MAY 26, 2021

ELECTRICITY MARKETS II + III

Courses: ESSn5021 Energy Commodities I., MEBn5012 Technicko-ekonomické aspekty energetiky II

Ľubica Krajčovič, OKTE a.s.
Patrícia Brhlíková, SEPS a.s.

FSS Masaryk University, Brno

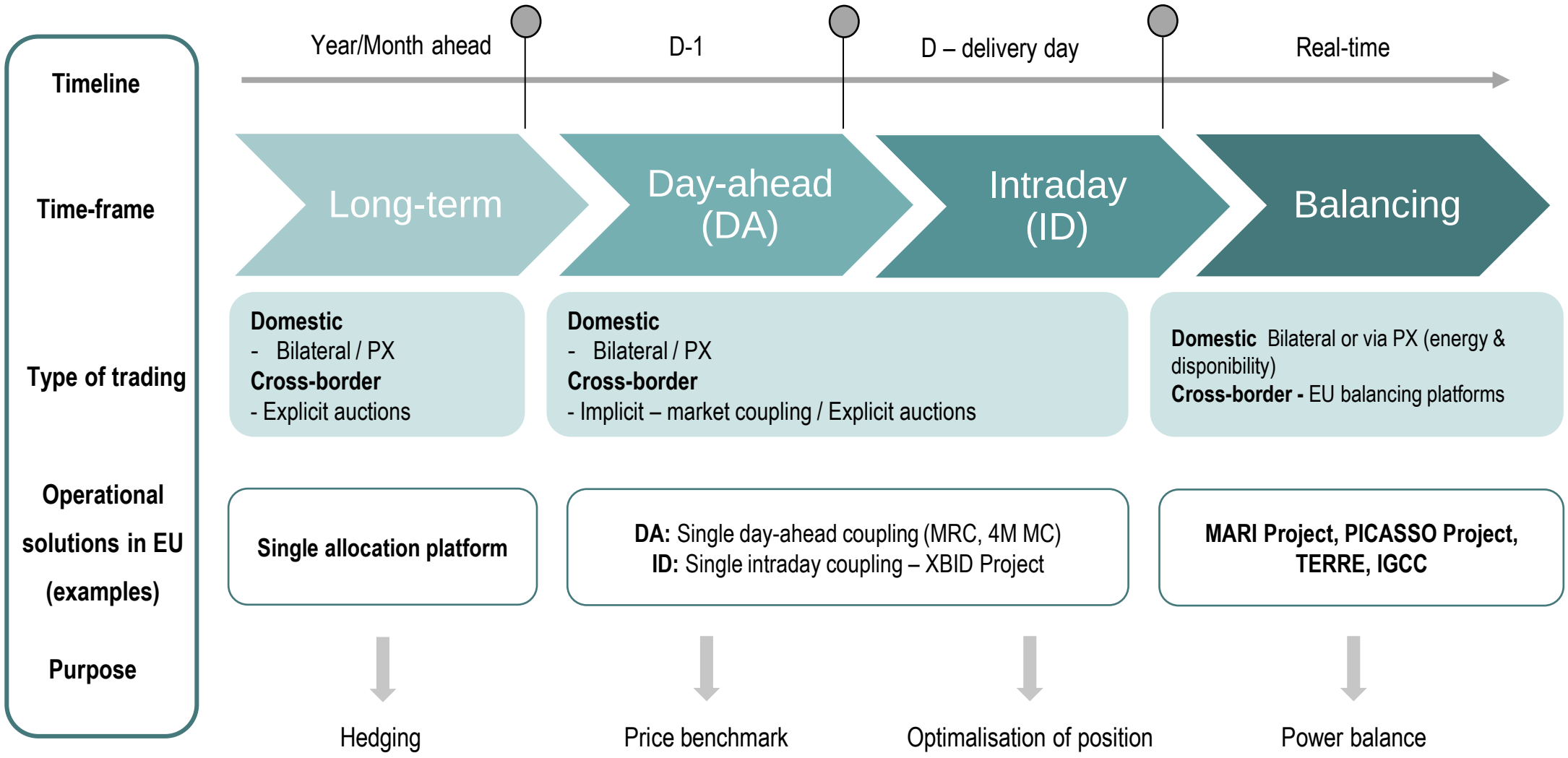
CONTENT

1. Long-term Markets
   Day-ahead Markets
   Intraday Markets

2. Electricity balancing
   Imbalance settlement
   Capacity mechanisms


PART
ONE

Electricity market: Multiple marketplaces – one market



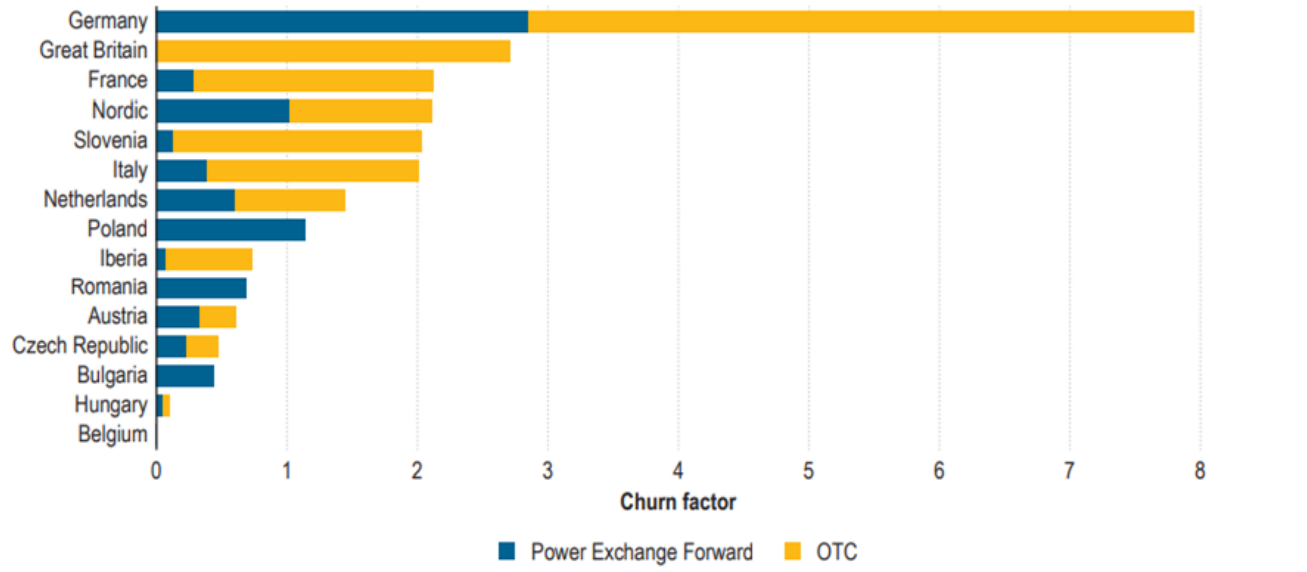
Long-term market 1/3

What is traded?

- **Electricity** → Trading of electricity for periods longer than one day
  - Structure of forward markets varies widely across Europe – domestic and cross border
  - Trading of electricity via power exchanges (futures) and OTC contracts - with or without borkers (forwards)

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 16: Forward markets churn factor per type of trade in the largest European forward markets – 2019



Most markets and regions witnessed an increase in traded volumes in 2020 (except UK and Italy) on forward markets:

- The largest annual rises in France (+29%), Belgium (+17%) and Germany (+12%), driven mainly by the OTC sector.

Contract type change:

- Germany: more activity both at exchanges (+5%) and in OTC contracts (+14%).
- Nordics: Major decrease in bilateral OTC deals (-80%), increase of exchange-based volumes (+16%).
- The largest falls in exchange-based volumes were reported in Belgium (-18%) and the Netherlands (-14%).

Source: ACER/CEER report Annual Report on the Results of Monitoring the Internal Electricity and Gas Market

Long-term market 2/3

What is traded (cross-border relevant only)?

Transmission capacity via (at least) Yearly and Monthly explicit auctions

- Access to the cross-zonal capacity/hedging tool for trading on short term markets

  → granted via Long-term Transmission Rights (LTTRs) – physical (PTR) or financial (FTR)

What are transmission rights?

PTR

- gives the holder the exclusive right to use a particular interconnection in one direction to transfer a predefined quantity of energy from one market hub to the other.
- PTRs with the Use-It-Or-Sell-It (UIOSI) principle are, with limited exceptions, the dominant type of Long Term Transmission Rights applied

FTR

- allows the holder to be paid the difference in price between two coupled markets, but do not give any nomination right or allow the holder to influence the flow of energy between coupled markets

Target model defined by Commission Regulation (EU) 2016/1719 establishing a guideline on forward capacity allocation (FCA):

2 Steps:

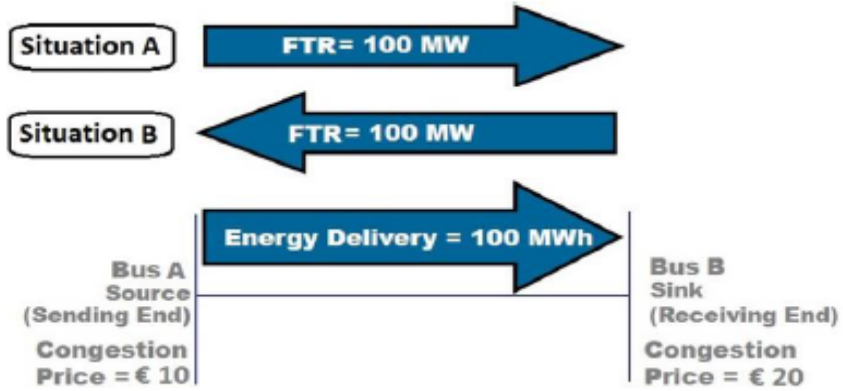
1. Coordinated capacity calculation – on capacity calculation regional level – input for the auction
2. Allocation of cross-border capacity in form of Long-term Transmission Rights (LTTRs) via Single Allocation Platform (established in Q3 2017)– pan-european level

Status quo:

- capacity calculation bilaterally coordinated = not in line with FCA target model - on majority of BZBs (66% in month-ahead and 64% in year-ahead) - development of methodologies delayed/ongoing
- Long-term capacity allocation - **Single Allocation Platform (the Joint Allocation Office)** performs auctions for 26 EU MS – as of 2020, SAP covers 71 bidding zone directional borders

