

Flow-Based Concept and Methodology

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Joint NordREG / Nordic TSO workshop on Flow-Based Capacity Calculation

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Questions?

- Always welcome, do not hesitate to ask!

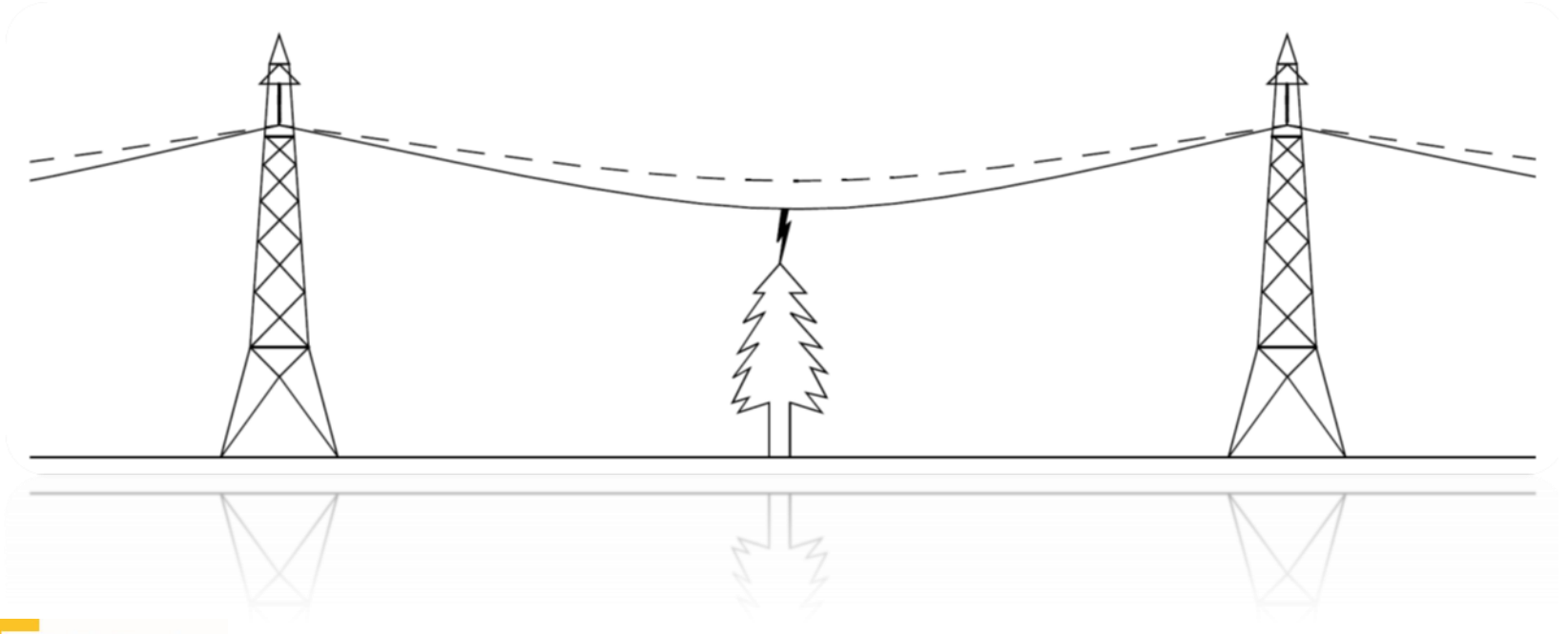
Congestion management

What is congestion?

Source: Schavemaker, Tessensohn, Beune, "Optimal European Electricity Market Design Under Future Grid Developments", European cross border power trading forum, Berlin, May 2011.

What is congestion?

- commercial: more capacity requested by the market than is available
- physical: overloaded transmission lines leading to outages



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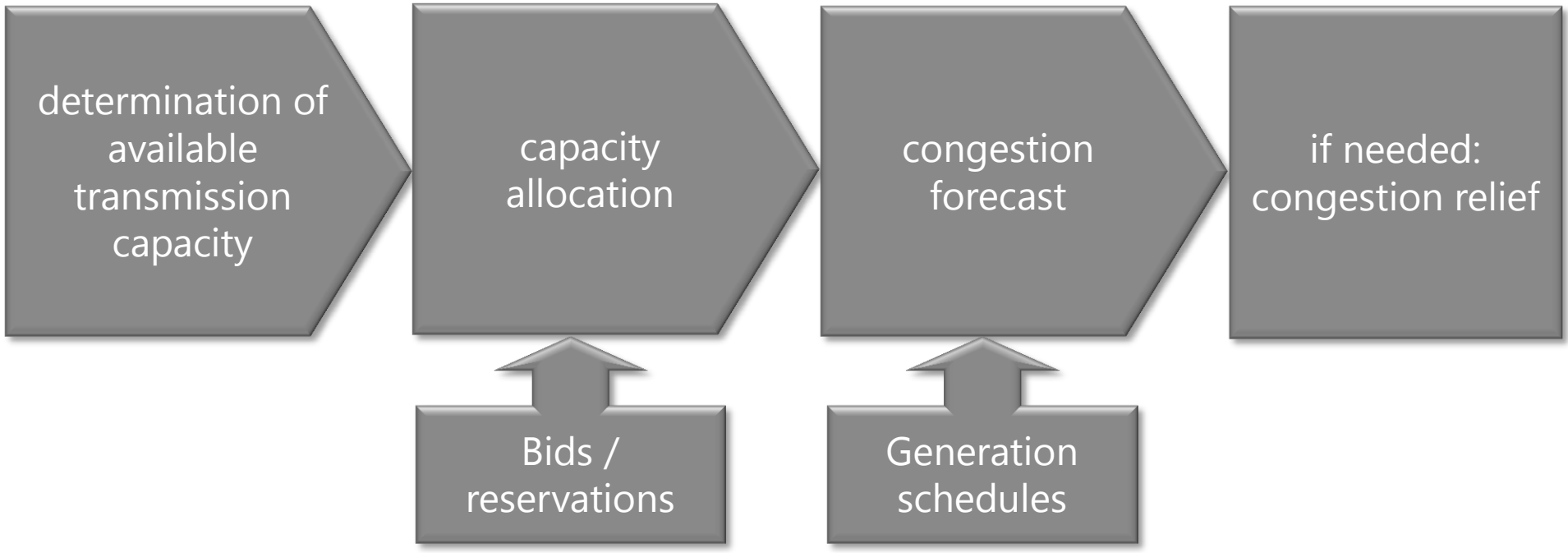
Congestion management in the broadest sense



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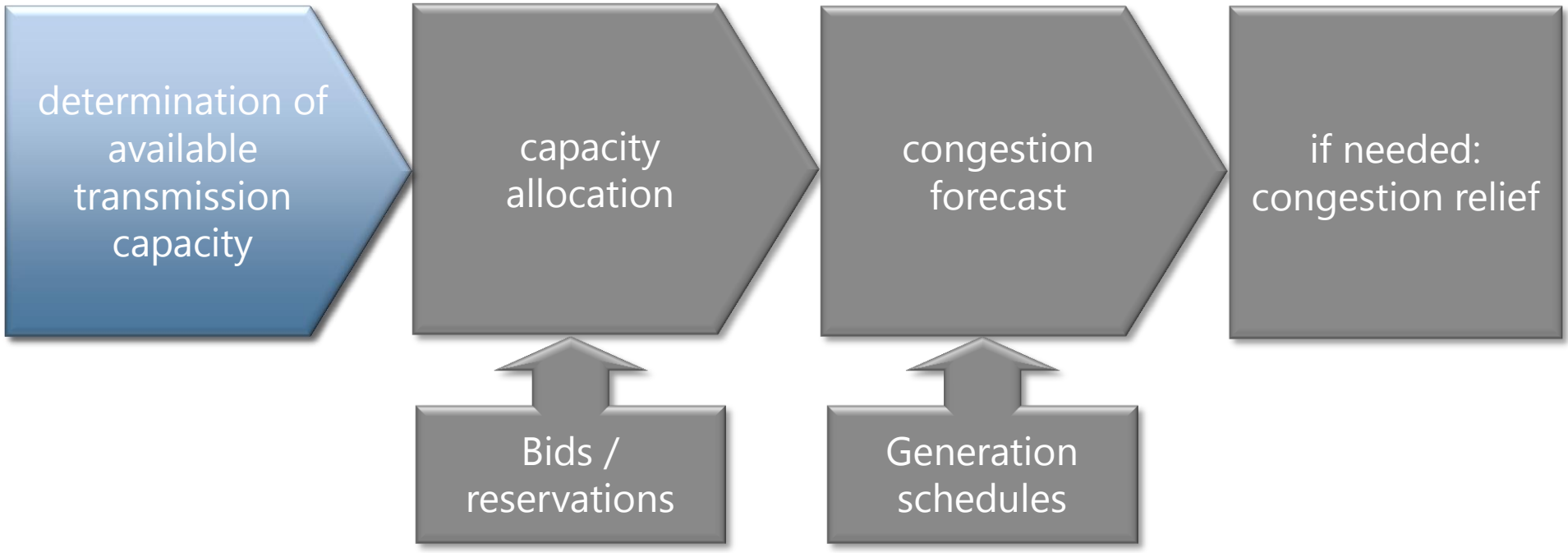

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Network Code on Capacity Allocation & Congestion Management

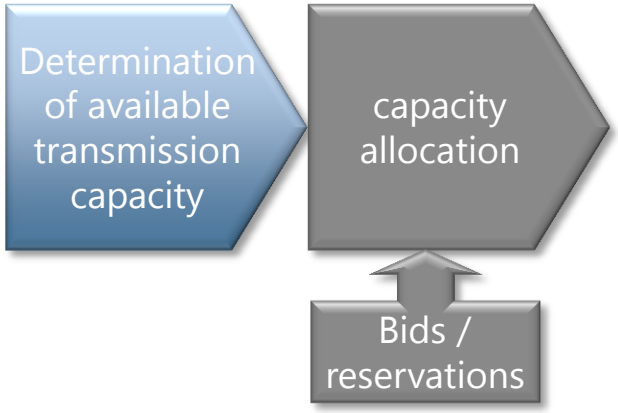
Source: http://networkcodes.entsoe.eu/

ENTSO-E CACM network code (final draft, 27 September 2012)

'There are two permissible approaches when calculating cross zonal capacity: Flow based or coordinated net transmission capacity based. The flow based approach is preferred over the coordinated net transmission capacity approach for day ahead and intraday capacity calculation where interdependencies of cross zonal capacity between bidding zones is high.'

