The Nordic Capacity Calculation Methodology (CCM) project

MESC

Brussels, 8 June 2018

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Agenda

1. **Overview of the Nordic CCM project**
2. Mathematical description
3. Operational security limits, contingencies and remedial actions
4. Shift keys
5. Reliability margin
6. Internal and cross zonal exchanges

Proposal

- Day-ahead: Flowbased
- Intraday: Stepwise implementation
  - ✓ Interim solution: CNTC
    - Go-live together with DA FB go-live
  - ✓ Long term target: flow based
    - XBID able to handle FB parameters
    - FB tested and proven to be efficient in DA in ID

A brief history of the Nordic CCM project

18 Sept.
CCM proposal

2010/2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017

Internal TSO phase

External communication → Stakeholder Forums → Stakeholder Group →News letters →Info platform

SN Flow Based Project

Assess the FB concept
Assess literature & practice
Develop ideas

Nordic Flow Based Project

Nordic CCM Project

Prefeasibility study

Project development
Model studies
Market assessments
Work shops

Feasibility study

Methodology and technical requirements for a Nordic FB
Prototype development
FB capacity calculation and market simulation experiments
Stakeholder communication

Pre-implementation phase

Capacity calculation and market simulations
Welfare analyses
Infrastructure development (IT platforms)
Stakeholder processes
CCM proposal process
CNTC development
DA → DA and ID

