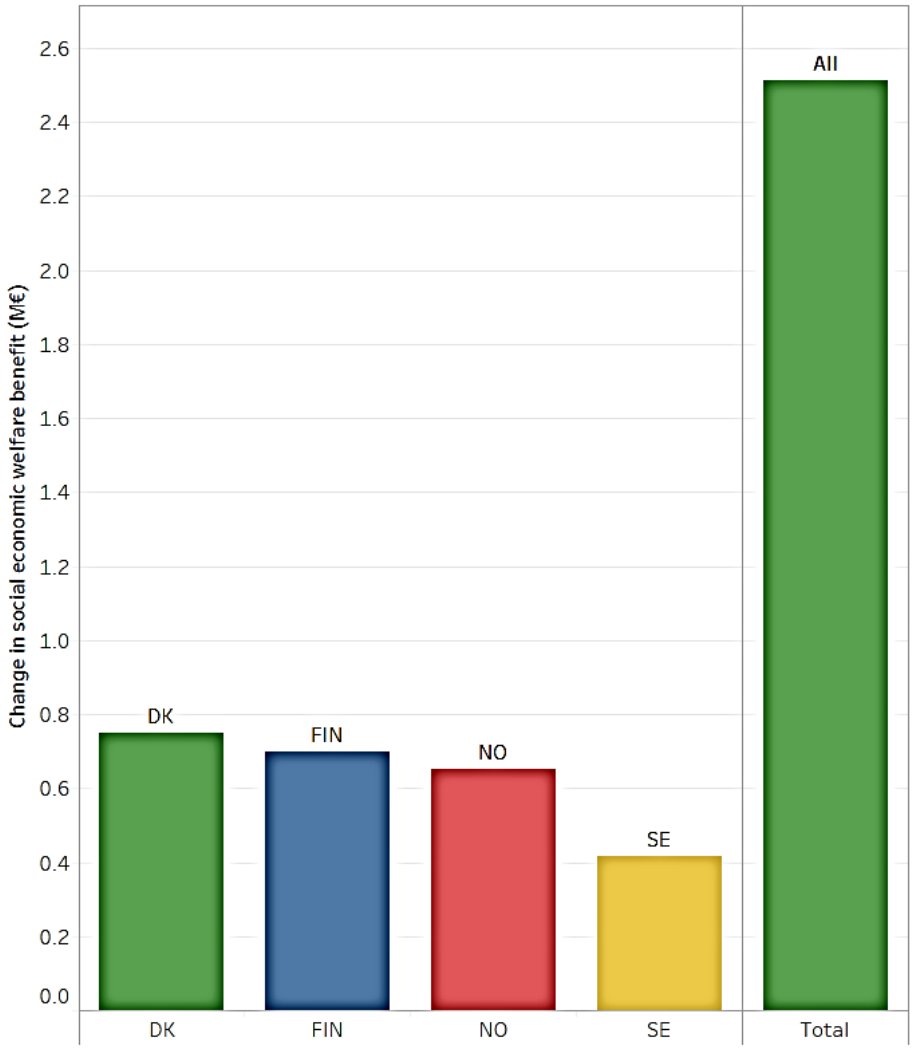
FB simulations: setup



- FB simulations are being performed by the project, based on
  - Prototype CGMs
  - Prototype tooling to perform the DA FB capacity calculation
  - The so-called NEMO's Simulation Facility to simulate the SDAC using the FB constraints and actual historical order books
- With the implementation ongoing at the Nordic RSC, gradually, elements in this process will be replaced by more robust data and IT modules

FB simulations: socioeconomic welfare gains

- The following results are for weeks 1-6 and 8-12, 2017 and compare the market outcomes with FB and with historical NTCs.
- The graphs show the difference between the day-ahead socioeconomic welfare (SEW) with FB and with historical NTCs
- Day-ahead SEW = producer surplus + consumer surplus + congestion income
- Structural congestions such as West Coast corridor and export limitations in Norway dealt with in a more efficient way with flowbased:
  - No need to limit capacities ex ante.
  - Instead: full capacities + critical network elements given to the market => capacity allocated in the market in a more efficient way.



ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Week 1: 4 January, 03.00: A windy night
Example of the West-Coast Corridor

FB

NTC

- A lot of wind to be exported from DK/GE to the Nordics
- With NTC, ex-ante limitations on DK1->SE3 and DK2->SE4 due to West Coast corridor
- With FB, capacity allocation in the market considers directly the West Coast corridor without need for limitations.
- Note that the limitations GE->SE4 are due to limitations on the German side.

ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Agenda

1 Background

2 The status in Europe and the Nordics

3 Capacity calculation: FB and NTC

4 Nordic capacity calculation methodology: where are we now?

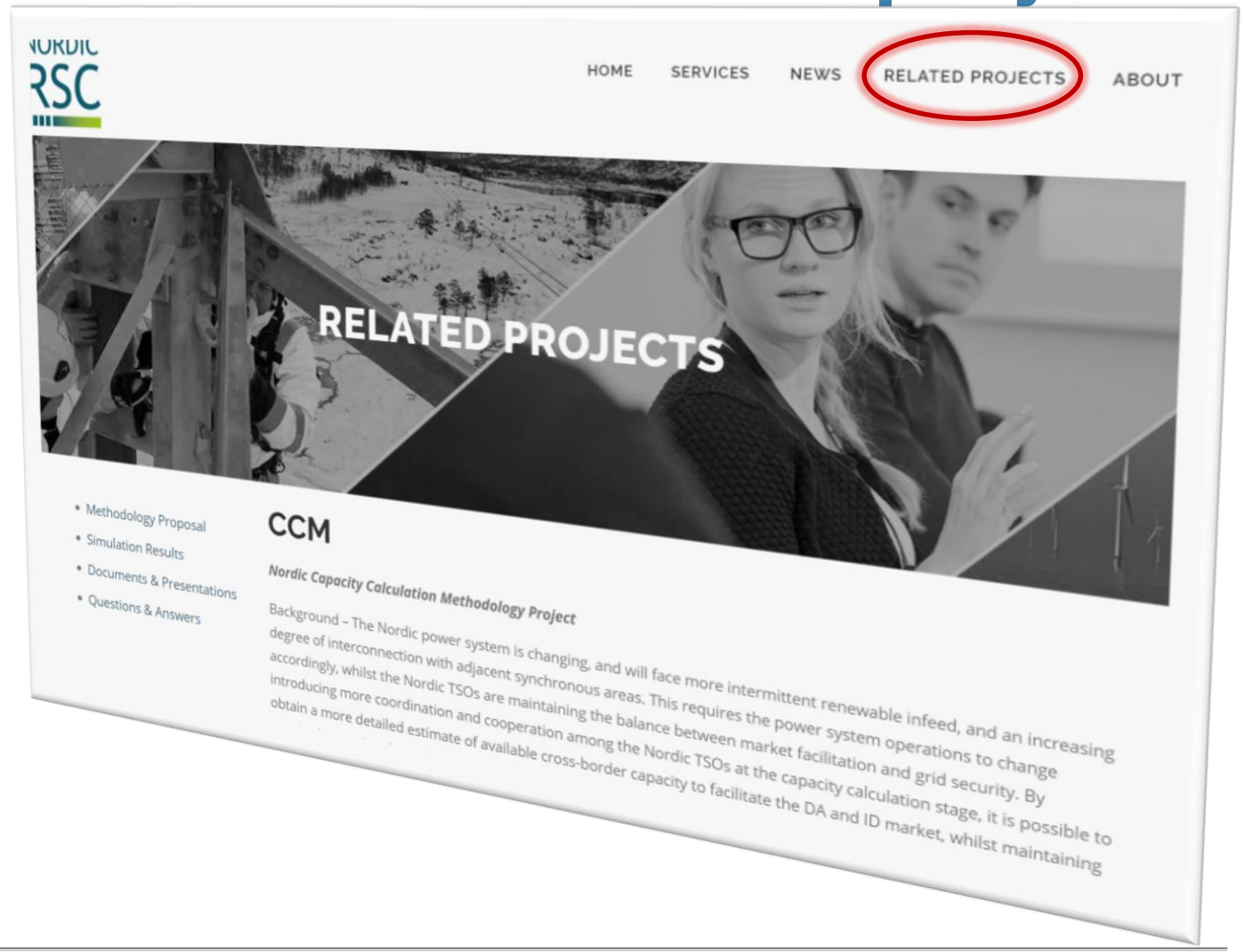
5 Example results

6 Questions

More information on the Nordic CCM project?

