

Electricity market integration: Challenges & opportunities

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- **General Developments in European electricity markets**
- **Electricity markets: How they work and how to improve them?**
Challenges – some case studies
- **European Electricity target model 2.0**

General developments in EU electricity markets



**+41 TWh
rise**

in solar generation,
leading the overall
rise in European
renewable generation.



**-16% annual
drop**

in European electricity
prices, bringing them
to their lowest levels
since 2021, with notable
regional disparities.



**-3% base load
+10% peak load**

electricity produced from
gas, revealing a shift in
the role of gas in
power generation.

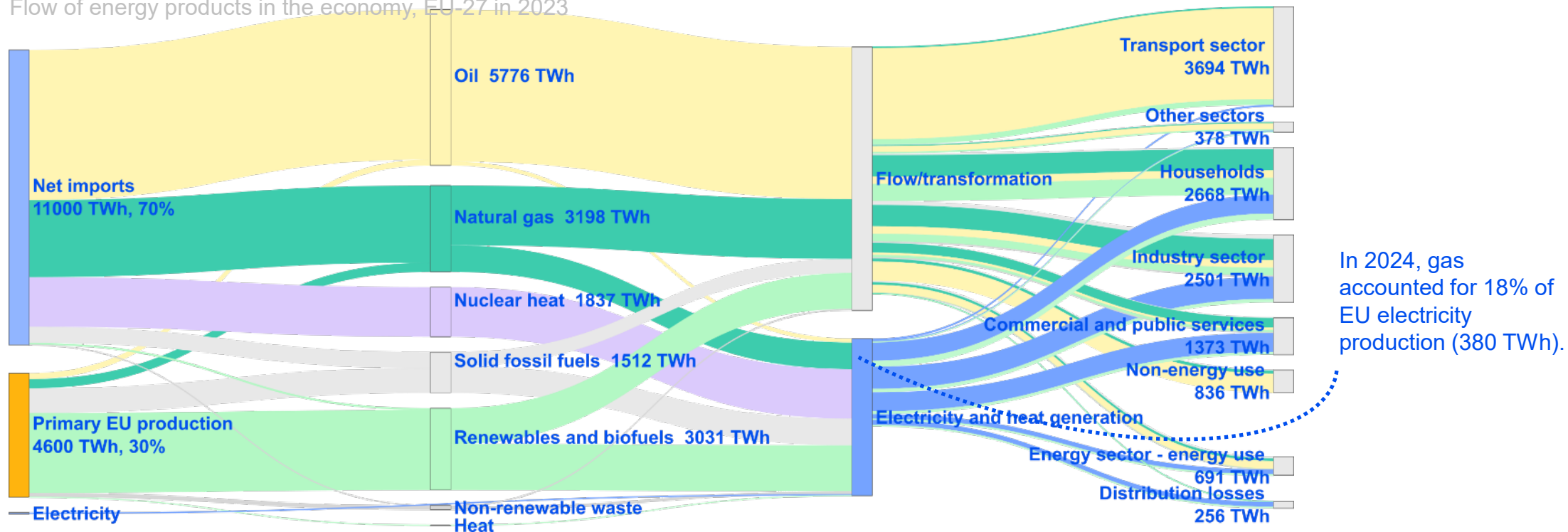


Renewable growth and fossil fuel reliance in Europe

European energy policies are critical for competitiveness, security and decarbonisation towards climate neutrality by 2050.

Final energy consumption reflects Europe's progress toward energy security, efficiency and sustainability goals.

Flow of energy products in the economy, EU-27 in 2023

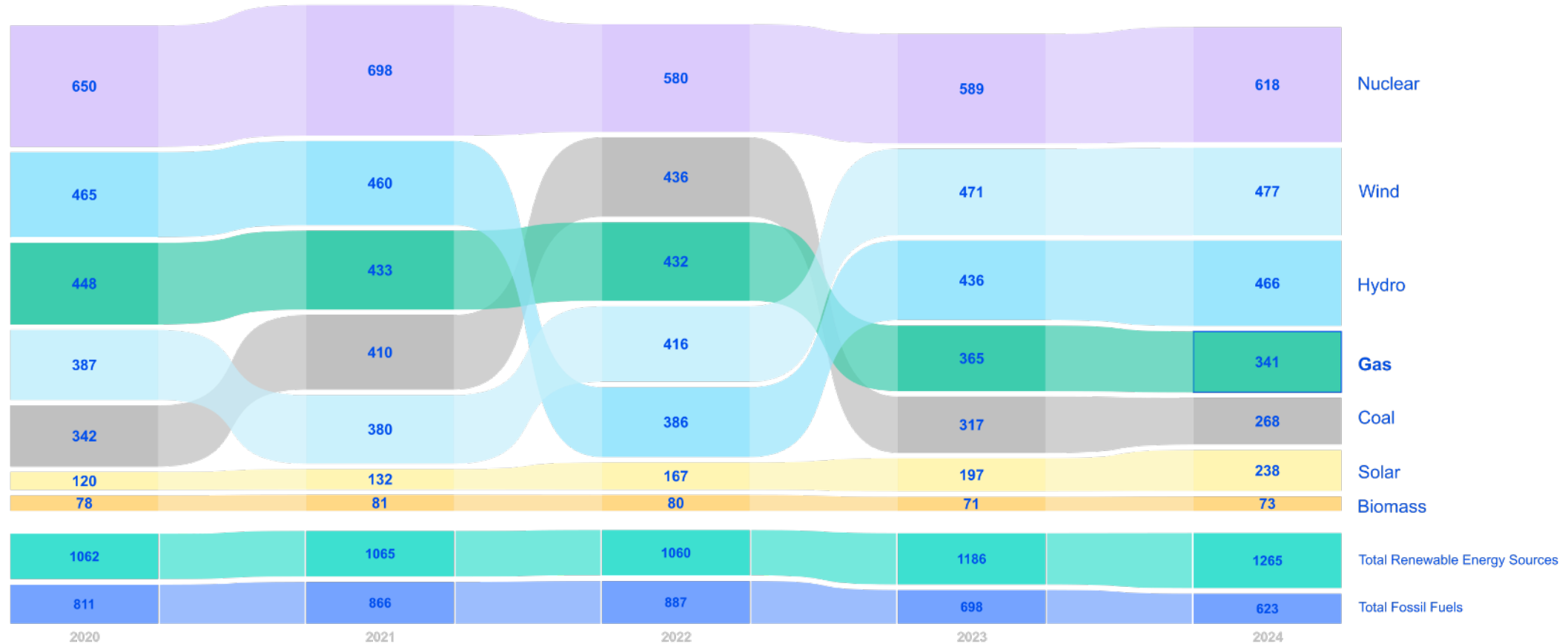


Additional efforts are needed to meet the 2030 target to cut EU greenhouse gas emissions by at least 55%, compared to 1990, and become climate neutral by 2050. Europe remains significantly reliant on imported fossil fuels (oil and gas).

Renewables generation surged, fossil fuels declined further

Electricity generation: in 2024, wind confirmed its position, solar drove transition, coal, gas declined

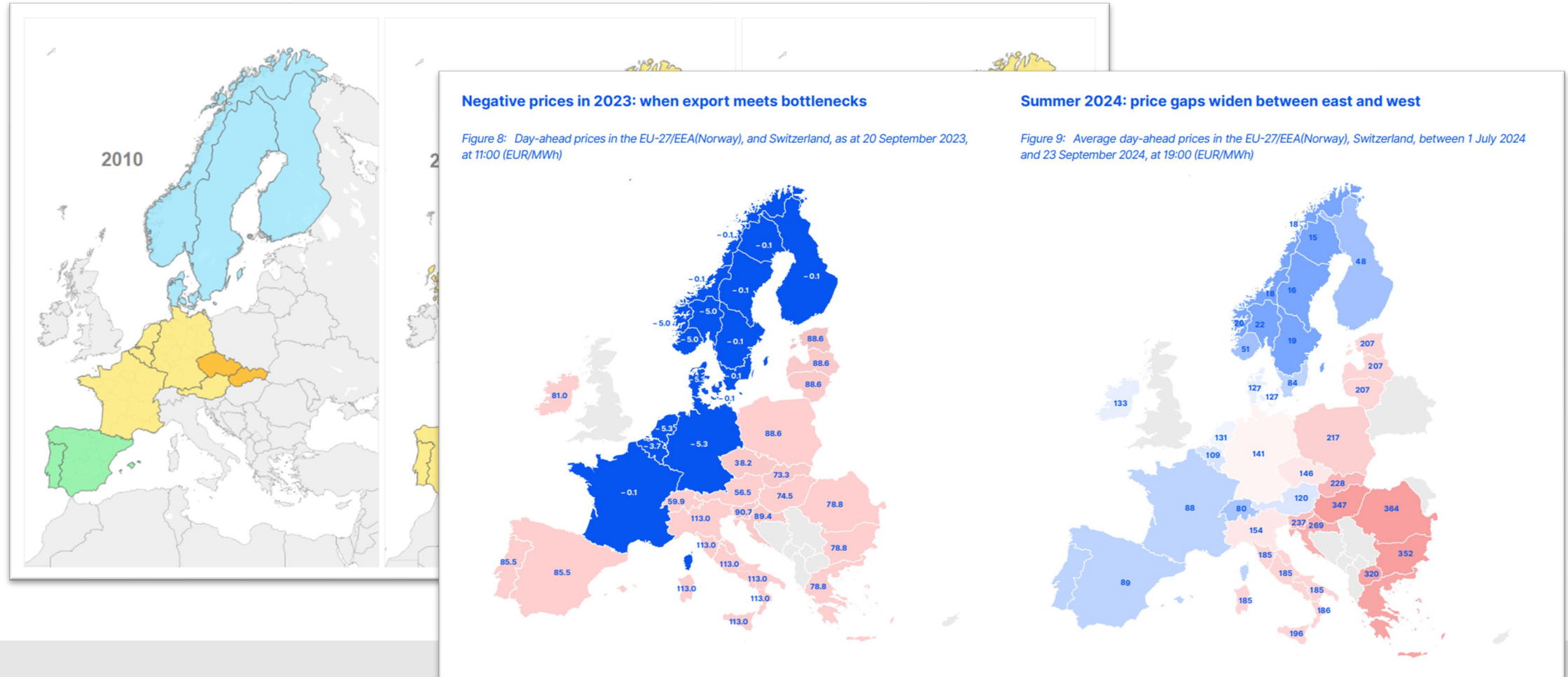
Evolution of generation per type in the EU-27 / EEA(Norway) – 2020-2024 (TWh)