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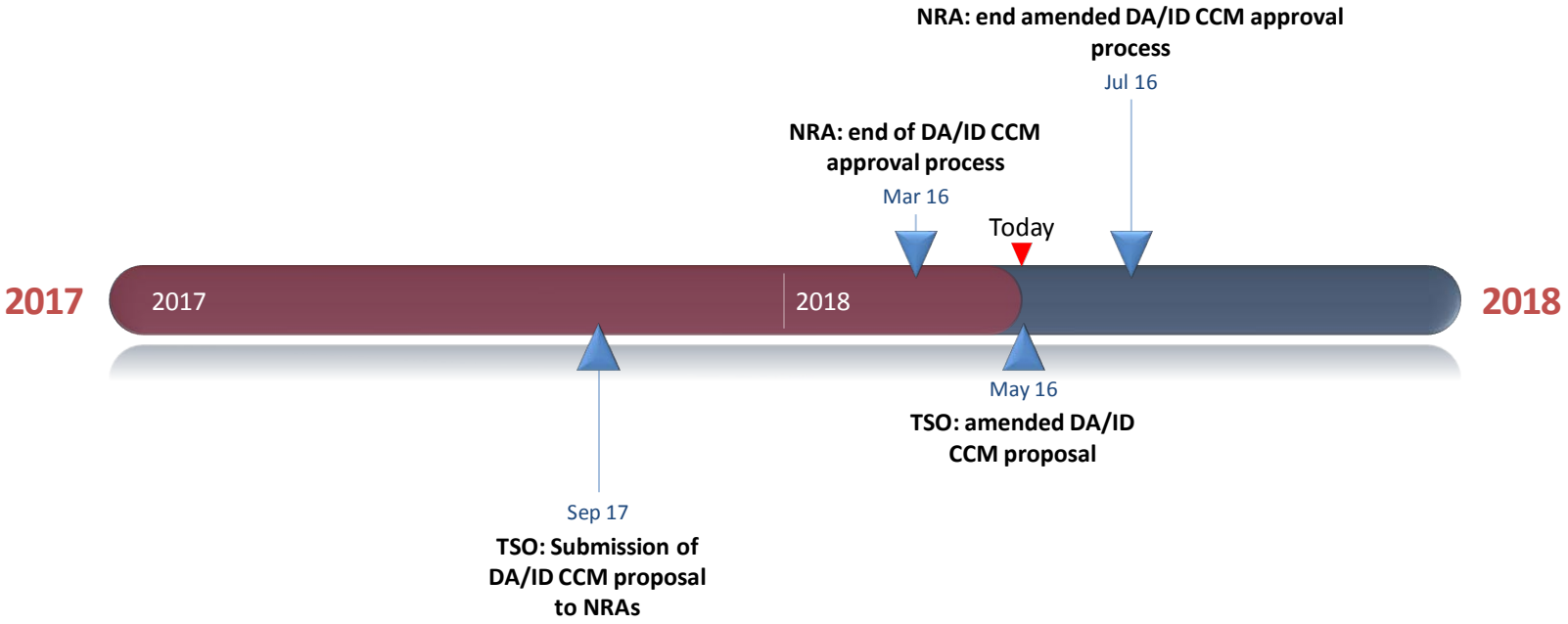
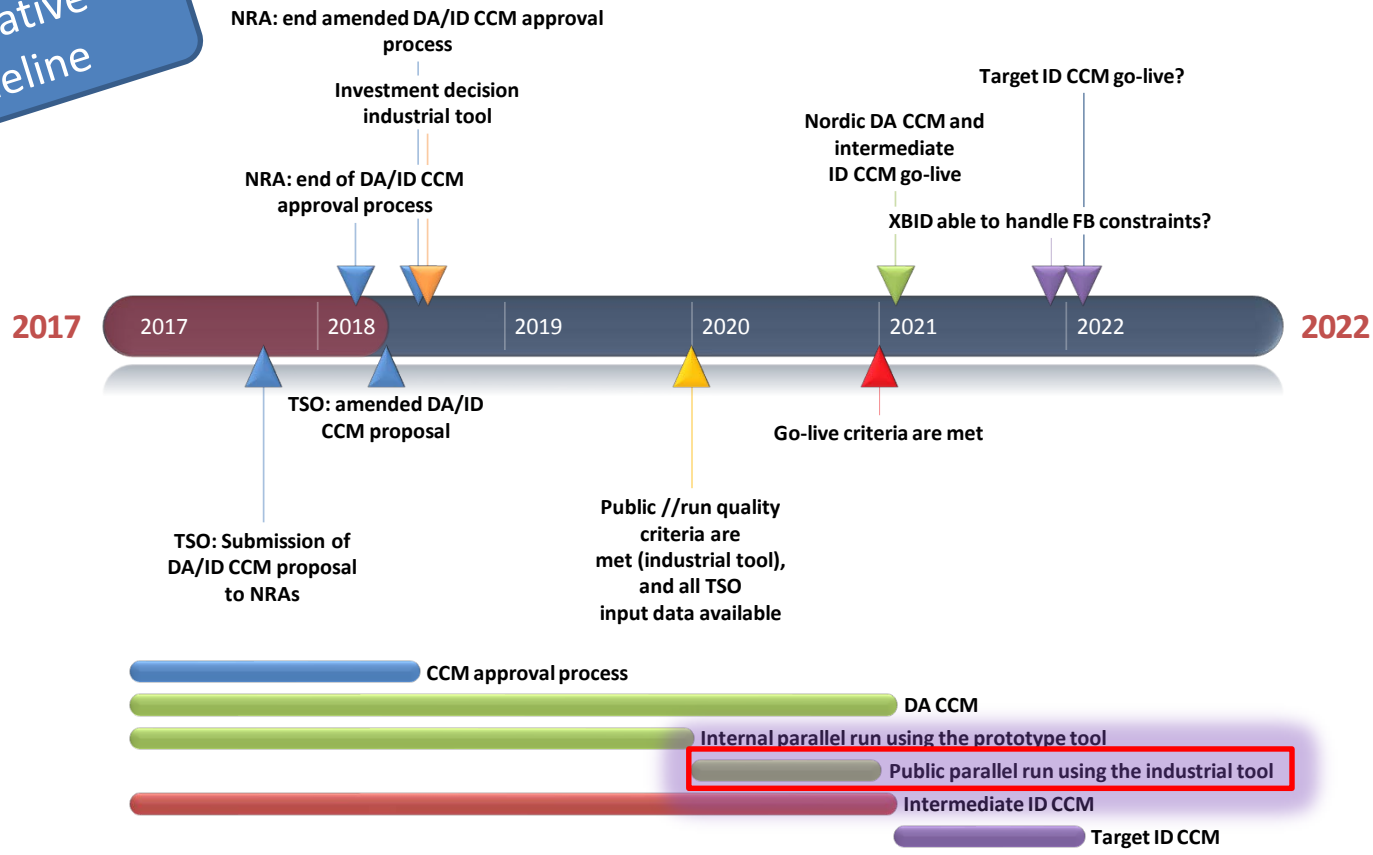
Amended CCM proposal submitted on May 16



Indicative timeline

A parallel run period of 12 months is proposed

