SEERMAP

South-East Europe Electricity Roadmap

Introduction to cross-border capacities – economic and technical characteristics

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SEERMAP Network Training

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REKK FOUNDATION

Lecture outline

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- Characteristics of electricity transmission
  - Network losses
  - Service quality
  - Physical vs. commercial flow
- Role of interconnectors – economic considerations
- Capacity allocation methods
  - Administrative
  - Explicit, NTC based auctions
  - Market coupling
  - Flow-based auctions
- CBC investment

Characteristics of electricity transmission

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- Electricity transmission is a natural monopoly
  - Transmission and distribution tariffs are regulated
- Electricity transmission capacities are limited
  - congestion management is needed
- Between countries transmission capacities are usually more constrained
  - These lines have been planned due to security reasons and not to commercial aim
- Electricity follows physical rules, not commercial arrangements in the transmission network
  - Commercial transactions and physical flows are often decoupled

Network losses

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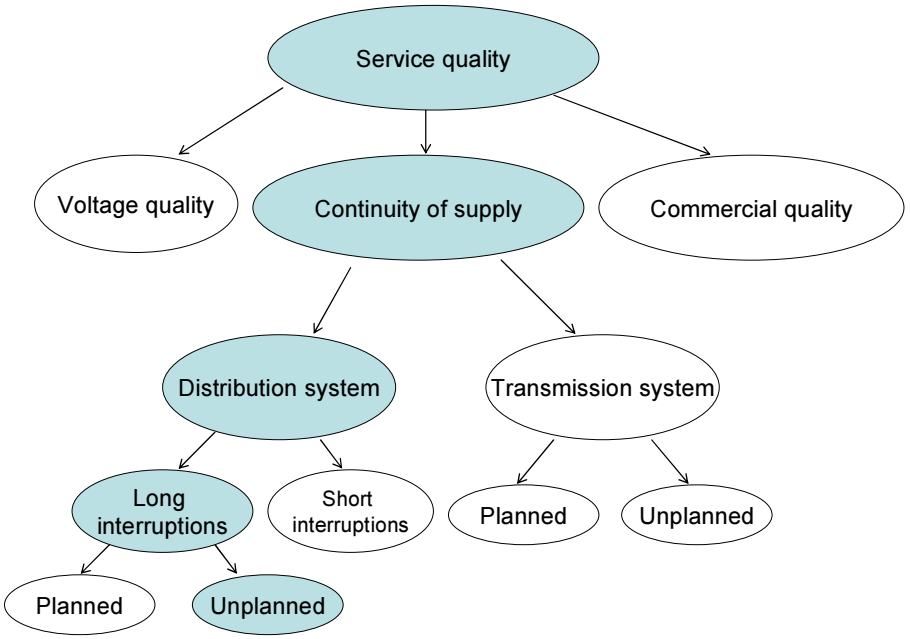
- Network losses dependent on:
  - On voltage level: higher voltage level means less losses
  - Length: the longer route means higher losses
  - Lower in underground cable
- Transmission losses:
  - ~2-4 % of the generated electricity
- Distribution losses:
  - Technical and commercial losses (not billed or not paid)
  - 4-9 % of the generated electricity

Service quality



Name	Short Form	Units of measurement
System Average Interruption Duration Index	SAIDI	Minutes per customer per year
System Average Interruption Frequency Index	SAIFI	Interruptions per customer per year
Customer Average Interruption Duration Index	CAIDI	Minutes per interruption
Energy Not Supplied	ENS	GWh

Characteristics of electricity flow

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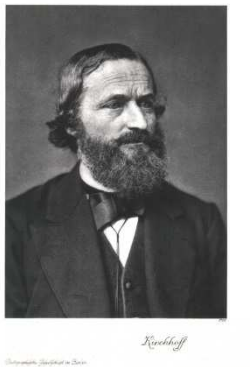
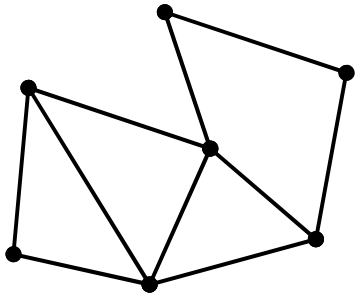
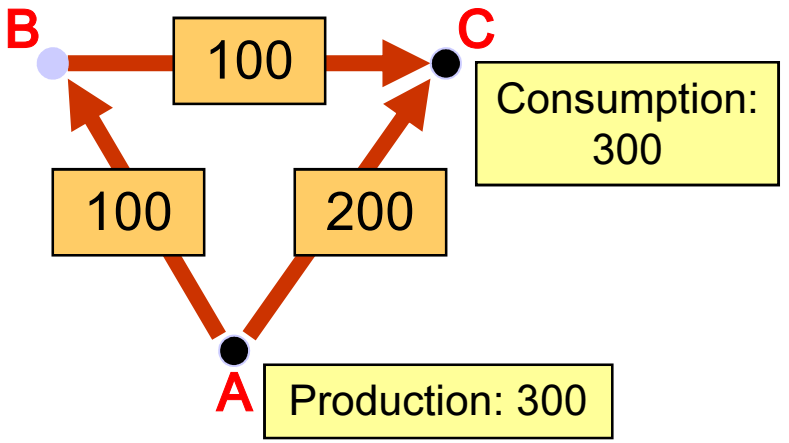


Network is the aggregation of nodes and lines. Nodes include generation and consumption, while in the lines flow the electricity.



Kirchhoff's 1st (Current) Law: The current flow into any point (node) in a circuit equals the current flow out.

•Kirchhoff's 2nd (Voltage) Law: Kirchhoff's Voltage Law states that power flowing from node A to node B on a network distributes itself along all parallel paths between the two points, roughly in inverse proportion to the impedance/resistance of each path.



PTDF (Power Transfer Distribution Factor) matrix

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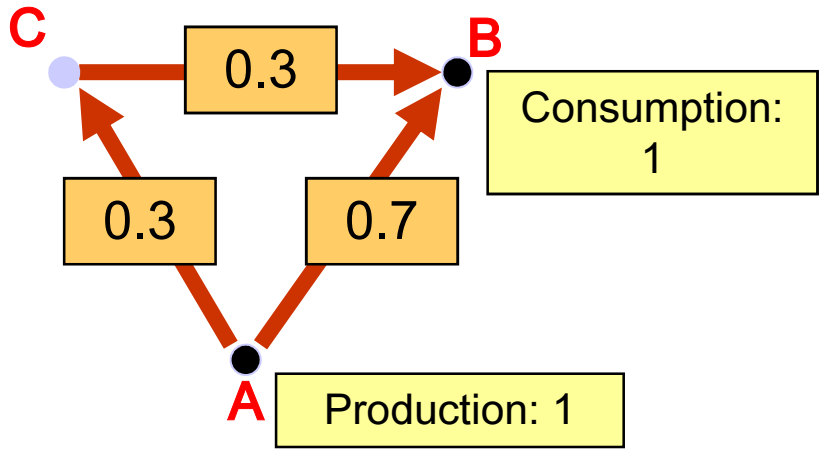
		Physical		
		A->B	A->C	B->C
Commercial	A->B	0,7	0,3	-0,3
	A->C	0,3	0,7	0,3
	B->C	-0,3	0,3	0,7



A real PTDF matrix: 100 MW electricity export from HU to AT

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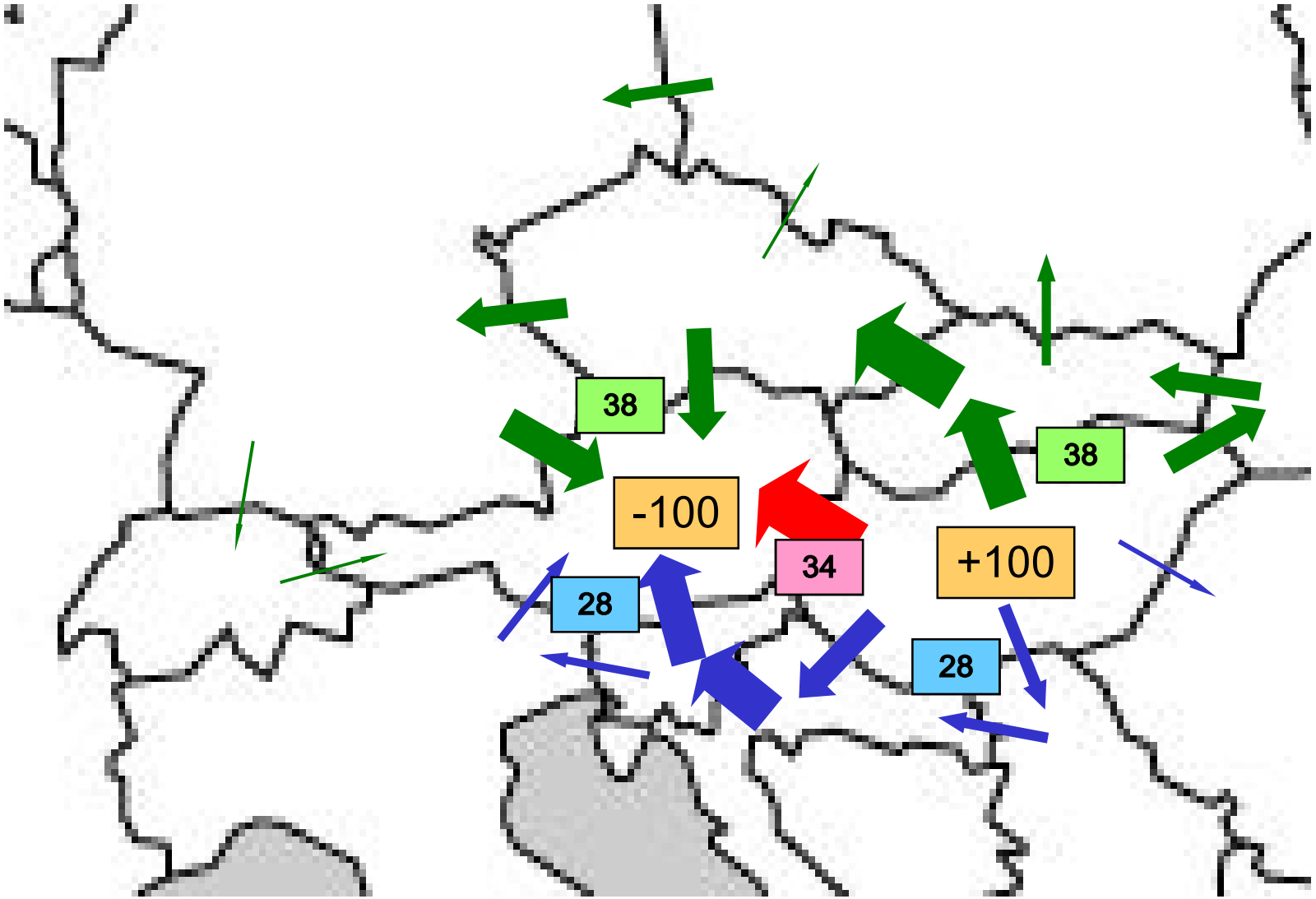