By 2024, Fossil fuel use fell to a record low, contributing just 28% of EU power generation, less than a third of EU power for the second consecutive year.

Electricity wholesale Markets: new challenges are up..

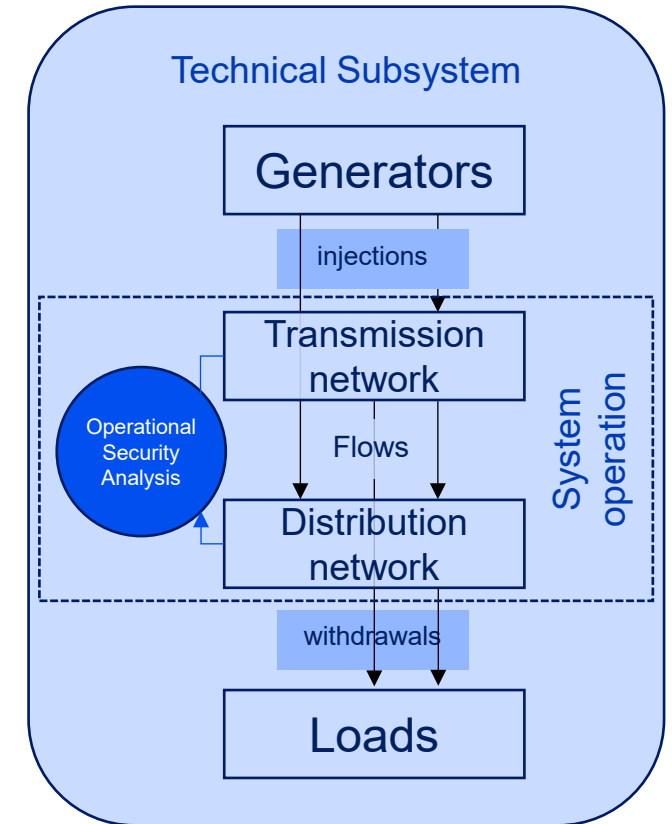
- The completion of DA and ID markets integration through market coupling is largely complete for DA & ID ... but new challenges are up



Electricity markets: How they work and how to improve them?



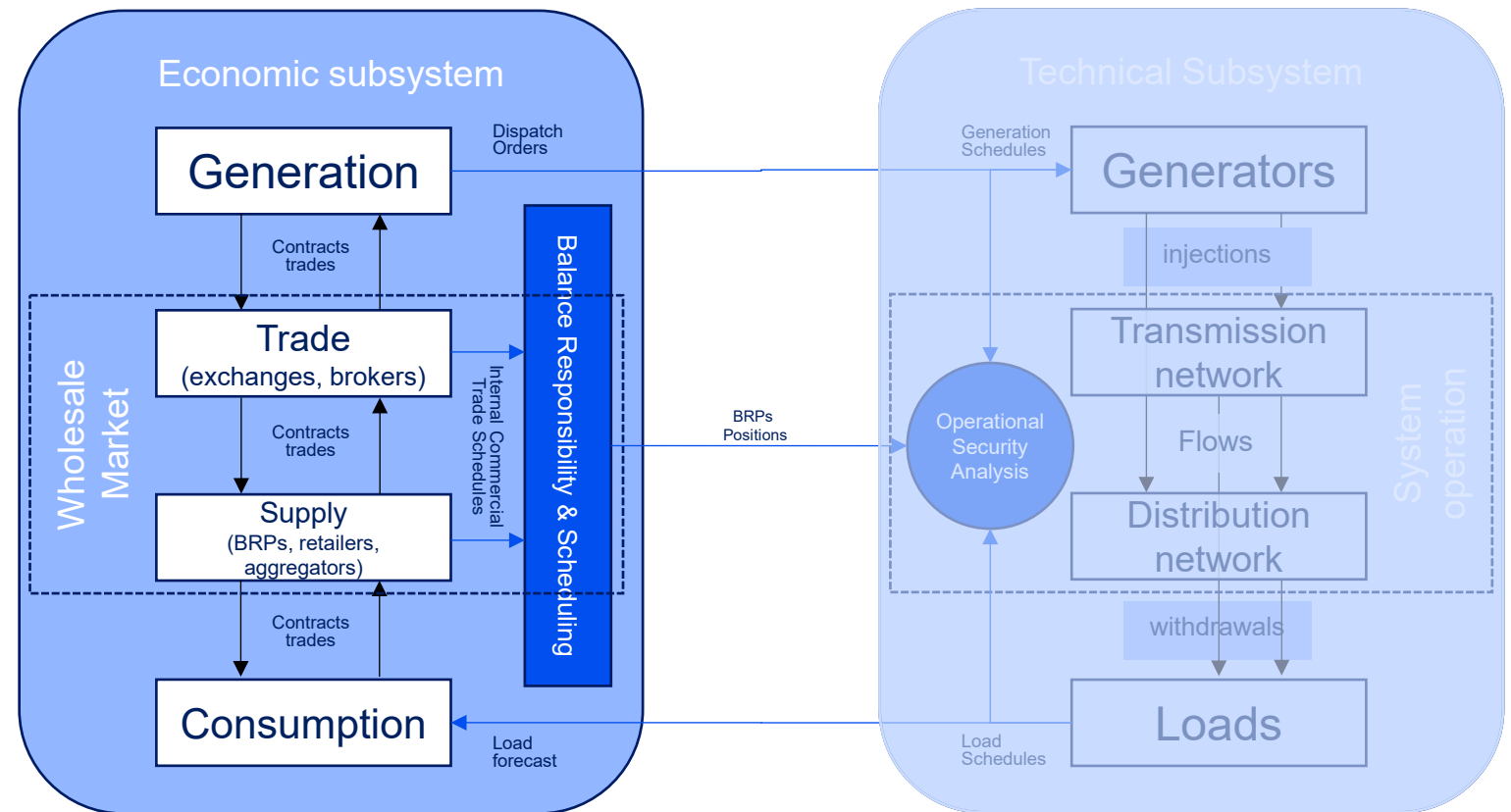
- The technical subsystem describes electricity **generators, injections, flows** through the **transmission** and **distribution** system and **withdrawals** of electricity by **loads**
- In order for the **physical flows** to be kept within the **operational security limits** the TSO calculates load flows (forecasted & real time) to determine the **Operational security** of the system (also after an outage of a network component, **N-1**)