'The coordinated net transmission capacity approach may be applied in regions where interdependencies between cross zonal capacity are low and the added value of the flow based method cannot be proven.'

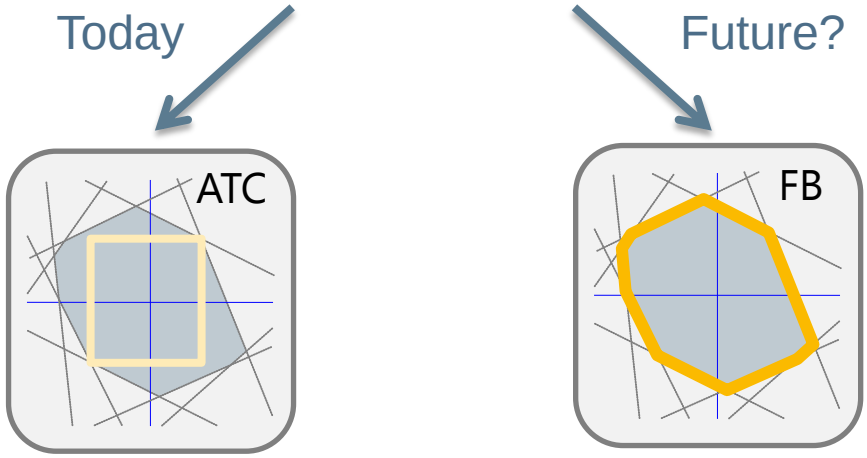
Source: ENTSO-E: Network Code on Capacity Allocation and Congestion Management, 27 September 2012.



Market Coupling: a constrained optimization problem

- 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

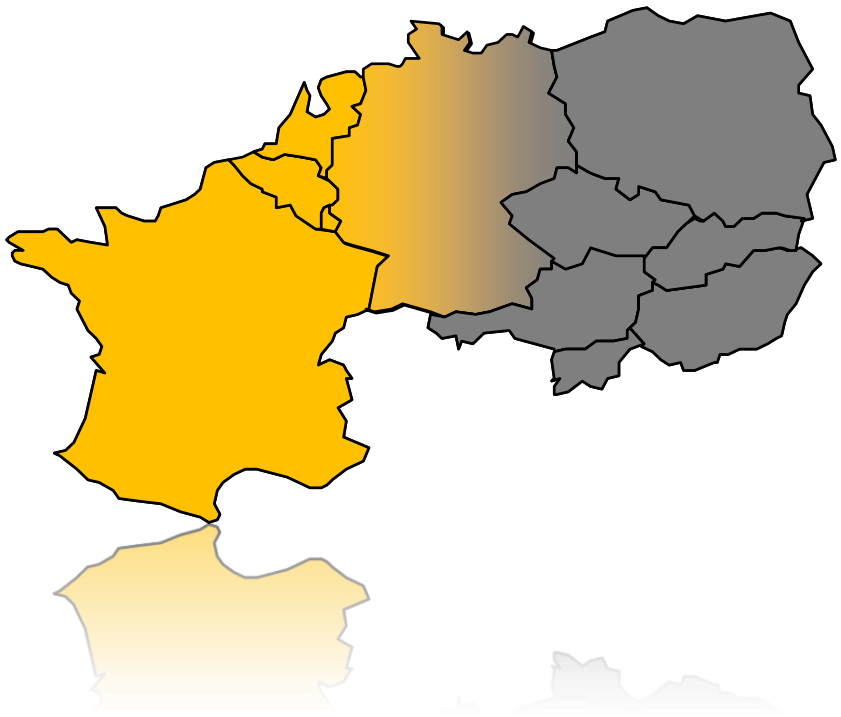


Flow Based in Europe

Flow-Based (FB):
the 'next-step' coordinated capacity calculation method

CWE

amprion
apx power spot exchange
belpex part of apx
creos
elia Powering a world in progress
EPEXSPOT EUROPEAN POWER EXCHANGE
Rte Réseau de transport d'électricité
TenneT Taking power further
TRANSNET BW



CEE

cao
50hertz
APG
cepsi a.s.
ELES
MAVIR
PSE
SEPS
TenneT Taking power further

After ETSO created the fundament of the flow-based methodology (based on flow gates), the current flow-based methodology (based on critical branches) was developed more or less independently in both CWE and CEE.

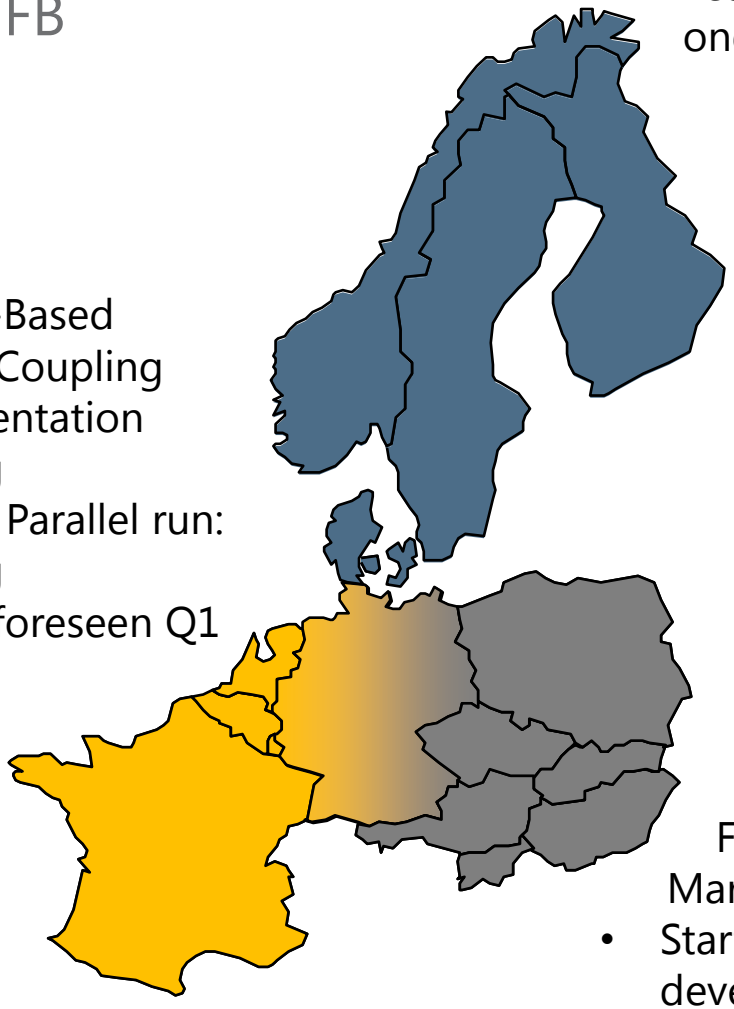
Current status of FB

Nordics

Flow-Based Market Coupling
- Feasibility study ongoing

CWE

Flow-Based Market Coupling
- Implementation ongoing
- External Parallel run: ongoing
- Go-live foreseen Q1 2015



Flow-Based Market Coupling
- Started FB development for FB explicit auctions
- Project ongoing to introduce FBMC

CEE

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What is Flow Based and what is the difference with ATCs?

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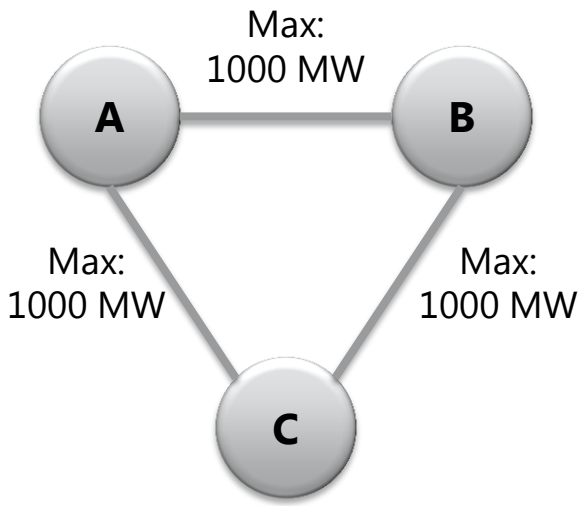
- ATC