Long-term market 3/3 - 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

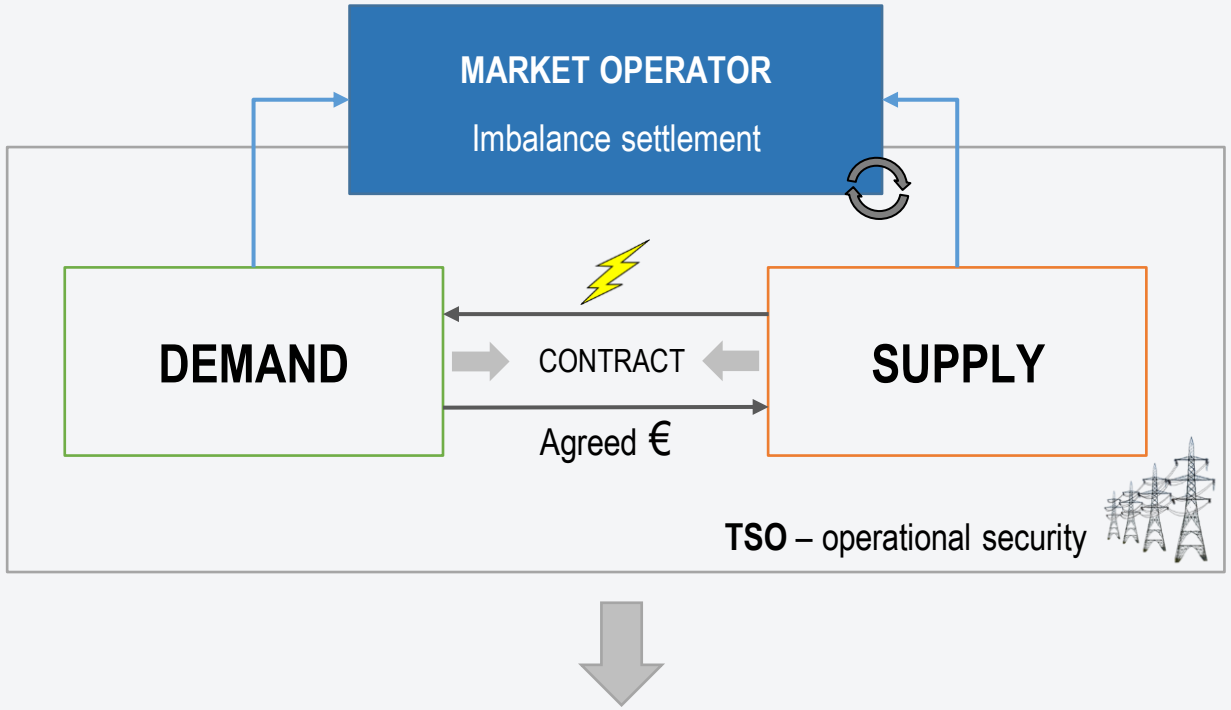
- Day-ahead market – growing importance
- Contracts for delivery of power the following day
- From 00:00 CET the next day, electricity is physically delivered hour by hour according to the contracts agreed.

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

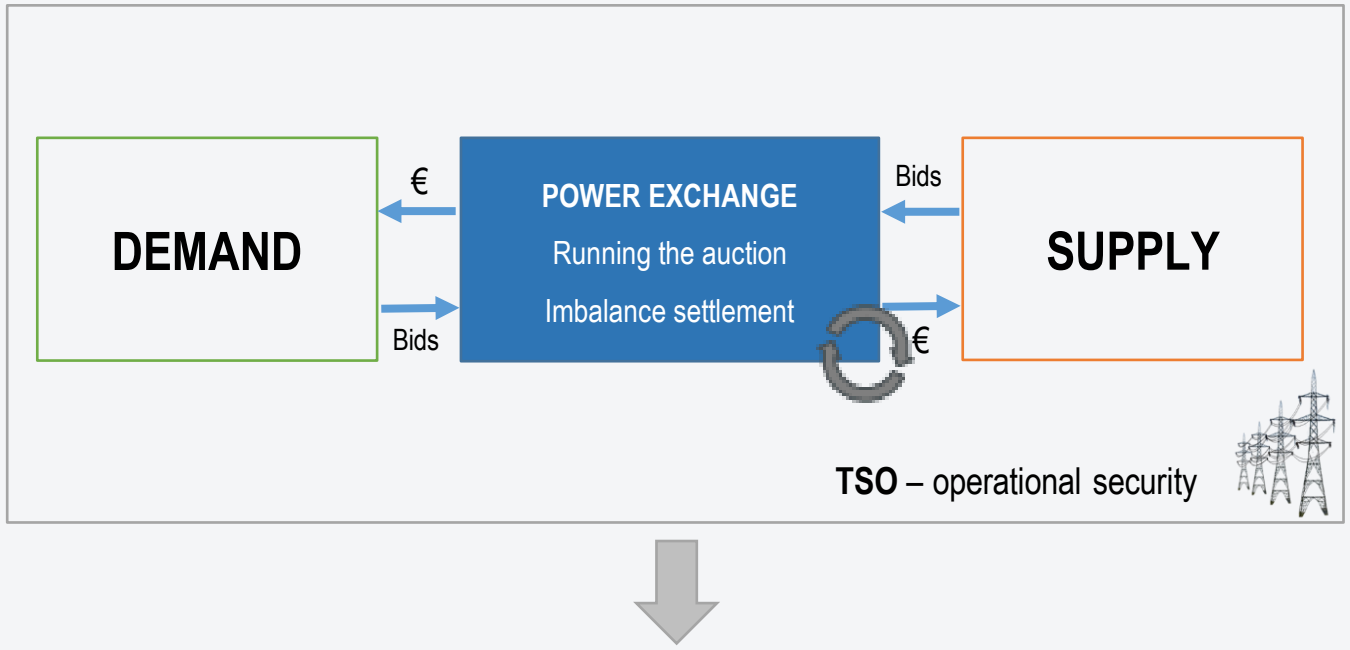


Result → domestic trade based on bilaterally agreed price within one bidding zone

