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ELECTRICITY TRADING AND ELECTRICITY MARKETS

Courses: MEB412 Technicko-ekonomické aspekty energetiky II and ESS421 Energy Commodities I

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CONTENT


PART
ONE

Electricity as a commodity

- Electricity is a specific type of commodity:
  - It cannot be stored in large quantities in economically efficient manner
  - It flows through the least-resistance route in line with laws of physics
  - Its transport is dependent on a fixed network
  - Each unit is qualitatively identical (irrespective of the source)

- All of these characteristics have implications for the way electricity is traded as well as the whole electricity market design

Wholesale vs Retail market

- Retail market - supply to the end-users with regulated prices consisting of several tariff elements besides the actual cost of electricity – e.g. market operator, system services, renewables and cogeneration, distribution and transmission

- Wholesale market - end-users usually do not direct act on this type of market – primary purpose is B2B, wholesale prices are not regulated – energy-only prices reflecting short-run marginal costs of generation as well as actual demand and supply...(?)

Trading models

When?

- Long-term vs. short term (day-ahead, intraday, balancing)

Where?

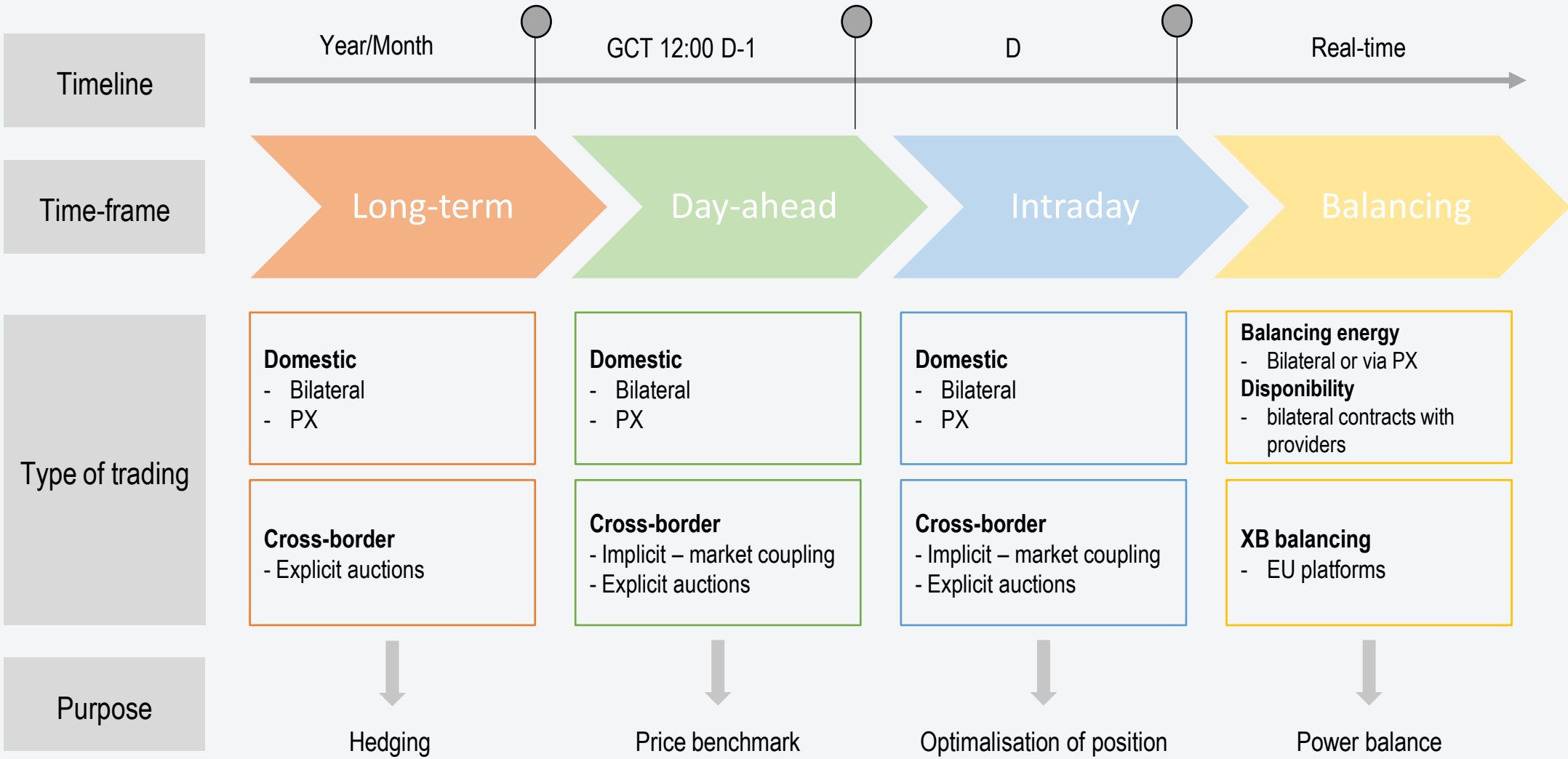
- Domestic vs. Cross-border (XB) trading
- XB can be based on implicit vs. explicit allocation of capacity

How?

- organized (power exchange)
  - auction
  - continuous trading
- bilateral (OTC, broker)

*Based on the specific trading model and corresponding timeframe – different types of products

Market sequence – only one electricity market?



EU legislative framework

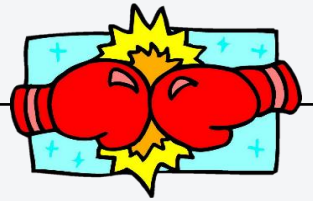
Legislative packages 1996 – 2003 – 2009

Network Codes
* Art. 6 of 714/2009

Connection Codes
- HVDC Connections
- Requirements for Generators
- Demand Connection

Operations Codes
- System Operations
- Emergency and Restoration

Market Codes – „target model“
- Forward Capacity Allocation
- Capacity Allocation & Congestionn Management
- Electricity Balancing



- Long-term
- Day-ahead
- Intraday
- Balancing

Clean Energy Package

Market actors

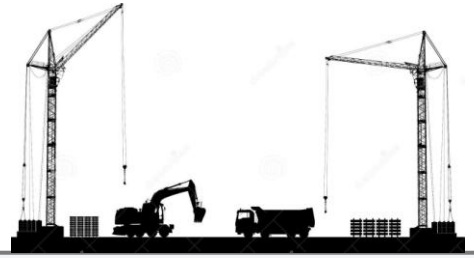
Different roles - same vision

Architects of the market

- EU Institutions
- Member States
- ACER
- National regulatory authorities (NRAs)

Builders and managers

- TSOs
- ENTSO-E
- NEMOs
- NEMO Committee
- Common governance structures



Players a.k.a Market participants

- Individual generators/large consumers
- Traders and suppliers
- Unions and associations

Q&A


PART
TWO

Long-term market 1/4

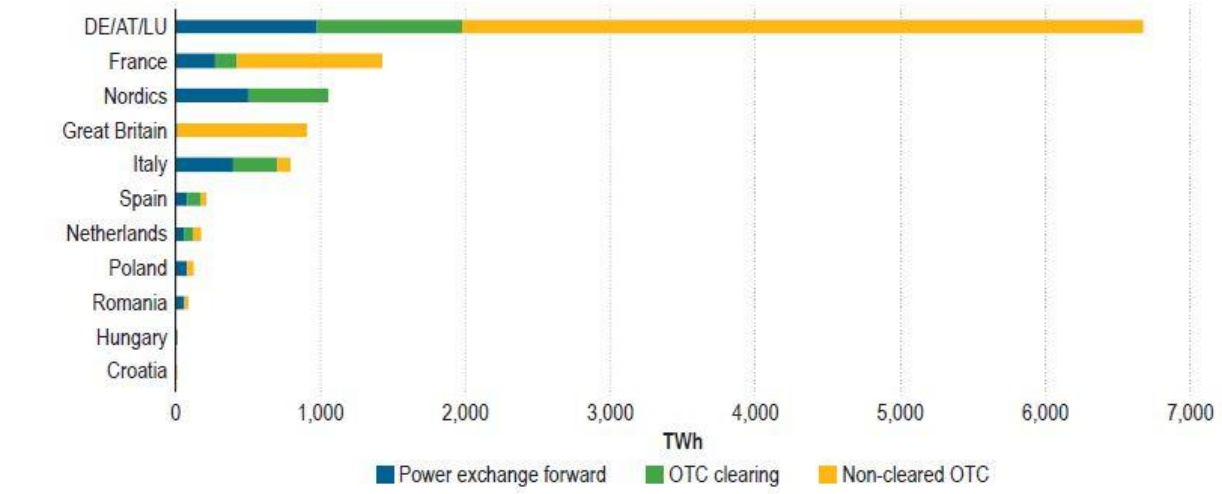
What is traded?

- **Electricity** → the structure of forward markets varies widely across Europe – domestic and cross border
  - Trading of electricity for periods longer than one day
  - Forwards/futures market – via power exchanges and broker platforms/OTC contracts

OTC trades (with/without broker) – counterparties known to each other, bilaterally agreed contractual basis → physical delivery

Power Exchange – anonymised and standardised trading in accordance with PX trading and settlement rules → physical delivery or financial instruments

Figure 20: Forward market trading volumes per type in the biggest European forward markets – 2017 (TWh)



Source: European Power Trading 2017 report, © Prospex Research Ltd and NRAs (2018).

Between 2016 and 2017

- the most liquid markets – DE/AT/LU, Nordic, FR, IT GB – large BZs with relatively low market concentration and higher level of market integration or unique market design
- the main increases Romania (+19%), the Netherlands (+10%) and Italy (+9%);
- large decreases Poland (-43%), Great Britain (-30%), the Nordic markets (-26%) and France (-23%).

Source:

Long-term market 2/4

What is traded (cross-border relevant only)?

Transmission capacity via (at least) Yearly and Monthly auctions

Allocation of transmission capacity based on **FCA target model** - **2 Steps**:

1. Coordinated capacity calculation

2. Long-term Transmission Rights (LTTRs) allocation via Single Allocation Platform

Today:

- capacity calculation bilaterally coordinated = not in line with FCA target model - on majority of BZBs (66% in month-ahead and 64% in year-ahead)
- Long-term capacity allocation - **Single Allocation Platform (the Joint Allocation Office)** performs auctions at 77% of the borders with long-term capacity allocation

Long-term market 3/4

How is the transmission capacity traded?