An example three-node network

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



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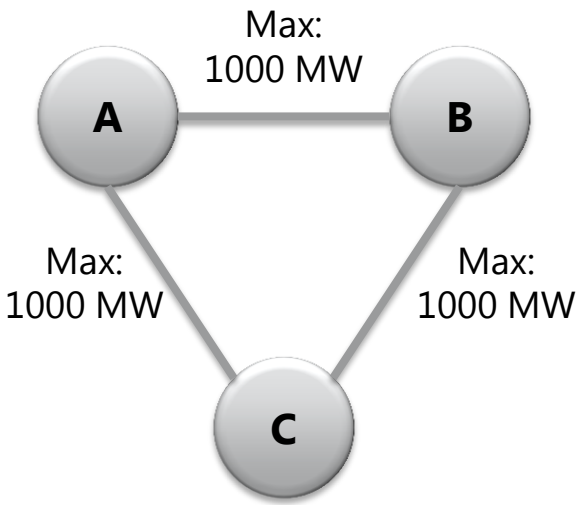
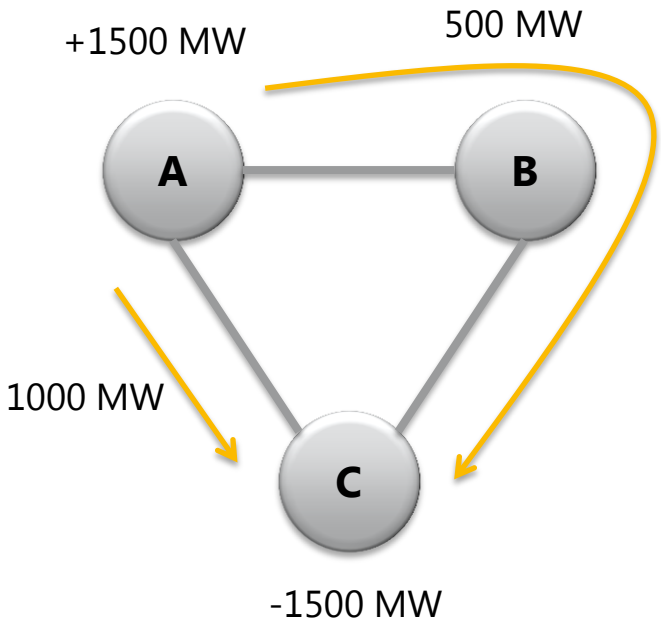


- The maximum export from A to another bidding area amounts 1500 MW:



An example three-node network: ATCs

- ATCs are determined by the TSOs to facilitate the market while safeguarding the grid
  - An ATC limits a commercial exchange between two bidding areas
  - ATCs are simultaneously feasible

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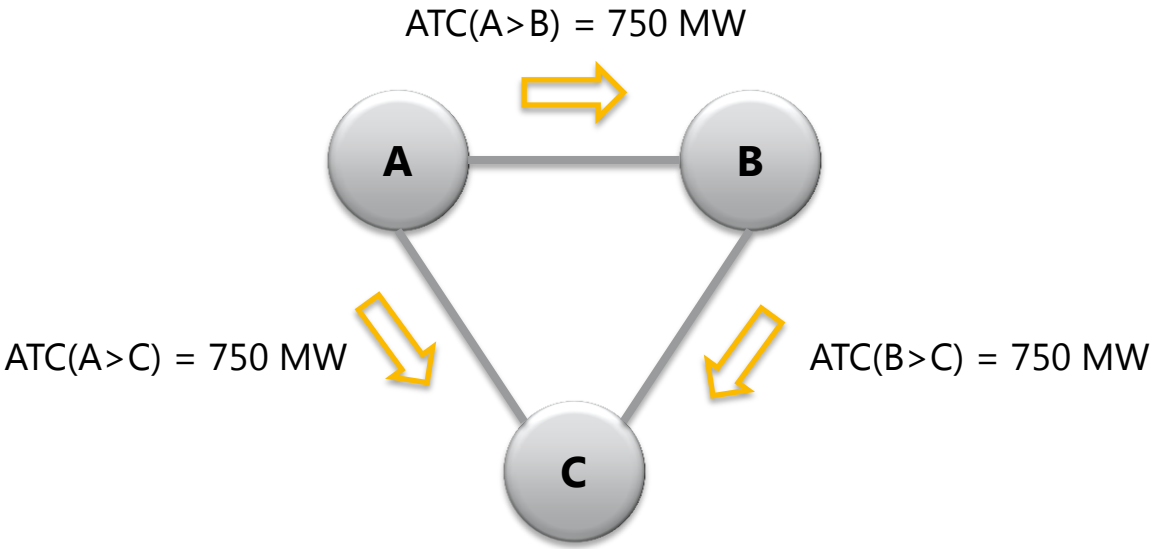
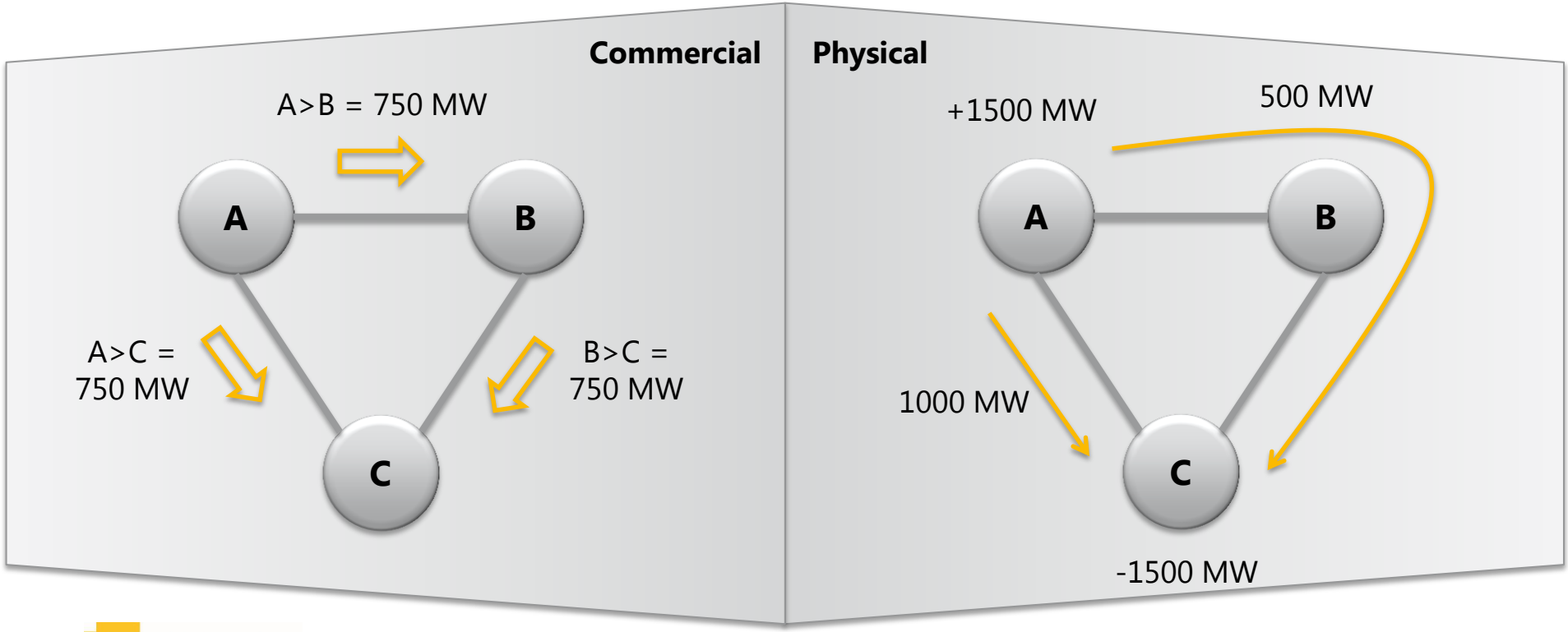
- ATCs are determined by the TSOs to facilitate the market while safeguarding the grid
  - An ATC limits a commercial exchange between two bidding areas
  - ATCs are simultaneously feasible

- Given the maximum export of bidding area A, the TSO needs to split the 1500 MW export capability into two bilateral exchanges, for example:
  - ATC(A>B) = 750 MW
  - ATC(A>C) = 750 MW



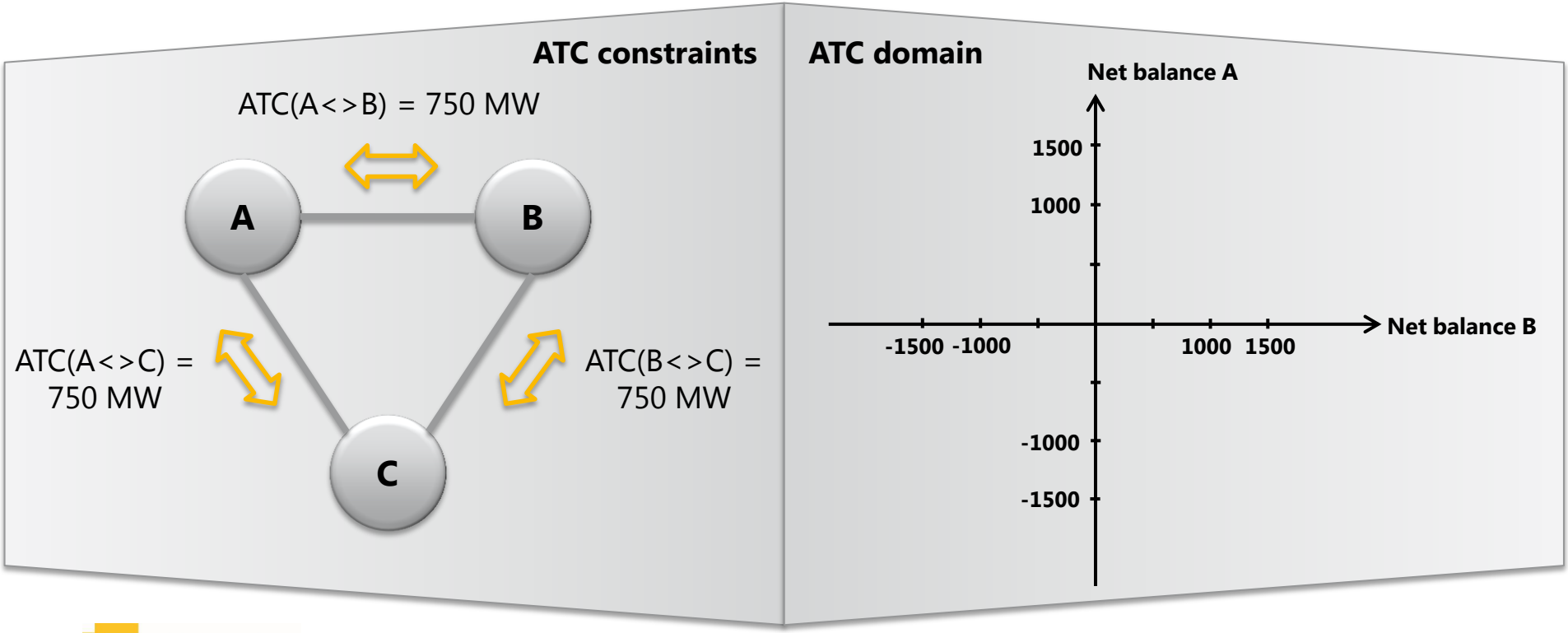
An example three-node network: ATCs and physical flows