- Please refer to the website of the Nordic RSC
- https://nordic-rsc.net/related-projects/

- Or contact us by email: ccm@nordic-rsc.net



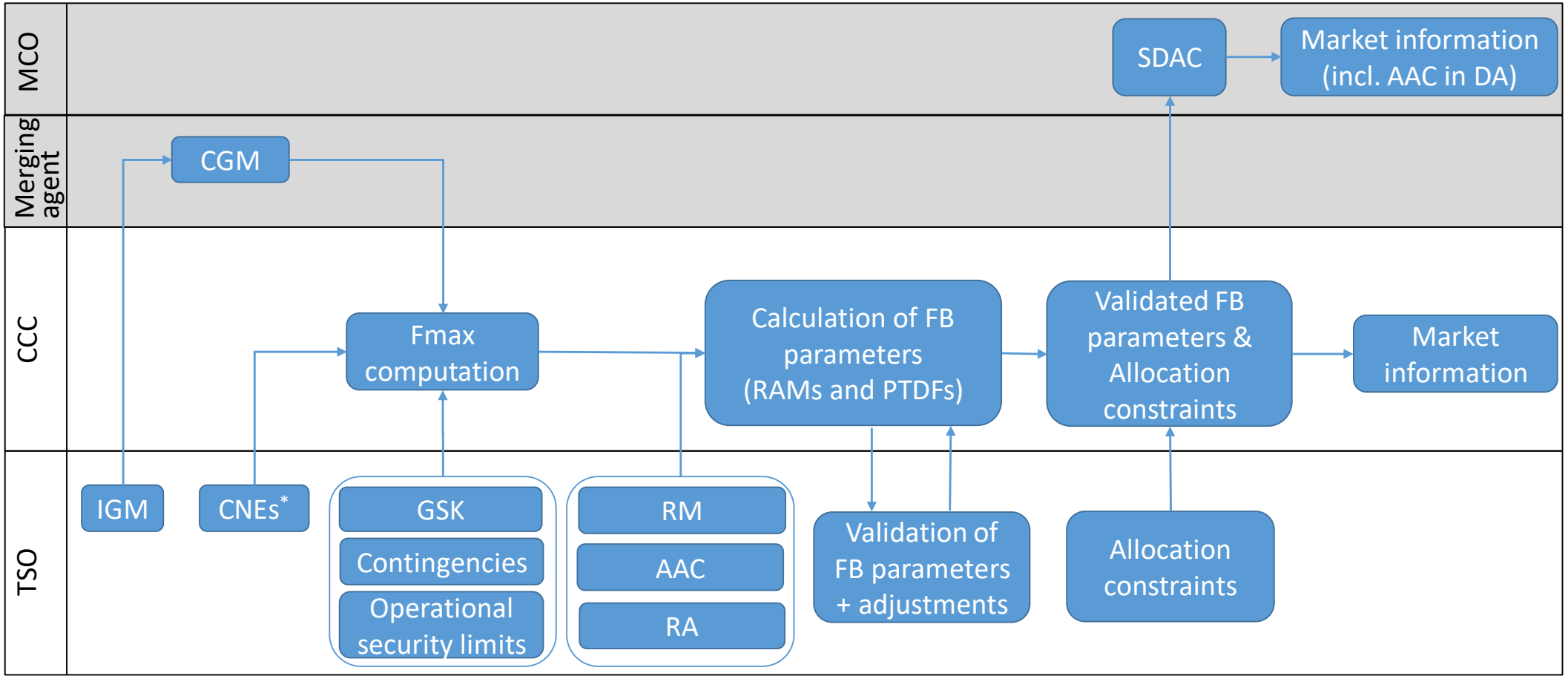
ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett

Questions?

Backup slides

Implementation of new CCM in the Nordics

CCC - coordinated capacity calculator
MCO - Market Coupling Operator



ENERGINET SVENSKA KRAFTNÄT FINGRID Statnett