Long-term transmission rights (LTTRs)

- Regional design of LTTRs – NRA decision on the type of transmission right to be issued on the BZB
- hedging opportunities for market participants – with/without physical nomination
- Secured price/availability of transmission capacity

2 TYPES:

Physical Transmission Rights (PTRs)

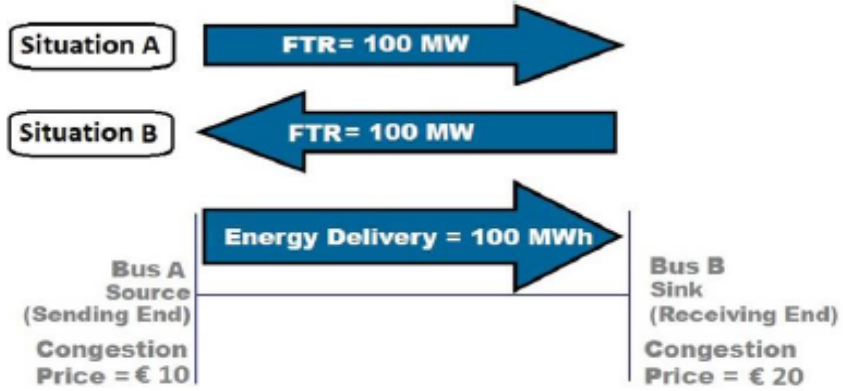
- PTRs give the holder the right to nominate physical transaction between the bidding zones (i.e. right to nominate cross-zonal capacity utilization). If this right is not utilized by the PTR holder before certain deadline (i.e. long term nomination deadline), this right becomes financial. This means that the PTR holder loses its right to nominate the capacity utilization, but gets the financial right to the cross-zonal day-ahead market price difference. The capacity resulting from the non-nominated PTRs is offered to the market during the day-ahead market process.

Financial Transmission Rights options/obligations (FTRs)

- Prerequisite of FTRs implementation is implicit market coupling in day-ahead timeframe.
- FTRs give the holder the financial right to the cross-zonal day-ahead market price difference. The capacity resulting from FTR is offered to the market during the day-ahead market process.

Long-term market 4/4 - Example

Imagine the following two situations under a certain energy delivery scenario. Which statement is wrong?



a.) If I hold an FTR-option in situation A, I gain €1000
b.) If I hold an FTR-obligation in situation A, I gain €1000
c.) If I hold an FTR-option in situation B, I lose €1000
d.) If I hold an FTR-obligation in situation B, I lose €1000

The wrong statement: c
Justification: In situation A, the outcome for an option and an obligation are the same. The holder of both FTRs gain (20 €/MWh-10 €/MWh)*100 MWh= €1000. In situation B only the holder of an FTR-obligation has to pay (20 €/MWh-10 €/MWh)*-100 MWh= -€1000. A holder of an option will not exercise the option in this case and would not lose any money (except the price paid beforehand for acquiring the option). In other words, in situation A both FTR-obligations and options are a benefit. In situation B, an FTR-obligation is a liability, while an FTR-option is neither a liability nor benefit.

Source: Meeus, L. Schittekatte, T. 2019. The EU Electricity Network Codes. Florence School of Regulation A

Day-ahead market 1/5

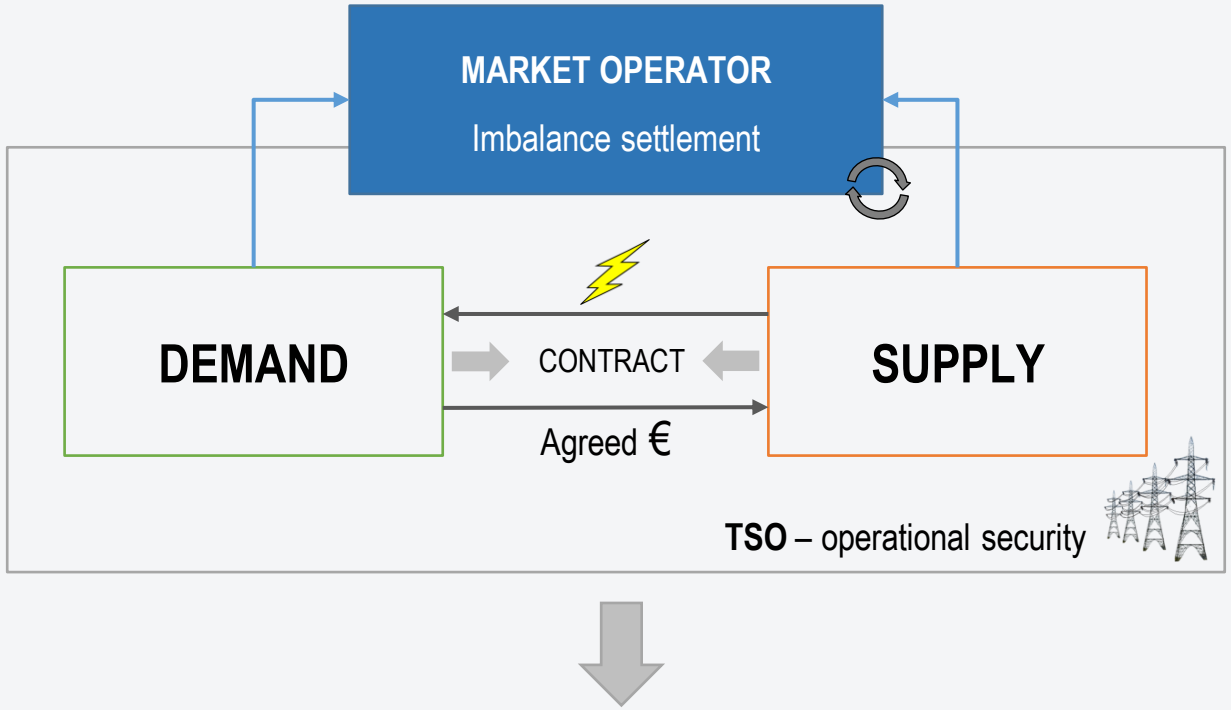
- Day-ahead market – growing importance
- Contracts for delivery of power the following day
- From 00:00 CET the next day, electricity is physically delivered hour by hour according to the contracts agreed.

Day-ahead market 2/5

Multiple ways electricity can be traded in the day-ahead timeframe:

- Domestically: both bilaterally or via PX
- Cross-border market: both bilaterally (explicitly) or PX (implicit market coupling)

1. Domestic – bilateral

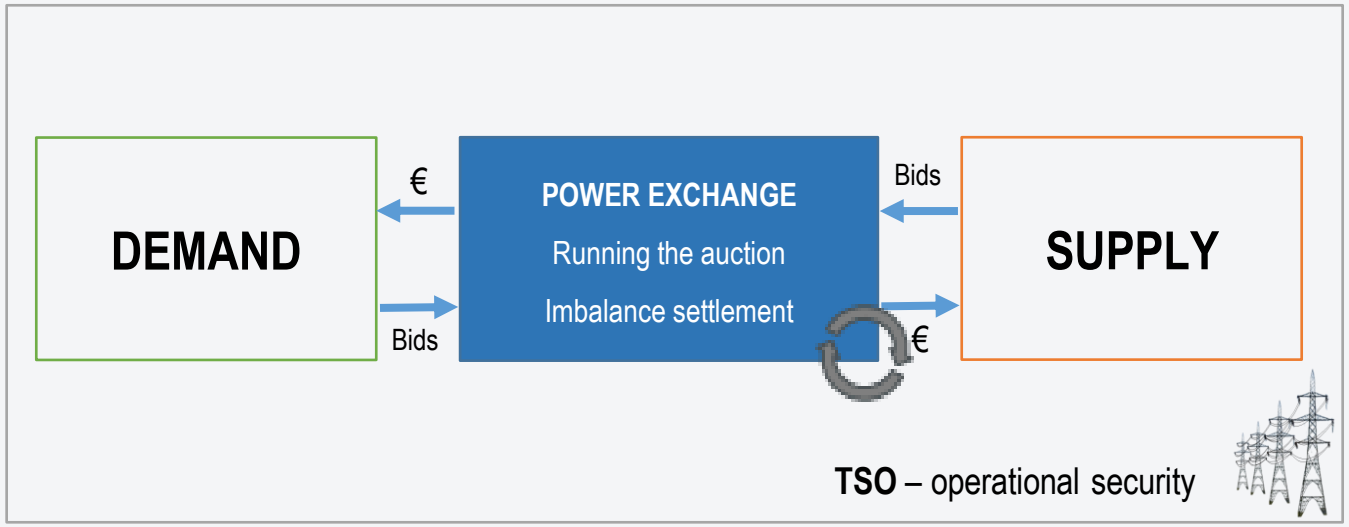


Result → domestic trade based on bilaterally agreed price within one bidding zone

Day-ahead market 3/5

2. Domestic – organised (via PX)

- Power Exchange (NEMO) is the central counterparty for all trades
- Trading done within one bidding area – one price is generated
- Multiple platforms can be used for bid collection
- Applied mostly in „isolated“ markets or in case of regional decoupling