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

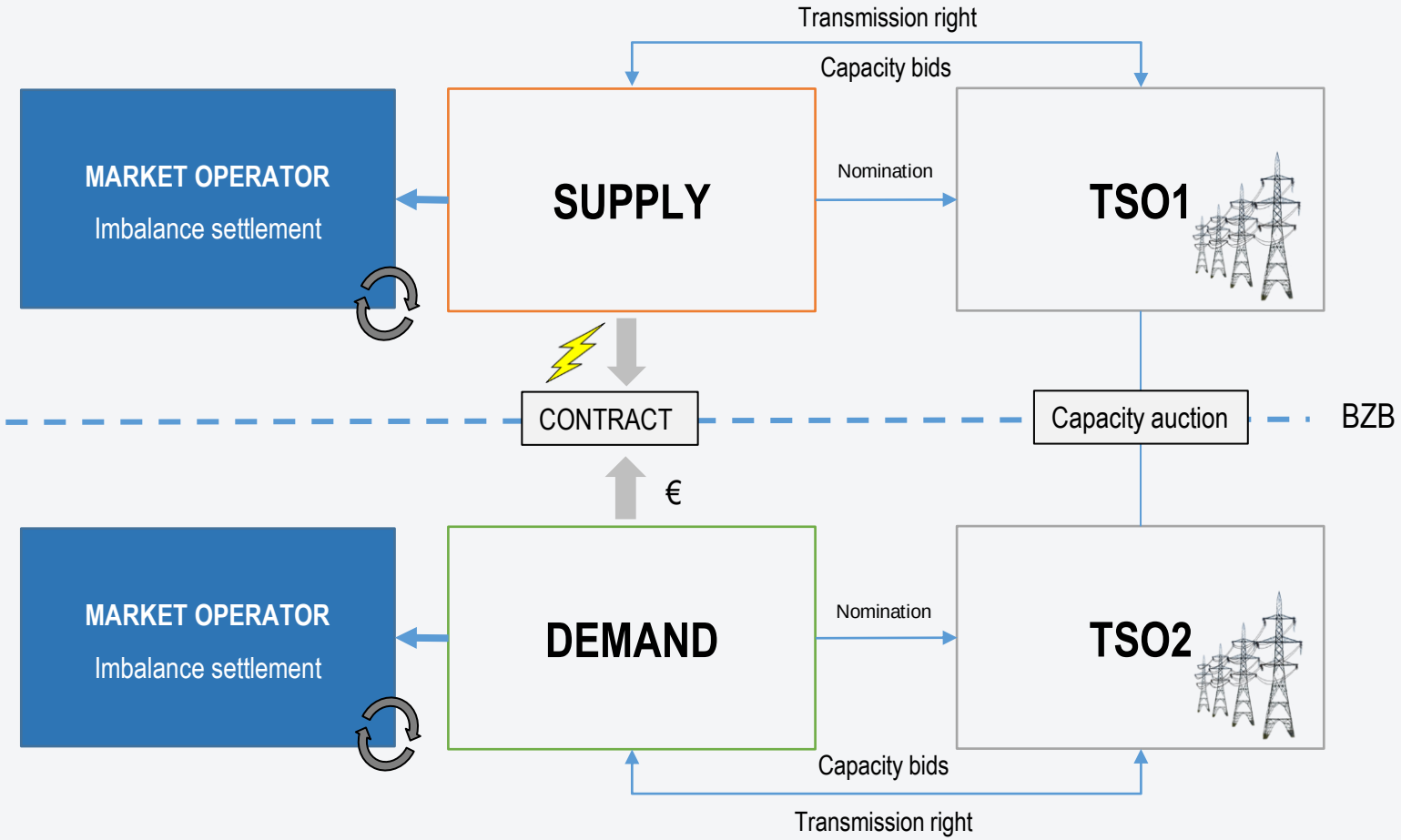


Result → domestic trade based on auction price within one bidding zone

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 or centrally



Day-ahead market 5/5

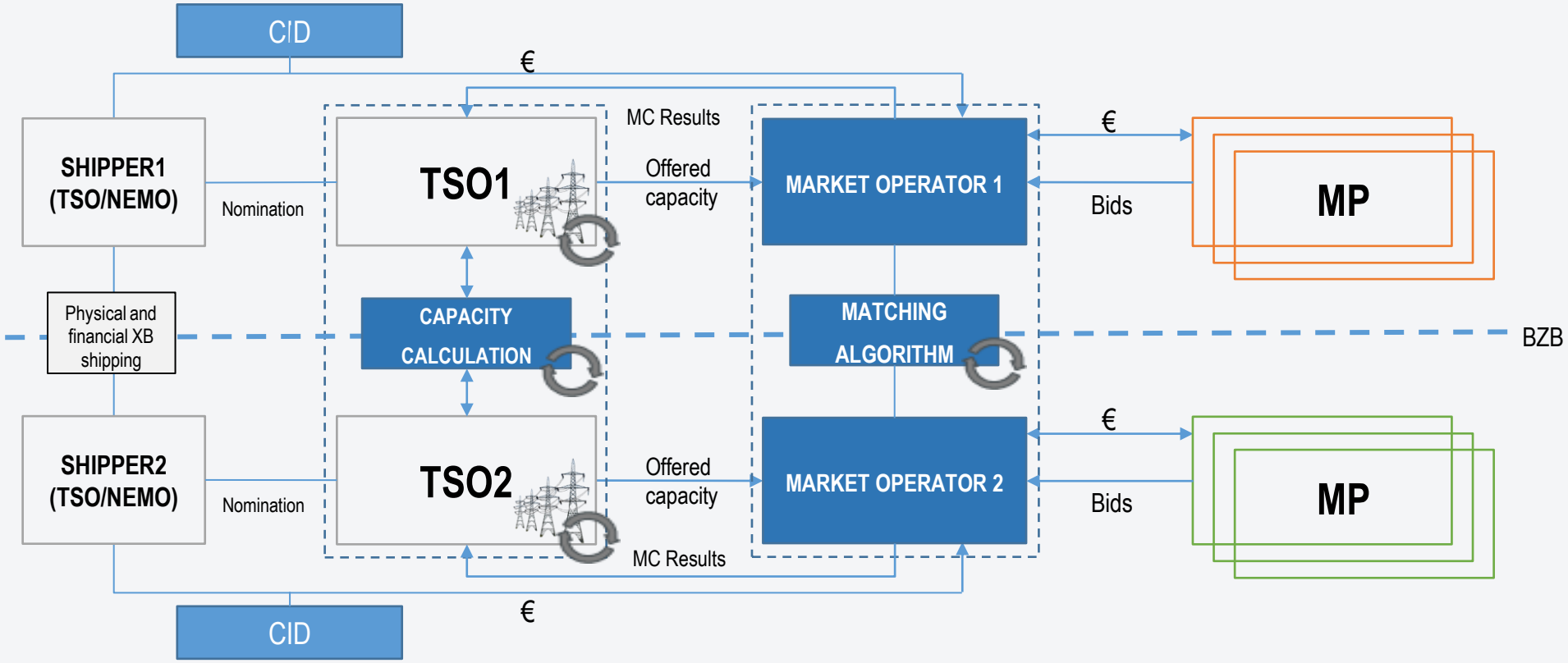
4. Market coupling

- Cross-border auction based trading with implicit capacity allocation; cleared once per day

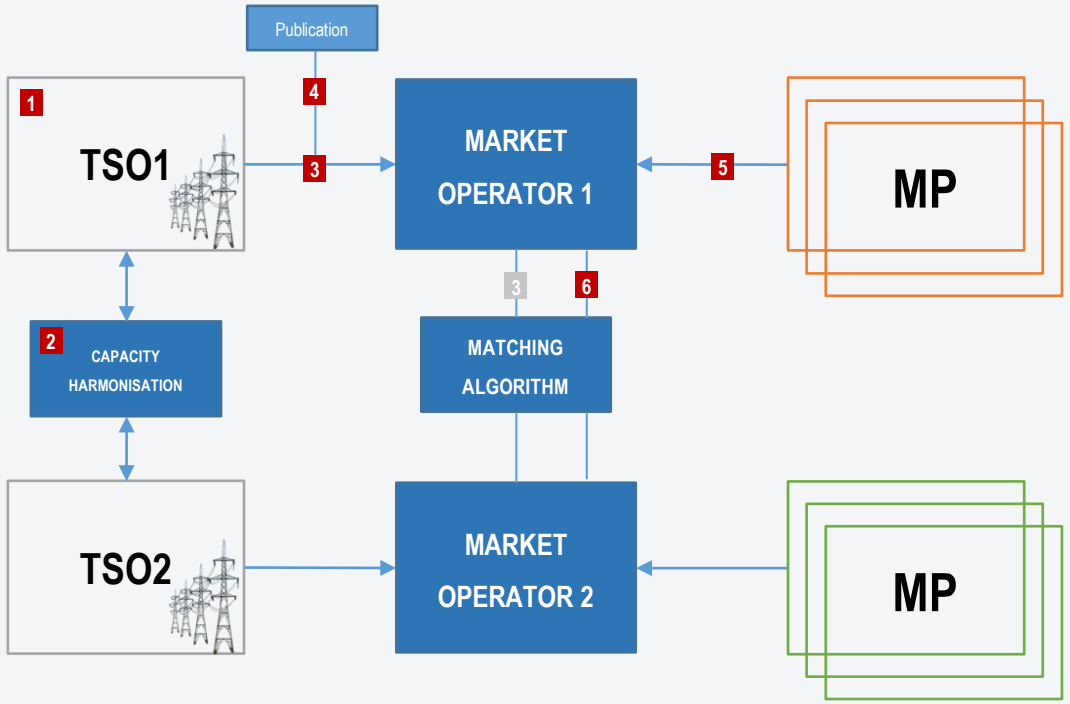
Target model defined by Commission Regulation (EU) 2015/1222 establishing a guideline on capacity allocation and congestion management (CACM) using the price coupling algorithm – optimal price formation **:**

- **Input** – allocation constraints/cross-zonal capacity and collected bids (orders)
- **Outputs** – prices, net positions and flows

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

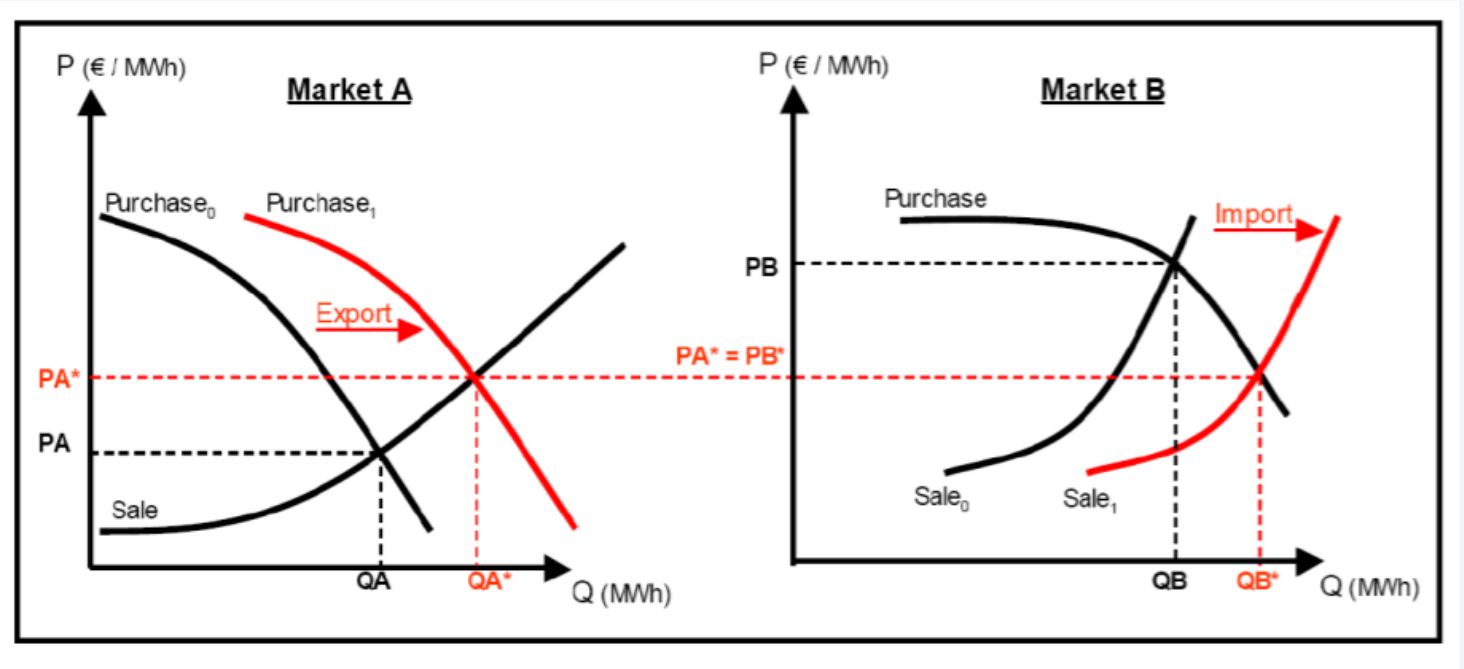
Collection of energy buy/sell orders and processing

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

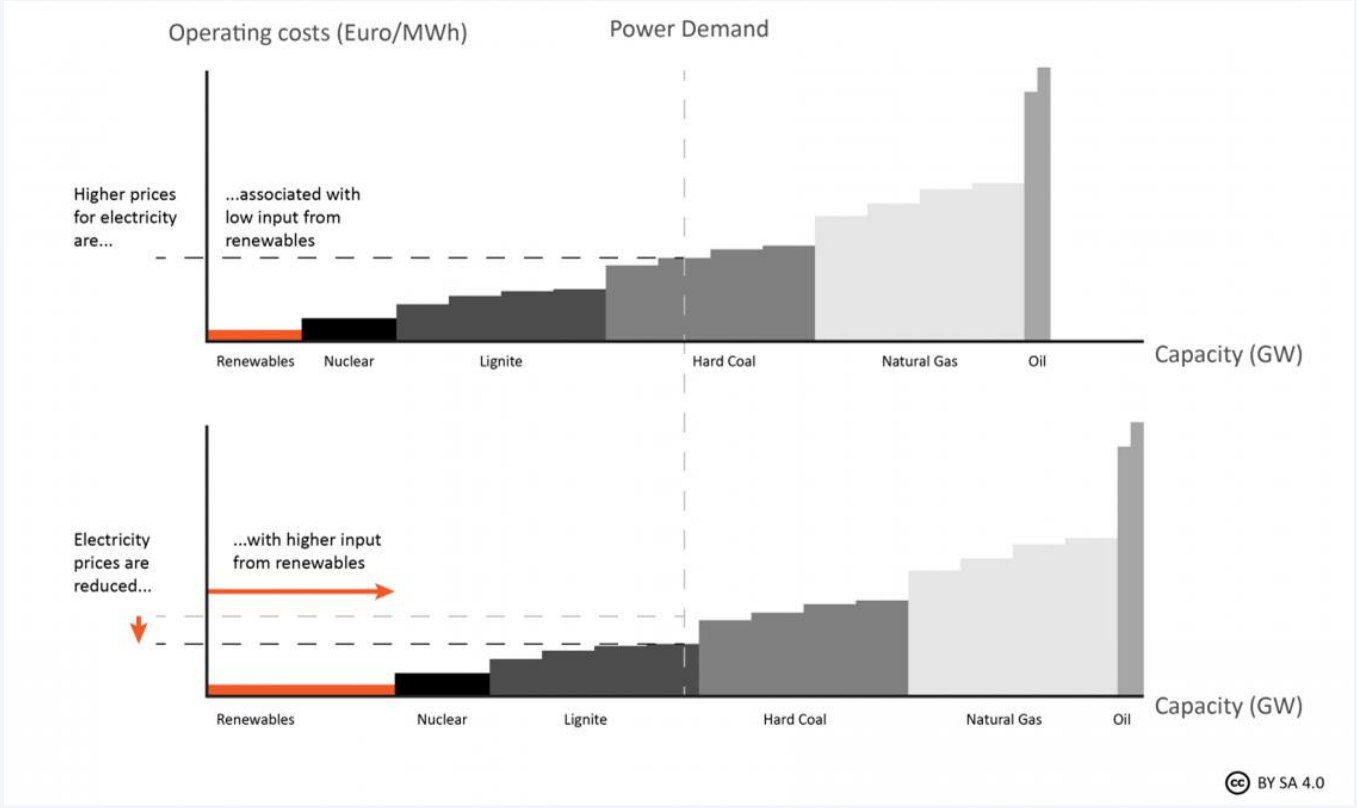
- In the coupling phase, market clearing prices for each bidding area, net positions of bidding areas and the XB flows are calculated
- Price formation on the cross border day-ahead market:
  - An automatic, anonymized process carried out by the algorithm (Euphemia)
  - It is based on the aggregated 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