Different types of electricity flows

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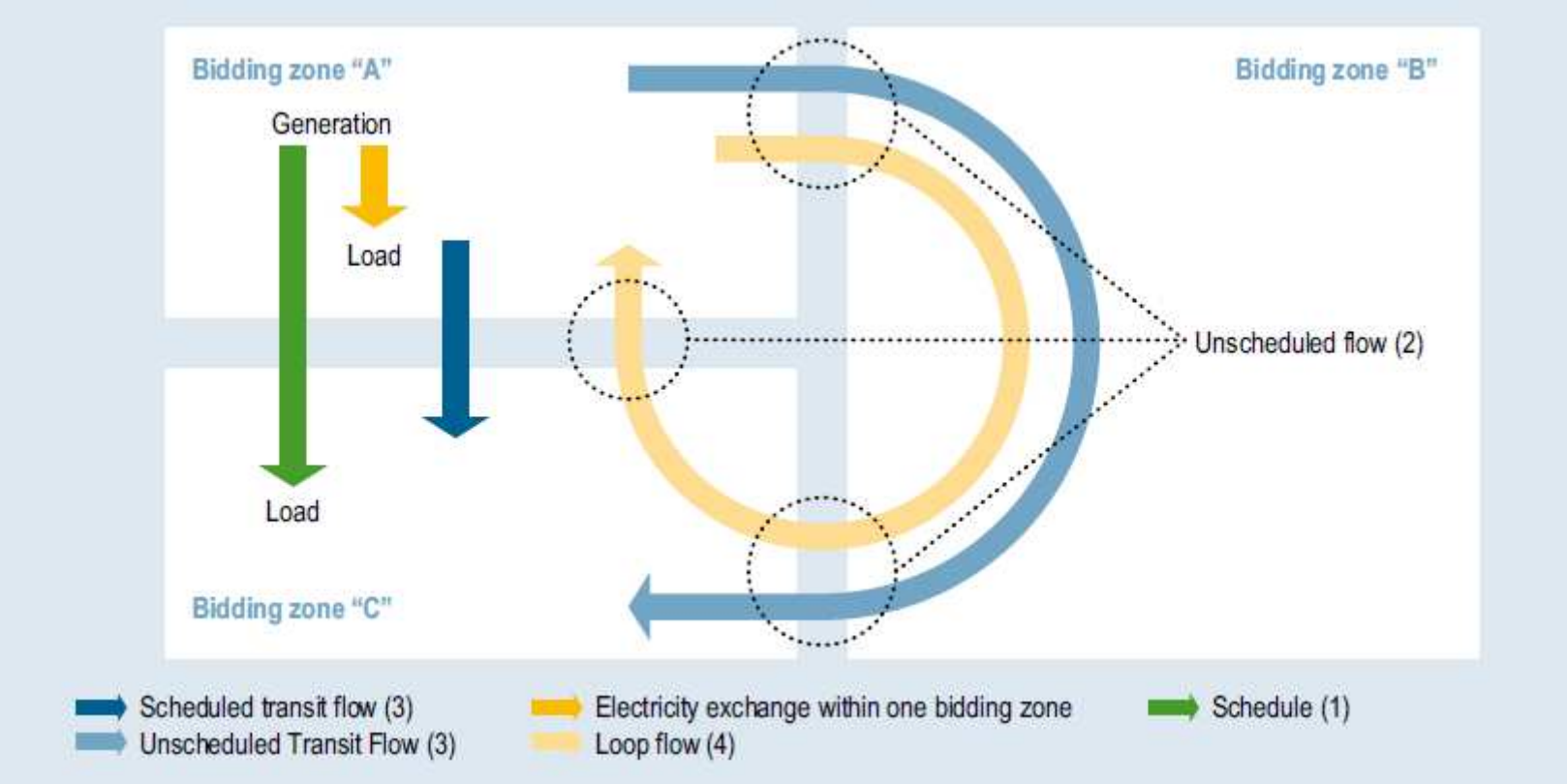

Source: ACER

Average unscheduled flow indicator, 2015 (MW)

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Source: ACER, 2016

Physical vs. commercial flows

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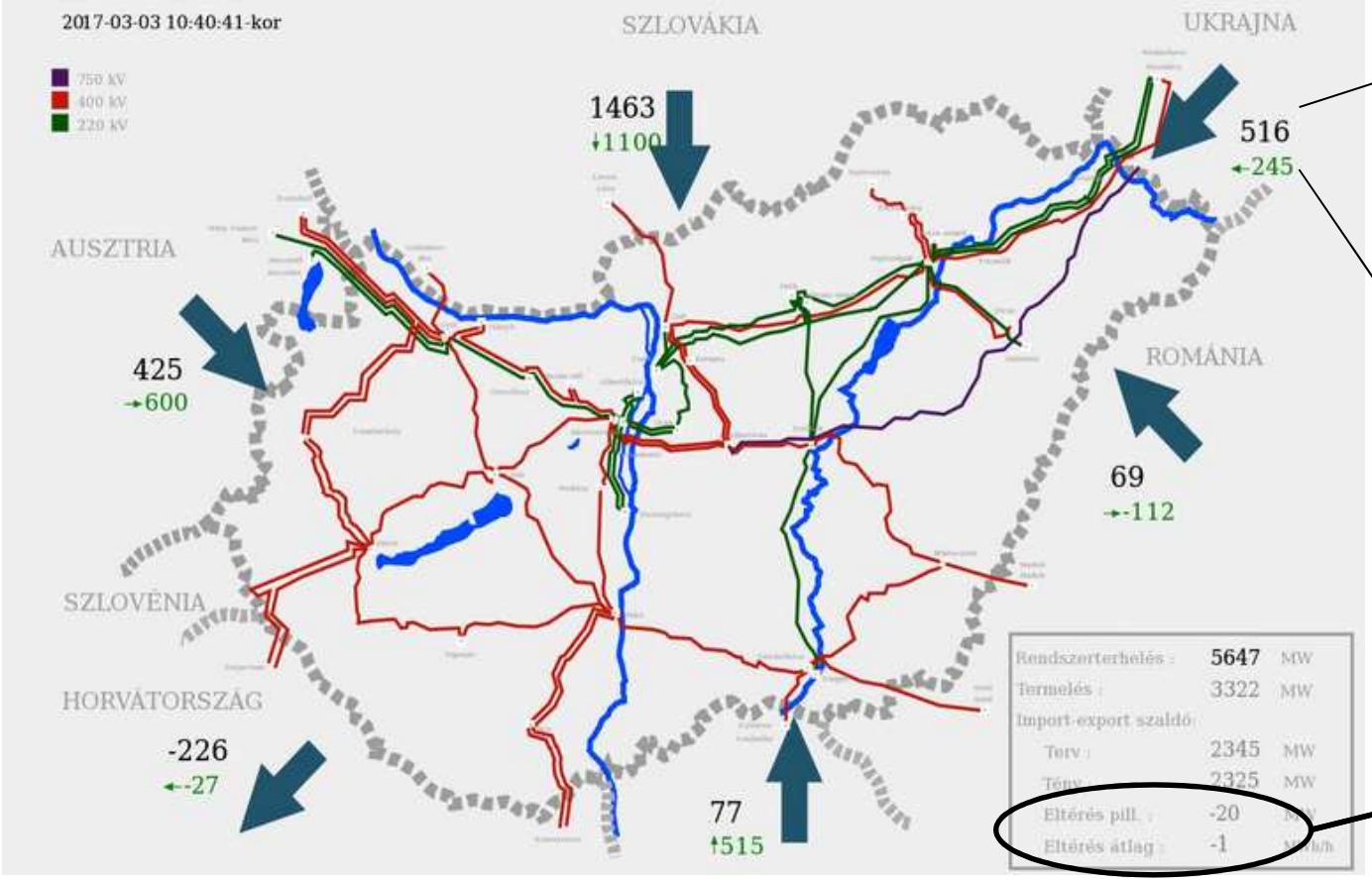