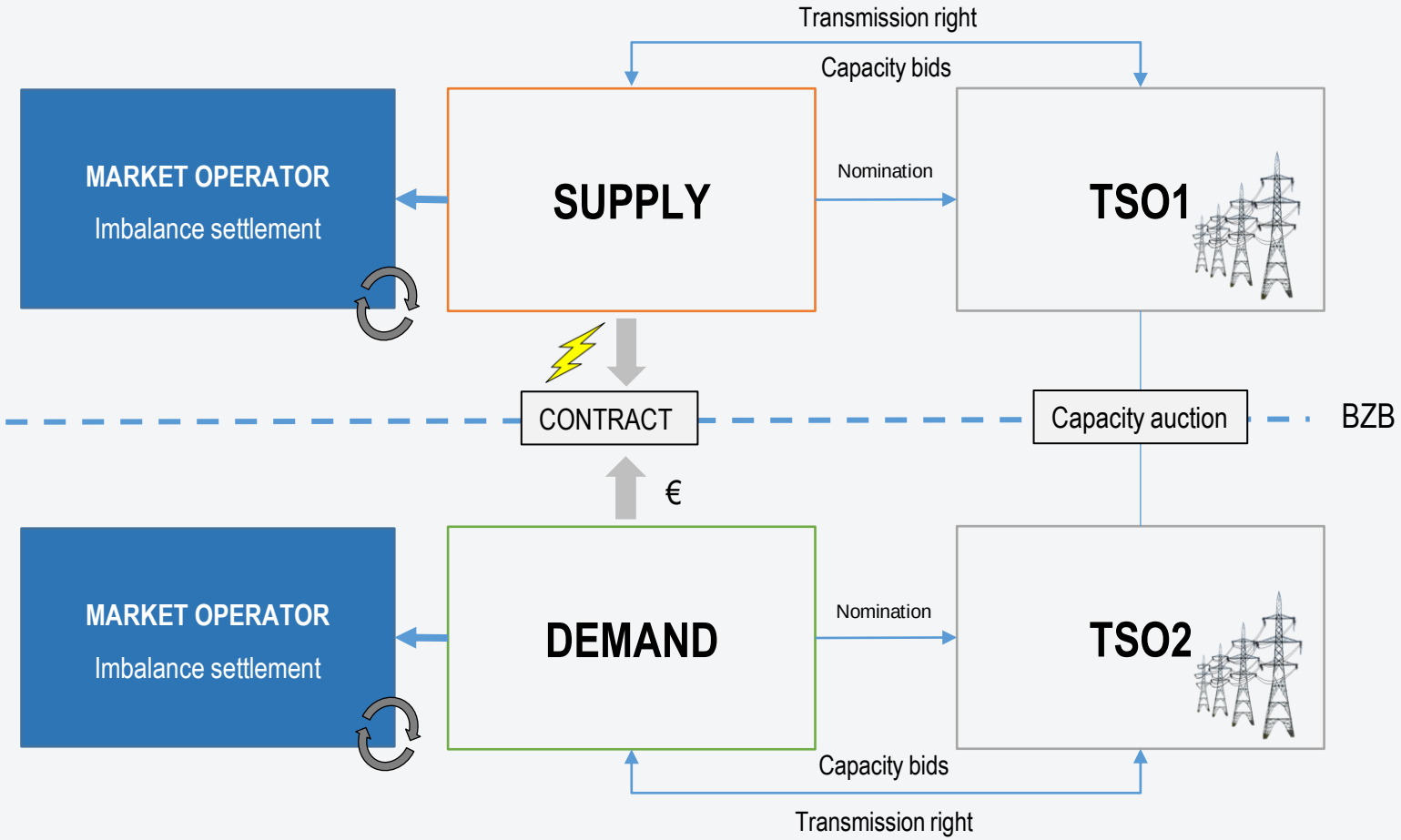


Result → domestic trade based on auction price within one bidding zone

Day-ahead market 4/5

3. Cross-border explicit capacity allocation

- separate trading of transmission rights and electricity
- electricity traded bilaterally
- transmission rights via TSO auction office of centrally

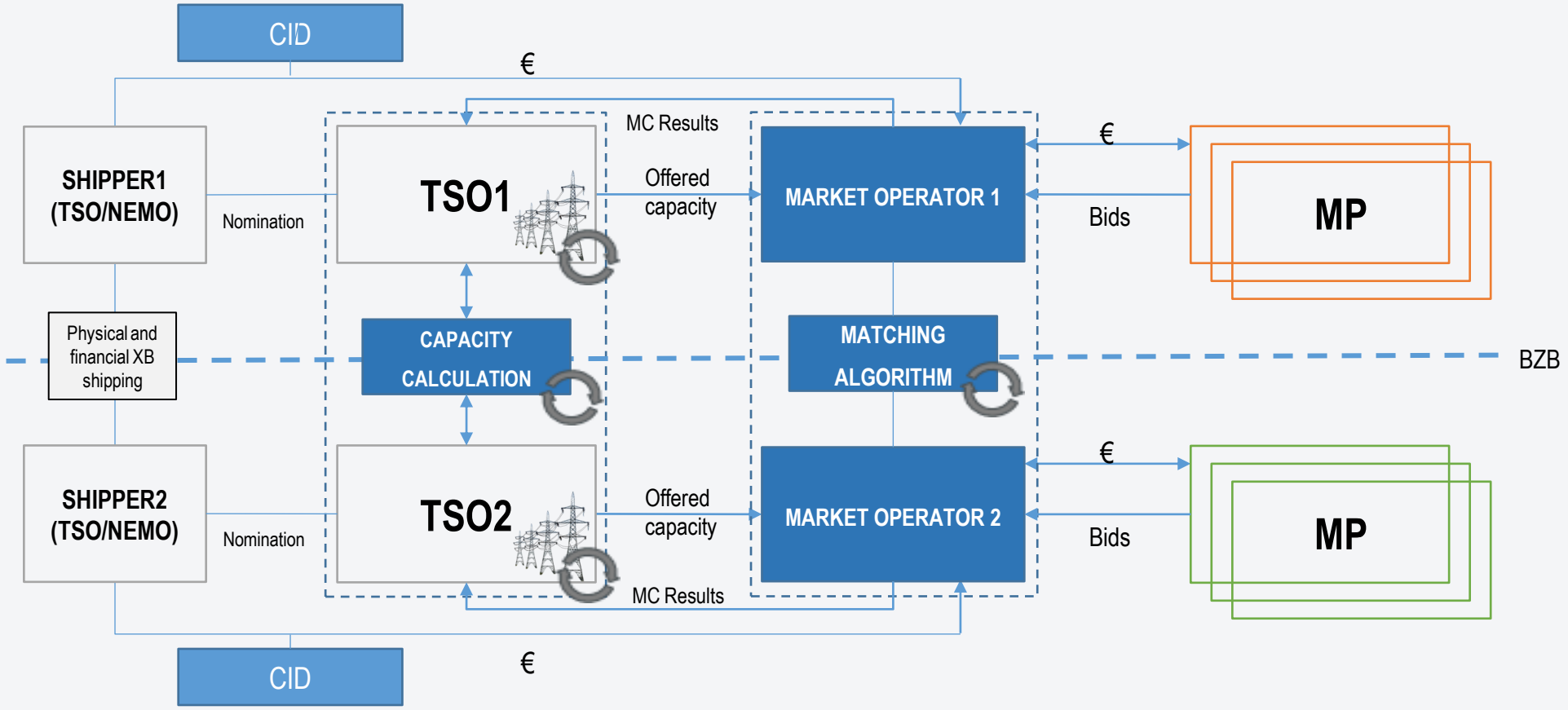


Day-ahead market 5/5

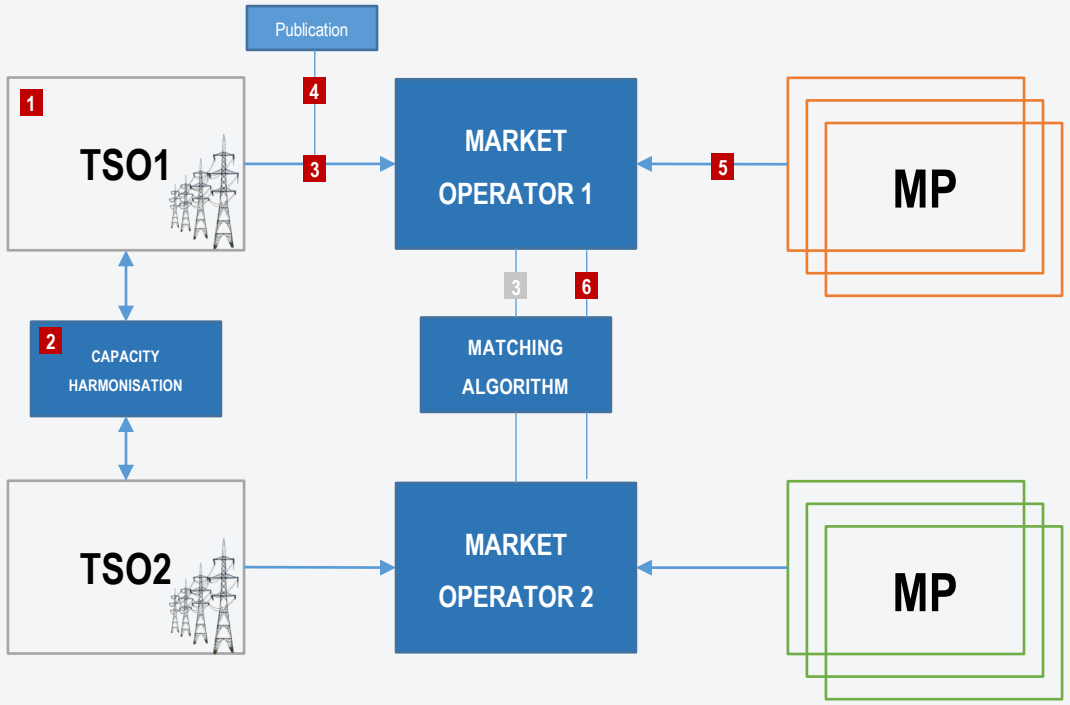
4. Market coupling

- Cross-border auction based trading with implicit capacity allocation; cleared once per day
- Input – transmission capacity and bids
- Outputs – prices, net positions and flows
- The core – price coupling algorithm – optimal price formation

Main aim of implicit market coupling = optimal use of transmission capacity and price convergence



Market coupling 1/3: Pre-coupling phase



Processes on TSO side:

Provision of the Cross Zonal Capacities

Capacity calculation

1. Individual TSO calculation
2. Harmonisation/coordinated calculation
   - Bilateral per BZB (i.e. NTC approach)
   - Coordinated (i.e. cNTC or flow-based approach)
3. Submission of FOC to NEMOs
4. Publication of FOC