Such to balance between the former proposed 6 months and the 18 months requested for by NRAs



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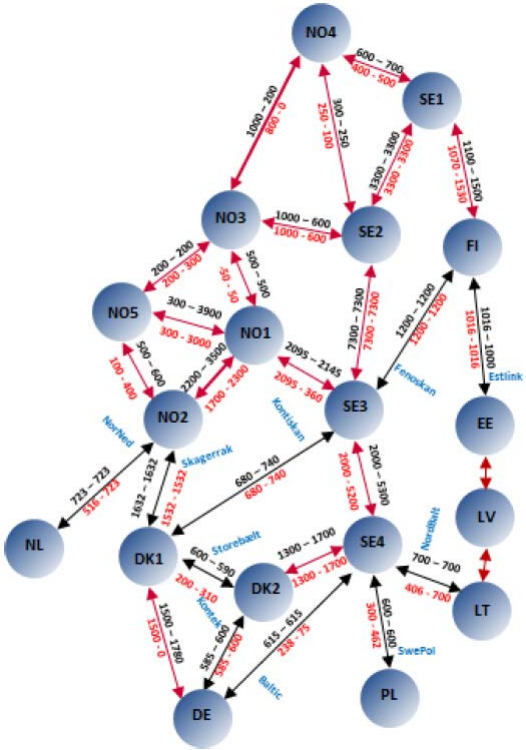
Characteristics of the Nordic FB