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



An example three-node network: ATC domain

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



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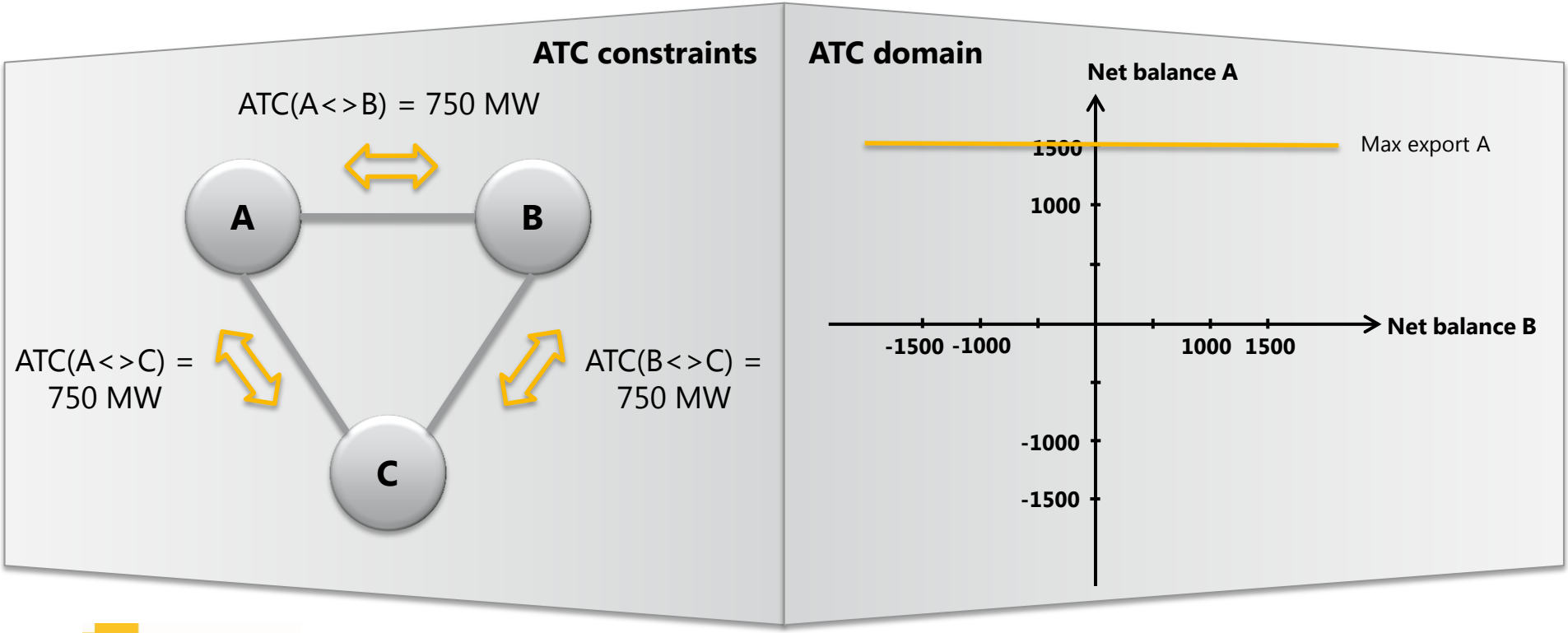

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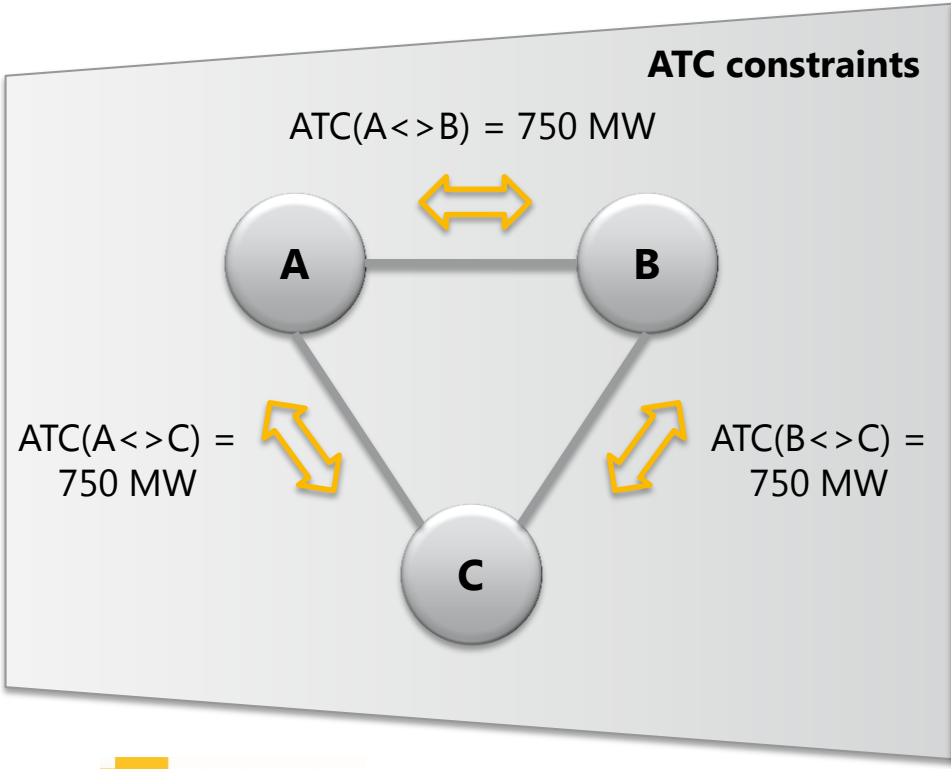