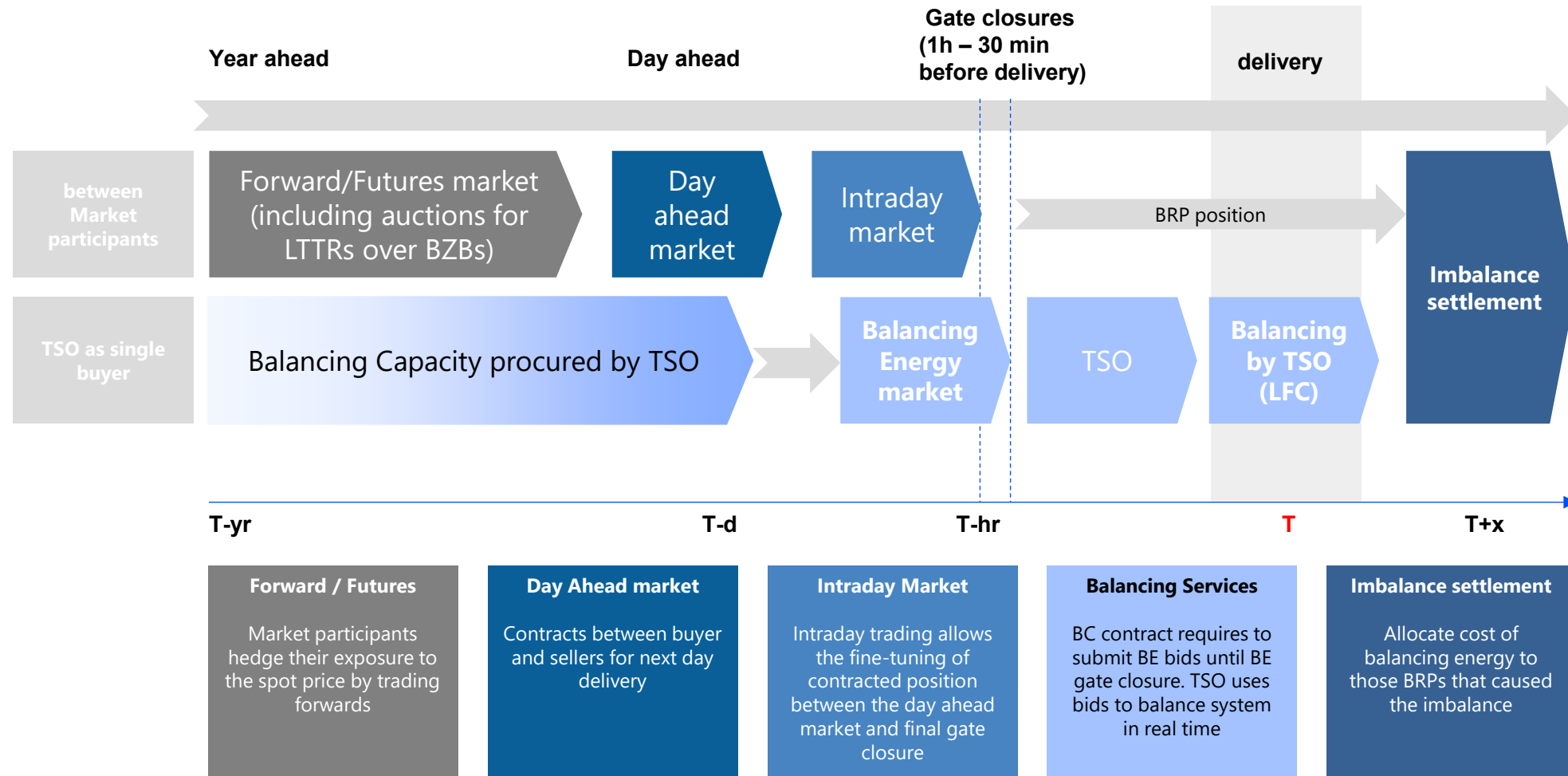
National Electricity Markets

Technical & Economic Subsystems

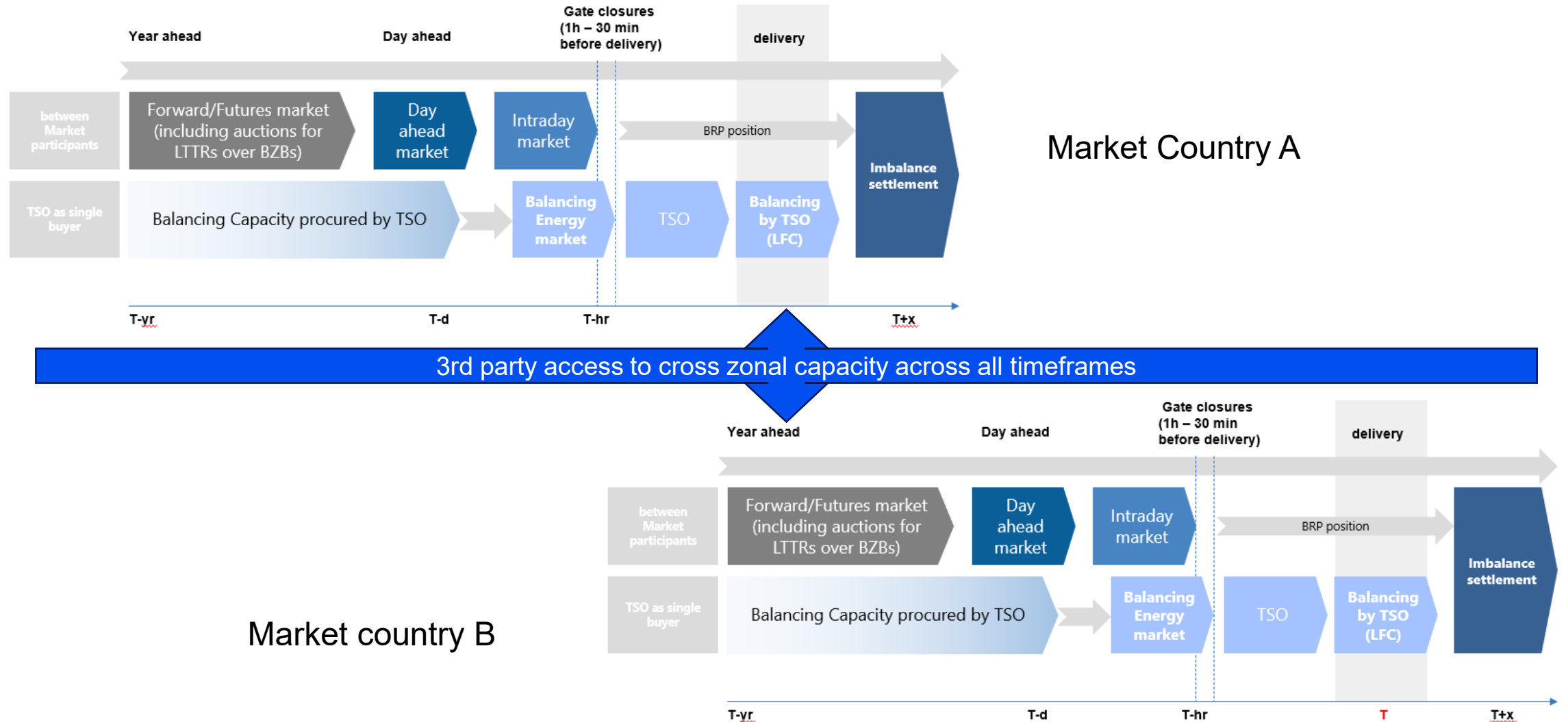
- The economic subsystem describes the market actors in generation, trade, supply and consumption and the contractual interactions between them.
- Trade** is generally organised bilaterally or through exchanges between the different **market participants** on the wholesale market (NEMOs, electricity undertakings, aggregators, suppliers)
- In the wholesale market every **trade or contract** is notified to the TSO in the form of a (change of) their **commercial trade schedules / position** by the respective **BRP** of each market participants
- Information exchange** between market participants and the TSO(s) allow the TSO to assess the operational security of the network



Electricity market(s) sequence



But what makes markets integrate?



What is (next) the “EU Electricity target model”?

EU Target model

Forward market

- Explicit auction of long-term CZ capacity rights via the Single Allocation Platform (SAP)
- FTR or PTRs Nomination day-1 + Use-it-or-sell-it (UIOSI)

?

Day-ahead market

- Implicit auction electricity & capacity via Single Day Ahead Coupling (SDAC)
- Nomination day-1
- Flowbased Capacity Calculation

?

Intraday market

- Continuous trading in electricity & implicit allocation of CZ capacity via Single Intraday Coupling (SIDC or XBID)
- Residual capacity from day-ahead market

?

Balancing Market

- TSO-TSO model w/ Common Merit Order
- EU Platforms for different products
- Uniform BE pricing & imbalance settlement

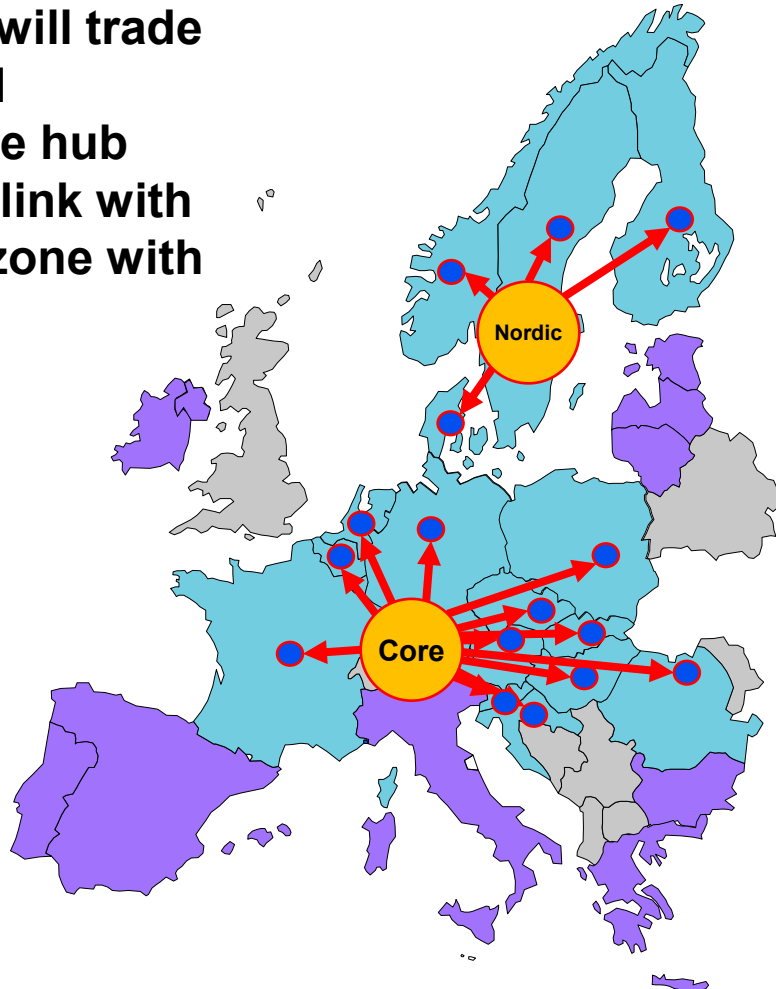
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- Objectives of forward markets
 - To hedge price and volume risks over extended periods
 - Commodity forward markets are structured around hubs with standardized products such as Henry and Brent
- EU forward markets are organised by bidding zones, with Germany being the most liquid hub;
 - EU bidding zones with less liquid forward products use liquid proxy products (i.e. hubs) for hedging
- In case of insufficient correlation between the local bidding zone price with proxy products, the hedge may be complemented with Long-Term Transmission Rights (LTTRs):
 - LTTRs lack liquidity, and most EU bidding zones do not have a bidding zone border with Germany and therefore require multiple interconnected LTTRs to reach a liquid proxy product for hedging.
- ACER has proposed long-term cross-zonal capacity allocation ‘hubs’ to provide each EU bidding zone with access to liquid forward markets, limiting the number of LTTRs needed from Zone to Zone to a maximum of two*.
- Flow-based allocation will be implemented and should be based on statistical flow-based capacity calculation results