Physical flow

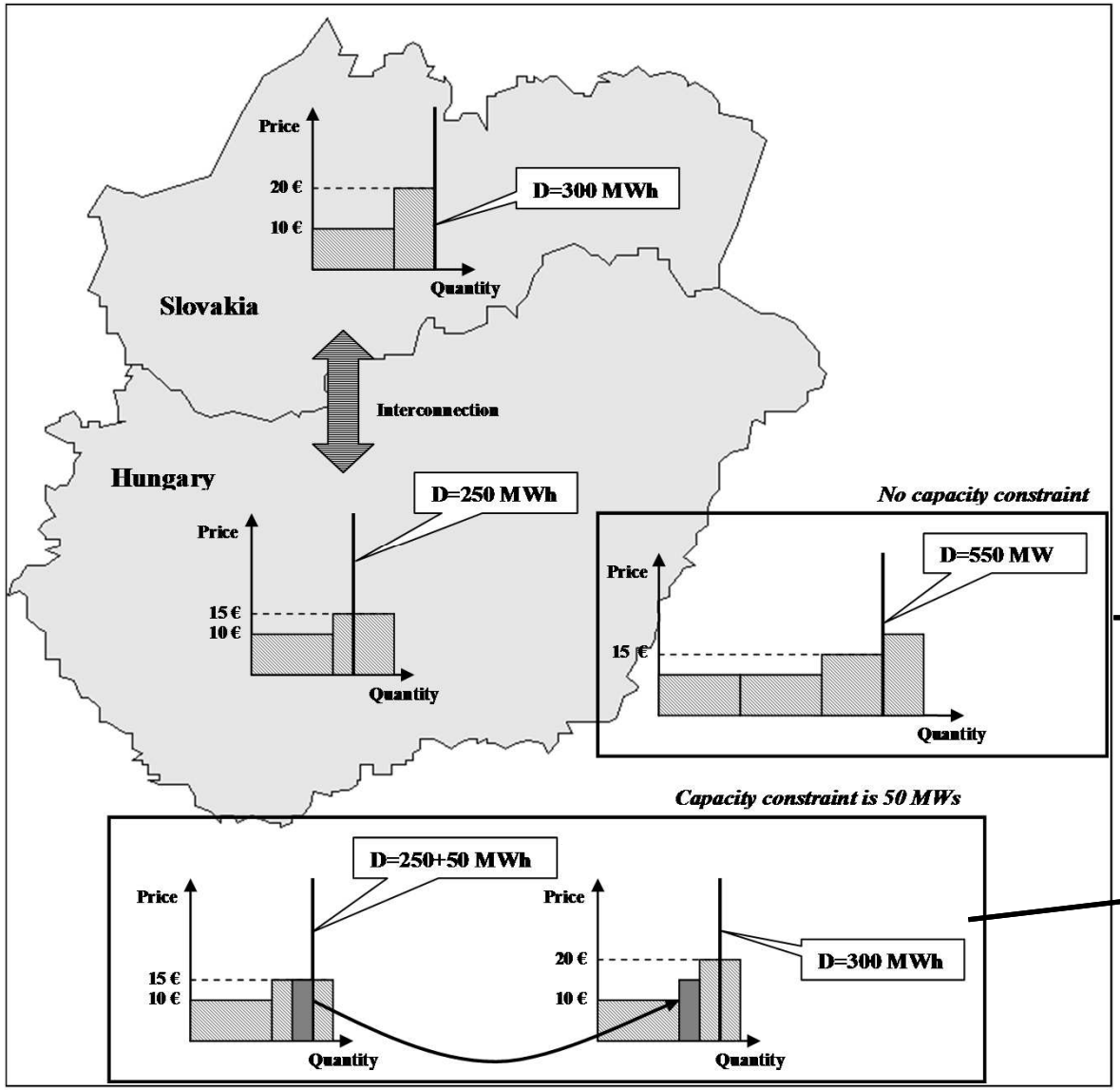
Commercial flow

Difference of net commercial and net physical flows almost zero

Source: MAVIR, 2017-03-03

Role of interconnectors – economic considerations

Congestion pricing example

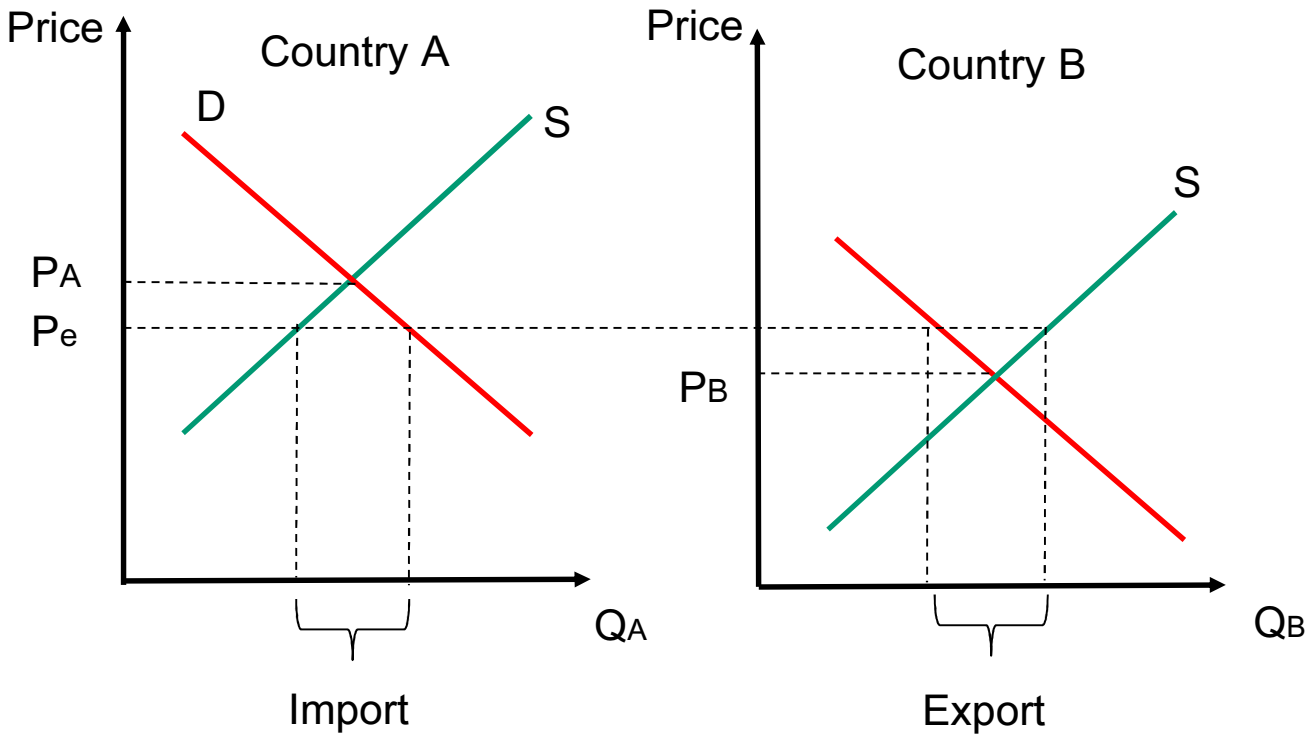


What is the price of cross border transmission capacity right?

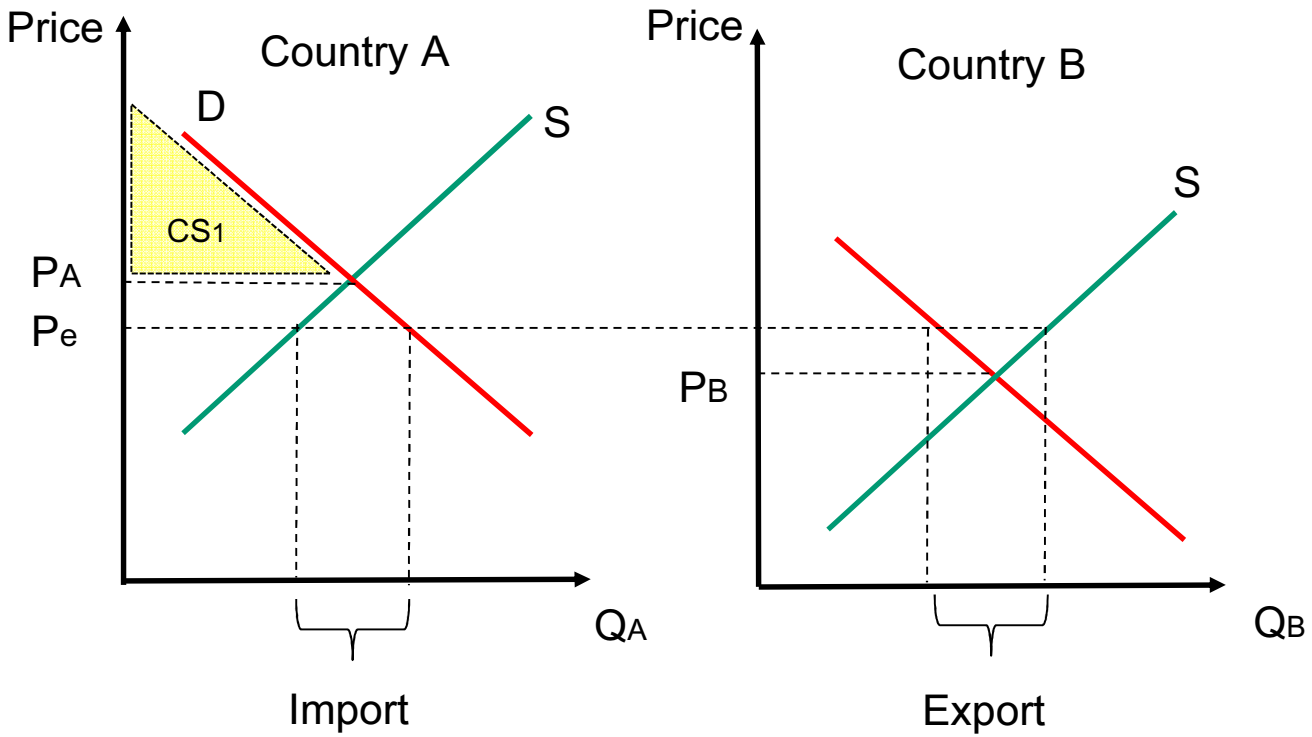
→ ?