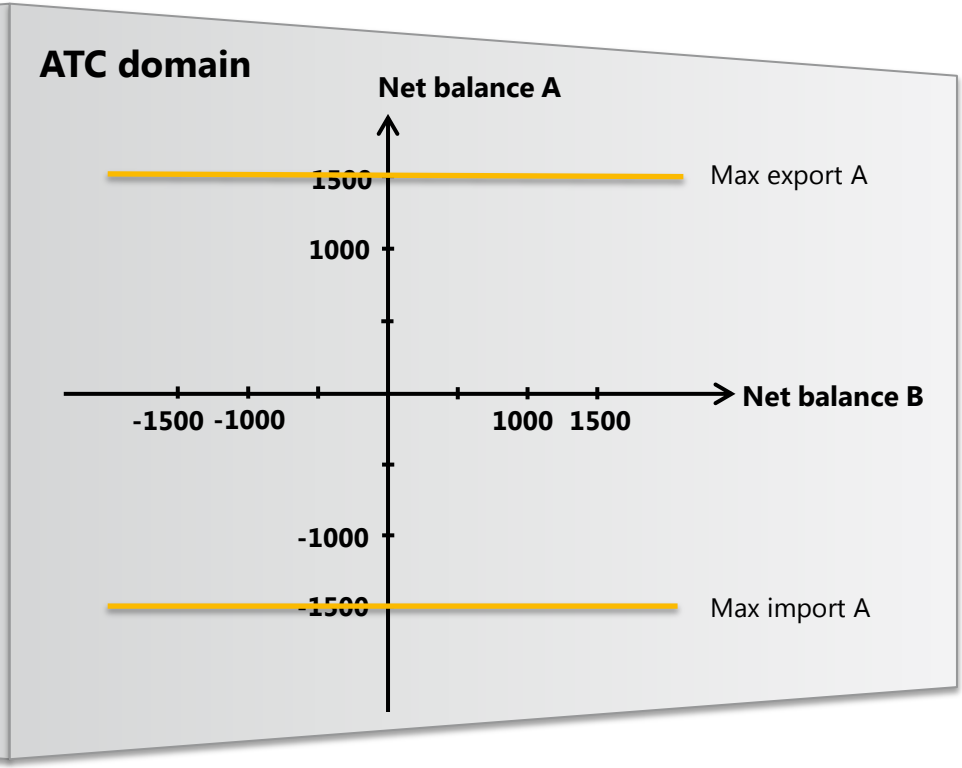

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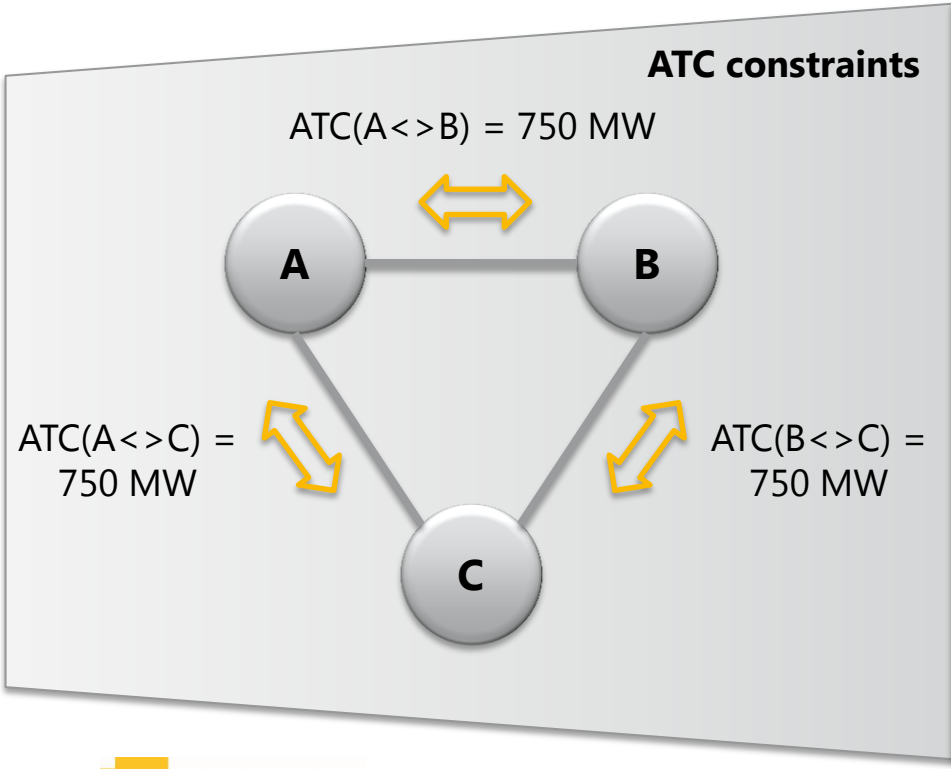

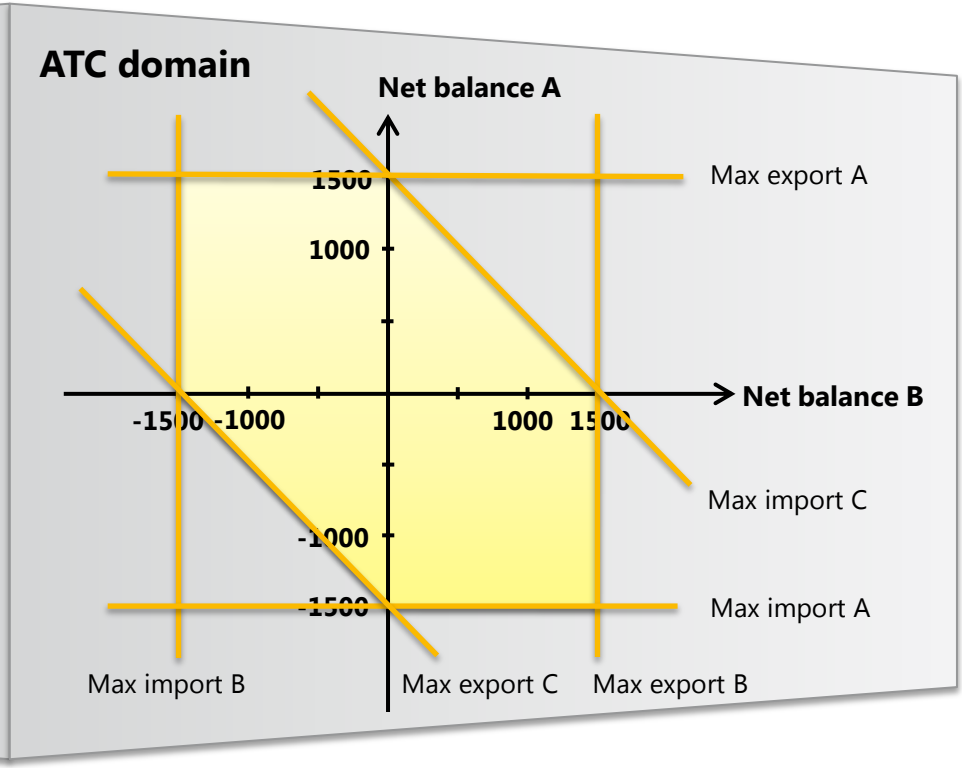

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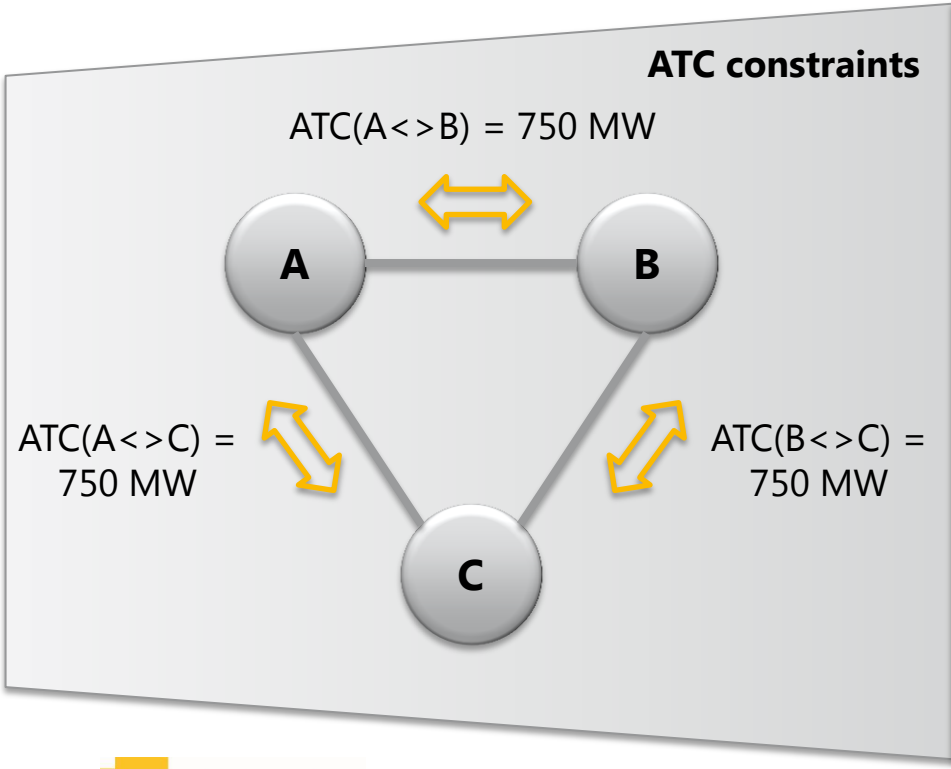
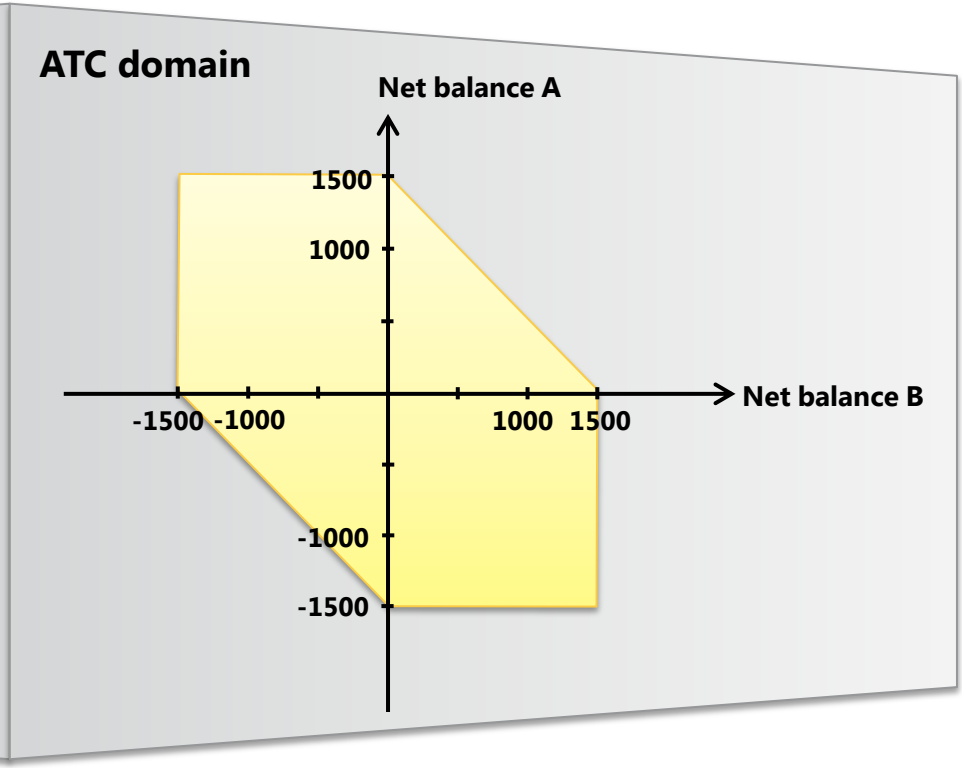


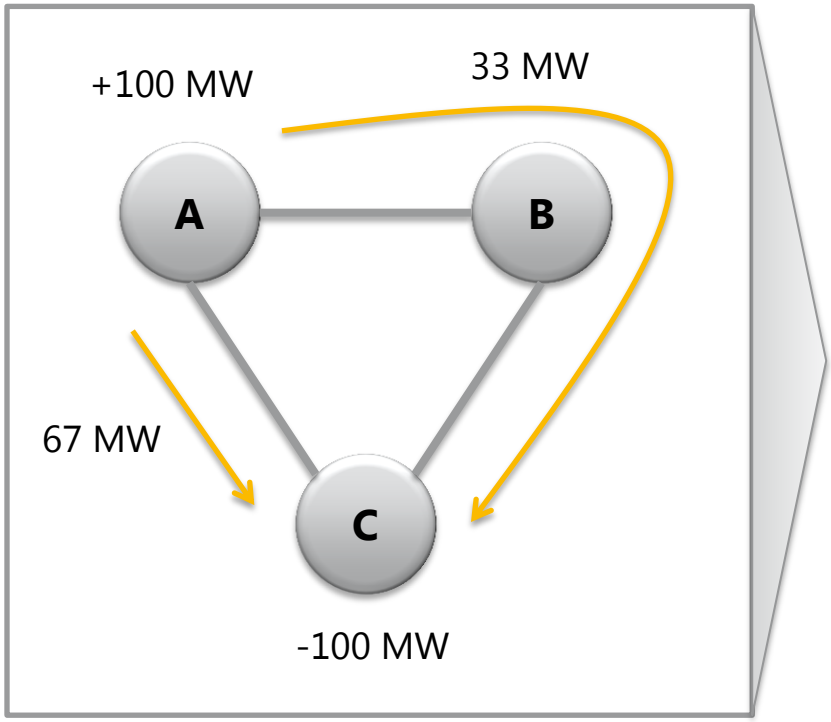


What is Flow Based and what is the difference with ATCs?