Processes on NEMOs side

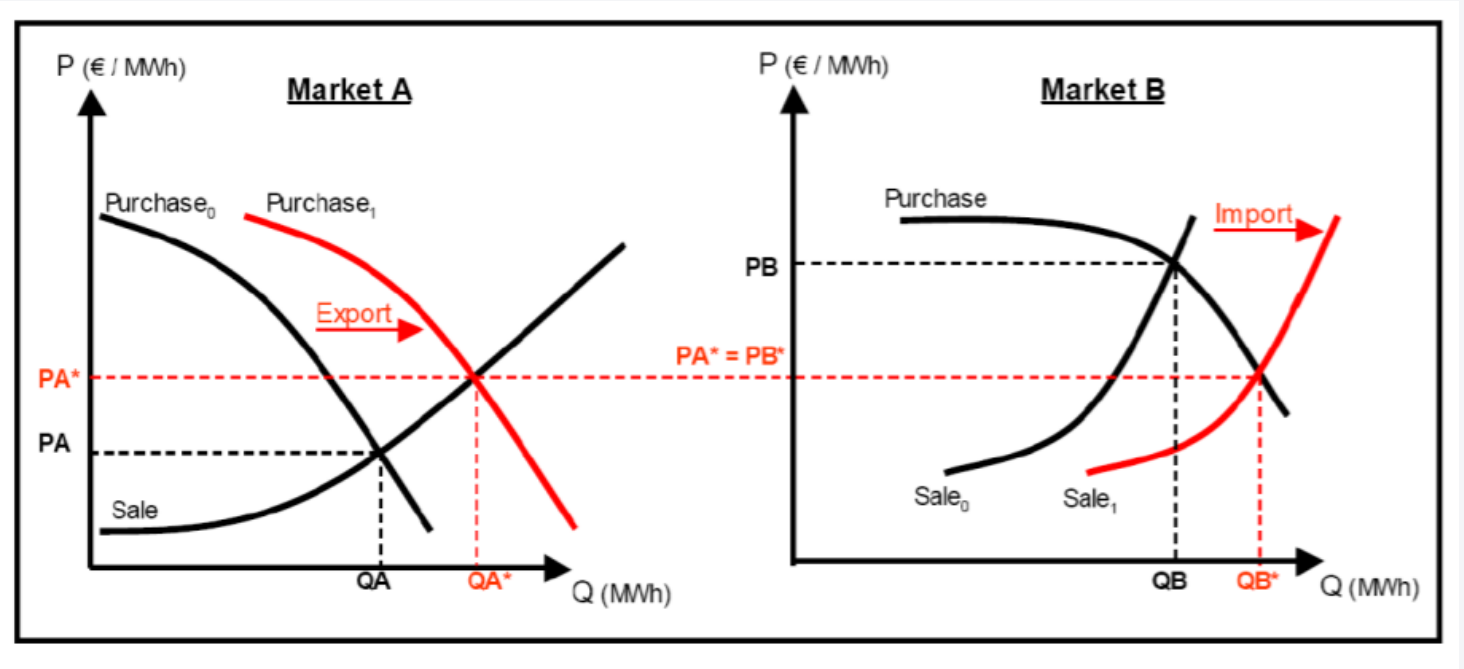
Collection of energy buy/sell orders and processing

5. NEMOs collect orders from market participants via an interface (until GCT)
6. NEMOs transform the orders to aggregated Order Books (OBKs) → provision to the central algorithm

Market coupling 2/3: Coupling phase

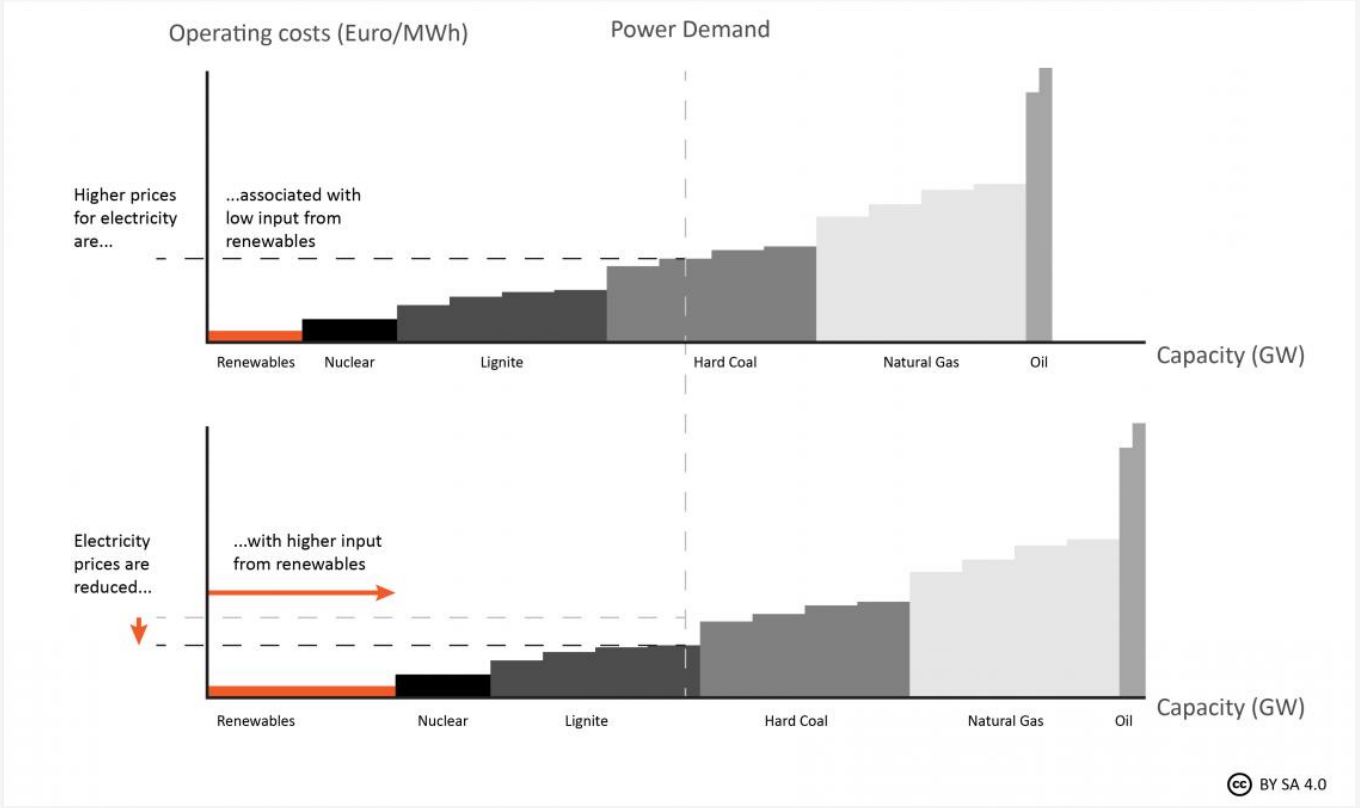
- In the coupling phase, market clearing prices for each bidding area, net positions of bidding areas and the XB flows are calculated
- Price formation on the cross border day-ahead market:
  - An automatic, anonymized process carried out by the algorithm (Euphemia)
  - It is based on the aggregated supply and demand curves (created by aggregation of individual orders)
  - The price is set at a point where supply and demand curves meet
  - The algorithm takes into account the constraint in form of available transmission capacity (ATC)

- Price convergence between bidding areas is only occurring to the extent permitted by the ATC → with unlimited ATC, there would be no congestion and full price convergence



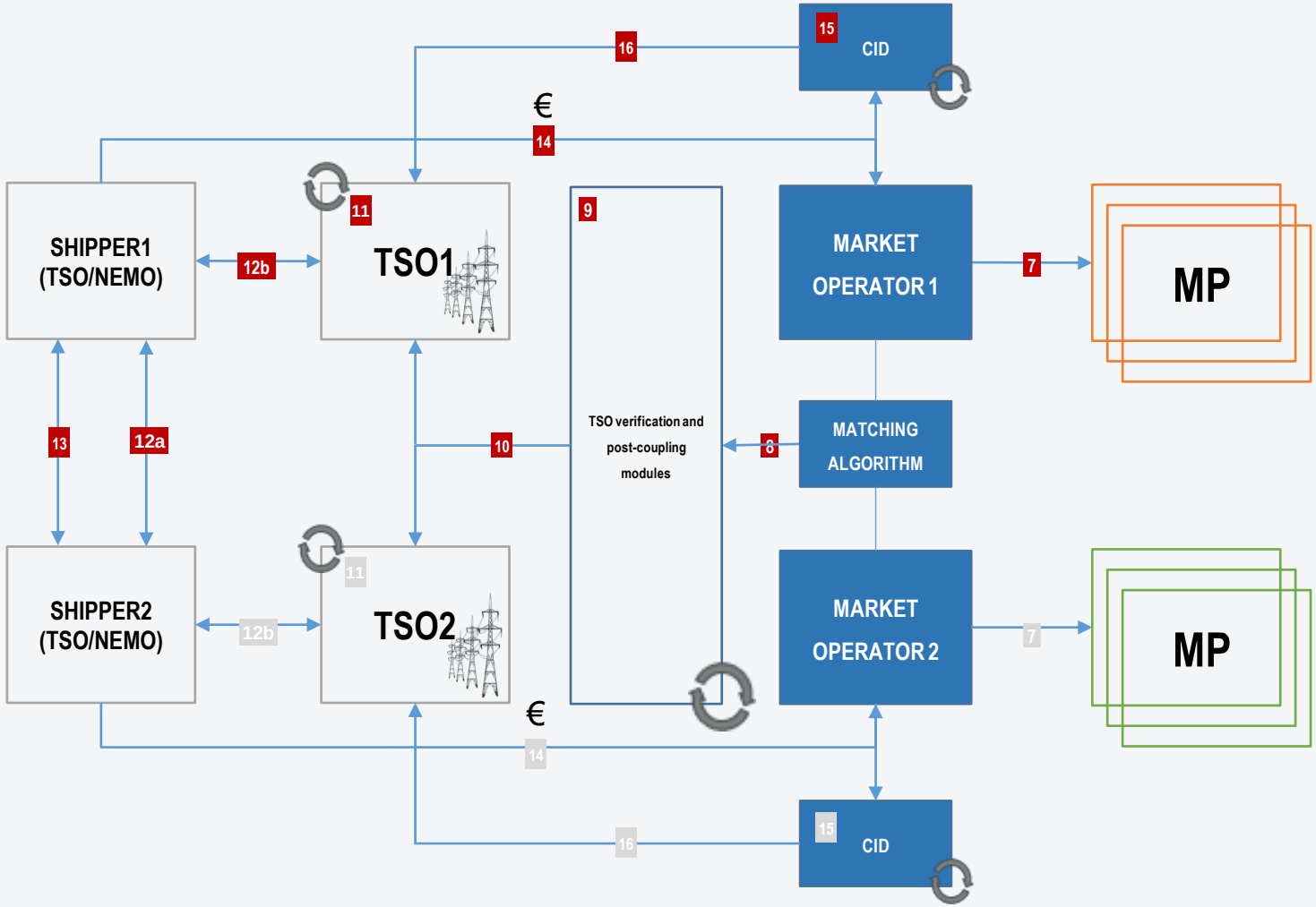
Merit order

- Market price has implications for all market participants
- It also shapes the energy mix by influencing the profitability of different power sources
- There are significant shifts caused by the onset of renewables with low OPEX → generation adequacy problems?