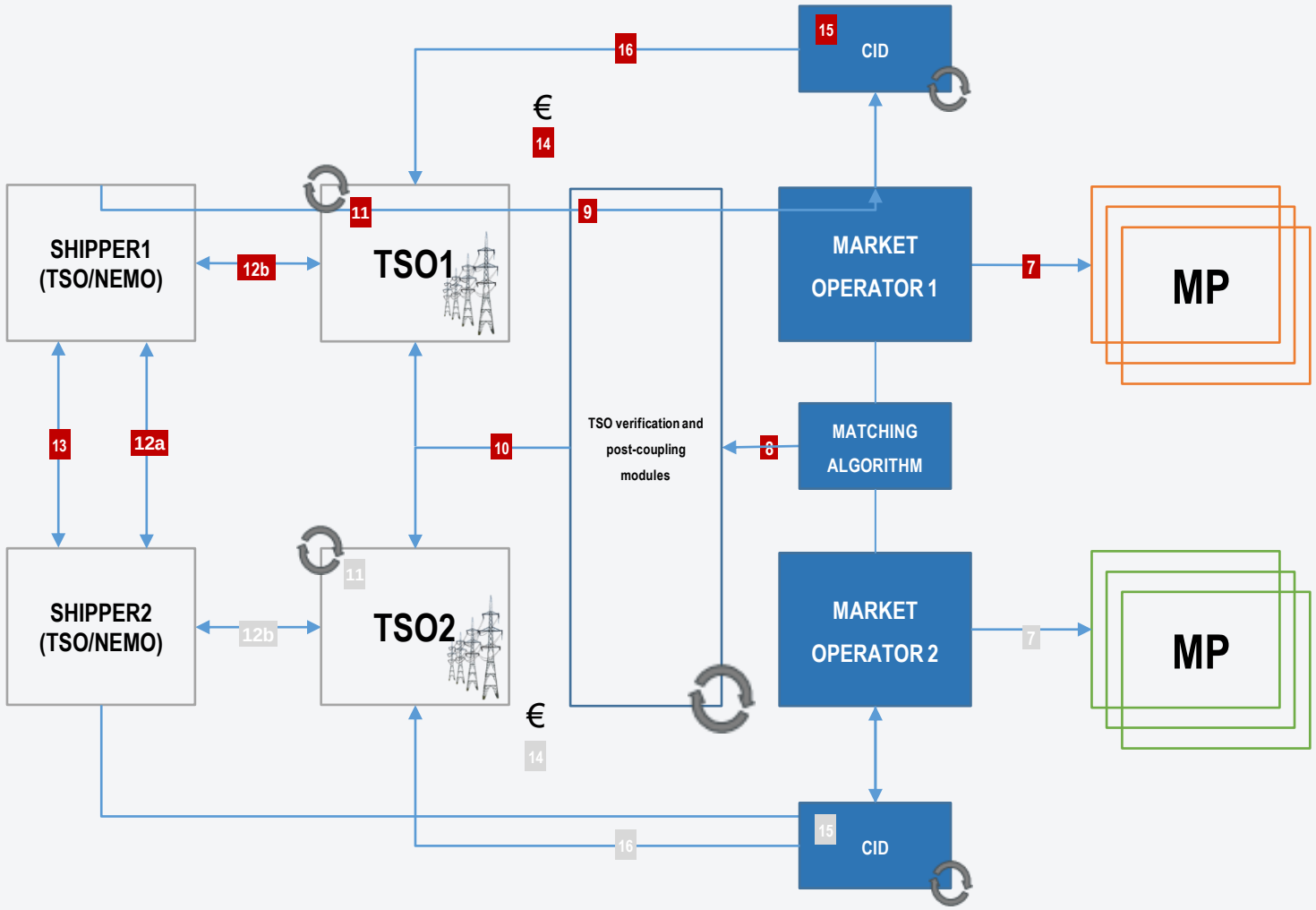
Merit order

- 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

Physical shipping

11. Generation of schedules – how much capacity shall be transferred across the border (CAS document)?
12. Nomination of cross-border schedules – how much capacity is going to be used?

12b. TSO check nominated flows against capacity limits

13. Financial shipping of electricity, 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 2019/943 defines in Art. 19(2) rules for usage of any congestion income generated:

a. guaranteeing the actual availability of the allocated capacity including firmness compensation; or
b. maintaining or increasing cross-zonal capacities through optimisation of the usage of existing interconnectors by means of coordinated remedial actions, where applicable, or covering costs resulting from network investments that are relevant to reduce interconnector congestion.

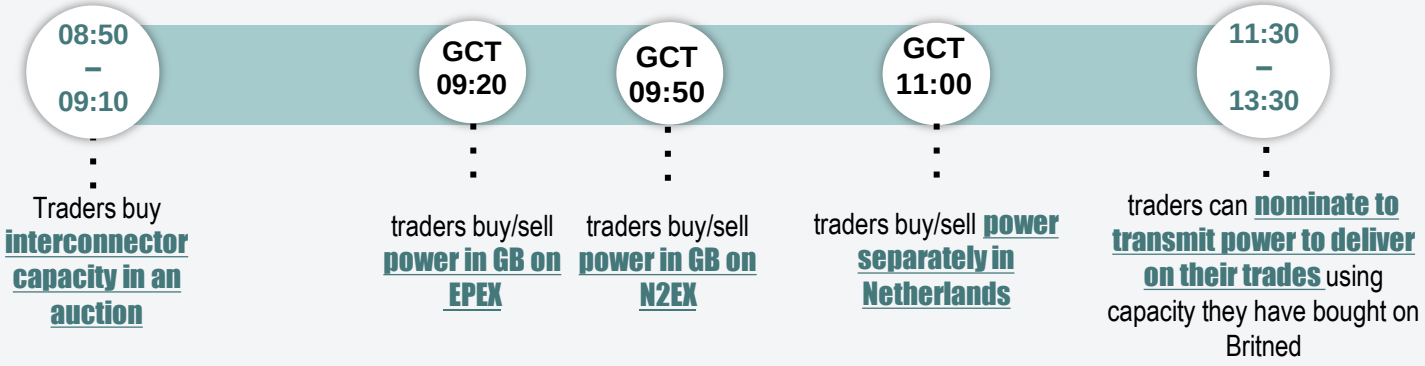
If the revenues cannot be efficiently used for these specific purposes – tariff reduction applied based on NRA decision and/or placement on a separate account line.

Is the efficiency of implicit trading so much higher?

- EU legislation sets out a harmonised process (Single day-ahead coupling) to maximise efficiency of costs (price convergence) and use of interconnectors → post Brexit, GB is no longer part of it and GB interconnectors have returned to an explicit auction process.

How does the process look like on the cable (BritNed) between GB and Netherlands?

- i.e. traders buying a right to capacity to flow electricity between GB and the Netherlands before the electricity price in either GB or the Netherlands is known.



What are the risks associated with such arrangement?

- traders run the risk that they get their forecast of the price differential wrong when they bid for interconnector capacity (for example, undervaluing capacity);
- society runs the risk that interconnector capacity is under-used.

- early anlysis showas lost value of trade of £45m indicating that the absence of efficient arrangements on the interconnectors does have a material cost.

- Another analysis shown that interconnectors operated under explicit auctions resulted in extreme prices for capacity when the GB market is under stress.

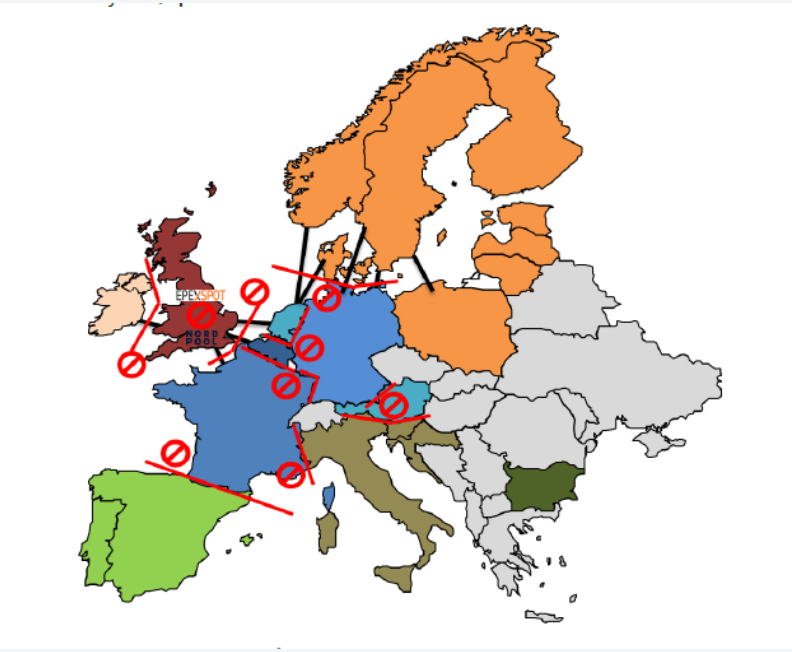
.

	January	February	March
2015 – 2020	£ 245.01	£ 222.60	£ 191.55
2021	£ 1500.00	£ 300.19	£ 683.00

Image: EnAppSys.

What happens when market coupling fails?