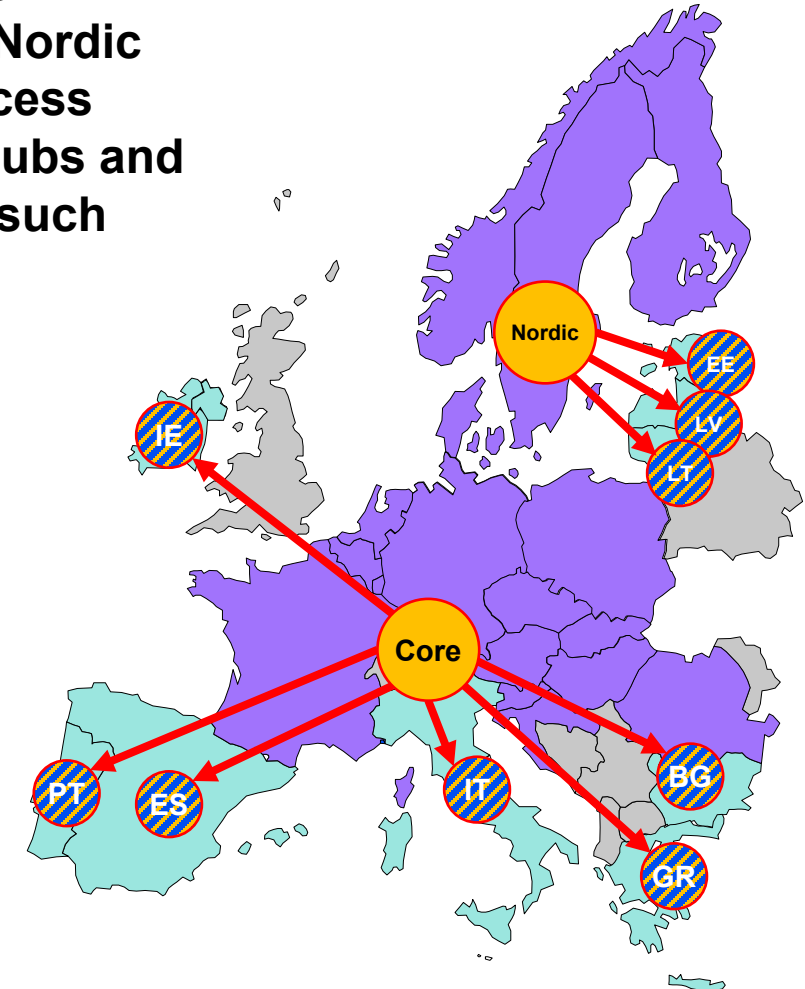


* = a hub with zone to hub LTTR Obligations are effectively equal to EPADs to the Nordic system price

Market participants in Core/Nordics will trade future/forward products at the hub and make the link with their bidding zone with FTRs.



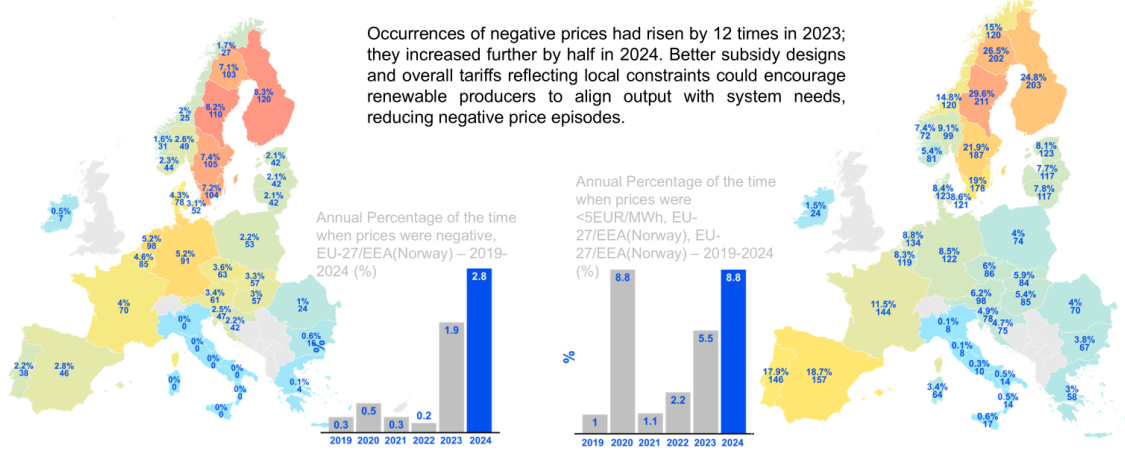
Bidding zones outside Core/Nordic could also access Core/Nordic hubs and offer FTRs to such hubs.



Negative and low electricity prices increased

Surge in negative electricity prices across the EU in 2023 intensifies further in 2024

Percentage of the time and number of days when prices were negative (left) and below 5€/MWh (right), EU-27/EEA(Norway), 2024



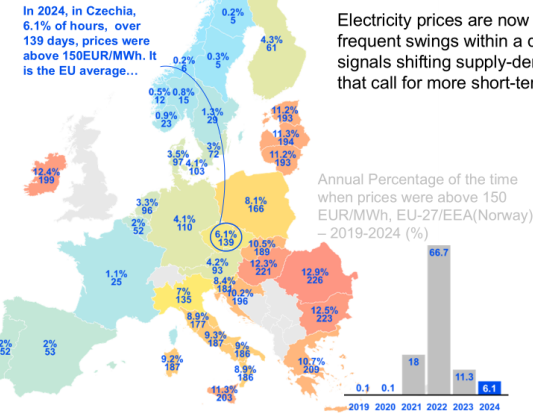
Source: ACER calculations based on ENTSO-E transparency platform.

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Electricity prices reveal a need for short-term flexibility

Fewer extreme price spikes after the crisis...

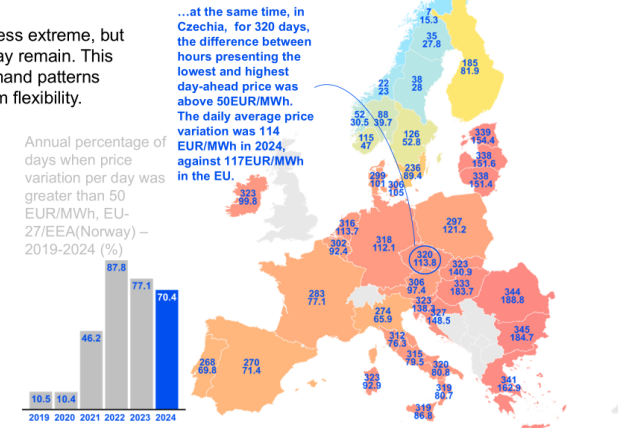
Share of hours and number of days with electricity prices above 150€/MWh, EU-27/EEA – 2024



Source: ENTSO-E transparency platform.

...but strong price swings persist

Number of days with price swings above 50€ and average within-day price difference, EU-27/EEA – 2024

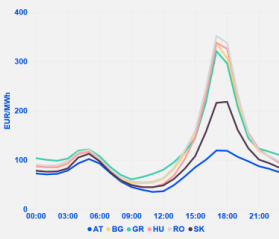


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Case study Summer electricity price spikes in Southeastern Europe

From mid-July to mid-September 2024, southern and central eastern Europe experienced sustained high evening day-ahead prices, with price decorrelation from western-European bidding zones.

Evolution of average day-ahead prices in select EU bidding zones – July to September 2024 (EUR/MWh)



Source: ACER calculation based on ENTSO-E transparency platform data.