- FB

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 %		

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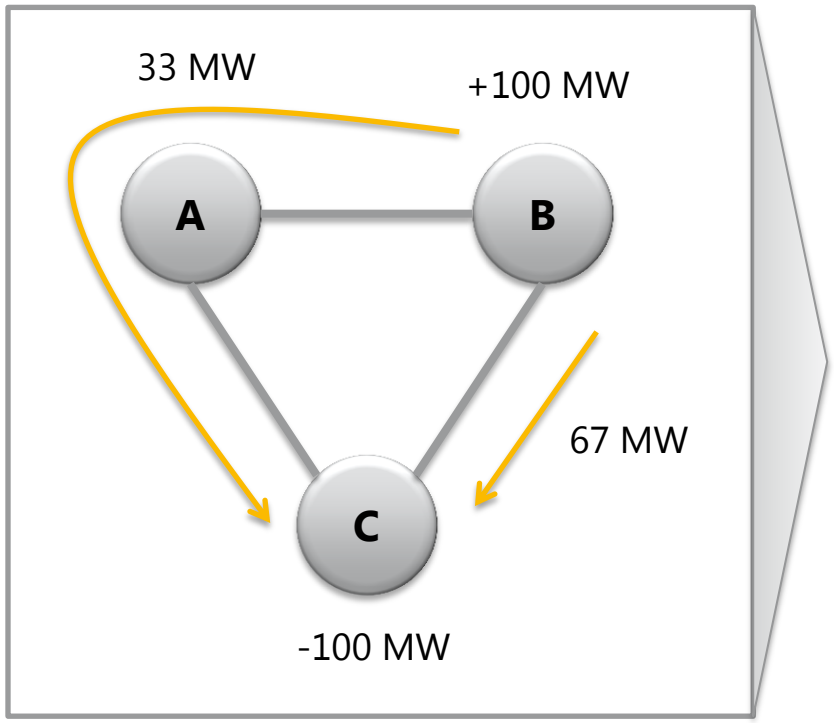

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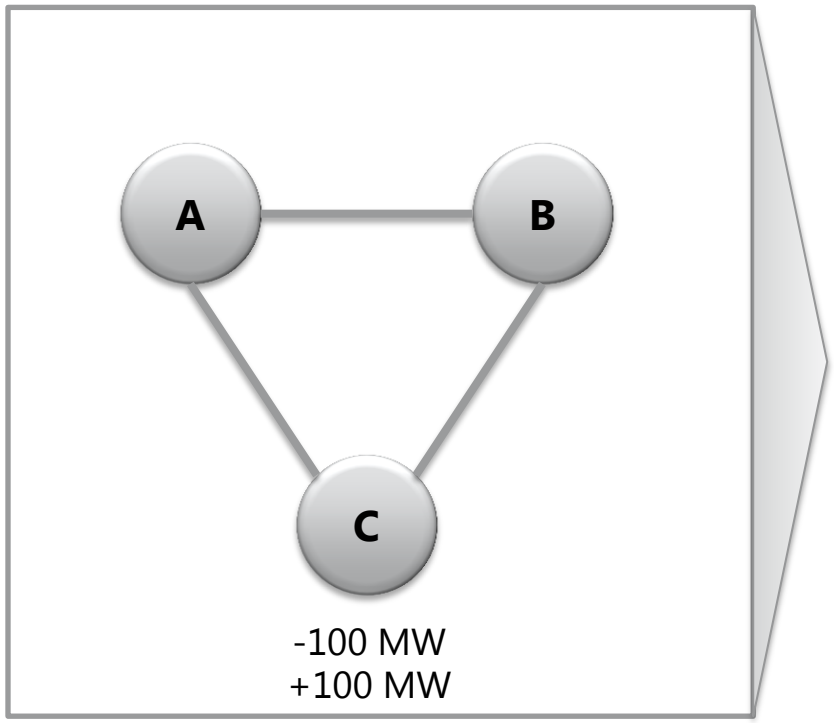

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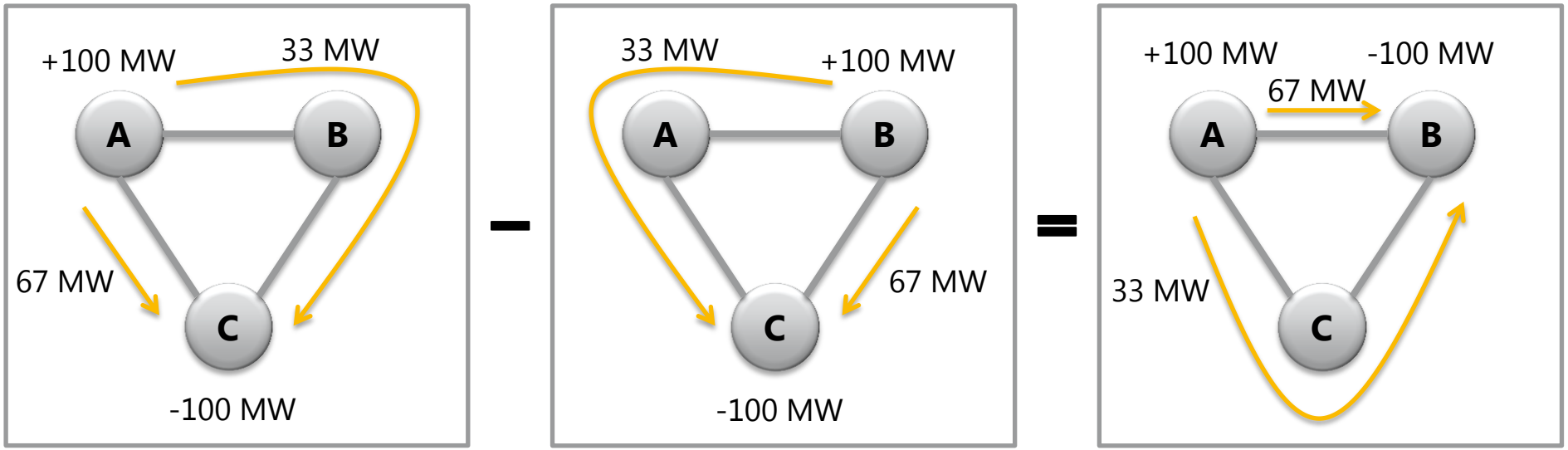
B>C	1000 MW	33 %	67 %	0
A>C	1000 MW	67 %	33 %	0

An example three-node network: FB and the reference node

- An exchange of 100 MW from bidding area A to bidding area B is equivalent to: an exchange of 100 MW from area A to the reference node C – an exchange of 100 MW from area B to the reference node C

- This property holds due to the linearity of the PTDF computation (DC load flow)



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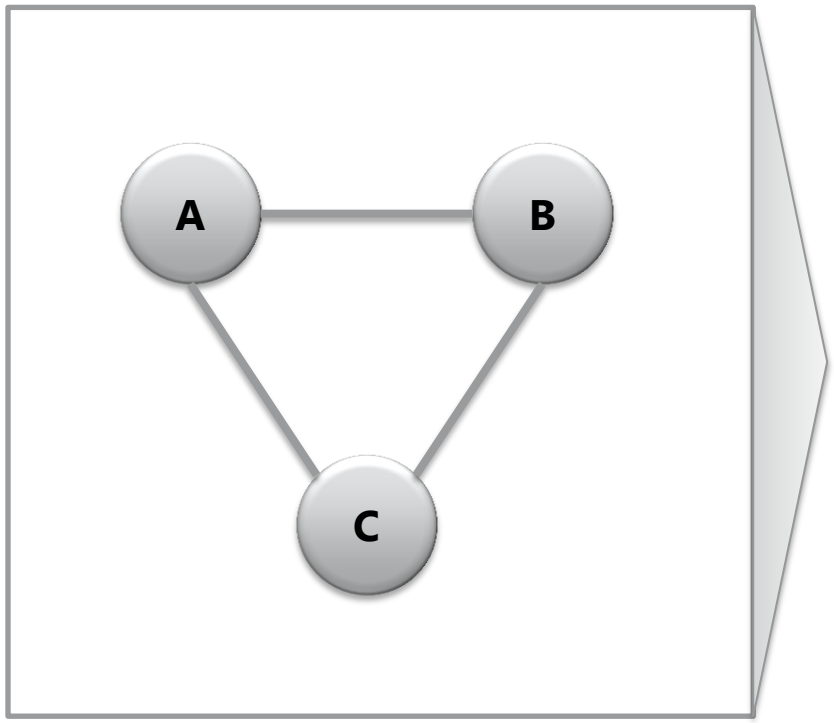