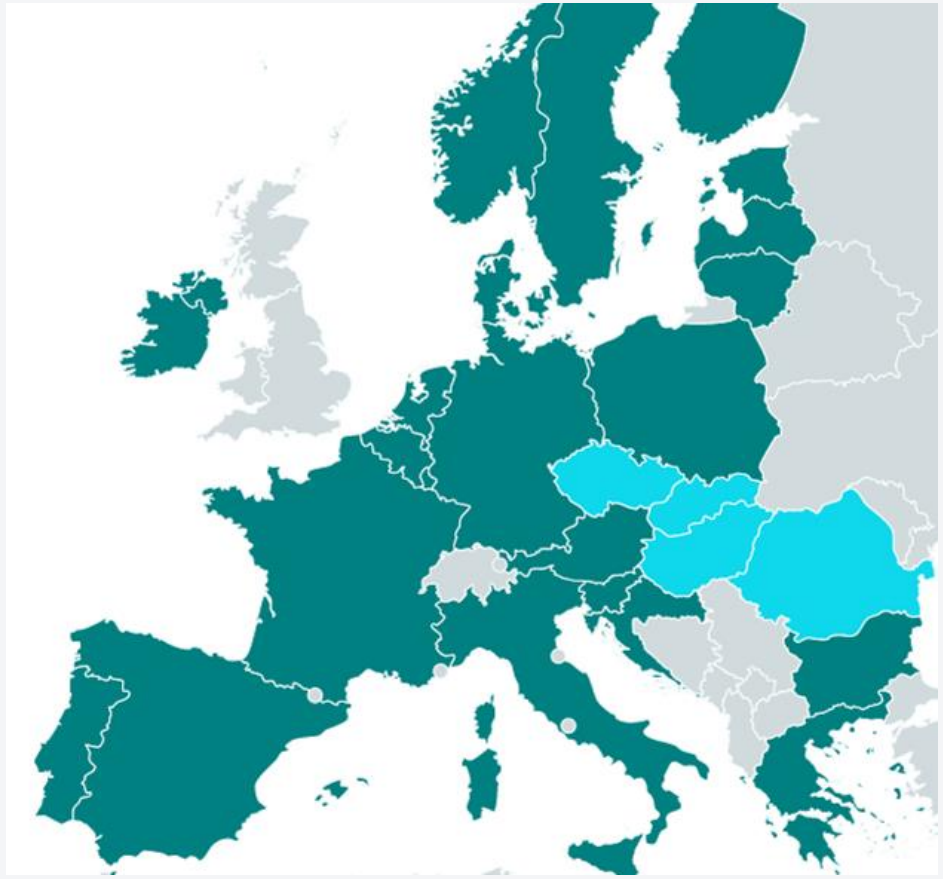
- When the trading of electricity together with XB capacity is no longer possible, the situation is called decoupling. Based on the scope of the issue, we distinguish:
  - Partial decoupling – some borders or bidding areas are decoupled
  - Full decoupling – all of the borders and bidding areas are decoupled



- It is a rare occurance, mainly due to technical issues experienced by any of the NEMOs or TSOs. This makes coupled market highly interdependent and its safe operation requires robust governance structure and strict operational procedures.
- The economic impact caused by the decoupling of the markets can be great.
- Potential mitigation of the effects – Multi-NEMO Arrangement?

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

Operational status quo



Multi-regional Coupling (MRC)

4M MC

- 2 independent operational solutions in Europe – MRC & 4MMC
- One coupling algorithm – EUPHEMIA

- Step towards fully integrated markets ⟶ 28.03.2019 – Single Day-ahead Operational agreement
- Multiple ways how to couple MRC and 4MMC – capacity calculation concern
- **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**)

- **Interim solution** – 4MMC and MRC coupling via respective BZBs using the NTC capacity calculation method

- **Target solution** – CORE Flow-based market coupling using coordinated capacity calculation method

Q&A AND COFFEE BREAK

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)

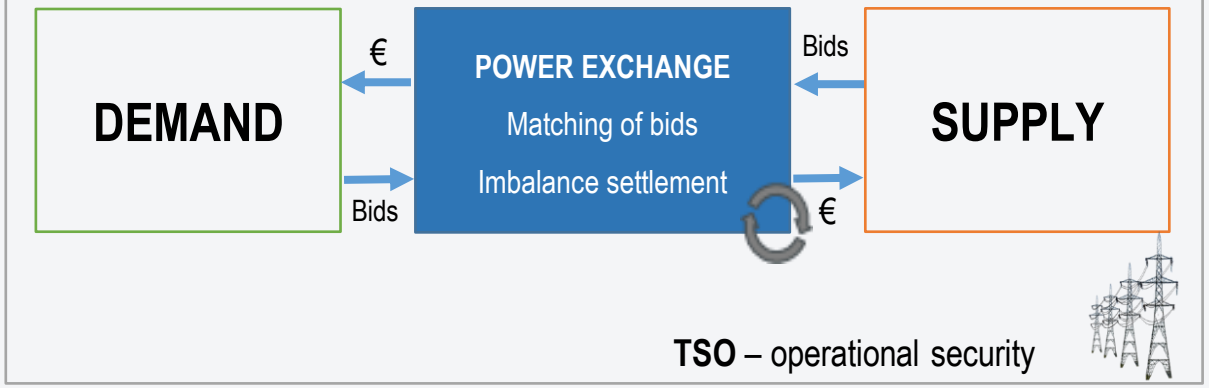
     → target = Single Intraday Coupling (SIDC))