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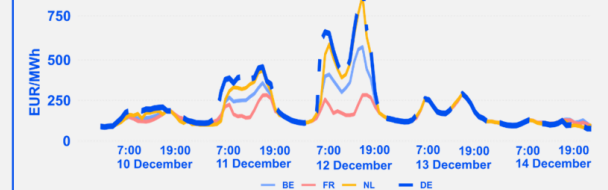
Case study Electricity price spikes in Germany - 11 December

Germany faced a Dunkelflaute in December 2024, with wind generation falling significantly below the seasonal norm.

- “Dunkelflaute” refers to periods of low solar and wind power generation, lasting hours or days, which challenge renewable-based energy systems.
- On 12 December day-ahead and intraday power prices neared 1,000 EUR/MWh, far exceeding the annual average of 79 EUR/MWh.
- Cold weather drove demand up, while fossil fuel plants and imports had to compensate for 11 GW of fossil capacity outages.
 - As fossil fuel plants remain key at peak times, better EU-wide coordination of plant planned outages is increasingly vital.
- Energy-intensive industries reduced production to avoid costs, but long-term contracts shielded most consumers.

Source: ACER calculation based on ENTSO-E transparency platform data.

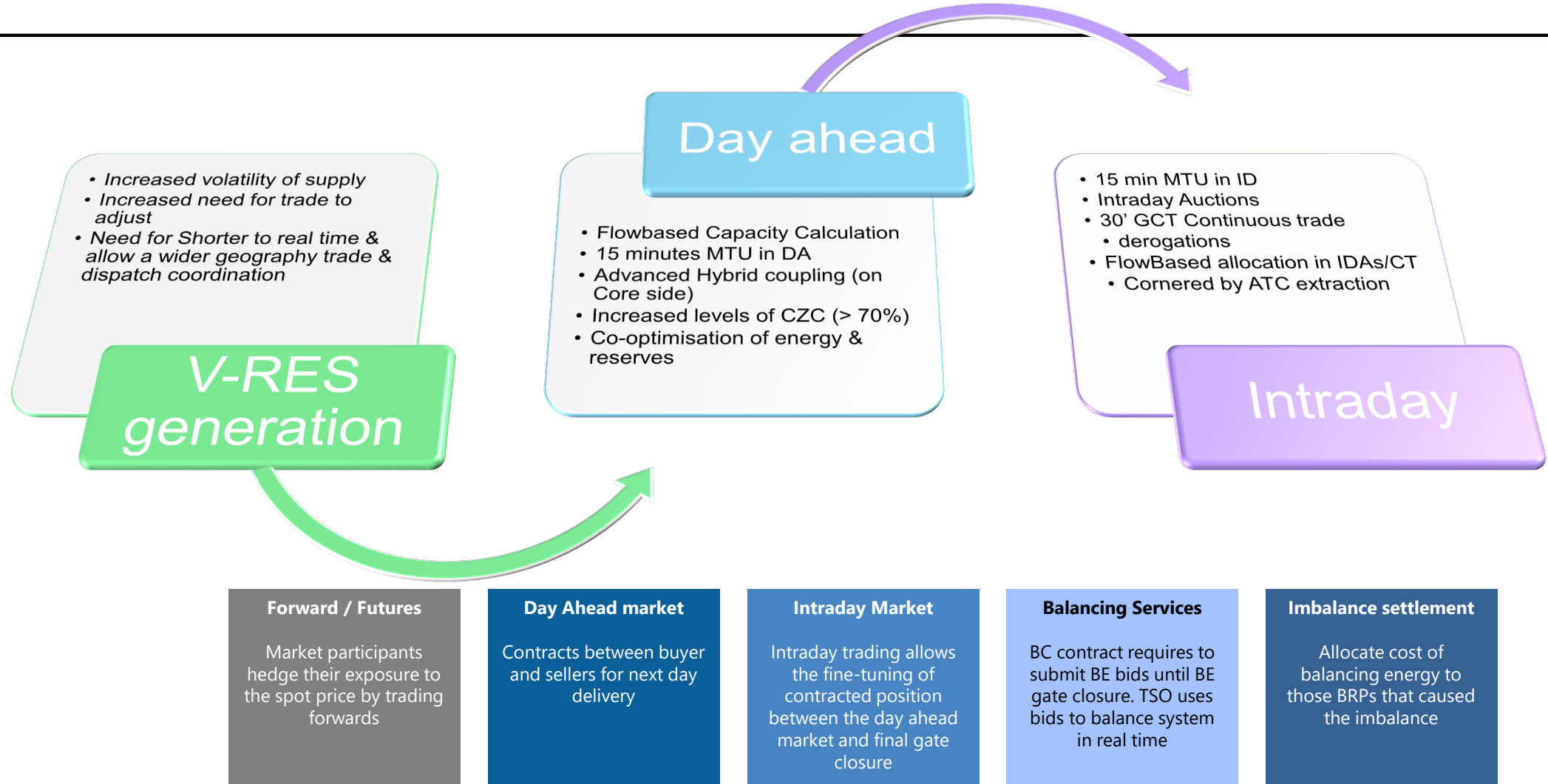
Day-ahead prices in Belgium, France, Germany and the Netherlands, 10 to 12 December 2024 (EUR/MWh)



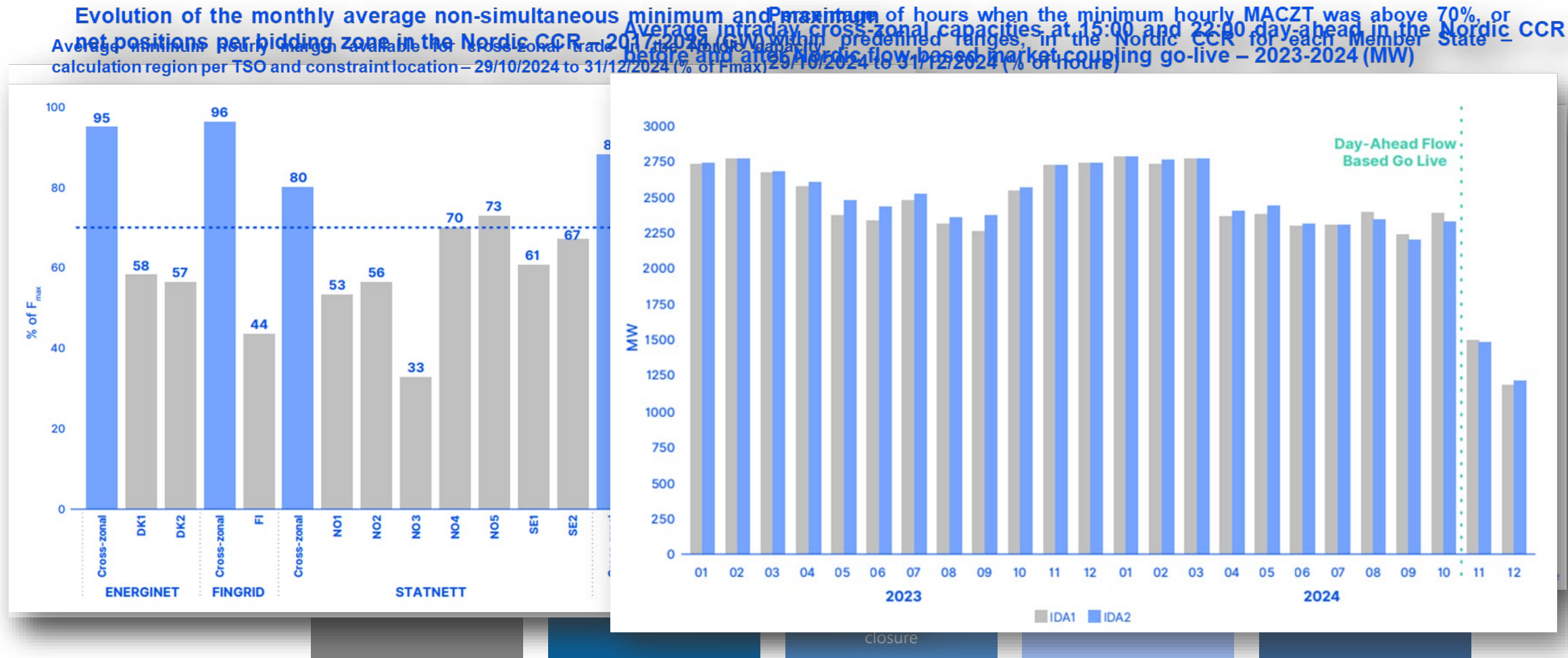
- These events highlight the need for EU-wide grid interconnection and other flexibility sources, possibly in the form of backup generation capacity (such as thermal generation, storage or demand-response).
- Local flexibility will help manage short dunkelflaute episodes, while longer ones may require energy imports.
- Strengthening overall system flexibility will help ensure supply security during severe conditions and prevent more extreme situations (one example outside the EU being the 2021 Texas gas and power crisis).