→ ?

Trade – price equalisation



Consumer surplus 1



Consumer surplus (CS):

Consumer surplus is the difference between the maximum price a consumer is willing to pay and the actual price they do pay.

Consumer surplus 2

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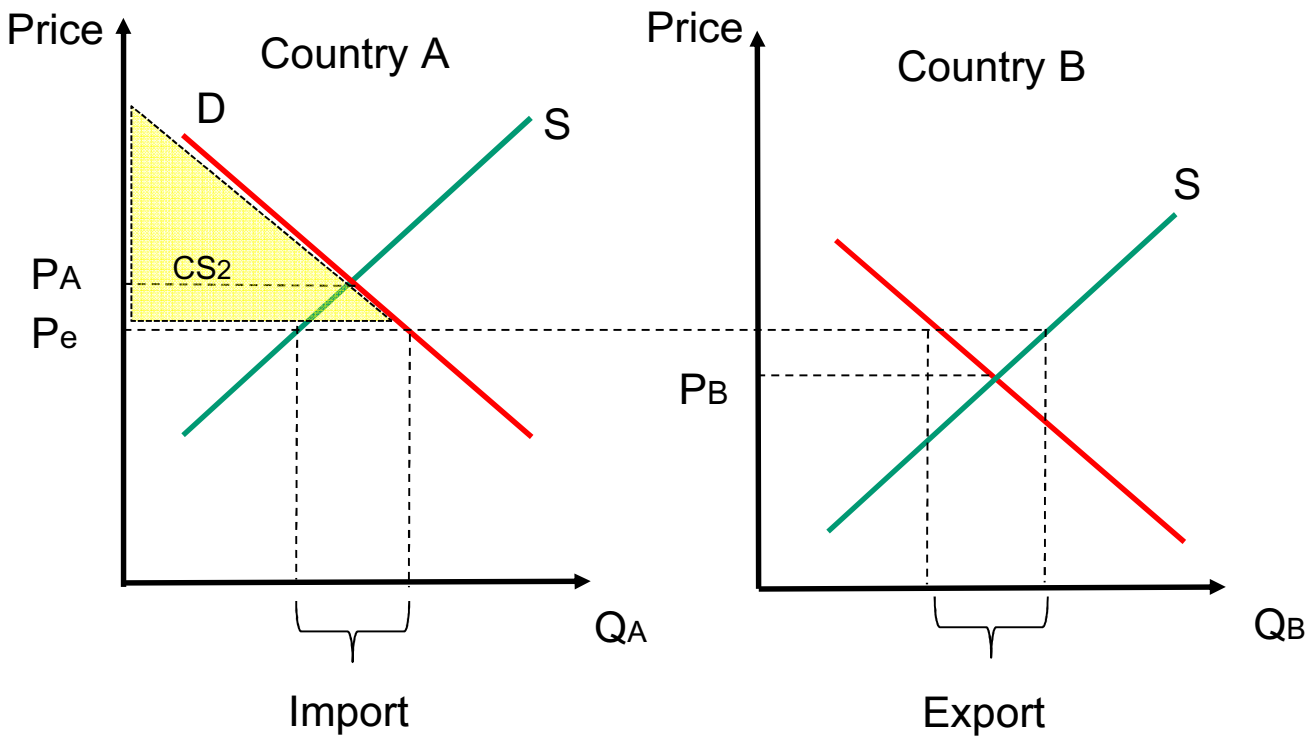

Why interconnections are important? I.

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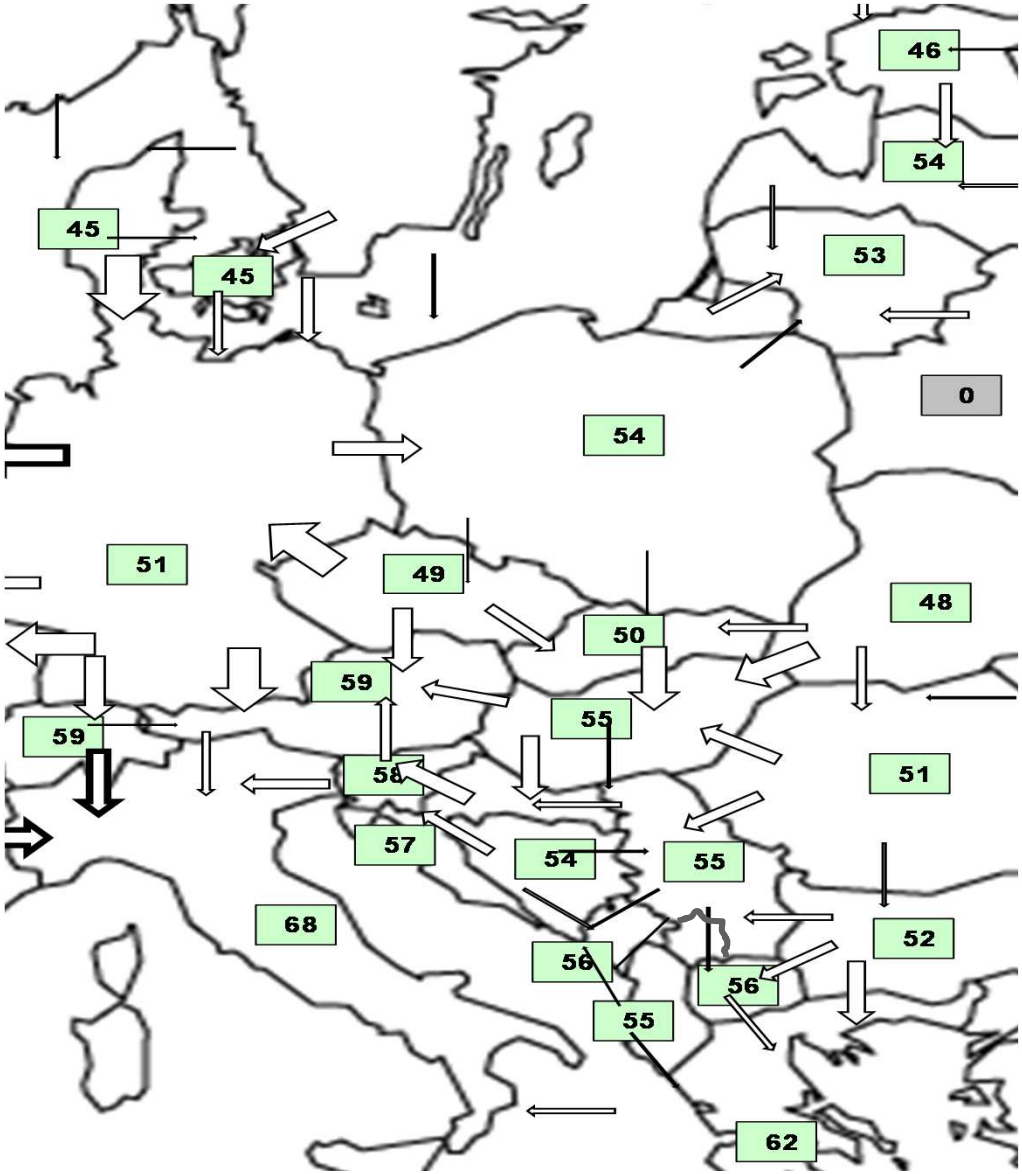

- The picture shows a simulated European Electricity Market (for 2014)
- Yearly baseload prices and commercial trade (boxes) flows are (arrows) depicted
- Average baseload prices vary between 40-70 €/MWh

Why interconnections are important? II.