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

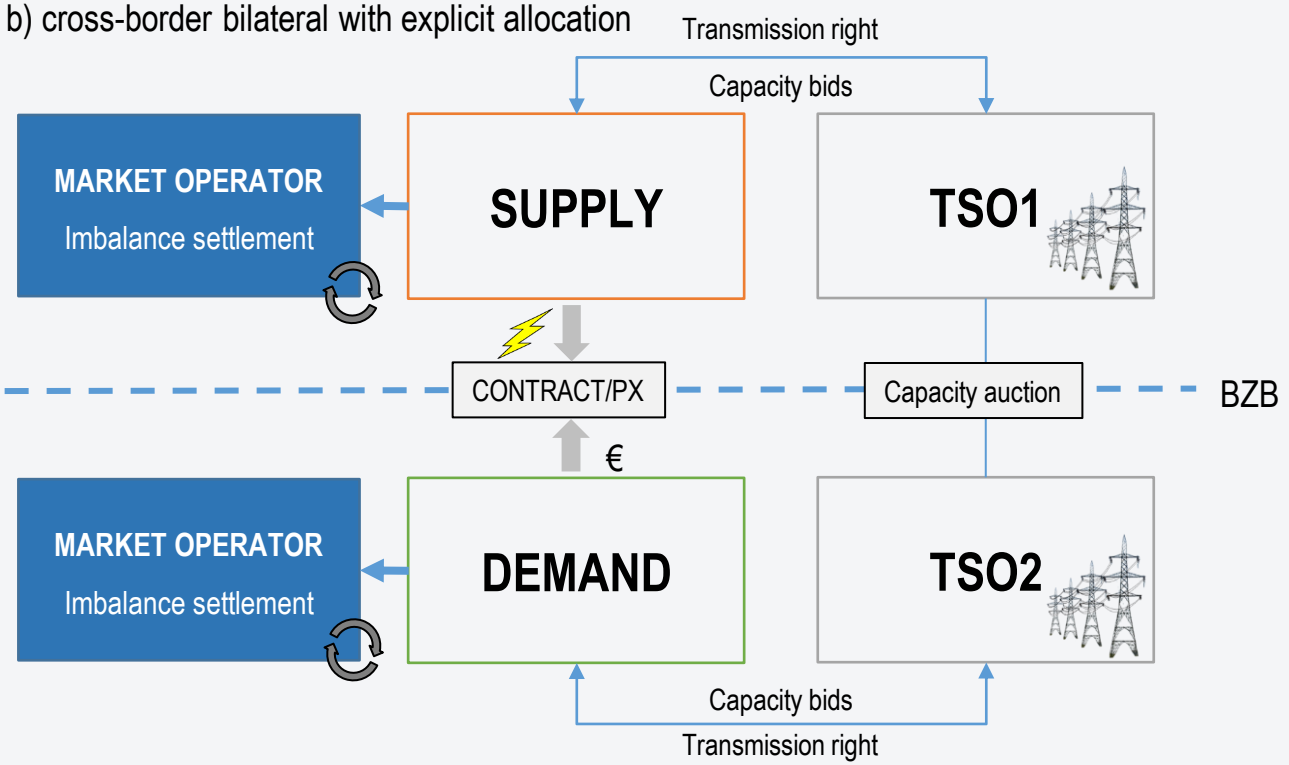
Intraday 3/6

a) domestic

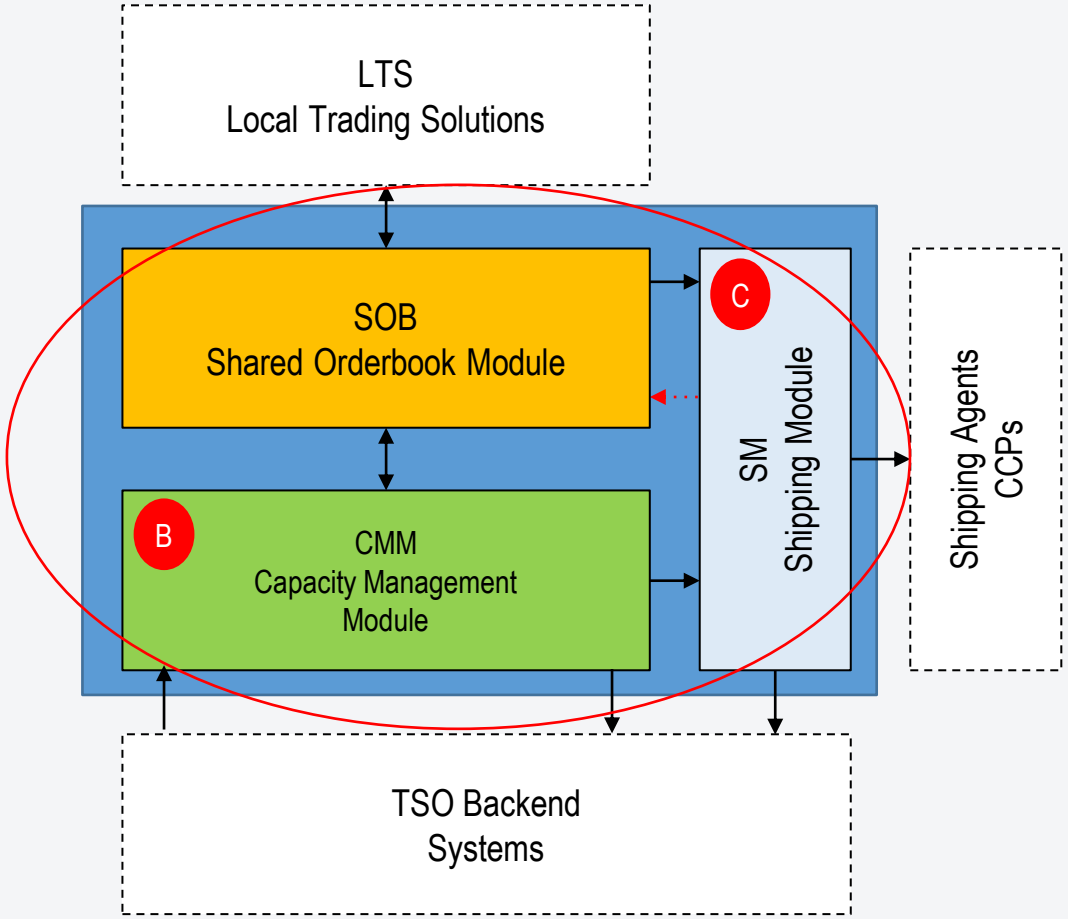


TSO – operational security

b) cross-border bilateral with explicit allocation



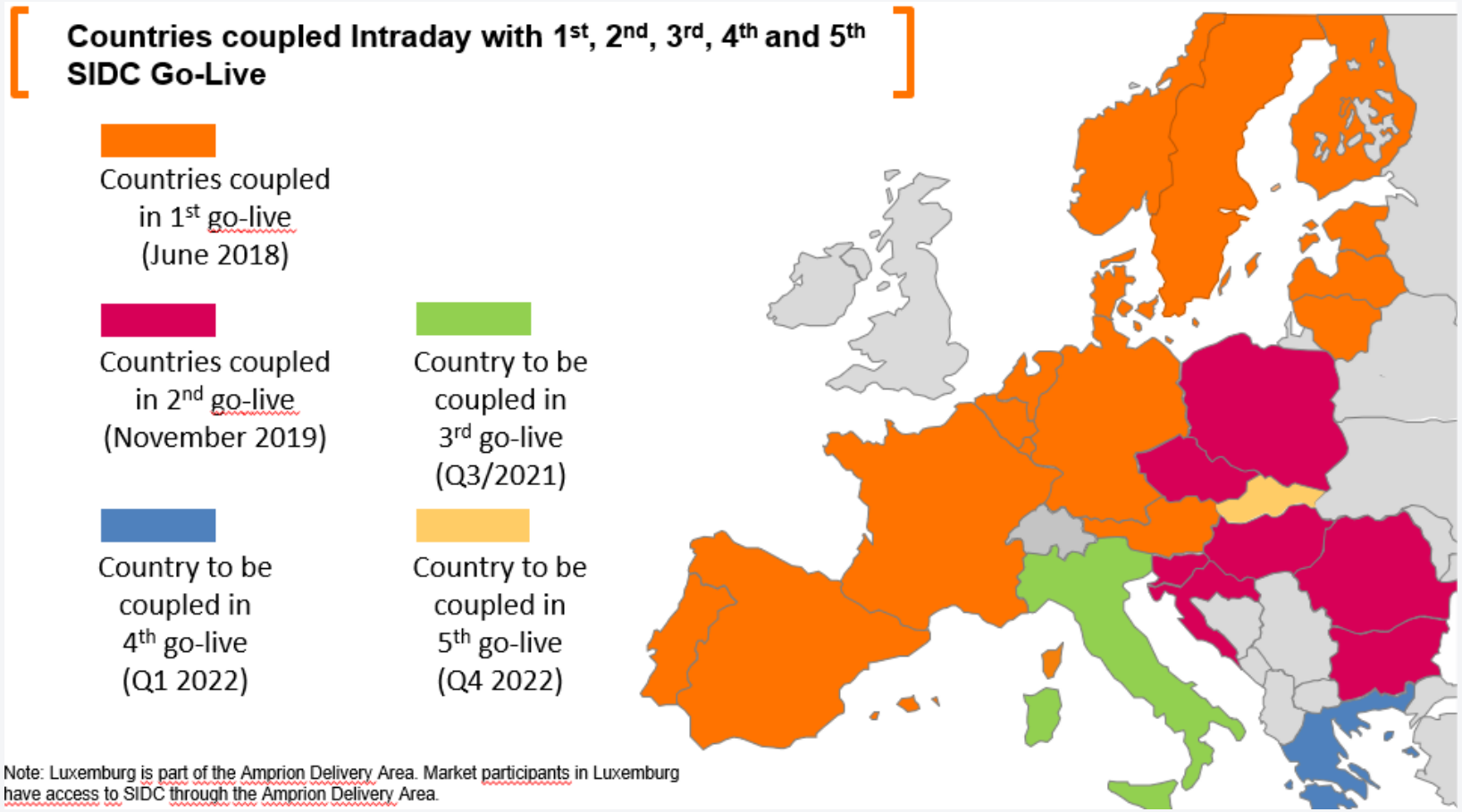
Intraday 4/6 : XBID project



- 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 go-live in November 2019, next waves – 2021+
- Implementation of LIPs requires inter alia changes of the local trading systems and integration to the common system.

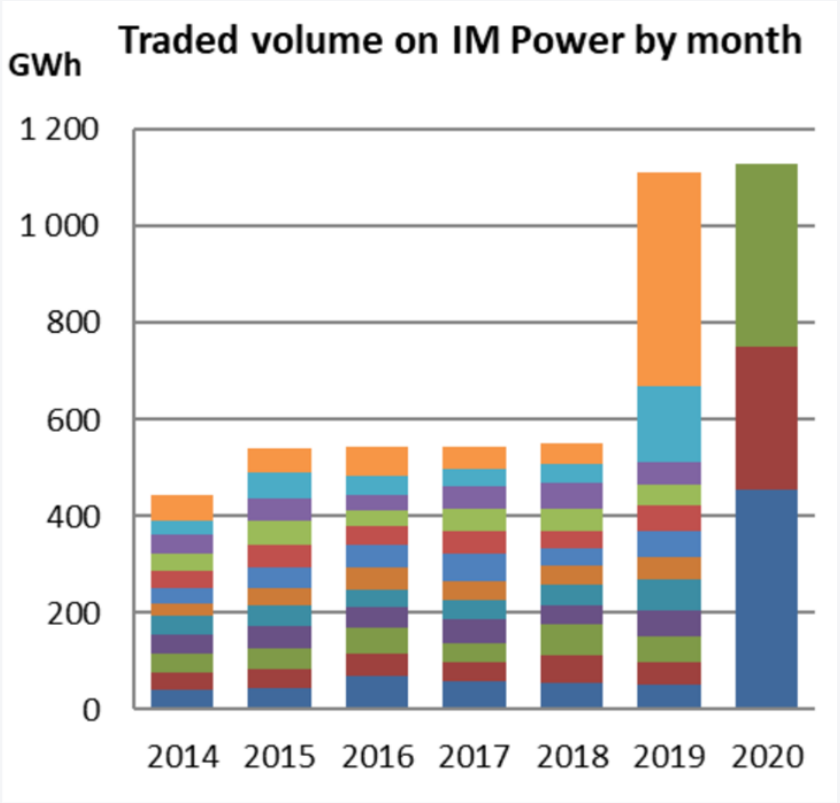


Source: XBID project

Intraday 6/6 : Launch of the second wave in numbers

- XBID project expanded in November 2019 („Second wave“) – solution now covers also BZBs of Bulgaria, Croatia, Czech Republic, Hungary, Poland, Romania and Slovenia.
- For Czech republic alone - 2018's maximum in the intra-day electricity market - 550 GWh exceeded on Thursday, 20 November 2019, i.e. the first day after XBID go live on the respective BZBs of Czech republic.
- In 2020 - 4439 GWh of electricity was traded on Intraday market in Czech republic → 3328 GWh more than in 2019
- increase of 70% between 2018 and 2019, and increase of nearly 300% from 2019 to 2020.

Electricity traded (GWh) on ID market in Czech republic (by year in montly resolution)



Source: https://www.ote-cr.cz/en/about-ote/ote-news/the-volume-of-traded-electricity-on-the-intra-day-electricity-market-is-growing-record-breaking-the-importance-of-the-intraday-market-continues-to-grow

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 (ISP) of 15 minutes in all scheduling areas
- The Electricity Regulation (2019/943) requires the Market Time Unit (MTU) to be as short as the imbalance settlement period by 2021
- However, derrogations have been granted in multiple countries, which poses significant challenge to the implementation of the shorter ISP and MTU on the (coupled) day-ahead and intraday markets. With different bidding areas using different MTUs, it is difficult to configure cross-border trading.

Q&A


PART
TWO

Security of operation

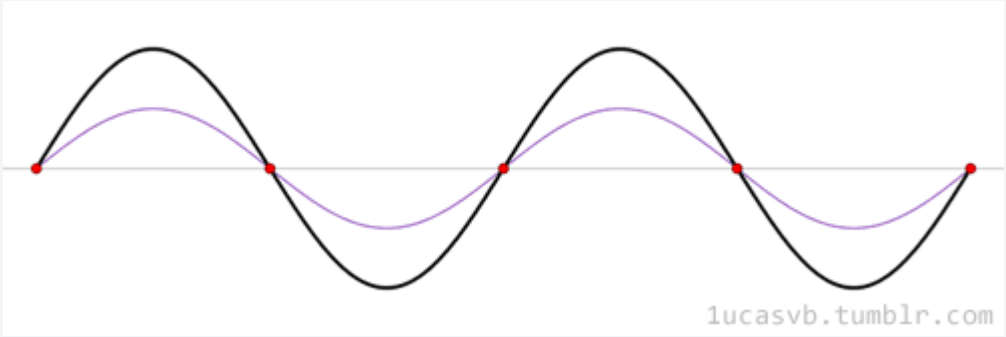
Balance between supply and demand

Demand and Supply must be balanced at all times

→ parameter: frequency set for 50 Hz when supply meets demand

What does 50 Hz frequency 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.