- Critical Network Elements (CNE):
  - ✓ Tielines and internal network elements
- Cuts: multiple lines modelled as a single CNE, with its own RAM and PTDFs
  - ✓ Voltage and dynamic constraints
- Number of presolved FB constraints
  - ✓ Around 85
- CNE selection
  - ✓ A method is being developed to select CNEs based on operational security and economic efficiency

Characteristics of the Nordic FB

- Advanced Hybrid Coupling is applied on all DC links.
- Number of Bidding Zones: 28
  - ✓ Nordic bidding zones: 12
  - ✓ Virtual bidding zones: 14
  - ✓ Due to the high dimensionality of the FB domain, the vertices and volume cannot be (easily) computed
- Two synchronous areas
  - ✓ DK1 is part of the continental European synchronous system
- FB plain is applied
  - ✓ Running the intuitive patch poses issues given the high dimensionality of the FB domain (over-constraining the system)

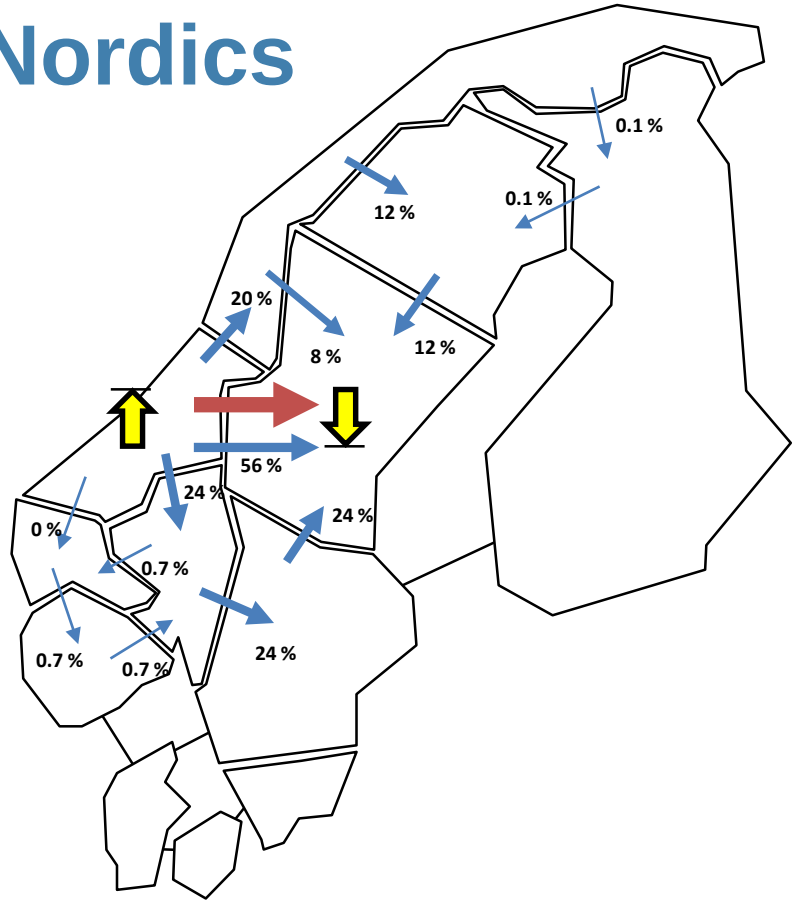


Transit flows in the Nordics

Commercial exchange between areas …

… impact on scheduled flow

	DK1-DE	DK1-SE3	DK1-NO2	DK1-DK2	DK2-DE	DK2-SE4	FIN-EE	FIN-SE3	FIN-NO4	FIN-SE1	NO1-NO2	NO1-NO3	NO1-NO5	NO1-SE3	NO2-NL	NO2-NO5	NO3-NO4	NO3-NO5	NO3-SE2	NO4-SE1	NO4-SE2	SE1-SE2	SE2-SE3	SE3-SE4	SE4-DE	SE4-LT	SE4-PL
DK1-DE	1																										
DK1-SE3		1																									
DK1-NO2			1								0.9	0.4	0.8	0.6		0.3	0.5	0.4	0.4	0.6	0.1	0.4	0.6				
DK1-DK2				1							0.2	0.1		0.8		0.2	0.1	0.1	0.4	0.1	0.1	0.1	0.2				
DK2-DE					1							0.2	0.1	0.6		0.2	0.2	0.1	0.6	0.1	0.1	0.1	0.2				
DK2-SE4						1								0.2		0.2	0.2	0.1	0.2	0.1	0.1	0.1	0.2				
FIN-EE							1																				
FIN-SE3								1																			
FIN-NO4																											
FIN-SE1									1	1																	
NO1-NO2											0.9	0.2		0.7		0.2											
NO1-NO3											0.1	0.4	0.2	0.2		0.4	0.2	0.1	0.1								
NO1-NO5											0.1	0.8		0.6		0.7											
NO1-SE3											0.1	0.6	0.8			0.2	0.6	0.2	0.1	0.1							
NO2-NL															1												
NO2-NO5											0.1	0.2		0.3		0.2											
NO3-NO4										0.2		0.1		0.5		0.1	0.2	0.2	0.3	0.1							
NO3-NO5												0.2		0.4		0.1											
NO3-SE2										0.2		0.4	0.1			0.4	0.4	0.6	0.2	0.2	0.1						
NO4-SE1										0.6		0.1		0.4		0.1	0.1	0.6	0.5	0.1							
NO4-SE2										0.1		0.1		0.1		0.1	0.1	0.1	0.2								
SE1-SE2										0.4		0.1		0.5		0.1	0.1	0.3	0.6	0.9							
SE2-SE3											0.6		0.2			0.2	0.6	0.2			1						
SE3-SE4																						1					
SE4-DE																							1				
SE4-LT																								1			
SE4-PL																									1		



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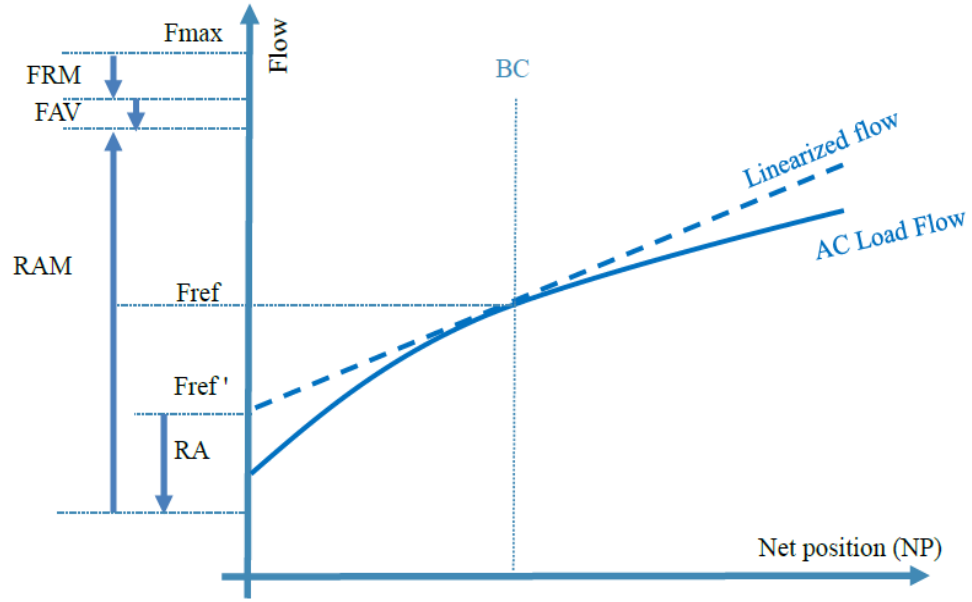
1. Overview of the Nordic CCM project
2. **Mathematical description**
3. Operational security limits, contingencies and remedial actions
4. Shift keys
5. Reliability margin
6. Internal and cross zonal exchanges