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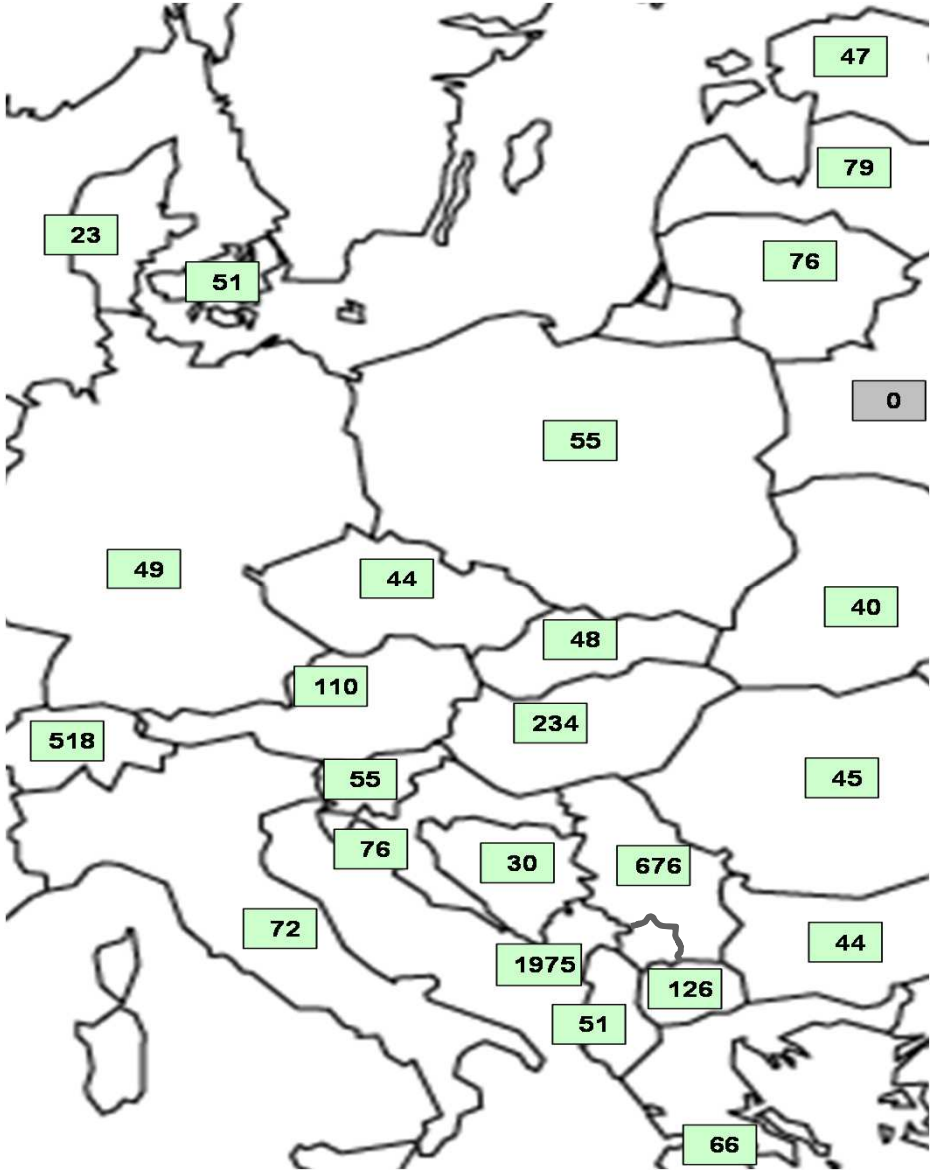

- Yearly baseload prices and commercial trade (boxes) flows are (arrows) depicted – Zero tarde assumptions!

- In some countries price goes down, e.g.
  - RO: 51-> 45
  - BG: 52-> 44
  - CZ: 49-> 44
  - BiH: 54-> 30
- In some countries extreme high prices can be visible
  - HU: 55->234
  - SR: 55->676
  - MK: 56->126
  - In these countries demand curtailment is needed

ROLE of TSOs

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- They are the responsible parties for building up new cross-border connection lines.
- How they could be made interested to reduce congestions – which will reduce their congestion rents?
- Classic economic problem: deliver a **public good**, where the main responsible to delver the good is not incentivised - or even negatively affected!
- EU answer:
  - Congestion rents must be used to develop CBC lines, where congestion occurs
  - There is also a planned 10% rule, where national CBC capacities must be increase to reach at least 10 % of production by 2020.
  - PCI process as well to help these developments
  - ENTSO-E 10 year development plan
  - Possibility to build up commercial line – where for some years the fundamental rule of third party access can be lifted – so all user will pay, even if no congestion exists (e.g. Eastlink line)

Congestion revenues - 2015

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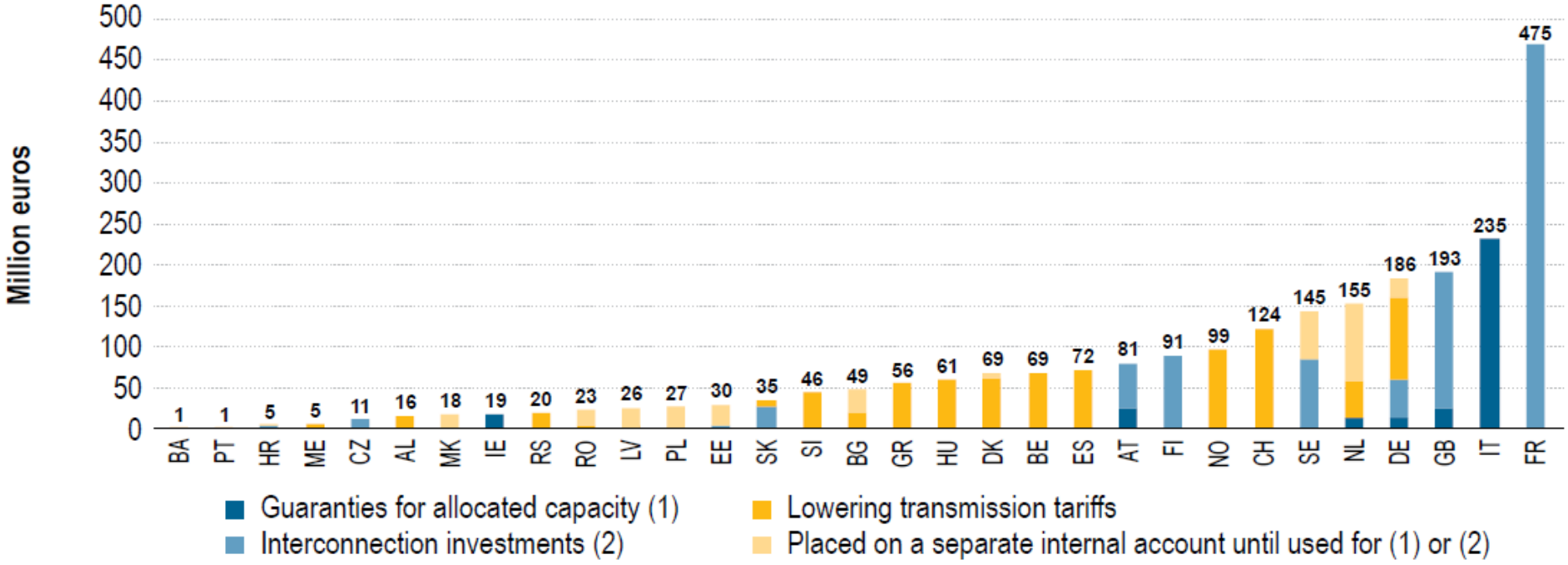
EU regulation: congestion rent must go to network development or lowering transmission tariffs:



Source: ACER MMR 2016, ENTSO-E

10 % rule for 2020?

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Country	CBC/ generation capacty
Albania	48%
Bosnia and Herzegovina	30%
Bulgaria	11%
Greece	9%
Croatia	55%
Kosovo*	na
Montenegro	167%
Macedonia	36%
Romania	6%
Serbia	44%

- Most SEE countries have no problem with the rule they inherited rather strong connections with the neighbours
- But lines are old, many needs replacement
- EU members Greece and Romania are rather week in this sense

Capacity allocation methods

Usual way to determine available cross-border transmission capacity

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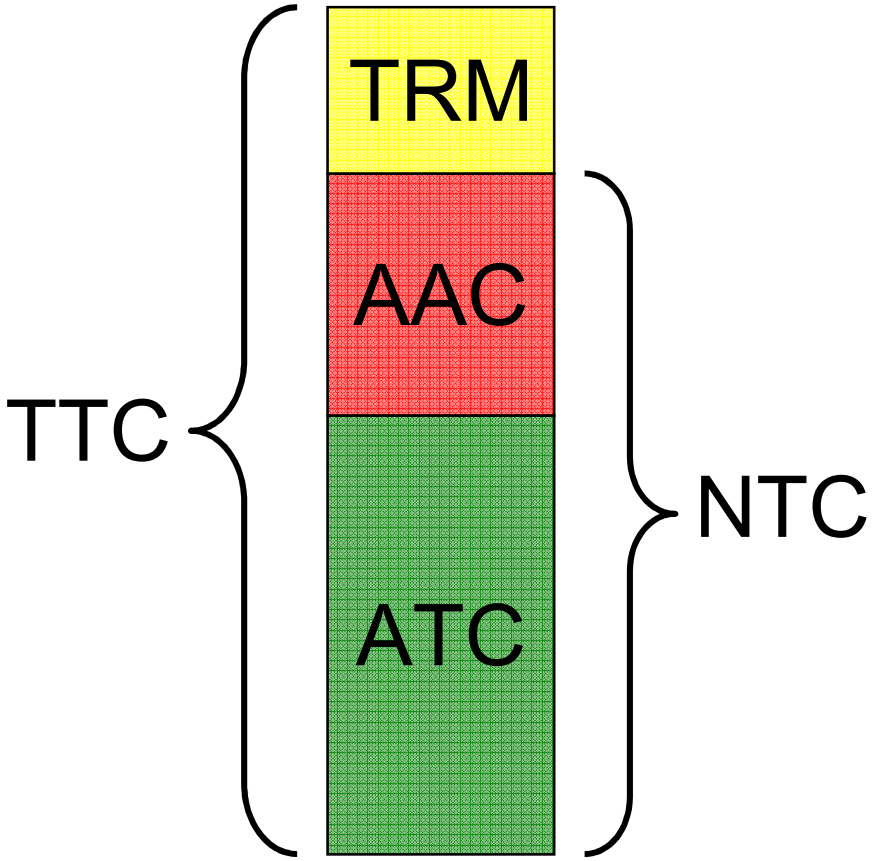