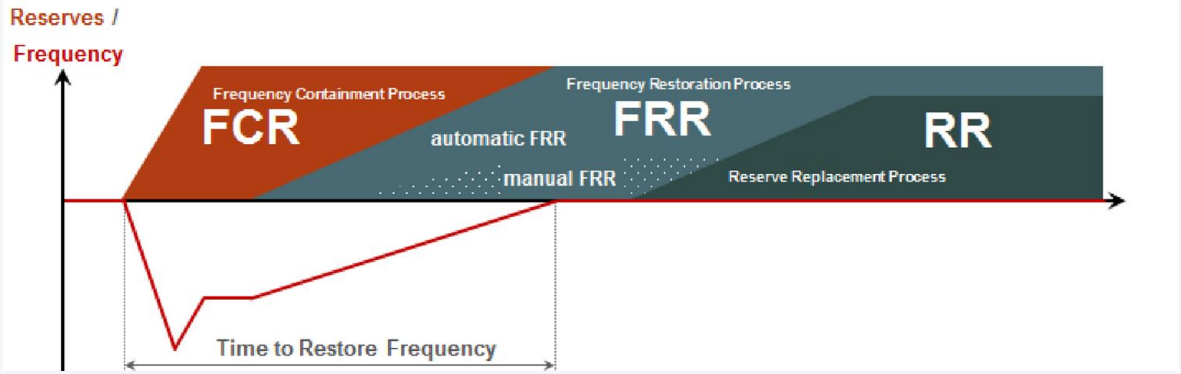
Security of operation
Ancillary Services

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 (balancing) capacity which can be activated/deactivated in order to maintain stability of the system

TSO procures relevant ancillary services via longterm contract or on specialised short term balancing markets:

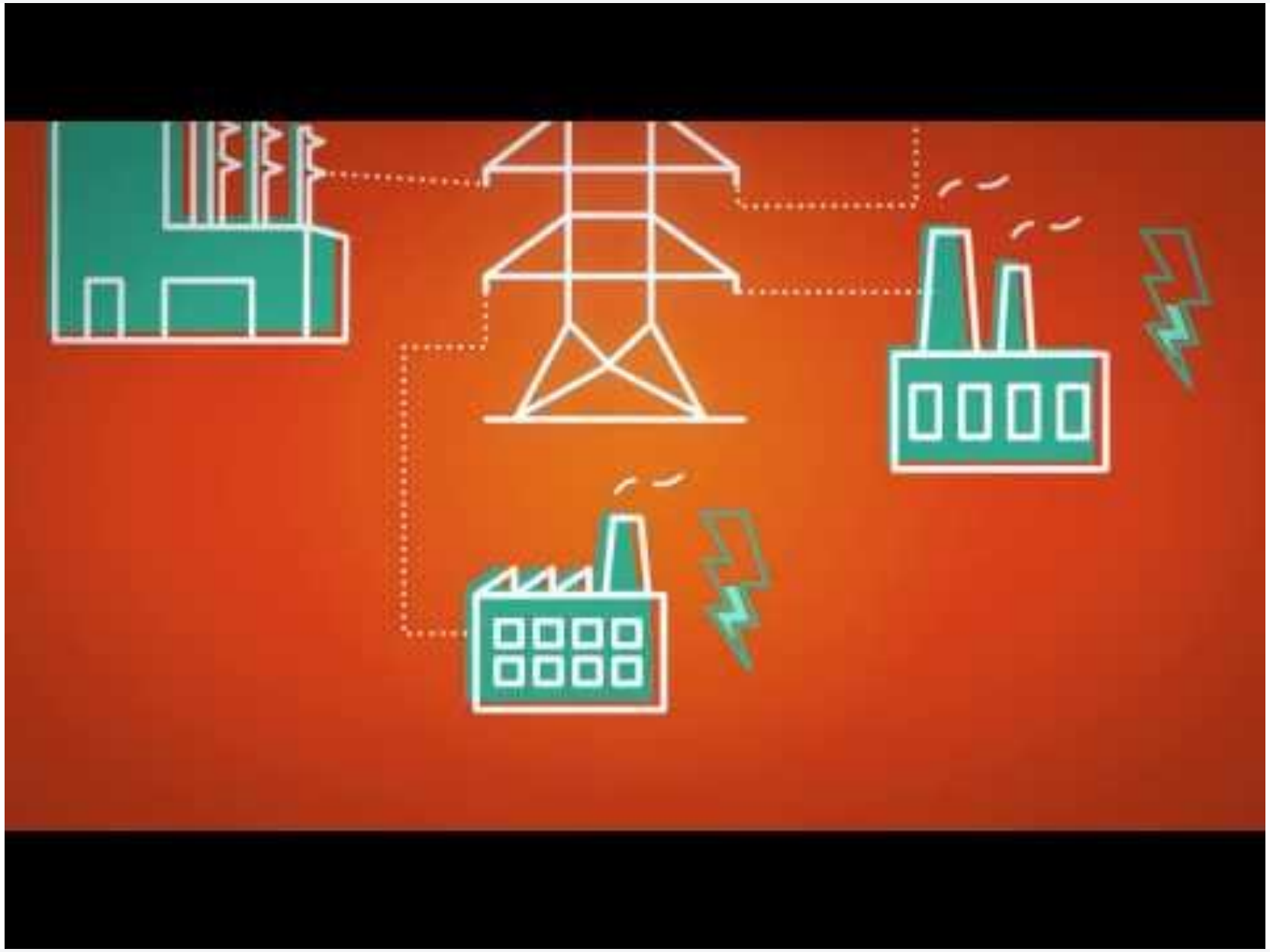
- **frequency containment reserve**
  - automatic response frequency fluctuation automatically within seconds.
  - The main aim: automatically adjust production in case of frequency fluctuation
  - Activation - solidarity principle of all synchronously interconnected transmission system operators (3000 MW for Continental Europe).
- **automatic or manual Frequency restoration reserve**
  - upward/downward regulation with activation time between 30 seconds and 15 minutes
  - directly activated by the TSO central dispatch centre and have to fulfil certain technical requirement and certification criteria.
- **replacement reserve** (ramping time up to 30 minutes)
  - restoration already exhausted reserves.
  - manually activated based on the specific request of the TSO.



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

EU regulation

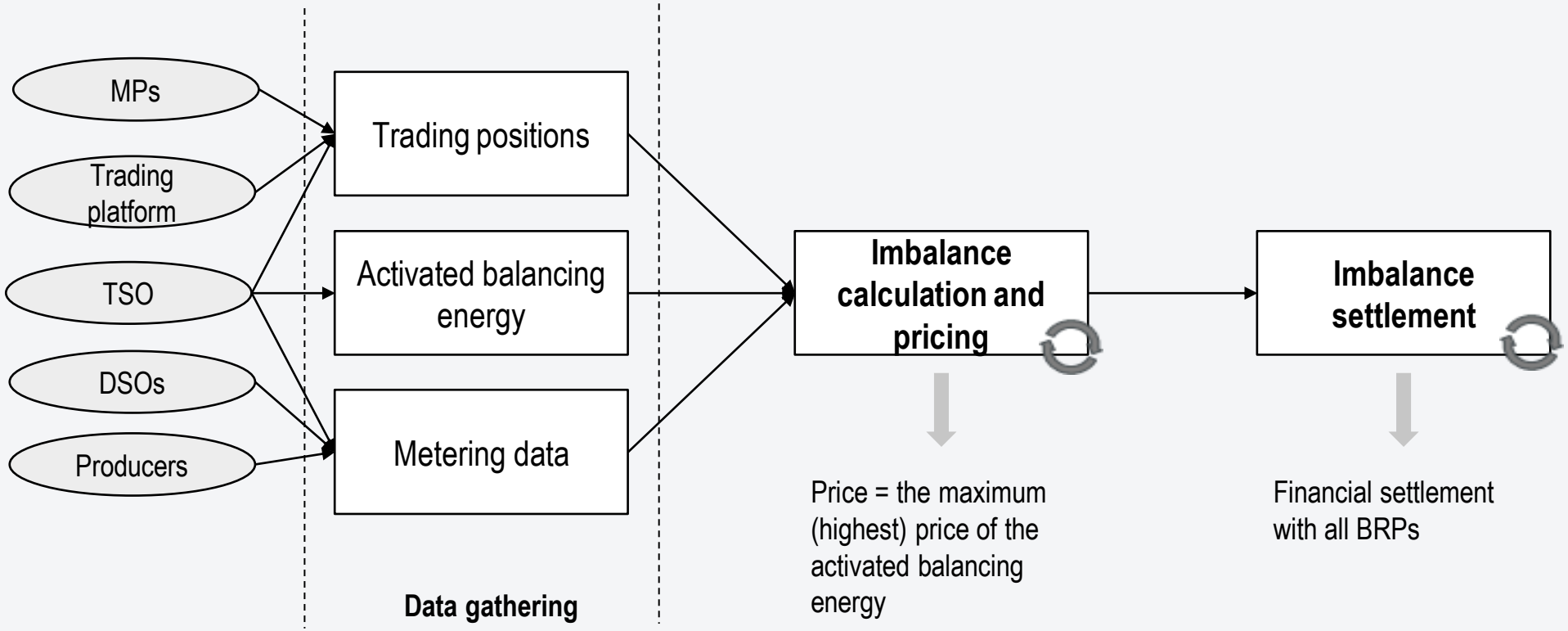
- Diverse balancing market design accross Europe – Electricity Balancing Guideline (EBGL) and CEP introduces set of harmonized rules fro procurement, activation pricing and settlement of balancing electricity.
- Aim is to have standardized products which shall be activated across-border with a „European“ price → trading platforms for each type of the reserve (IN, aFRR, mFRR and RR).



Source: Elia. 2016. https://www.youtube.com/watch?v=n7Chd2zi3qQ

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 market

What is generation adequacy problem?

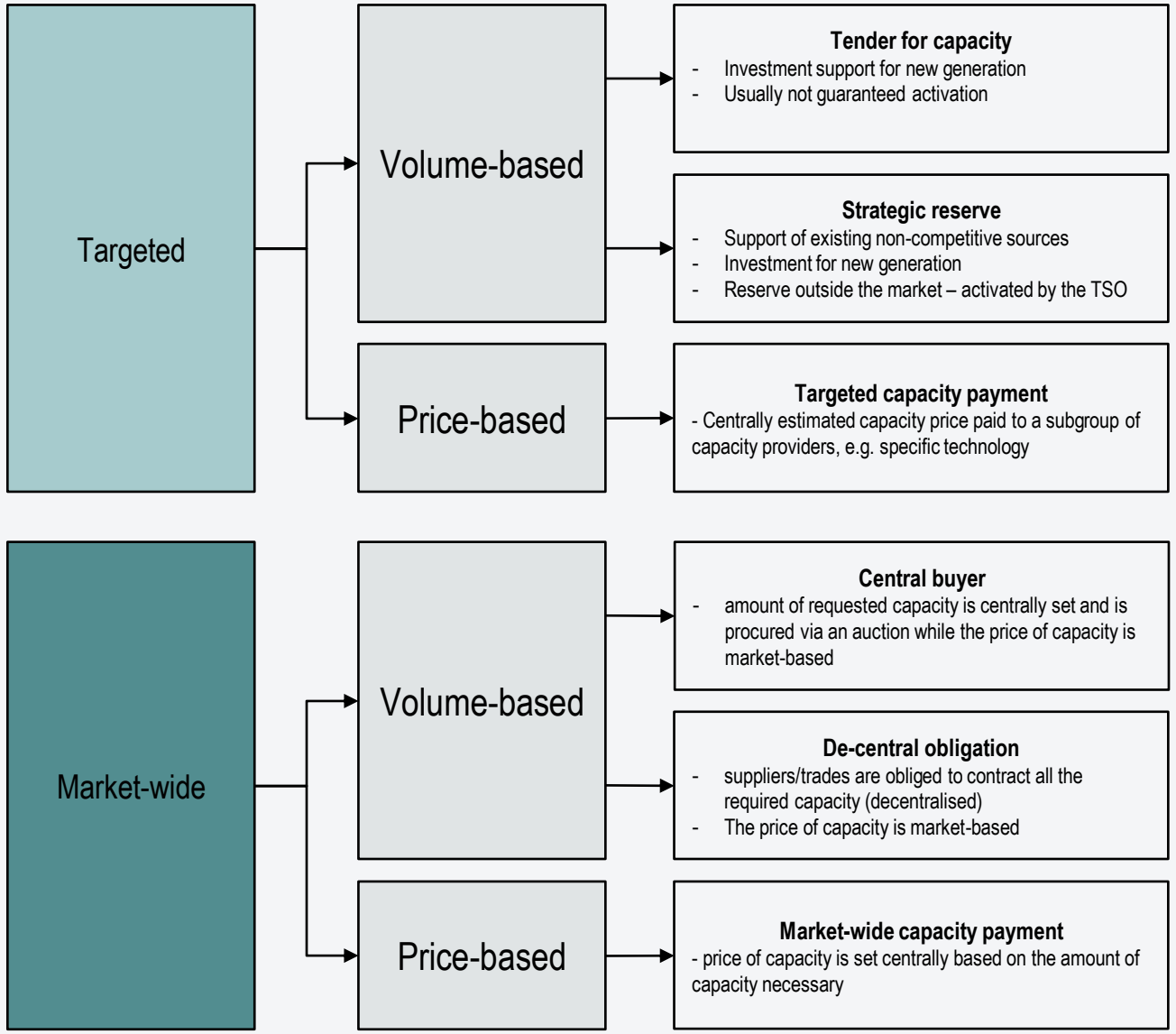
- Inability to maintain stability of the grid / supply does not meet demand;