Source: Appunn, K. 2015. Setting the Power Price: the merit order effect. Clean Energy Wire. Published January 23, 2015

Market coupling 3/3: Post-coupling phase



Main activities of the post-coupling phase are the following:

7. Clearing and settlement of individual internal trades – NEMO provision of settlement results to market participants and Shipping Agents/TSOs
8. Provision of results to common TSO systems
9. Validation of results, modification of results file for further processes and publication
10. Distribution of results to individual TSOs scheduling systems
11. Generation of schedules – how much capacity is it going to be nominated?
12. Nomination of cross-border schedules – how much capacity is going to be used?

12b. TSO check nominated flows against capacity limits)

13. Financial Energy shipping, i.e. Cross-border clearing and settlement
14. Transfer of € to NEMOs
15. in case of different market clearing prices in neighbouring bidding areas – e.g. congestion income is generated, the CID entity calculates and collects €
16. and distributes to TSOs/interconnector owners based on agreed sharing keys.

Price difference as an outcome of market coupling

Suppose that the day-ahead market auction for a certain hour results in a price in zone A of 50 €/MWh and a price in zone B of 60 €/MWh. The satisfied demand in zone A is 100 MW, the satisfied demand in zone B is 150 MW and the interconnector capacity allocated for trade between the two zones was 50 MW. As there is a price differential between the two zones, it implies that the cross-zonal interconnector capacity is fully utilized, i.e. the total electricity flowing through the interconnector is 50 MW. Electricity flows from the low price zone (A) to the high price zone (B).

Zone	Price	Demand	Generation	Demand cost	Generation cost
Zone A	50 €/MWh	100 MW	150 MW	€ 5000	€ 7500
Zone B	60 €/MWh	150 MW	100 MW (demand zone B – interconnector)	€ 9000	€ 6000
				€ 14 000	13 500

The total amount collected by generation over the two zones is € 13,500 while the total amount spent by demand equals € 14,000. The difference between the two is the congestion rent of € 500 equaling the price differential between the two zones (€ 10/MWh) multiplied by the capacity of the line (50 MW). This congestion rent is transferred to the TSO(s) owning the interconnector.

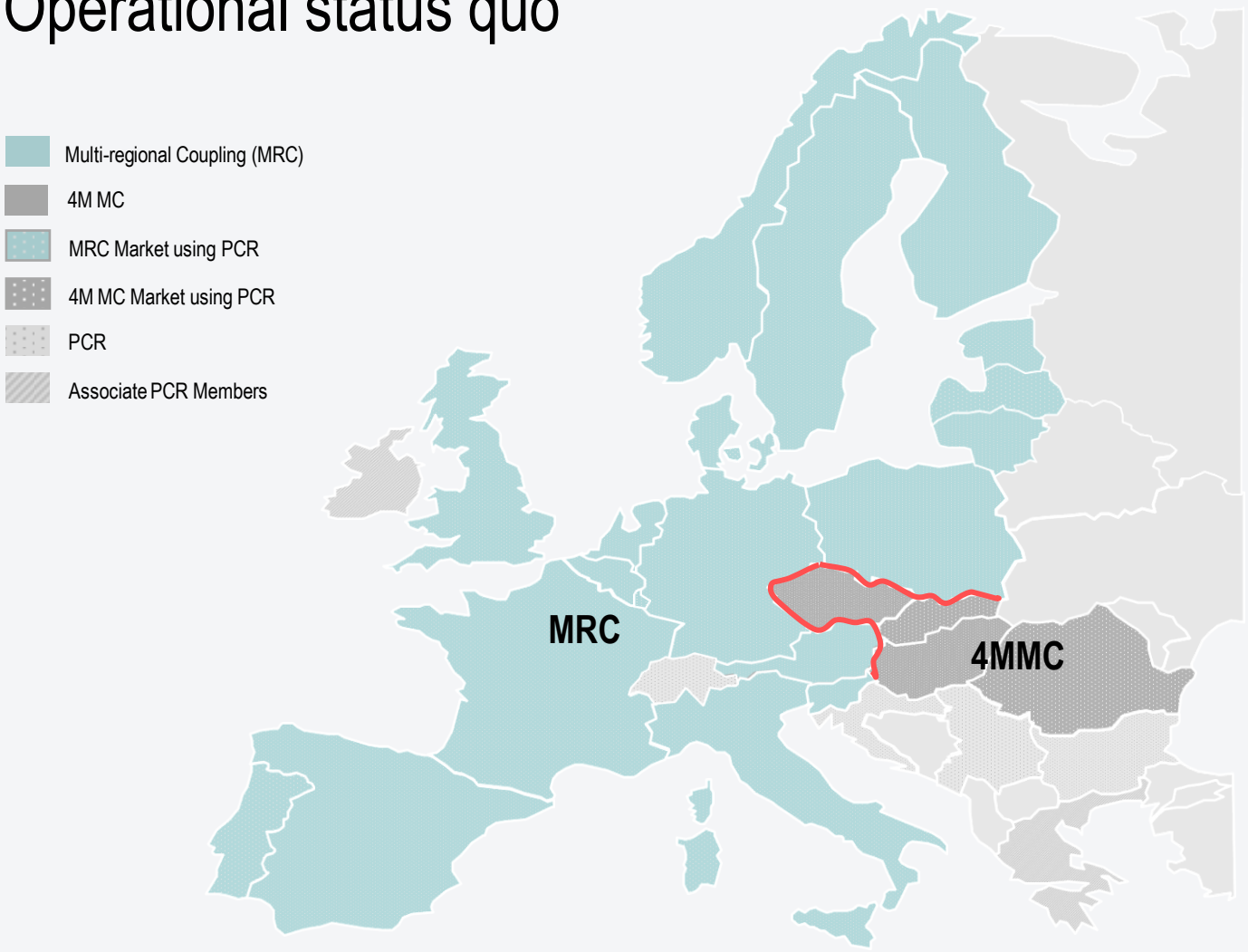
Regulation 714/2009 defines in Art. 16(6) rules for usage of any congestion income generated:

a. guaranteeing the actual availability of the allocated capacity; and/or
b. maintaining or increasing interconnection capacities through network investments, in particular in new interconnectors.

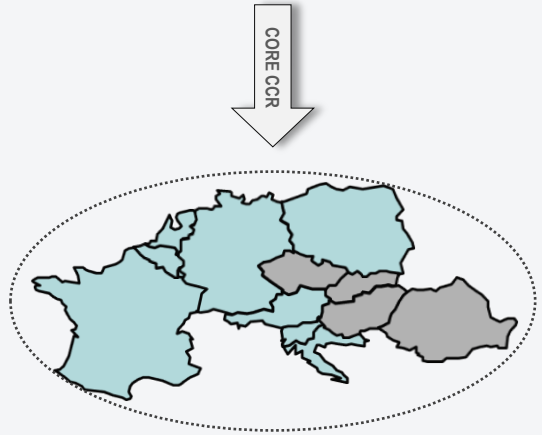
If the revenues cannot be efficiently used for these specific purposes – NRAs can take these revenues into account when estimating tariffs.

On the way to the EU Single Day-ahead Coupling (SDAC)

Operational status quo



- 2 independent operational solutions in Europe – MRC & 4MMC
- 28.03.2019 – Single Day-ahead Operational agreement
- One coupling algorithm – EUPHEMIA
- Multiple ways how to couple – capacity calculation concern
- Potential interim integration of 4MMC and MRC – NTC based
- **CACM compliant SDAC foresees transformation of both current MRC and 4MMC**
  - E.g. transformation based on design, conceptual solutions, methodologies and implementation timelines as defined by CACM (**specifically CCR solutions/obligations**)



Intraday market 1/6

Why is intraday market important?

„The importance of intraday markets for electricity in Europe is increasing together with the growing need for short-term adjustments due to the greater penetration of intermittent generation from renewable energy sources into the electricity systems.“

- A tool for market parties to keep positions balanced based on more accurate demand forecasts, weather conditions close to real-time
- Need for adjustment of positions - injections and/or off-take may change between the day-ahead stage and real-time operations.
- The growth of intermittent generation capacity has increased the importance of efficient Intraday markets – volatility on generation side (D-1 forecasts not fully reliable)
- Intraday market provides market participants with the opportunity to trade in energy in time intervals at least as short as the imbalance settlement period

Intraday market 2/6

- Similar trading models as in day-ahead market:
  a) Domestically: bilaterally or via PX platform
  b) Cross-border market – both:
     - Bilateral with explicit allocation
     - or PX (continuous trading with implicit capacity allocation)

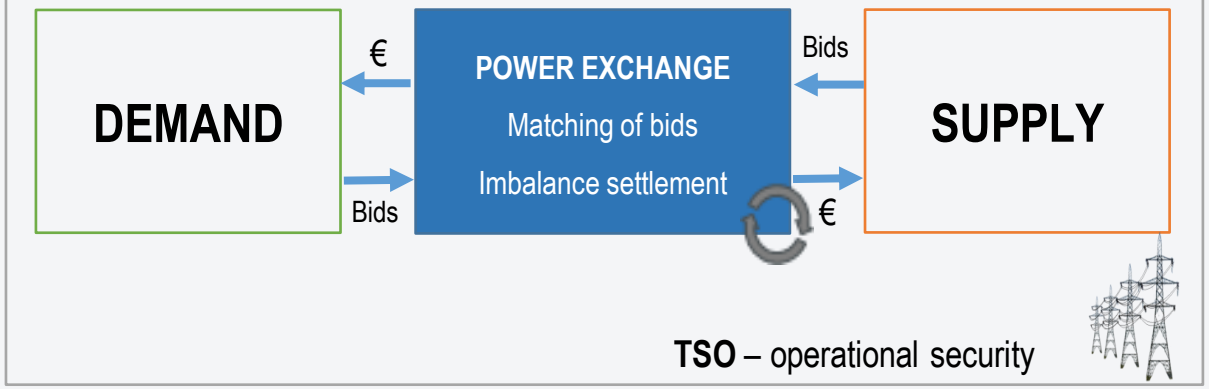
     → target = Single Intraday Coupling (SIDC))

Basic principle of PX intraday trading:

- Continuous trading - submitted bids are automatically/continually matched up to the capacity limit
- Gate closure time – max. 60 minutes before the delivery hour