Total transfer capacity (TTC): The maximum possible exchange between two compatible areas.
Transmission Reliability Margin (TRM): Security margin which copes with uncertainties.
Net Transfer Capacity (NTC): Maximum possible exchange between two areas taking into account uncertainties, thus NTC = TTC – TRM.
Already Allocated Capacity (AAC): The total amount of allocated transmission rights prior to auctioning.
Available Transmission Capacity (ATC): The remaining part of NTC, which is auctioned to market participants. ATC = NTC – AAC.
(*The definitions are based on ENTSO -E terminology.*)

NTC matrix, MW

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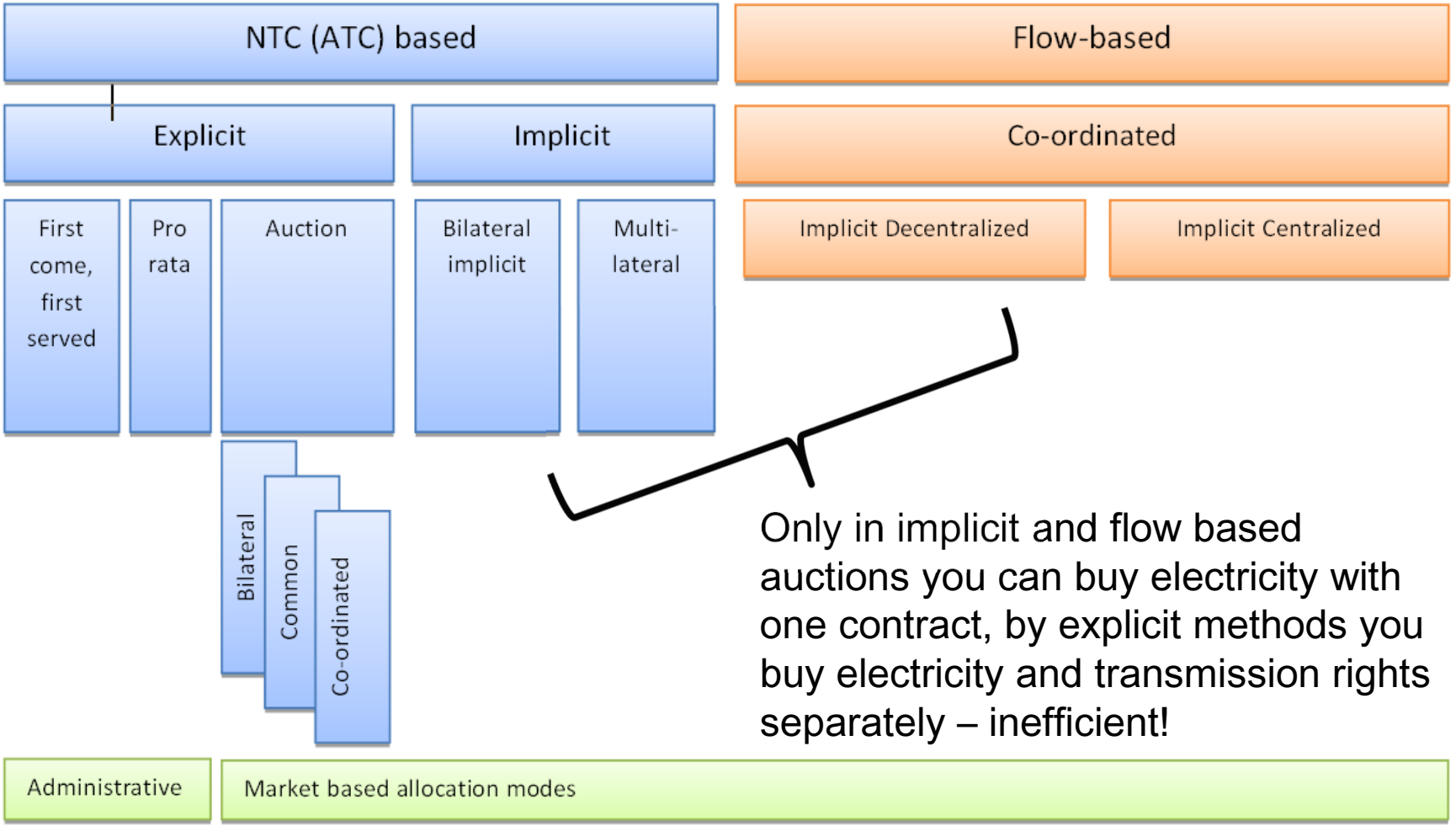
From / To	IE/NI	GB	MA	PT	ES	FR	BE	NL	LU	DE	DKw	DKe	NO
IE/NI		450											
GB	80					2000							
MA					900 MA								
PT					1700								
ES			600 MA	1500		1300							
FR		2000			500		2300			3200			
BE						3400		2400					
NL							2400			3850			
LU										980			
DE						2700		3000	NRL		1500	585 800 DE	
DKw										950			950 NO
DKe										600			
NO											950 NO		
SE										600	740	1700	3595

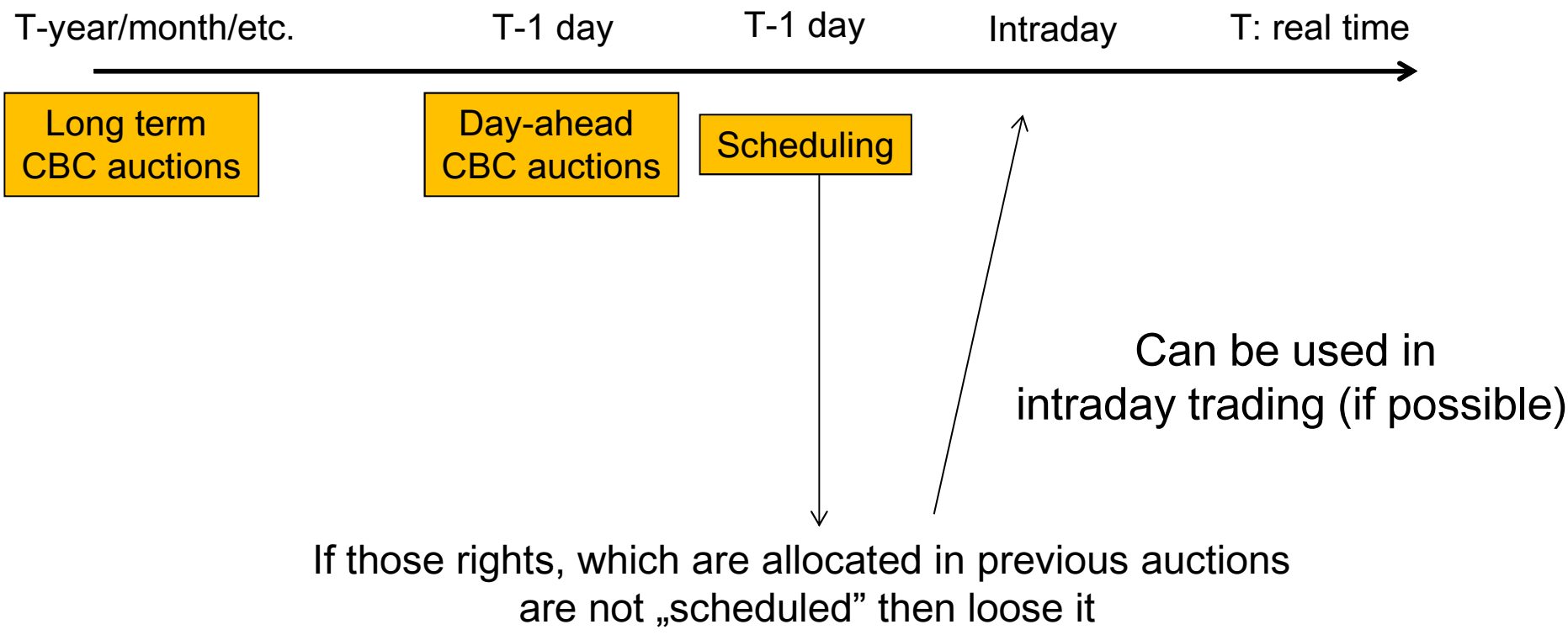
Source: ENTSO-E, 2014

DE TSO can accept 800 MW; DKe only 585 MW; the latter one can be distributed

Capacity allocation methods



„Use it or loose it" principle



Administrative allocation methods

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- First come, first served
  - If no congestion exist
  - Intraday market
- Pro rata
  - Cross border capacity rights are allocated according to the bid
  - E.g.:
    - Total ATC – 75 MW;
    - Two market player:
      - Company „A” bid: 50 MW
      - Company „B” bid: 100 MW
    - Allocated capacity right
      - Company „A”: 25 MW
      - Company „B”: 50 MW
  - Not commonly used, because of strategic behavior
    - Company „A” would like to win 50 MW, but its bid is 200 MW in order to win 50 MW

Explicit NTC based allocation method I.