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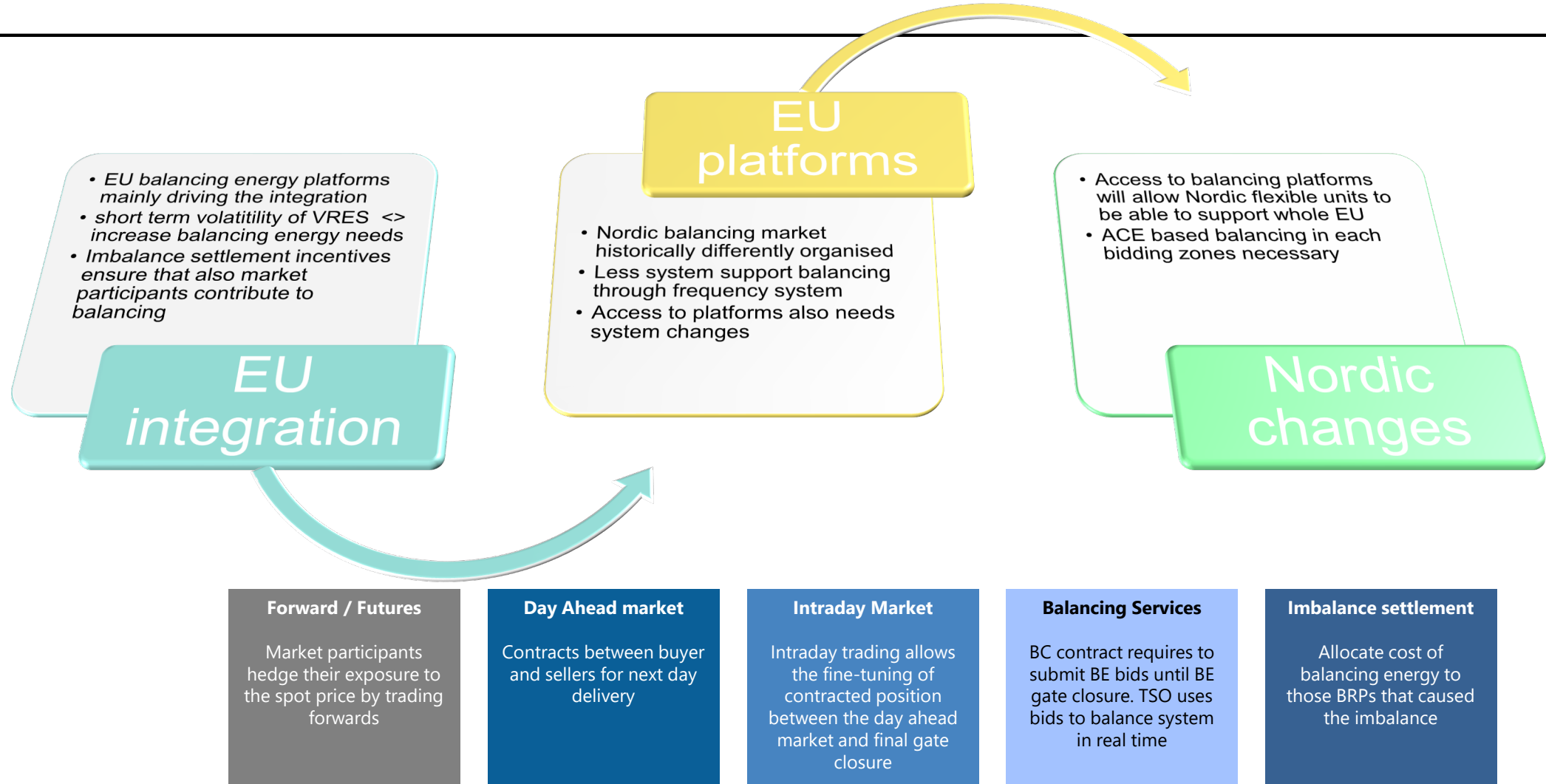
Day ahead & Intraday 'spot' markets



Evolution of cross zonal capacity in the Nordics

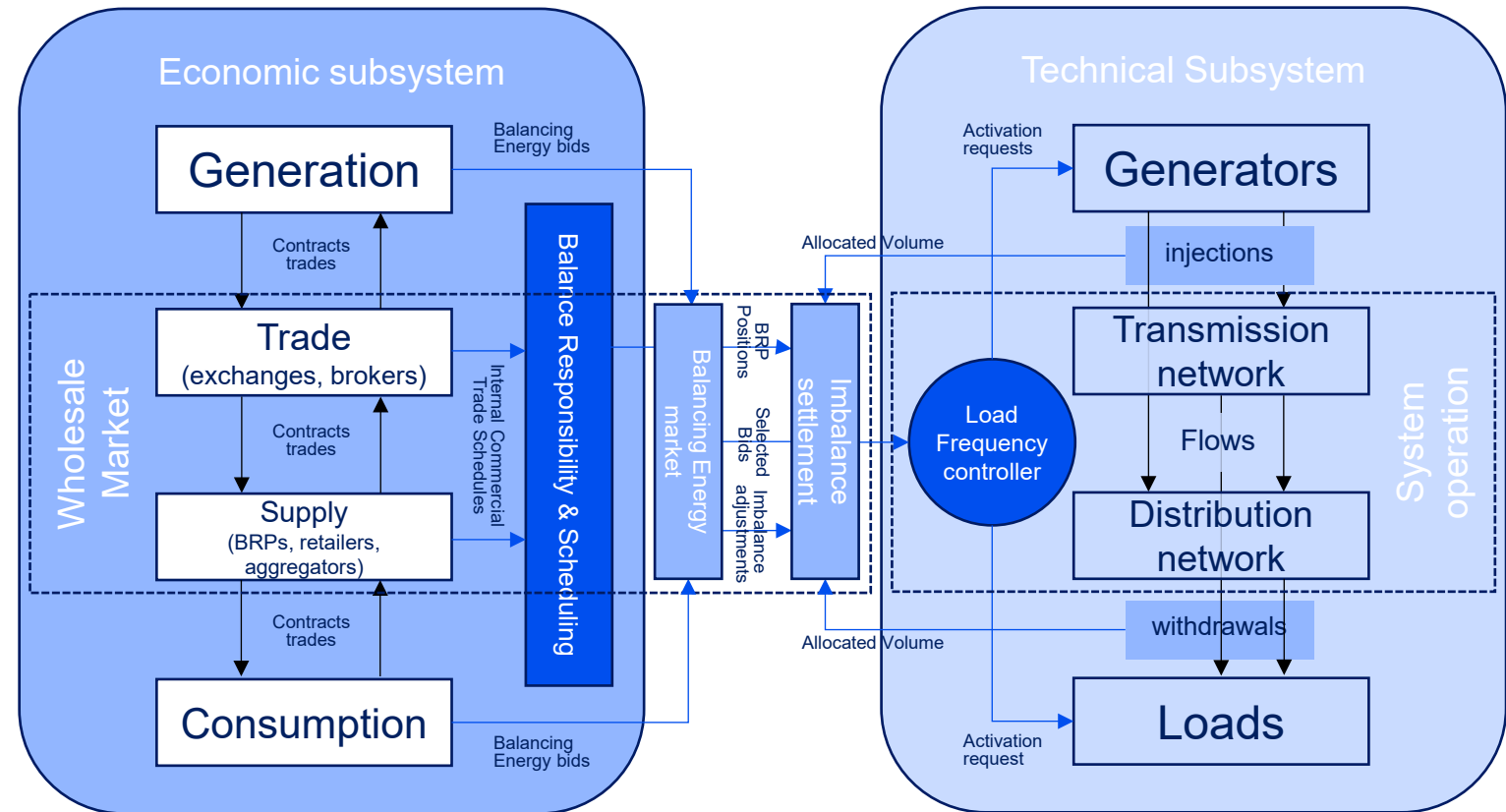


Balancing markets: EU wide balancing market integration & harmonisation



Economic & technical Subsystems interdependence for Balancing Energy & imbalance settlement

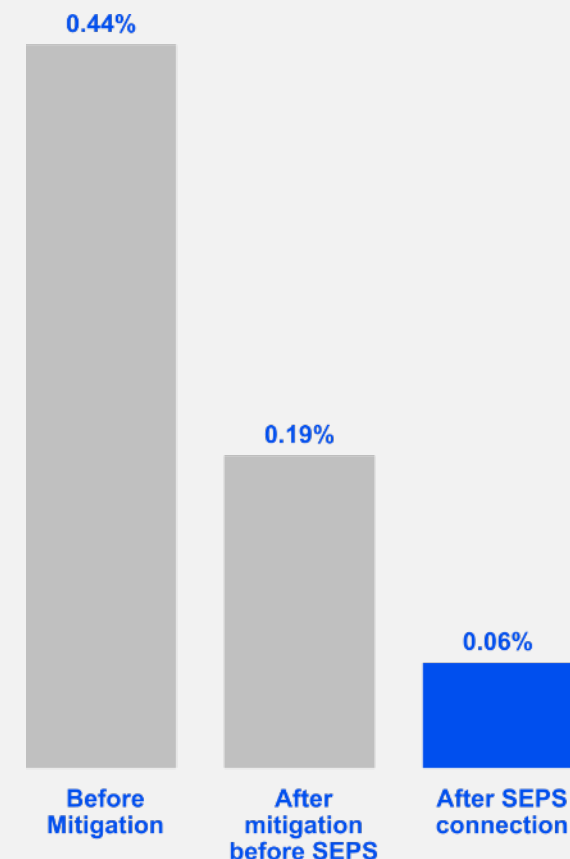
- In real time market participants will try their portfolio's to inject or withdraw (per ISP) a volume in MWh equal to their position
- TSO(s) will balance supply and demand in real time using the balancing energy market by selecting bids for the load frequency controller to restore the system balance (FRCE) within 15 min
- For every BRP the real injections and withdrawal will be measured and used (as allocated volume in MWh) to calculate the BRPs imbalance as difference with the BRP position.
- The imbalance is settled against the imbalance price which is calculated based on the cost or marginal price of activated balancing energy bids.