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A>C	1000 MW	67 %	33 %	0
B>A	1000 MW	-33 %	33 %	0
C>B	1000 MW	- 33 %	- 67 %	0
C>A	1000 MW	- 67 %	- 33 %	0

An example three-node network: FB domain

- The FB constraints in the three-node system define the FB domain:
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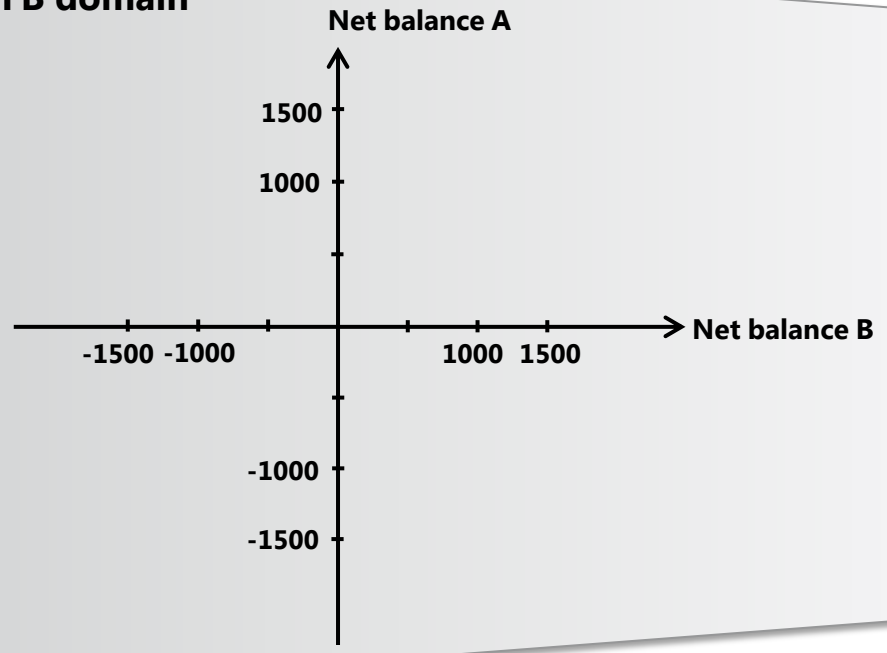
FB domain



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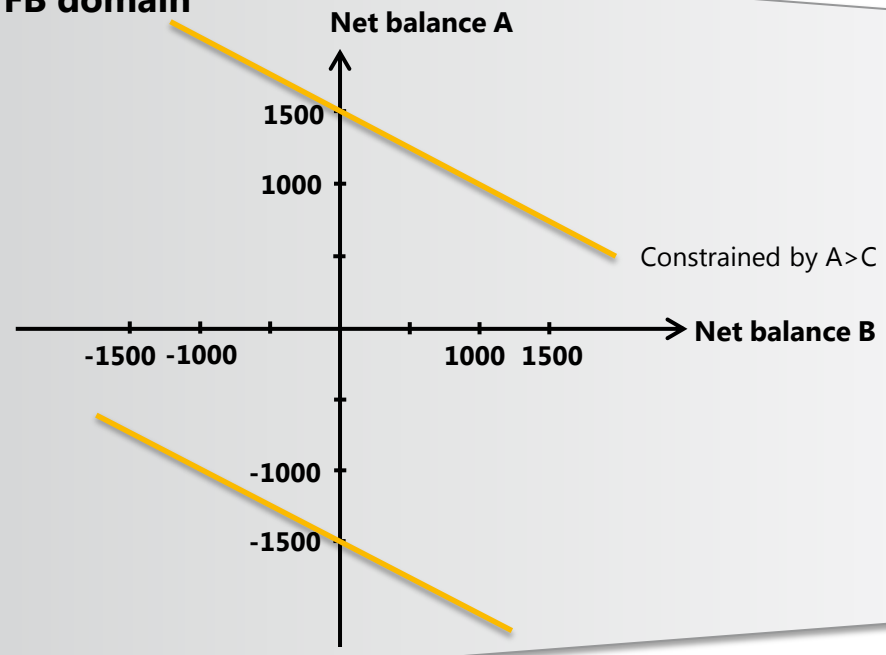

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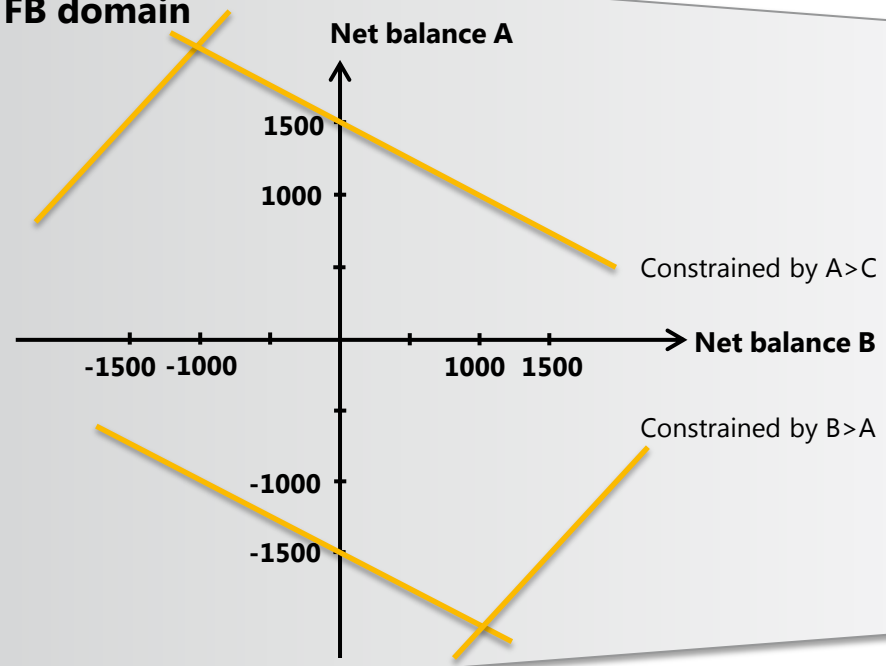
FB domain



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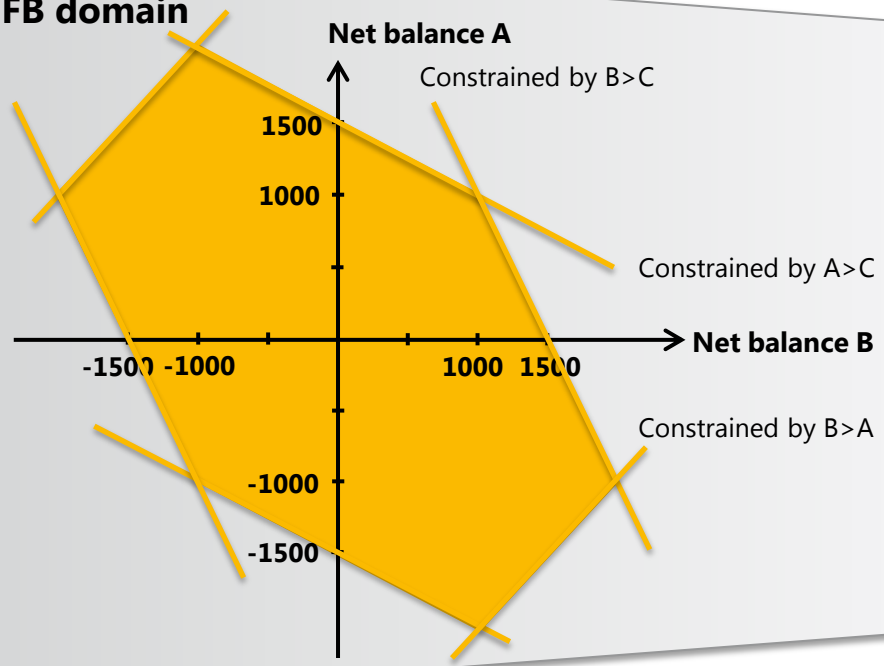

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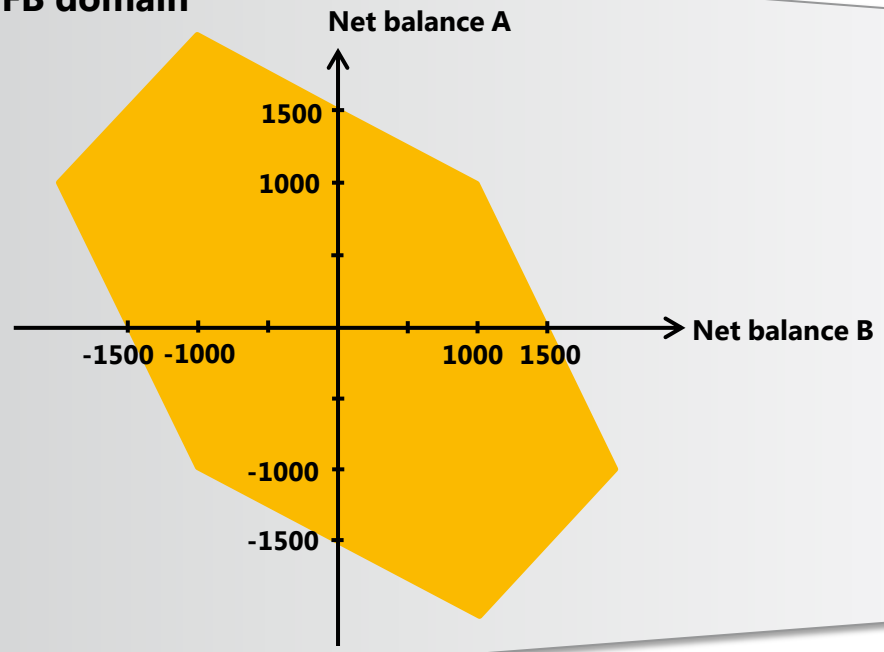