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- Bilateral
  - Two capacity rights are needed to import/export
    - E.g.: If a trader would like to export from Ukraine to Hungary, then capacity right is needed from UA TSO and HU TSO as well
  - Separate: 50-50 % allocated by the neighboring TSOs in separate auction(s)
- Common/joint
  - One TSO allocated the full capacity
  - Distribution of revenues: 50-50 %

Yearly and monthly cross border auctions in SEE in 2015 (MMR 2016)

Border	Yearly	Monthly	Daily	ID
AT-HU	PC	PC	PC	
BG-GR	PC	PC		
BG-RO	PC	PC		
GR-IT	BIL	BIL		
HR-HU	BIL	BIL		
HU-RO	PC	PC		
HU-SK	PC	PC	PC	

BIL: Bilateral (separate NTC calculation)
PC: Partially coordinated (common calculation, but not all affected borders are considered)

Explicit NTC based allocation method II.

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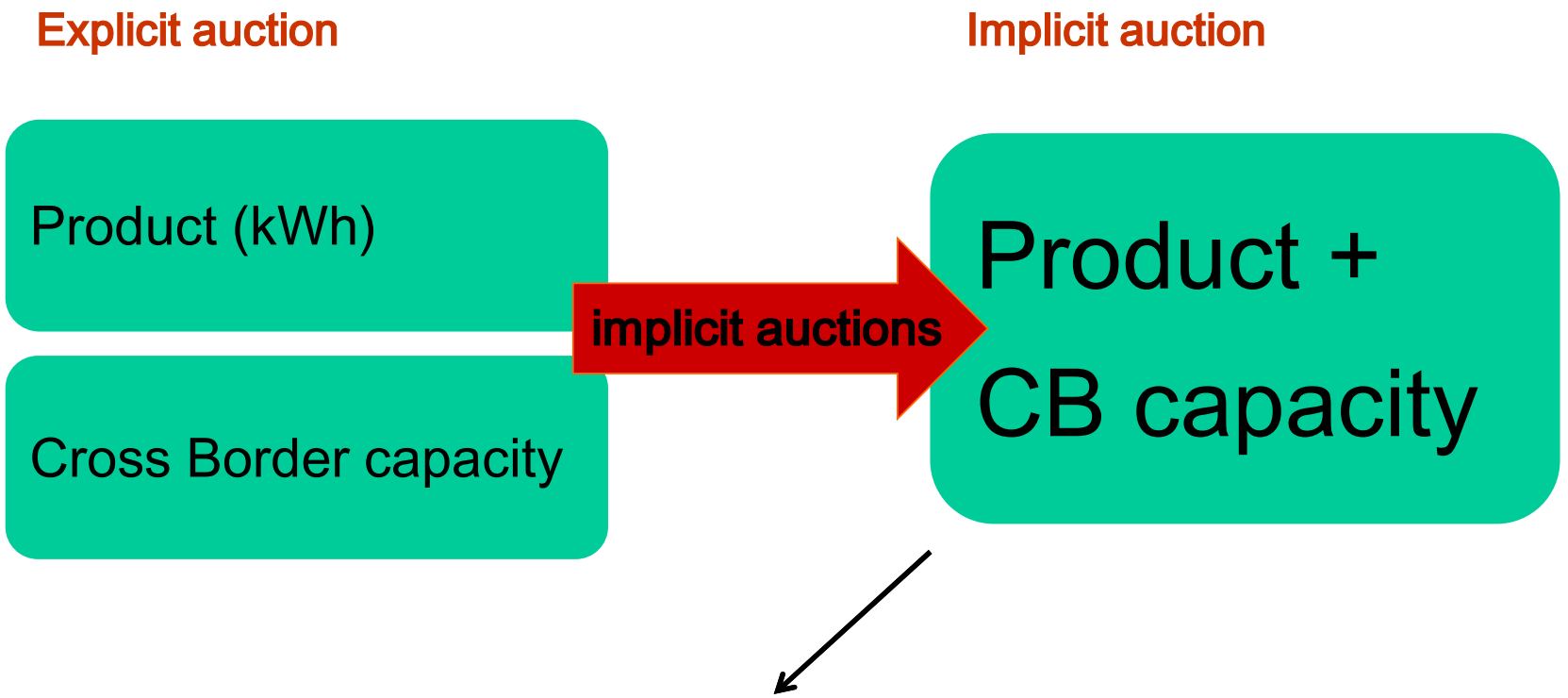
- Co-ordinated
  - Three or more TSOs organize common auctions
  - More efficient allocation
  - E.g.: Central Allocation Office

Implicit auctions



- Lower risk
- Higher utilization rate
- Help the market integration

CZ-SK-HU Market coupling

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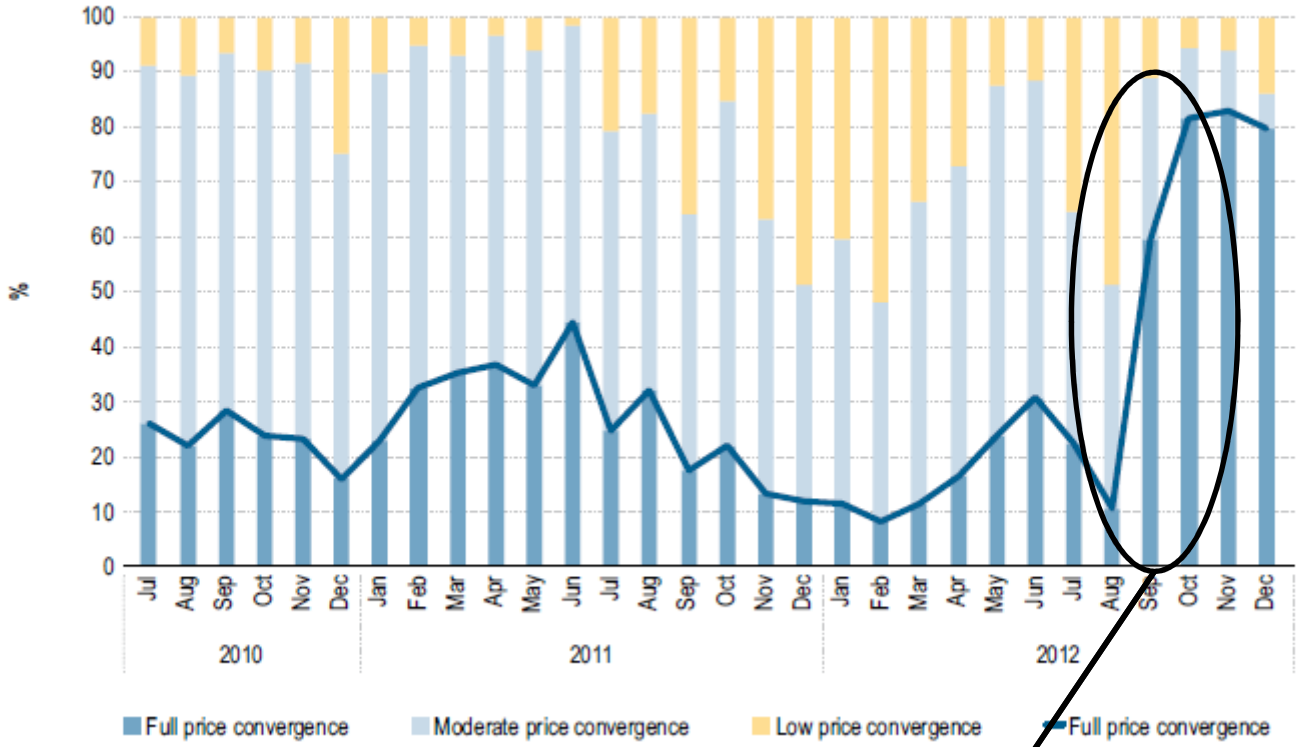
Figure 16: Price convergence between the Czech Republic, Hungary and Slovakia – July 2010 to December 2012 (%)



Source: Platts, OKTE and HUPX (2013) and ACER calculations

Launch of trilateral MC

Flow-based auctions

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1. Step: Determine the reference flow (without flow-based auctions), and the technical limit of a given line
2. Step: determine the PTDF matrix

	Reference flow	Technical limit
A->B	10	20
A->C	30	50
B->C	20	40

		Physical		
		A->B	A->C	B->C
Commercial	A->B	0,7	0,3	-0,3
	A->C	0,3	0,7	0,3
	B->C	-0,3	0,3	0,7

3. Step: Bidding

Trader	From	To	Quantity (MW)	Price (€/MW)
1.	A	B	20	80
2.	B	A	50	100
3.	A	C	60	50
4.	C	B	40	30

4. Step: Impacts of the bid to the physical flows
5. Step: Reduce the congestion in border A-C
   -> 1. trader or 3. trader can decrease it;
   3. trader bid is cheaper -> curtail to 58 MW instead of 60 MW

	A->B	A->C	B->C
1. trader	14	6	-6
2. trader	-35	-15	15
3. trader	18	42	18
4. trader	12	-12	-28
Total trading	9	21	-1
Reference flow	10	30	20
Total flow	19	51	19
Max. capacity	20	50	40

6. Step: 1. trader and 3. trader pays 50 €/MW, because they cause the congestion

Summary of CBC auctions

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		Frequency of auction	Cooperation of TSOs
NTC based auction	First come first served	Intraday	Weak
	Pro rata	Complementary tool	Weak
	Bilateral explicit auction	Daily/monthly/yearly	Weak/medium
	Common explicit auction	Daily/monthly/yearly	Medium
	Co-ordinated auction	Daily/monthly/yearly	Strong
	Bilateral implicit auction	Daily	Strong
	Implicit multilateral	Daily	Strong
Flow-based auction	Explicit auction	Daily	Very strong
	Implicit auction	Daily	Very strong

And where do we stand with CBC development in Europe?