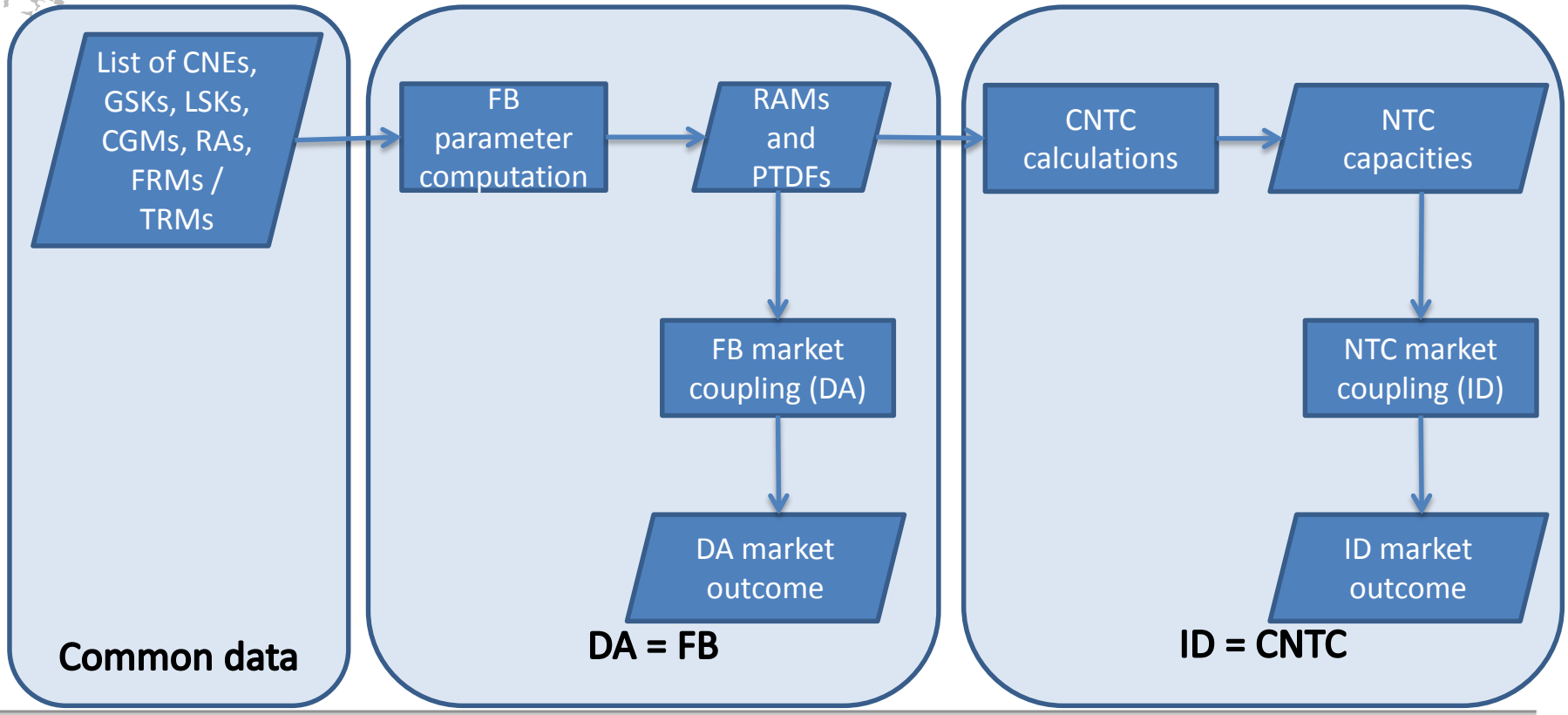
Mathematical description



$$RAM = F_{max} - FRM + RA - F'_{ref} - FAV - AAC$$

- Critical network elements (CNEs) can be
  - ✓ Cuts with stability limits or
  - ✓ ”CBCO” with thermal limits
- Each CNE is sent as a market constraint defined by
  - ✓ RAM and PTDF

Mathematical description



DA capacity calculation

- FB for DA
- Constraints sent to the DA FB market
  - ✓ FB constraints = CNE constraints: PTDF*NP<RAM
  - ✓ Non FB constraints = Allocation constraints:
    - Ramping constraints on HVDC cable
    - Threshold value on the net position of some areas
    - Implicit loss factors of DC links (ensuring that the DC link will not flow unless the welfare gain of flowing exceeds the costs of the corresponding losses)

ID capacity calculation

- Interim solution: CNTC
- ID CNTC calculations
  - ✓ Maximum exchanges on bidding zone borders are calculated using CGMs, GSKs, contingencies and operational security limits and adjusted taking into account RAs available for capacity calculation
  - ✓ Sharing rules are applied for interdependent borders: Aim is to maximise cross-zonal trading possibilities by taking into account the CGM base case for each hour
  - ✓ Finally TRM and AAC are taken into account
- Frequency update:
  - ✓ First computation for gate opening before D-1 CGM is available
  - ✓ Second computation after D-1 CGM is available and CSA performed
  - ✓ Other computations if needed (CSA is planned to be performed at least 3 times)

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Contingency list, operational security limits and remedial actions

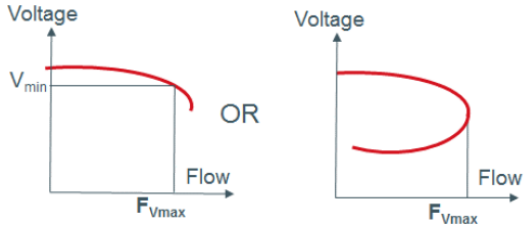
- Coordination with operational security analysis and DA capacity calculations
  - ✓ Same contingencies, operational security limits and remedial actions are applied in DA and ID capacity calculations and in operational security analysis