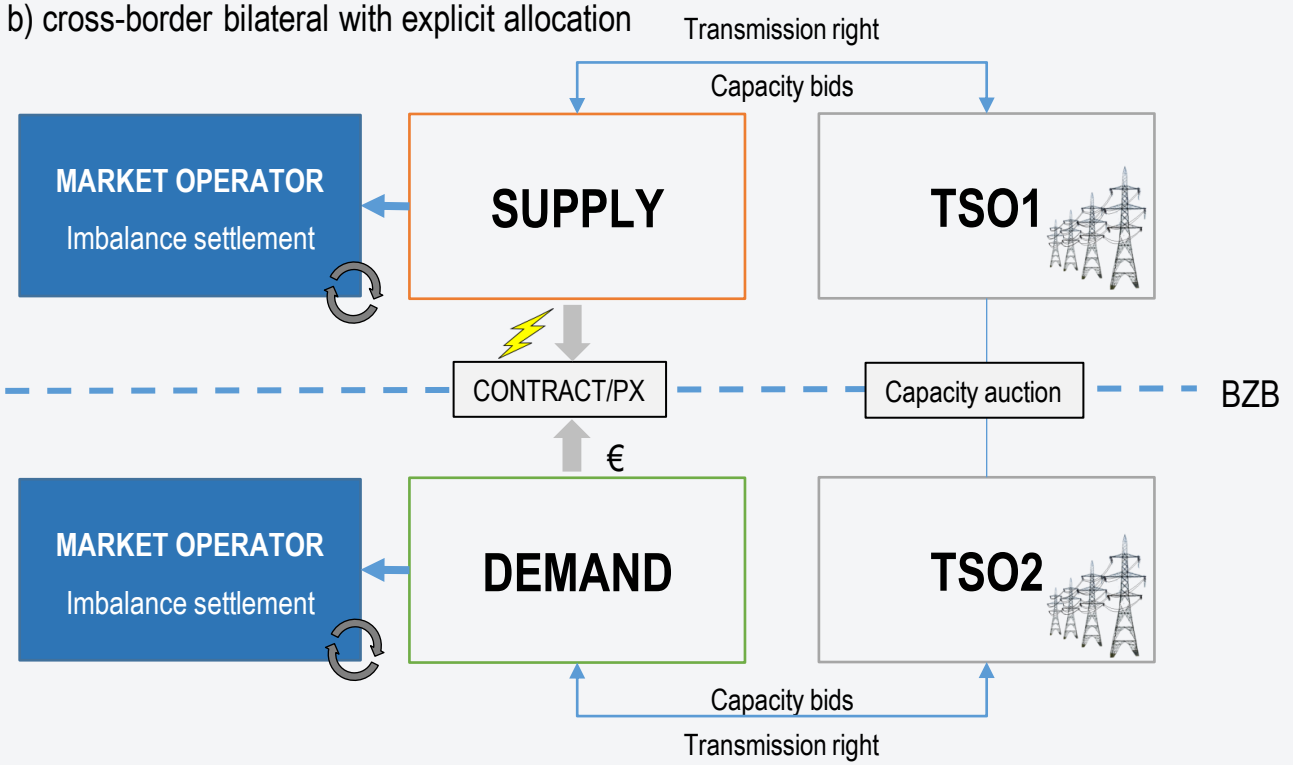
Intraday 3/6

a) domestic



TSO – operational security

b) cross-border bilateral with explicit allocation

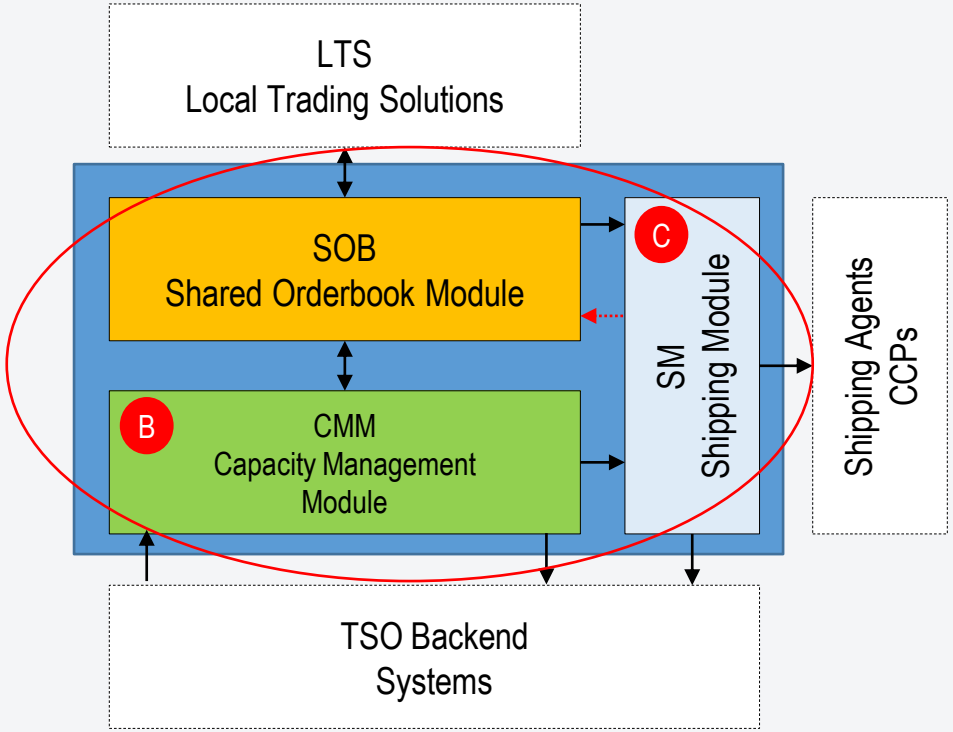


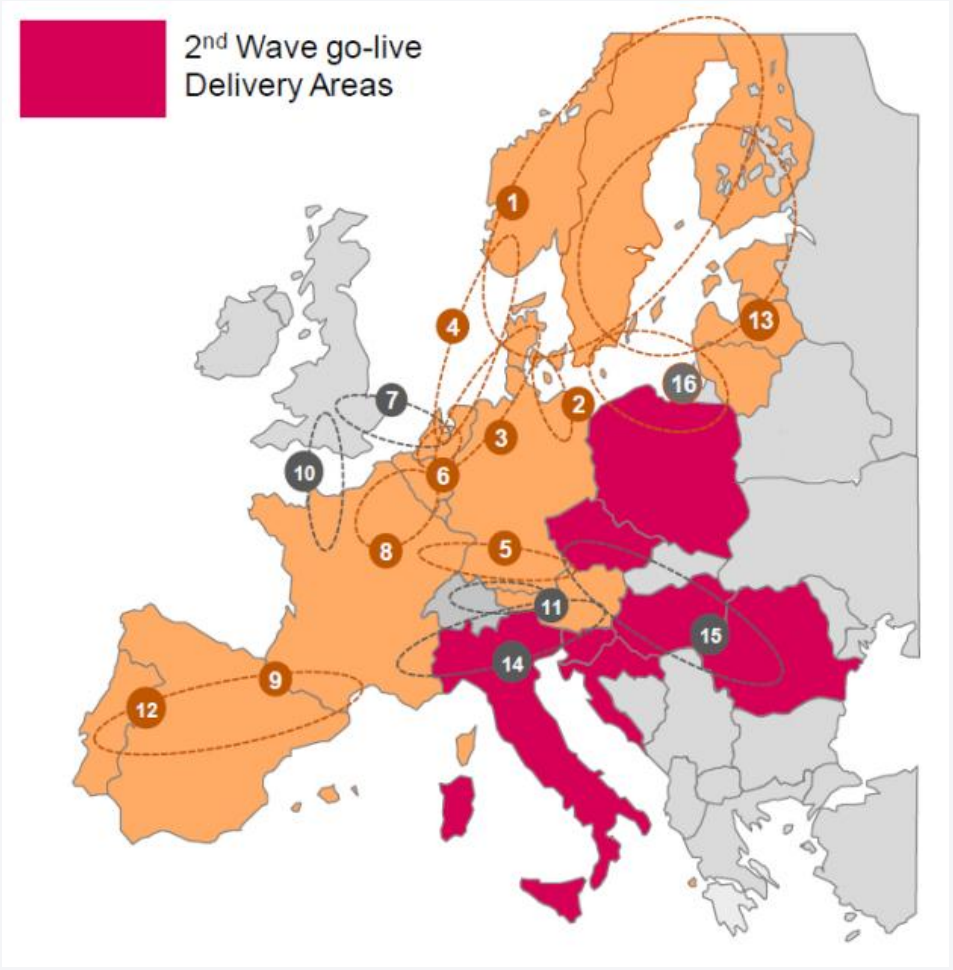
Intraday 4/6 : XBID project

- Established as an initiative of power exchanges in western Europe: APX / Belpex, EPEX SPOT, GME, NordPoolSpot a OMIE
- Aim: implementation and operation of the intraday continuous trading with implicit capacity allocation
- Centralised IT solution based on integrated Shared Order Books (SOBs) and Capacity Management module
- Auction generated marginal price (e.g. Day-ahead) substituted by pay-as-bid pricing
- Implemented via local implementation projects – LIPs (launched in „waves“)

Intraday 5/6 : XBID go-live

- Step-wise go live – „first wave“ launched in June 2018
- Second wave expected in Q3/Q4 2019, third wave – 2021+





Source: XBID project

Intraday 6/6 : Target model

Solution implemented today:

On the way to EU Single Intraday Coupling

Target solution:
SIDC
according to CACM

What is missing?

- Coordinated Flow-based capacity calculation in CORE
- Complementary methodologies (e.g. IDCZCP)
- All TSOs and all NEMOs „on board“

Market time unit

What is the target?

- According to Article 53 of the EBGL by three years after the entry into force of the said Regulation (i.e. by 18 December 2021), all TSOs shall apply the imbalance settlement period of 15 minutes in all scheduling areas
- Imbalance settlement period defines also applicable Market time unit (units in which electricity is traded – PT15, PT60 etc.)
- Within a bidding zone, MTU is the time period for which a price is established and corresponds (i.e. is equal) to the imbalance settlement period - MTU on the bidding zone border is the longer of the two imbalance settlement periods on either side of the bidding zone border.
- Relevant to all short-term markets

Q&A


PART
THREE

Security of operation

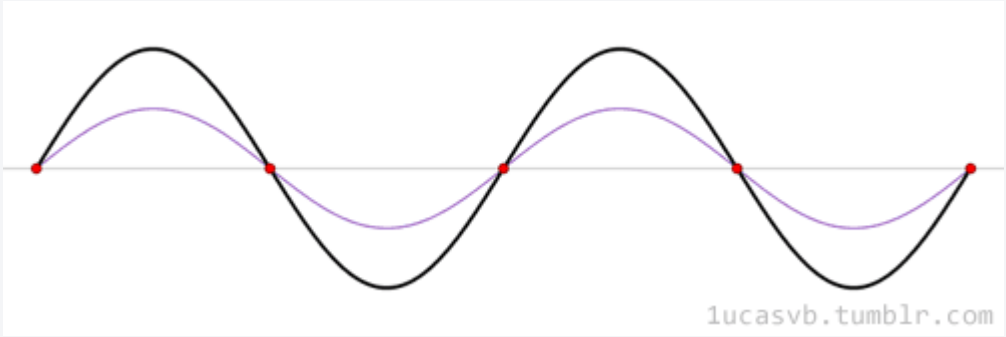
Balance between supply and demand

Dynamics of the power system - constantly changing condition

→ parameter: frequency set for 50 Hz when supply = off-take

What does it 50 Hz frequency level mean?