Cross-border investments in Europe till 2012

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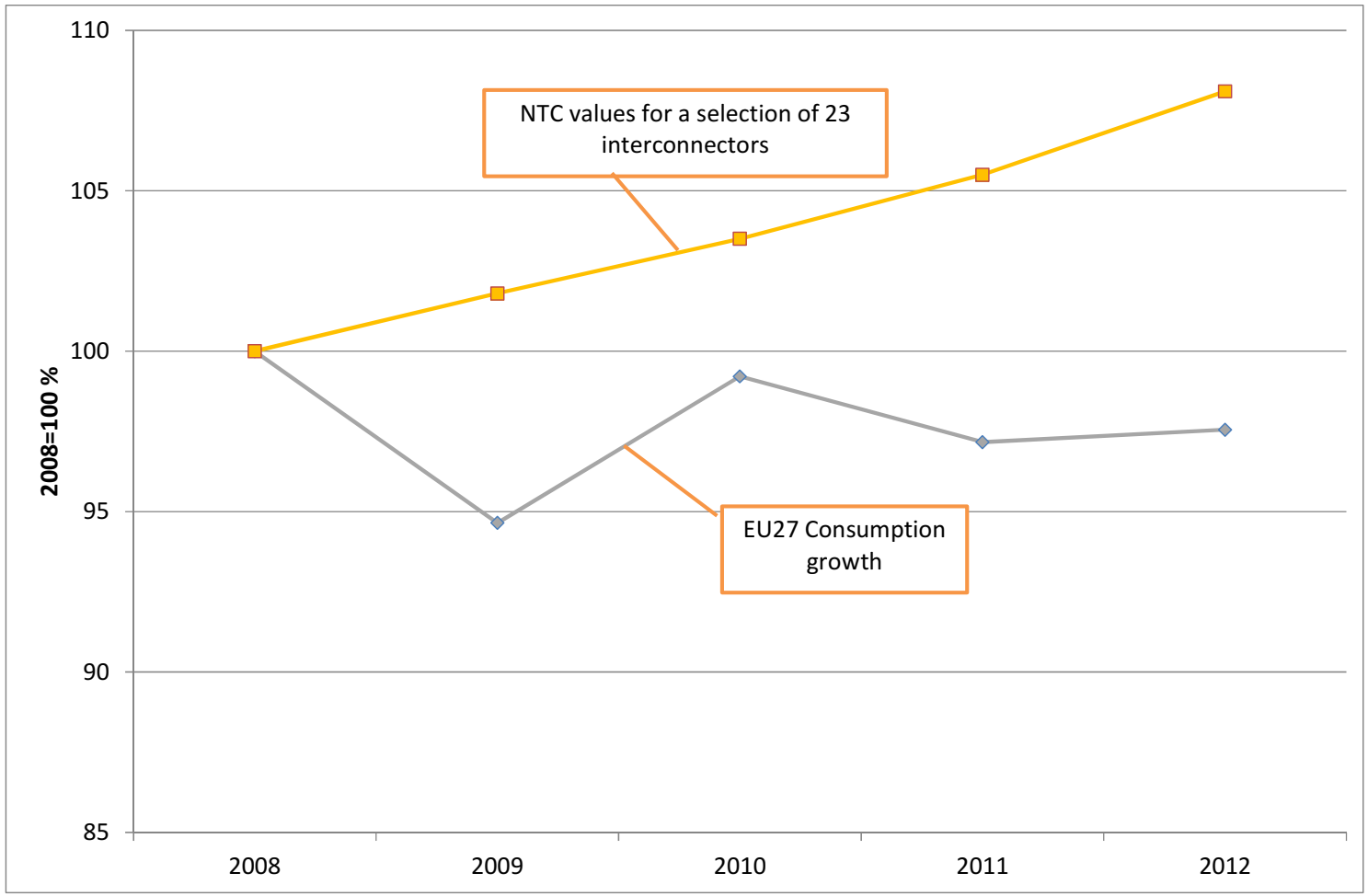

Aggregated NTC – 2010-2015

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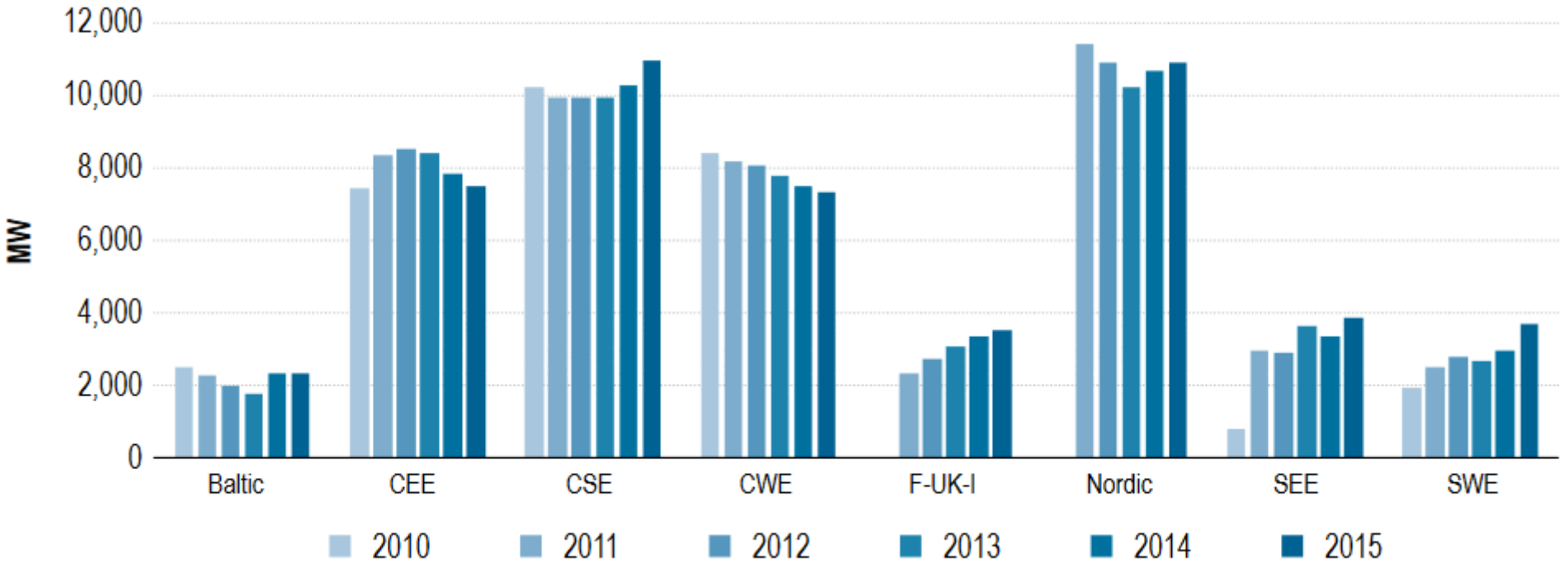

Source: ACER MMR 2015, ENTSO-E

NTC/physical capacities 2015

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- Although many incentives exist to increase NTC to physical capacity ratio, some region lags behind
- National interest of self-sufficiency frequently undermine overall economic welfare
- In SEE this ratio is the lowest in ENTSO-E!

HVAC/HVDC	Region	Tradable capacities (MW)	Physical capacities (MVA)	Ratio
HVAC	NORDIC	6,164	13,242	46.5%
	BALTIC	1,431	4,010	35.7%
	CWE	7,352	26,930	27.3%
	SWE	3,687	11,638	31.7%
	CSE	12,104	42,016	28.8%
	CEE	7,493	31,873	23.5%
	SEE	2,403	14,884	16.1%
HVDC	F-UK-I	3,303	3,500	94.4%
	BALTIC	913	1,000	91.3%
	CSE	384	500	76.7%
	NORDIC	4,741	6,130	77.3%

Source: ACER MMR 2016, ENTSO-E

Summary

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- Difficulties in determining NTCs – this has high impacts on trade and on consumer prices as well! Regulatory issues are serious, as consumers, producers will be significantly affected!
- Distributional effects are always to be considered! Multi-agent decision making is required!

- Low incentives on TSOs to develop CBC – but EU rules promote its further development:
  - PCI and PECI process
  - 10 % rule for 2020
  - Rules on the use of congestion rents!

THANK YOU FOR YOUR ATTENTION!

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