Contingency list and operational security limits

Thermal limit

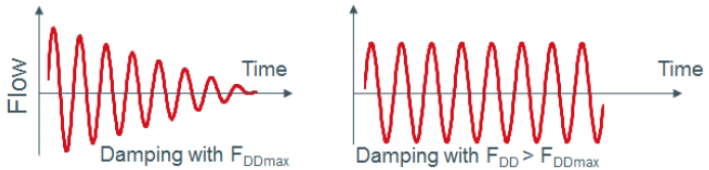
F_{Tmax} based on node voltage and max current for limiting component during a certain time

Voltage stability (static)



Dynamic system stability assessment

- **Voltage stability/collapse** - ability to maintain steady acceptable voltage and reactive power balance after disturbance → F_{DVmax}
- **Transient stability** - ability to maintain synchronism after disturbance → F_{DTmax}
- **Damping** – ability to damp power oscillations after disturbance → F_{DDmax}



Definition of maximum flow F_{max} on critical network element (FB) or on bidding zone border (CNTC)

Example:

Thermal limit → F_{Tmax}

Voltage limit (static) → F_{Vmax}

Voltage limit (dynamic) → F_{DVmax}

Transient stability → F_{DTmax}

Damping → F_{DDmax}

$F_{max} = \min(F_{Tmax}, F_{Vmax}, F_{DVmax}, F_{DTmax}, F_{DDmax})$

$= F_{DDmax}$

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Shift keys

Strategy number	GSK	LSK	Description/comment
0	k_g	k_l	Custom TSO GSK strategy with individual set of participating factors for each generator unit and load for the MTU
1	$\max\{P_g - P_{min}, 0\}$	0	Generators participate relative to their margin to the generation minimum (MW) for the unit
2	$\max\{P_{max} - P_g, 0\}$	0	Generators participate relative to their margin to the installed capacity (MW) for the unit
3	P_{max}	0	Generators participate relative to their maximum (installed) capacity (MW)
4	1.0	0	Flat participation of all generators, independently of the size of the generator unit
5	P_g	0	Generators participate relative to their current power generation (MW)
6	P_g	P_l	Generators and loads participate relative to their current power generation or load (MW)
7	0	P_l	Loads participate relative to their power loading (MW)
8	0	1.0	Flat participation of all loads, independently of size of load

where

k_g : Participation factor [pu] for generator *g*
k_l : Participation factor [pu] for load *l*
P_g : Current active generation [MW] for generator *g*
P_{min} : Minimum active power generator output [MW] for generator *g*
P_{max} : Maximum active power generator output [MW] for generator *g*
P_{load}: Current active power load for load *l*

- 8+1 strategies for shift keys proposed
- Bidding zones can have different shift key strategies
- Optimal GSK strategies = minimize overall reliability margin

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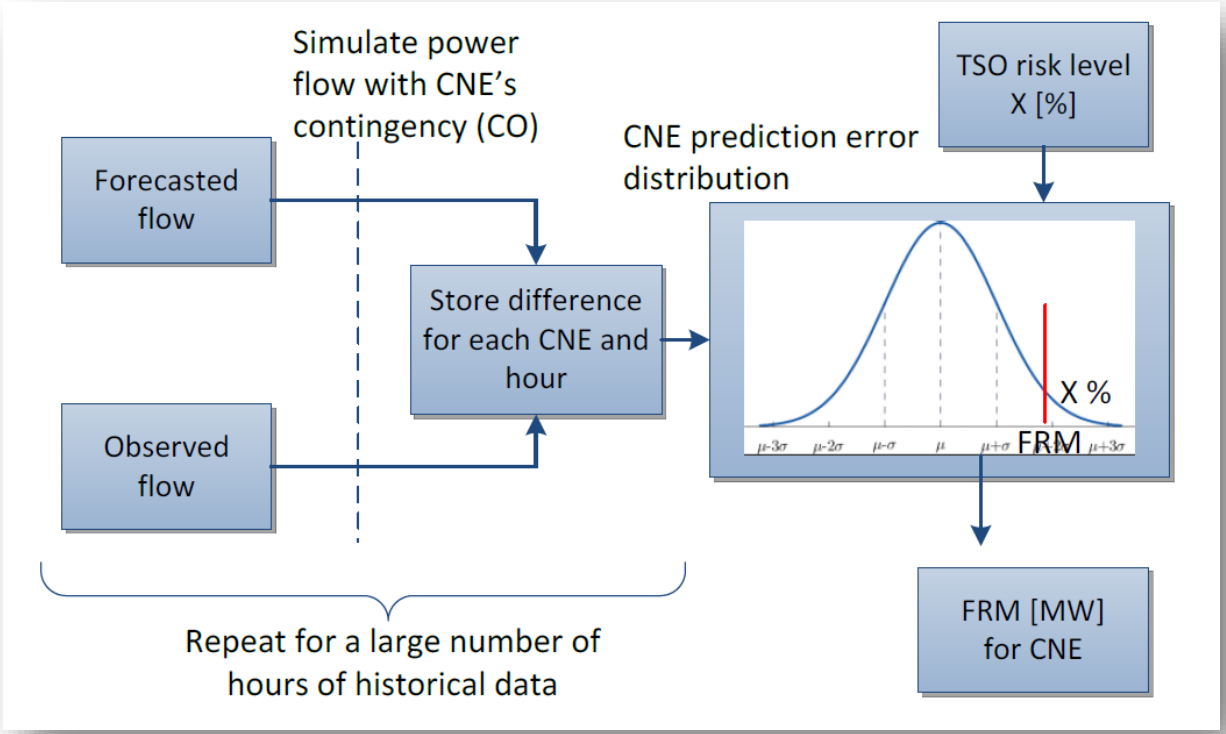
Reliability Margin (RM)