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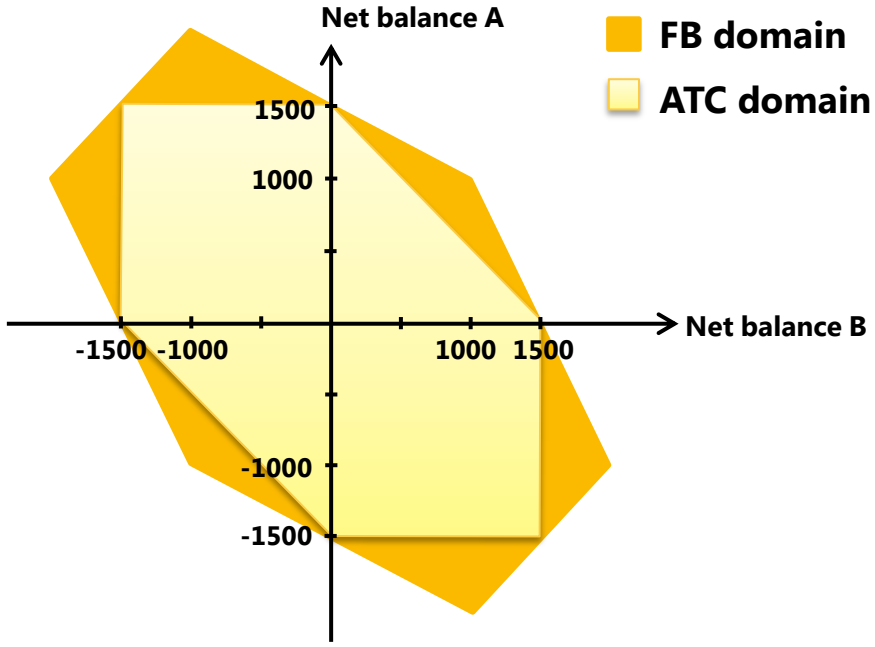
What is Flow Based and what is the difference with ATCs?

- ATC vs FB

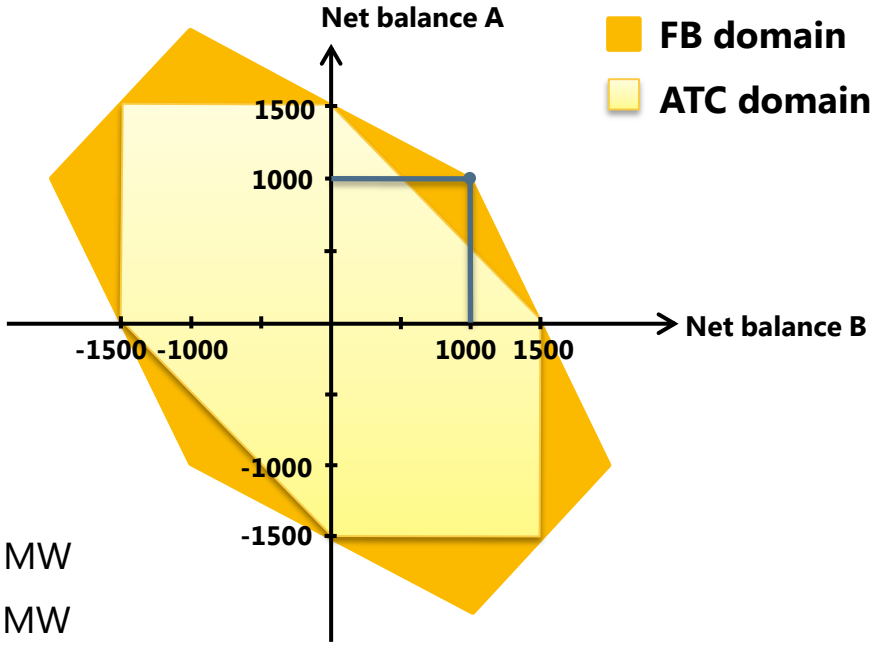
An example three-node network: ATC vs FB domain

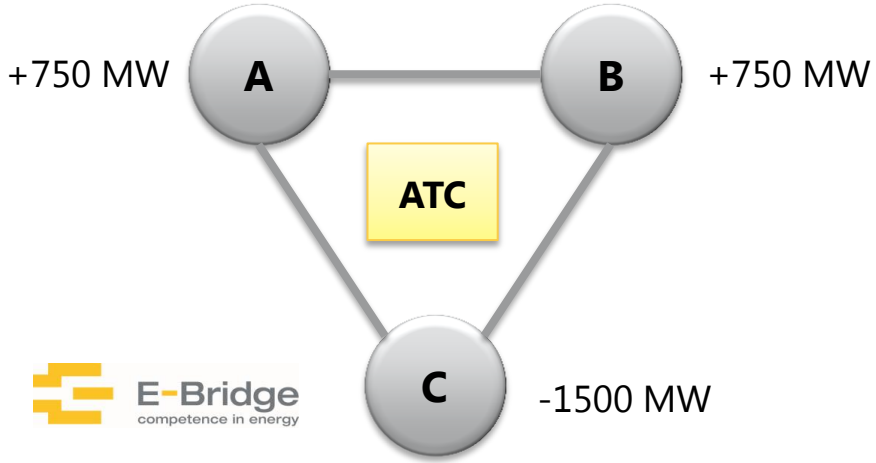
- In FB capacity split is not a choice of the TSO, but is market driven (at the time of allocation)
- FB offers more trading opportunities with the same level of security of supply

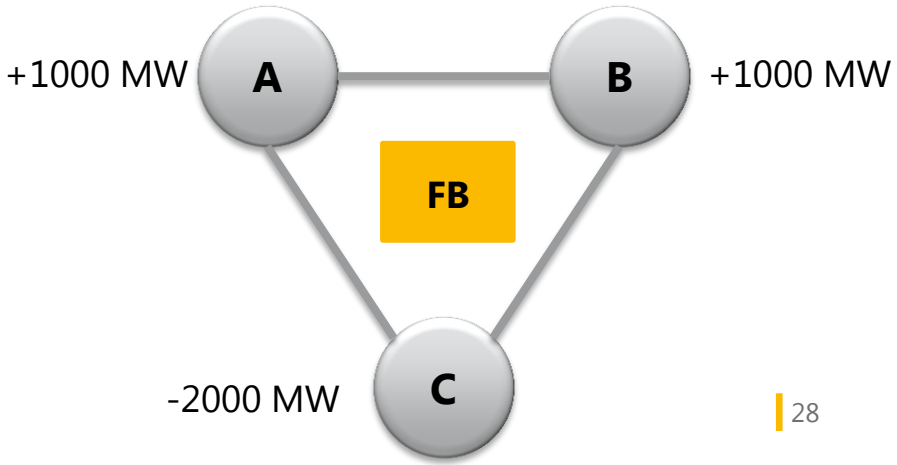


An example three-node network: ATC vs FB domain

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







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Advantages of the FB approach

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

FB allocation and price formation

Prices under a FBMC

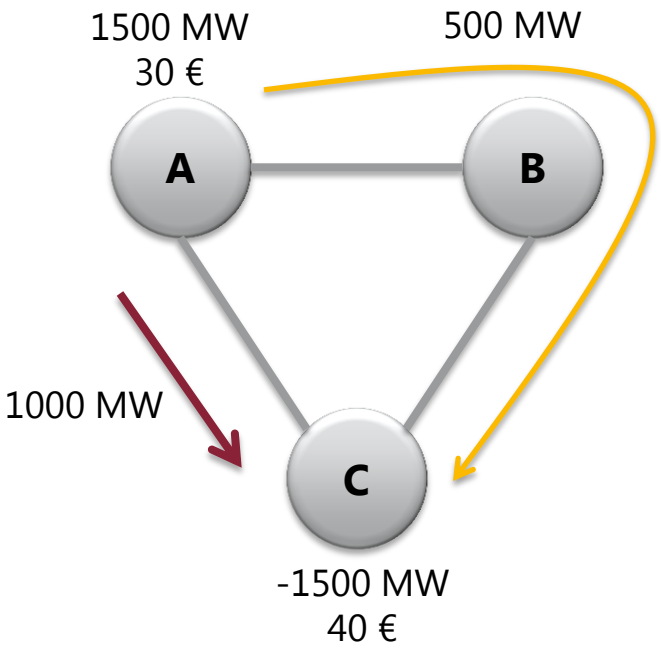
- FBMC optimization
  - Objective function: Maximize social welfare
  - Control variables: Net positions
  - Subject to: ∑ net positions = 0
    Grid constraints

- In case of congestion, the grid constraint receives a shadow price (μ):
  the increase of the objective function (being the social welfare) when the constraint is relieved with 1 MW

- Price relation under FB:

$$MCP_i - MCP_j = \sum_{cb} \left(PTDF_j^{cb} - PTDF_i^{cb} \right) \cdot \mu_{cb}$$

Prices under a FBMC: an example



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

- Price relation under FB:

$$MCP_C - MCP_A = \left(PTDF_A - PTDF_C\right) \cdot \mu$$

- Shadow price equals μ = 15 €/MW

$$40 - 30 = (0.67 - 0) \cdot 15$$

- Price in area B:

$$MCP_B - MCP_A = \left(PTDF_A - PTDF_B\right) \cdot \mu$$

$$MCP_B - 30 = (0.67 - 0.33) \cdot 15$$

$$MCP_B = 35$$

Prices under a FBMC: consequences

- In case there is no congestion, all bidding zones have the same price
- In case of congestion, the prices of the bidding zones are set in accordance to their electrical impact on the binding constraint (i.e. the PTDF factors)

Questions?

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