- total active power produced in the whole system equals the power consumed
- nominal frequency of the oscillations of alternating current (AC) in an electric power grid



What are the reasons for frequency fluctuations?

- planned and unplanned outage of generation, transmission system elements, extreme weather, sudden changes in production of intermittent sources
- “import” of specific operational situations from the adjacent control areas.

What happens when the balance is disrupted?

- changes in supply/demand must be immediately reflected → risk of overvoltage or undervoltage (consequence: brownouts, blackouts or island operation).
- Potential scenarios:
  - consumption rises/shortage at the level of production (i.e. supply) leads to immediate drop of frequency and voltage. To stabilise the frequency at 50Hz – reaction on the generation side needed – increase of production
  - drop of consumption/increase of production it would result in an increase in frequency and, could lead to the overvoltage of the grid.

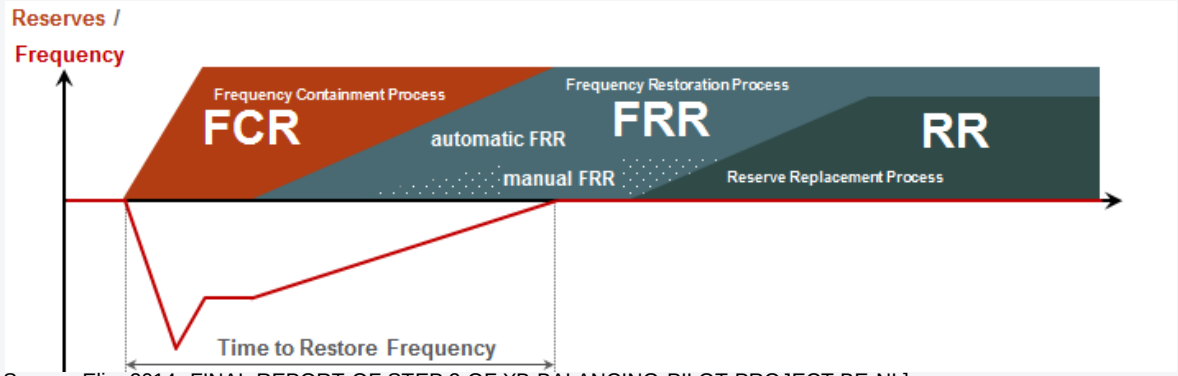
Security of operation
Ancillary Services

TSO has the obligation to maintain operational security of the power system - ensure tools and measures to maintain reliable supply and operational security (provider of system services)

→ pool of reserve capacity which can be activated/deactivated (ancillary services) in order to stabilise frequency and/or and interoperability of interconnected transmission systems

TSO procures relevant ancillary services:

- frequency containment reserve (primary reserve)
  - automatic response frequency fluctuation automatically within seconds.
  - Activation - solidarity principle of all synchronously interconnected transmission system operators.
  - primary reserve in Continental Europe is estimated at approximately 3000 MW (participation of domestic sources on pro rata basis of respective TSOs).
  - The main aim: automatically adjust production in case of frequency fluctuation
- automatic or manual Frequency restoration reserve (secondary reserve)
  - upward/downward regulation with activation time between 30 seconds and 15 minutes
  - System service secondary regulation is provided by secondary reserves directly activated by the TSO central dispatch centre and have to fulfil certain technical requirement and certification criteria.
- replacement reserve (tertiary reserve)
  - restoration already exhausted secondary reserves.
  - Teriary reserves are usually manually activated based on the specific request of the TSO with ramping time up to 30 minutes.

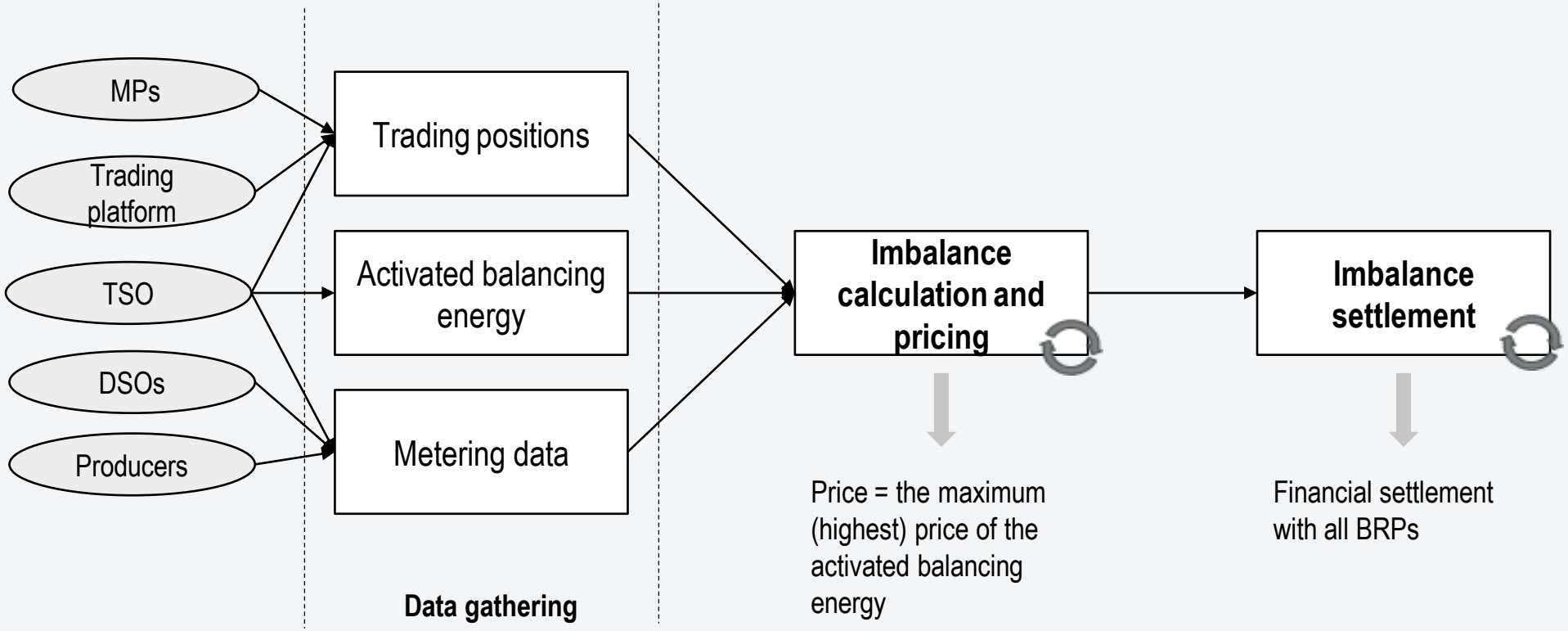


Source: Elia. 2014. FINAL REPORT OF STEP 2 OF XB BALANCING PILOT PROJECT BE-NL]. http://www.elia.be/~/media/files/Elia/users-group/CoBa_phase_2report_V6_1710.pdf

Source: Fingrid, 2016. https://www.youtube.com/watch?v=D51AVy5wByM

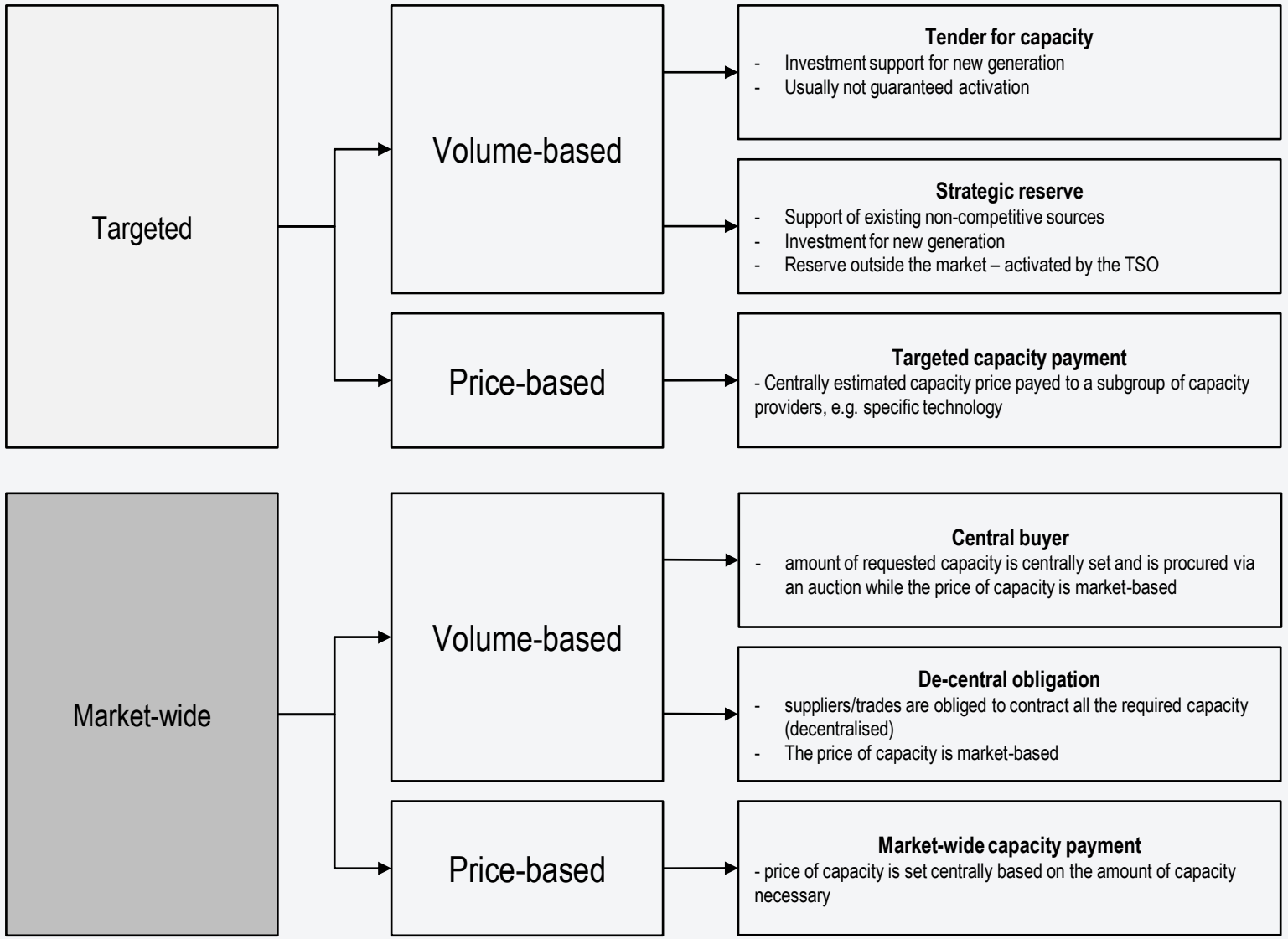
Imbalance settlement

- What is imbalance? Why do we need imbalance settlement?
- Who are balance responsible parties? Who is responsible for imbalance settlement?
- How does the process work?