The forecasted flow:
- Is the flow predicted by the FB model: F_forecasted = Fref'+NP*PTDF
- Where NP are the import and export positions from the realized schedules at the time of making the observation

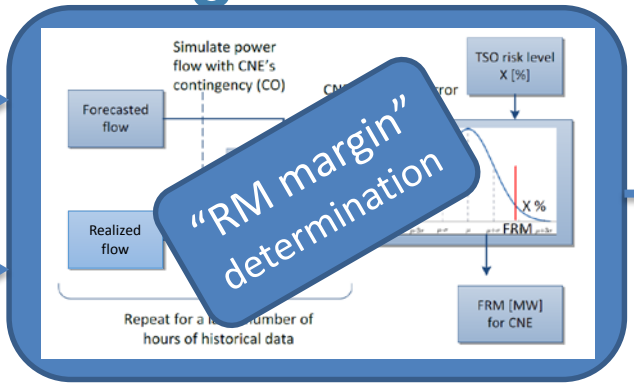
Or in other words:
- When the FB model would have been perfect, the forecasted flow should equal the observed flow



FCR margin and RM margin

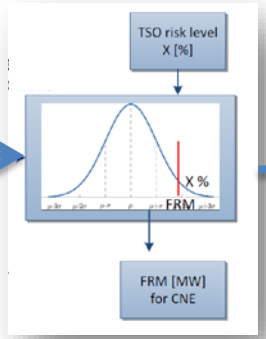
Forecasted flows

Realized flows



RM margin + FCR margin → RM

FCR balances → FB model → "FCR margin" (= PTDF * NP(FCR))



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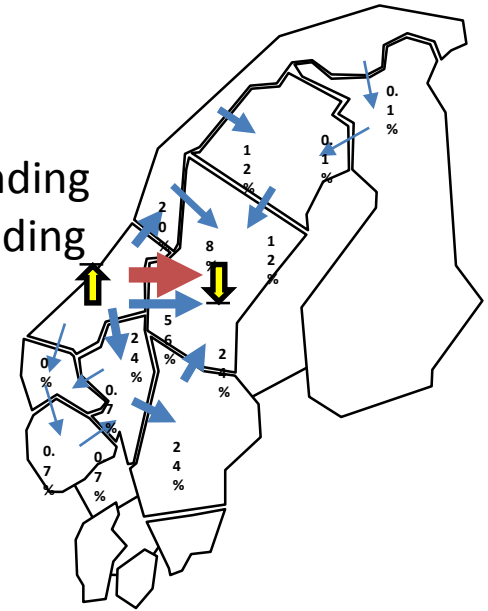
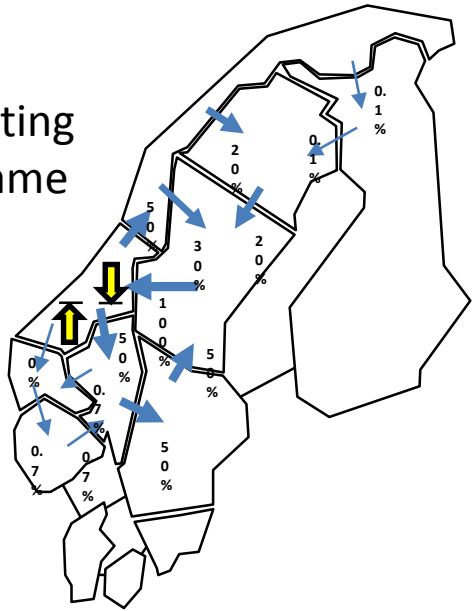
Loop flows vs Transit flows