Mitigating measures and the participation of more transmission system operators contributed to lowering the number of instances of electricity balancing price spikes.

- Balancing the electricity system is crucial for system security, ensuring supply-demand balance and frequency stability in real time. Integrating balancing markets across borders lower costs and improve efficiency by allowing TSOs to activate cheaper balancing energy bids.
- The new method for calculating cross-border marginal prices on the PICASSO platform¹ has greatly improved performance.
- Since adopting this alternative method, price incidents have dropped across all Load Frequency Control areas, with an average of 65%² decrease compared to earlier in 2024. Compared to the same time last year, incidents also fell by 60% on average, showing the improvement is not just seasonal.
- Further, additional participation of transmission system operators in balancing platforms has further improved their efficiency, e.g. in the Czech market with the participation of the Slovak transmission system operator, and a further reduction by 30% in price incidents.

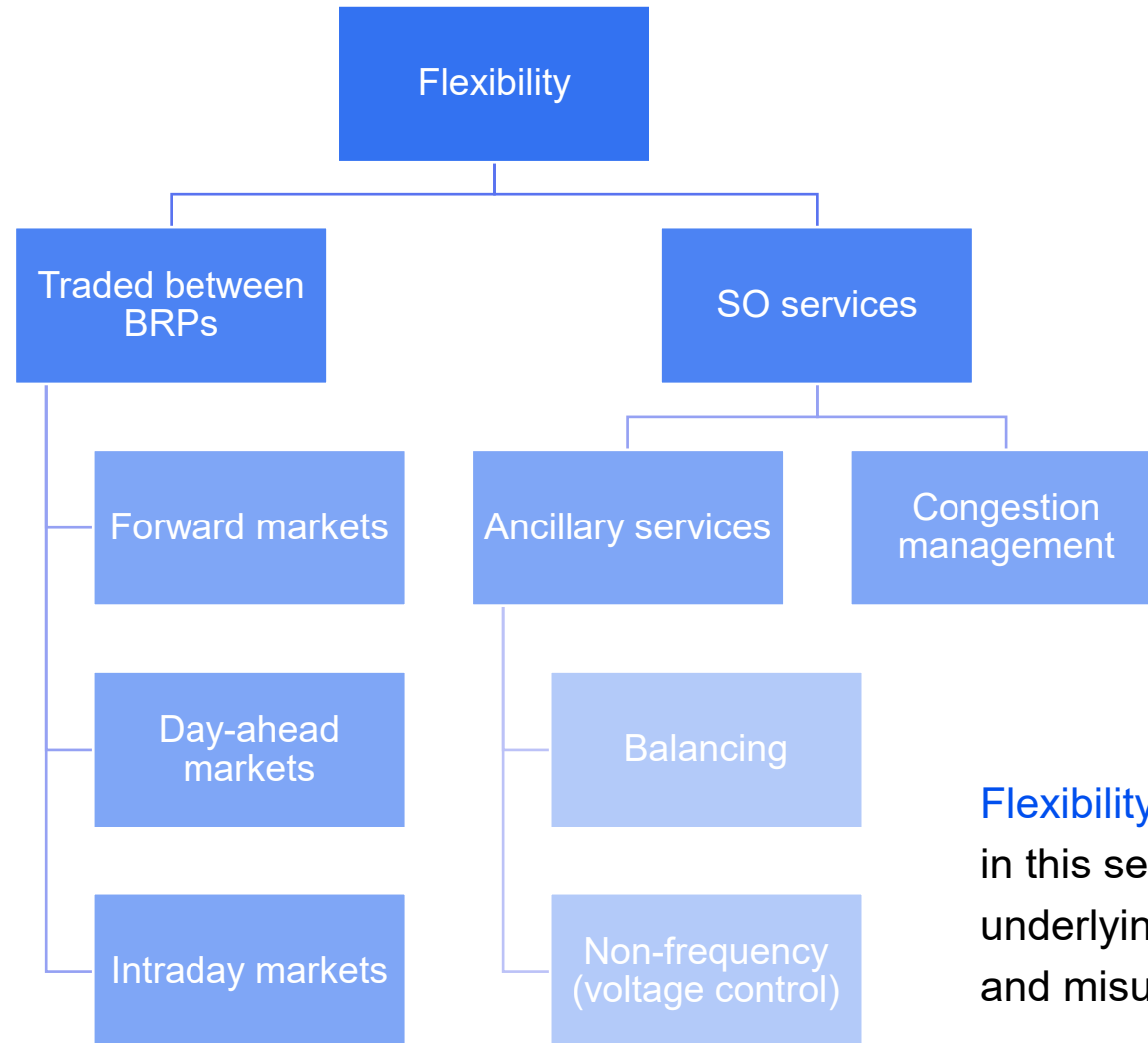
Slovak transmission system operator (SEPS) connection to the PICASSO platform on Czech market reduces price incidents, 2024² (%)



Source: Transnet BW.

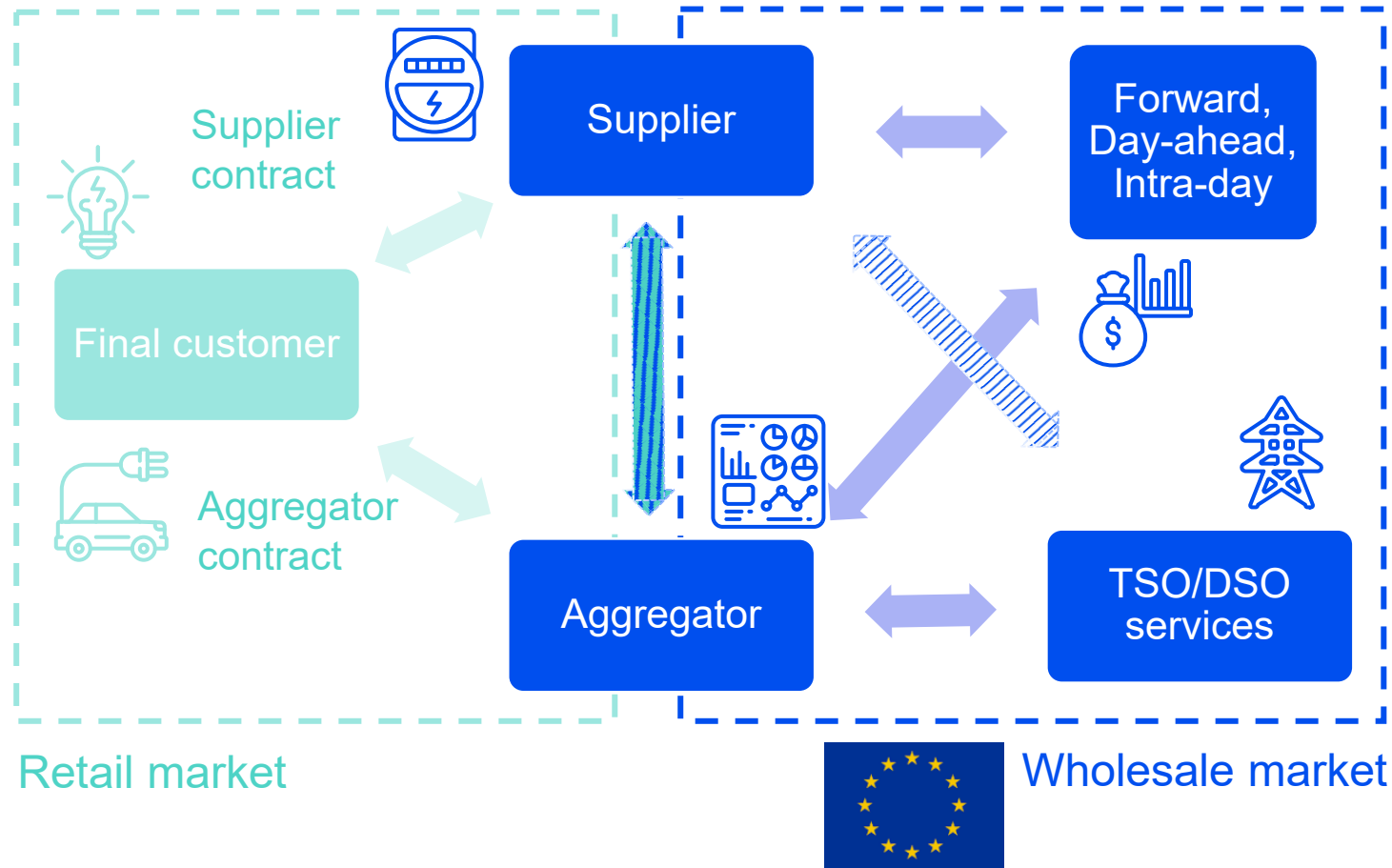
Note: 1. as approved by [ACER Decision 2024/08](#). See also [2024 ACER market integration report](#) page 33. - 2. these values represents the percentage of time with price incidents; the time unit considered here is an optimisation cycle.