Potential causes of generation adequacy issues:

- Extensive integration of RES – intermittent sources – **less base load and flexible capacity**
- Support schemes for RES – conventional sources not competitive → risk of underinvestment
- Energy-only market vs. capacity payments

<u>Security of supply is a key dimension of EU energy policy</u>

- **Solution:** support of existing (non-competitive) / new capacity sources - **capacity mechanisms (CM).**



Capacity mechanisms in the CEP-era

Before CEP

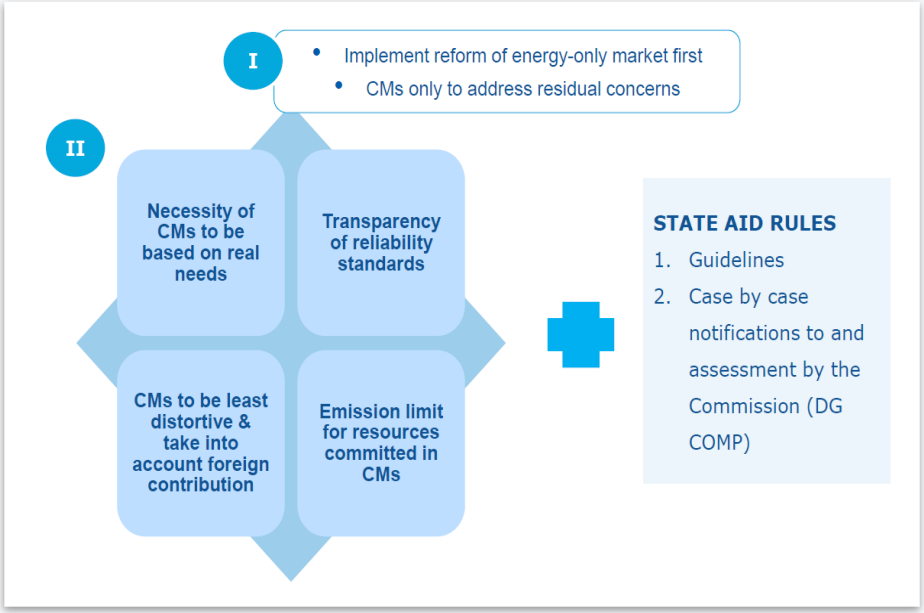
- Organic „growth“ ⟶ different designs, insufficient assessment of the market, unfair conditions – need for harmonization?

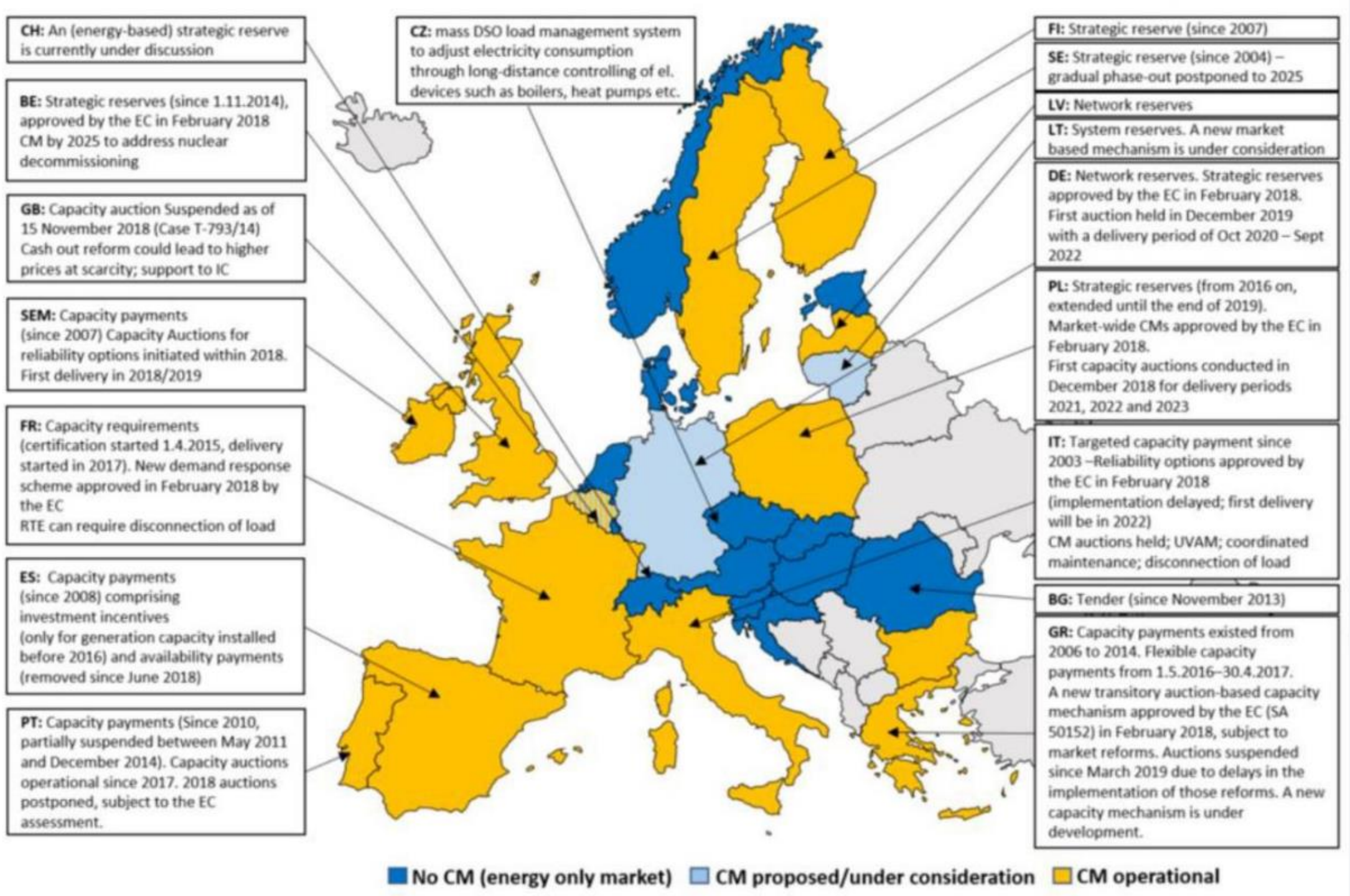
CEP

- capacity mechanisms = last resort tool to address adequacy concerns ⟶ implemented only **IF** the resource adequacy assessment (national and EU) shows the need for CM using defined implementation plans
- CEP defines common framework for CMs:
  - Emission limits for new and existing sources that can participate,
  - max. 10 years support,
  - cross-border participation of generation units etc.

Electricity Regulation 2019/943 (Art. 20 and 26) – clear common rules for:

- resource adequacy assessment,
- calculating the maximum entry capacity for XB participation,
- sharing the revenues, carrying out of availability check,
- determining when a non-availability payment is due,
- operation of the registry, identifying capacity eligible to participate in the capacity mechanism.




CH: An (energy-based) strategic reserve is currently under discussion
BE: Strategic reserves (since 1.11.2014), approved by the EC in February 2018 CM by 2025 to address nuclear decommissioning
GB: Capacity auction Suspended as of 15 November 2018 (Case T-793/14) Cash out reform could lead to higher prices at scarcity; support to IC
SEM: Capacity payments (since 2007) Capacity Auctions for reliability options initiated within 2018. First delivery in 2018/2019
FR: Capacity requirements (certification started 1.4.2015, delivery started in 2017). New demand response scheme approved in February 2018 by the EC
RTE can require disconnection of load
ES: Capacity payments (since 2008) comprising investment incentives (only for generation capacity installed before 2016) and availability payments (removed since June 2018)
PT: Capacity payments (Since 2010, partially suspended between May 2011 and December 2014). Capacity auctions operational since 2017. 2018 auctions postponed, subject to the EC assessment.
CZ: mass DSO load management system to adjust electricity consumption through long-distance controlling of el. devices such as boilers, heat pumps etc.
FI: Strategic reserve (since 2007)
SE: Strategic reserve (since 2004) – gradual phase-out postponed to 2025
LV: Network reserves
LT: System reserves. A new market based mechanism is under consideration
DE: Network reserves. Strategic reserves approved by the EC in February 2018. First auction held in December 2019 with a delivery period of Oct 2020 – Sept 2022
PL: Strategic reserves (from 2016 on, extended until the end of 2019). Market-wide CMs approved by the EC in February 2018. First capacity auctions conducted in December 2018 for delivery periods 2021, 2022 and 2023
IT: Targeted capacity payment since 2003 –Reliability options approved by the EC in February 2018 (implementation delayed; first delivery will be in 2022) CM auctions held; UVAM; coordinated maintenance; disconnection of load
BG: Tender (since November 2013)
GR: Capacity payments existed from 2006 to 2014. Flexible capacity payments from 1.5.2016–30.4.2017. A new transitory auction-based capacity mechanism approved by the EC (SA 50152) in February 2018, subject to market reforms. Auctions suspended since March 2019 due to delays in the implementation of those reforms. A new capacity mechanism is under development.
No CM (energy only market)
CM proposed/under consideration
CM operational

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!