Transit flows; starting and ending in different bidding zones



Loop flows; starting and ending in same bidding zone



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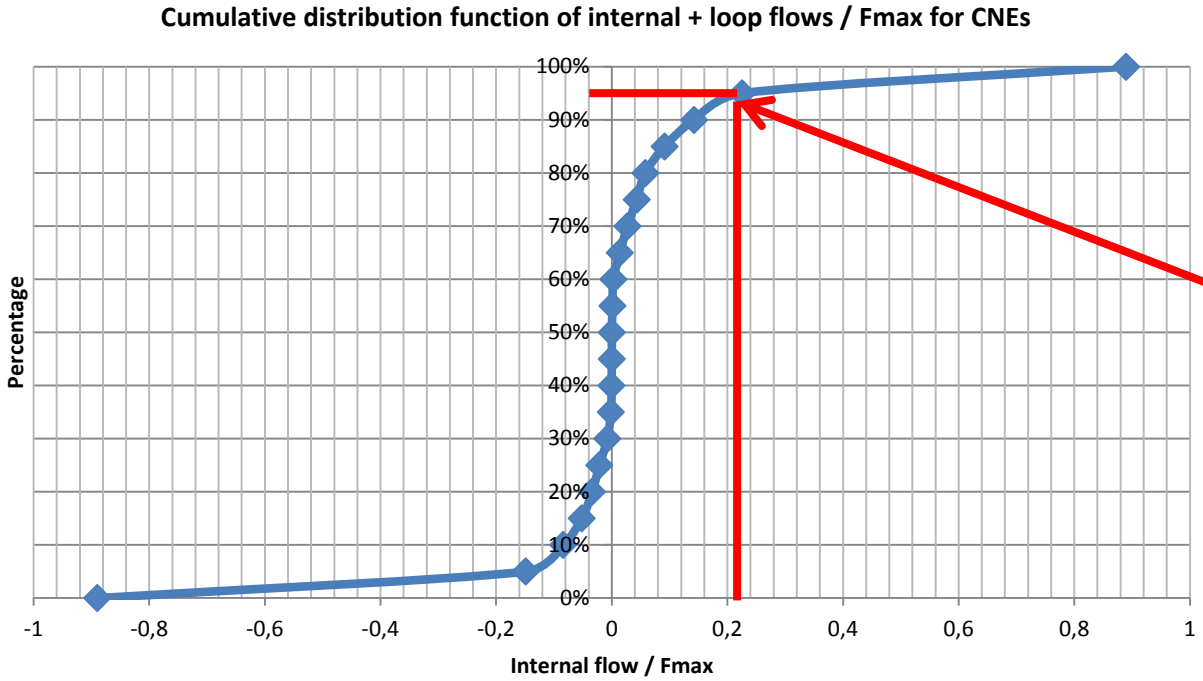
Analysis of internal and loop flows in the Nordics

- One day of data was used to analyze the magnitude of internal and loop flows in the Nordic system
- About 1500 CNEs per hour
  - ✓ Between 450 and 600 CNEs are market relevant for each hour
- 24 hours of one day are analyzed
- The sum of internal and loop flows is computed for each CNE
- Report on the ratio between internal flows and Fmax (Fmax: capacity of the CNE)

Internal and loop flows in CNEs



For about 95% of the CNEs, Internal + loop flows are smaller than 25% of Fmax

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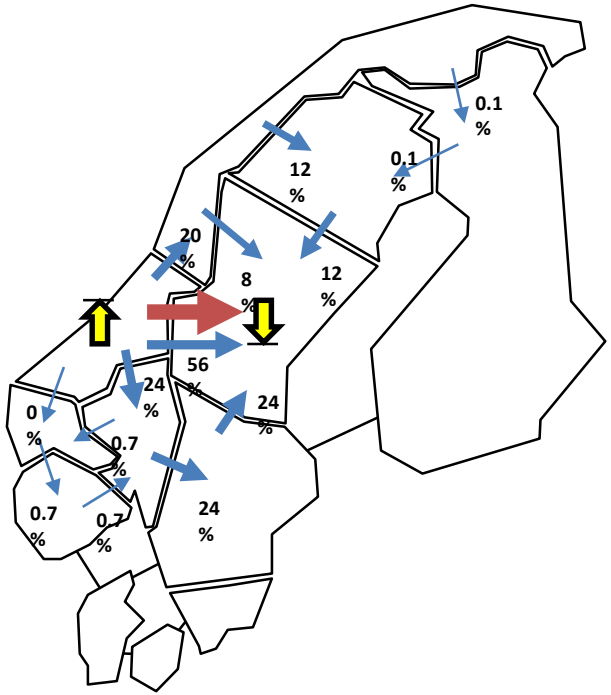
Thank you!



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