Generation adequacy & capacity mechanisms

- **more RES** – intermittent sources **– less base load and flexible capacity**
- Support schemes for RES – conventional sources not competitive → risk of underinvestment
- Inability to maintain stability of the grid / supply does not meet demand – **generation adequacy**
- **Solution:** support of existing (non-competitive) / new capacity sources - **capacity mechanisms.**



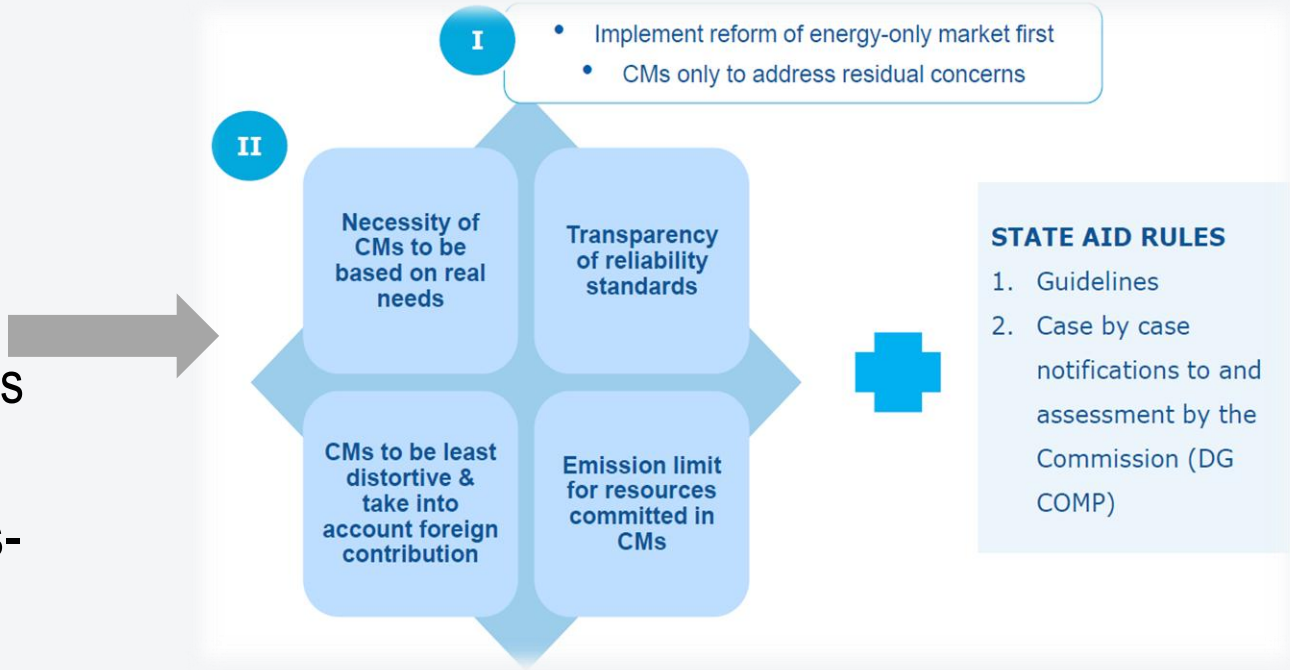
Regulation of capacity mechanisms

Before CEP

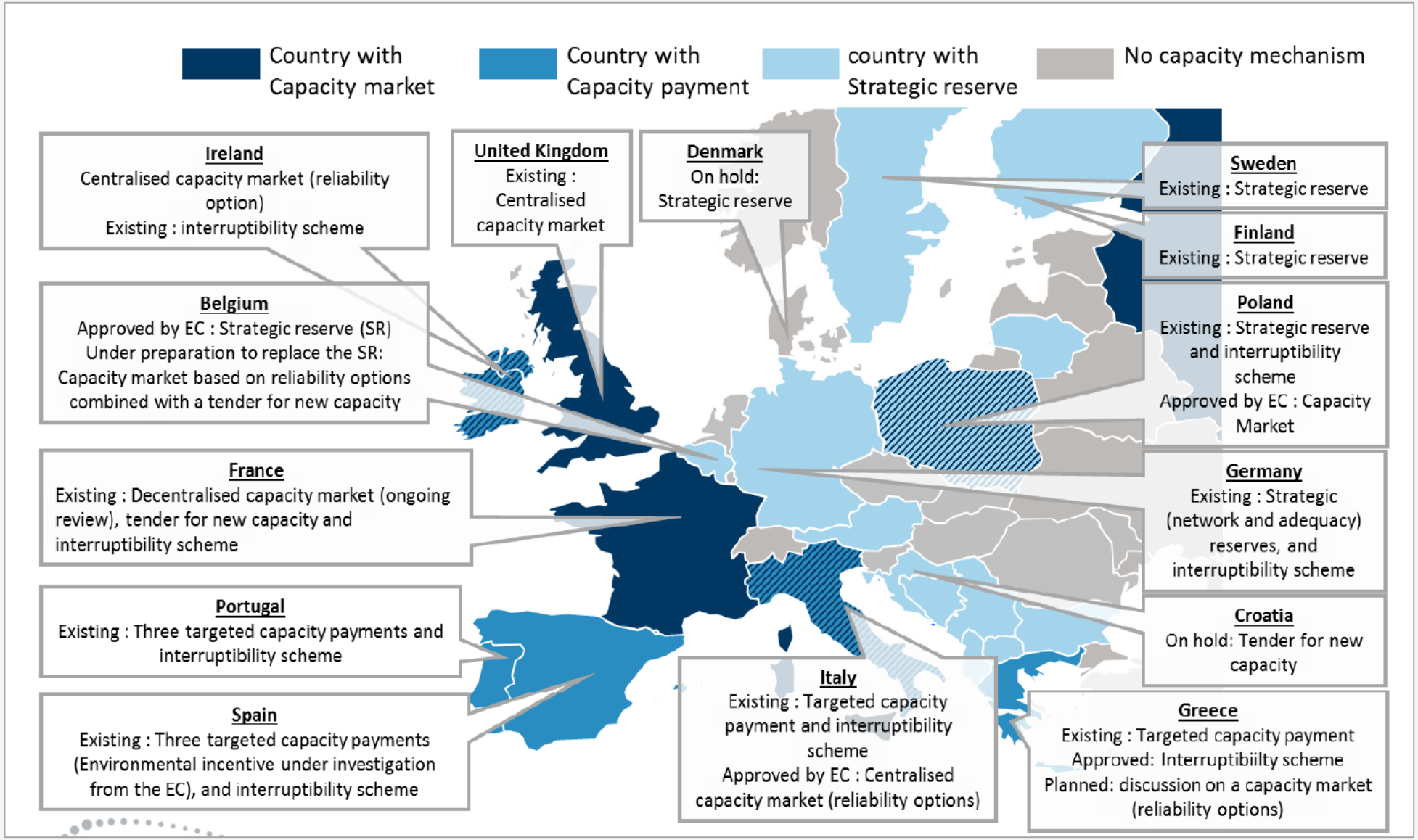
- Organic „growth → “different designs – harmonization?
- Regulated only by means of EU State aid rules - Guidelines on State aid for environmental protection and energy (EEAG) 2014-2020

CEP

- ElReg – generation adequacy monitoring and action plan measures (Chapter 4)
- Last resort tool – capacity mechanisms
- Emission limits for new and existing sources, max. 10 years support, cross-boarder participation of generation units etc.



Capacity mechanisms across Europe



Source: Roques, R. 2018. Capacity mechanisms: latest developments and potential for further coordiantio. Compass Lexecon. The 6th Vienna Forum on European Energy Law 2018. Energy Community.

Q&A

- specific characteristics of electricity determine market design and the trading in general
- national – highly regulated sector – with strong push for integration (SEM) despite the isolated historical development
- main benchmark – price generated on DA market
- motivation to integrate RES vs stability/security of operation

Bibliography

1. AEM. 2016. Úvod do liberalizované energetiky: Trh s elektřinou. (2nd edition). Asociace energetických manažerů, Praha 2016. ISBN 978-80-260-9212-4. https://www.mpo-efekt.cz/upload/7799f3fd595eeee1fa66875530f33e8a/kniha-trh-s-elektrinou.pdf
2. ACER/CEER. 2018. ACER/CEER - Annual Report on the Results of Monitoring the Internal Electricity and Natural Gas Markets in 2017 – Electricity Wholesale Markets Volume, October 2018. Accessed 13 May, 2019. https://acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/MMR%202017%20-%20ELECTRICITY.pdf
3. ETSO. 2006. Transmission Risk Hedging Products Solutions for the Market and Consequences for the TSOs. Background Paper - 20 April 2006. Accessed 13 May, 2019. https://sites.hks.harvard.edu/hepg/Papers/ETSO_Transmission_0406.pdf
4. Meeus, L. Schittekatte, T. 2019. The EU Electricity Network Codes. Florence School of Regulation Accessed 13 May, 2019. http://florenceonlineschool.eui.eu/wp-content/uploads/2016/09/FSR-NC-course-text.pdf
5. PCR. 2016. EUPHEMIA Public Description . Accessed 13 May, 2019. https://www.okte.sk/media/70968/euphemia-public-description.pdf.
6. 4M Market Coupling. 2014. 4M Market Coupling Extended High Level Market Design. Accessed 13 May, 2019. 4M Market Coupling Extended High Level Market Design. https://www.okte.sk/media/61388/4m-mc-publichighlevelmarketdesign-29042014.pdf

Thank you for your attention!