Is it about flexibility or Demand Response?



Flexibility is an “umbrella” term that covers existing services/needs; in this sense every time we use “flexibility” we mean something underlying and unless we are clear on what we mean, confusion and misunderstandings will **not allow us to communicate**.

Which markets does it cover?



Relevant for the
EU framework

Enabling market participation



Effective participation of small system users in electricity markets

- Clearer requirements to implement aggregation models
- European registry for baselining methodologies

Easier access to balancing and market-based procurement of local services

- Product verification or simpler and shorter prequalification, if applicable
- Flexibility information system

Transparent process to ensure market-based procurement of local services can be set up

- Market-based procurement of local services by default; deviation to non-market-based procurement duly justified
- Clear requirements for the interactions between markets

Ensure overall efficient operation

- TSO-DSO and DSO-DSO coordination for identifying and solving physical congestion and voltage control issues

EU Electricity market target model 2.0



European Internal Electricity Market integration

FULL EU DA&ID coverage in 2022

- SDAC&SIDC EU wide coverage in 2022

CONTINUOUS MONITORING

- ACER to engage in detailed implementation monitoring & progress reports on the IEM.
- Prioritization provides direction

INCENTIVES & ENFORCEMENT

Energy regulators commit to develop (further) **incentive frameworks for TSOs, NEMOs** and other entities for **earlier implementation of integration projects** and to **improve the enforcement** of compliance in case of delays.²

IEM target model since 2015

- EU legislation defined the EU target model
- Legal obligations on TSOs and NEMOs to implement
- ECA report(2023)¹ signaled overall slow implementation

URGENT: complete IEM implementation projects

- NEMOs to improve allocative efficiency linked to time & spatial granularity
- TSOs to Improve levels of Cross zonal capacity to at least 70%
- TSOs to Urgently ensure all TSOs accession to EU-wide balancing platforms

¹ – [ACER's reply to ECA's report | www.acer.europa.eu](https://www.acer.europa.eu/31.1.2023), 31.1.2023

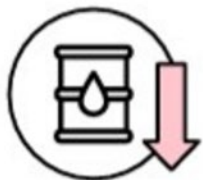
² – [Challenges of the future electricity system \(europa.eu\)](https://www.europa.eu/11.7.2024), 11.7.2024

‘Doing more together’ holds benefits

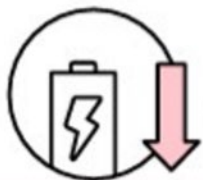
Techno-economic



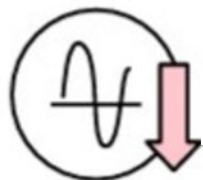
More security
with fewer backup
power plants



Less fuel use
- Less imports
- Less pollution



More flexibility with
fewer storage
investments



Lower price volatility

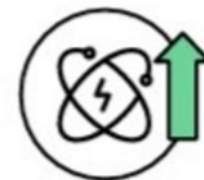


More renewables
generation with less
investment (thanks to
better location)

Managerial-governance



Lower capital cost



More innovation



Higher consumer surplus
thanks to more competition

Further [energy market] integration could increase (...) **benefits to up to EUR 40-43 billion per year** by 2030..

Regional cooperation across Europe, underpinned by better interconnectivity and closer coordination, can **reduce the need for flexibility investments by up to 20%...**

What is the “EU Electricity target model 2.0”?

EU Target model

EU Target model 2.0

Forward market

- Explicit auction of long-term CZ capacity rights via the Single Allocation Platform (SAP)
- FTR or PTRs Nomination day-1 + Use-it-or-sell-it (UIOSI)

- ⇒ Flowbased Capacity Calculation & Allocation
- ⇒ Zone2Hub FTR obligations

Day-ahead market

- Implicit auction electricity & capacity via Single Day Ahead Coupling (SDAC)
- Nomination day-1
- Flowbased Capacity Calculation

- ⇒ FlowBased extension & Advanced Hybrid Coupling
- ⇒ 15 minutes MTU
- ⇒ Co-optimisation of DA energy and Balancing Capacity

Intraday market

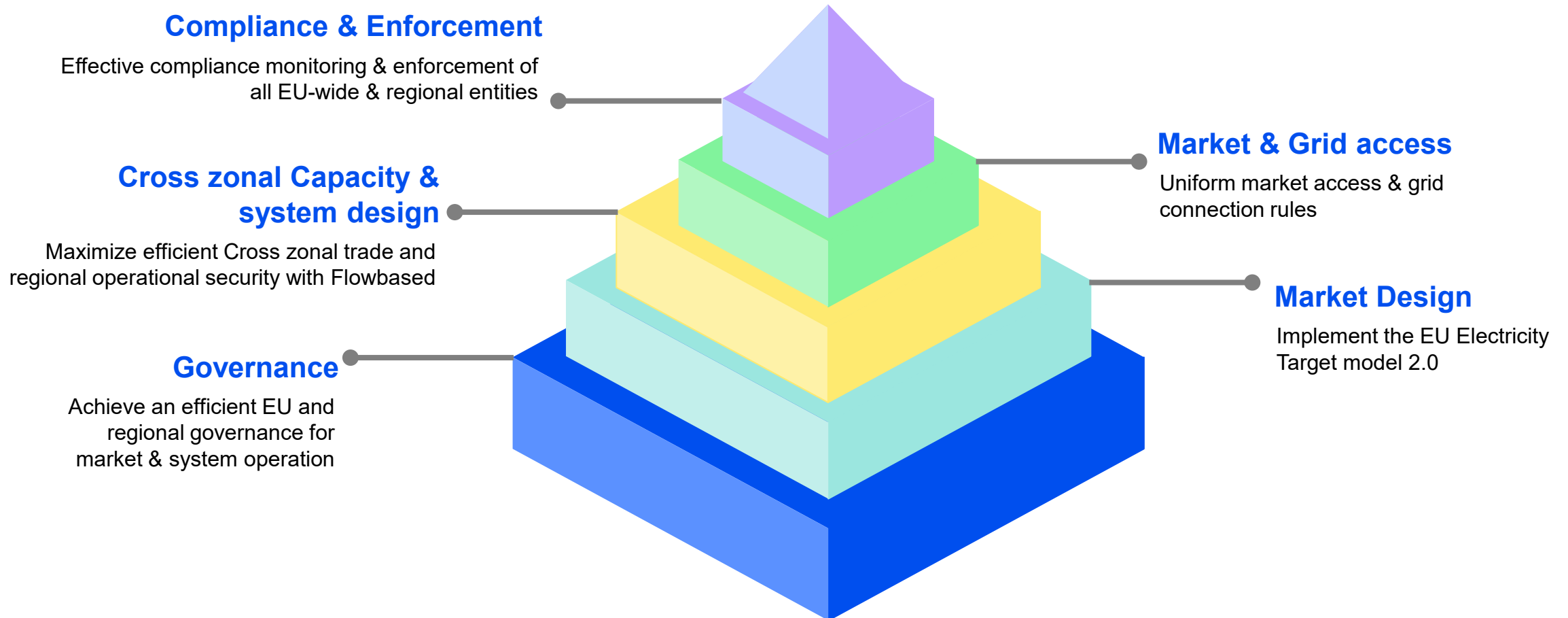
- Continuous trading in electricity & implicit allocation of CZ capacity via Single Intraday Coupling (SIDC or XBID)
- Residual capacity from day-ahead market

- ⇒ 3 daily Intraday Auctions w/ FB allocation
- ⇒ Flowbased Capacity Calculation
- ⇒ 15 min MTU & 30 min IDCZGCT

Balancing Market

- TSO-TSO model w/ Common Merit Order
- EU Platforms for different products
- Uniform BE pricing & imbalance settlement

- ⇒ Balancing capacity market integration
- ⇒ Co-optimisation of DA energy and Balancing Capacity
- ⇒ Harmonize settlement rules (imbalance & energy)



Thank you. Any questions?



The contents of this document do not necessarily reflect the position or opinion of the Agency.



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- **Supporting the integration of energy markets in the EU** (by common rules at EU level). Primarily directed towards transmission system operators and power exchanges.
- **Contributing to efficient trans-European energy infrastructure**, ensuring alignment with EU priorities.
- Monitoring energy markets to ensure that they function well, **detering market manipulation and abusive behaviour**.
- Where necessary, **coordinating cross-national regulatory action**.
- Governance: **Regulatory oversight is shared** with national regulators. **Decision-making** within ACER is collaborative and joint (formal decisions requiring 2/3 majority of national regulators). **Decentralised enforcement** at national level.
- Headquartered in Ljubljana, Slovenia. **Engaged across the EU**.

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Nordic slides and figures



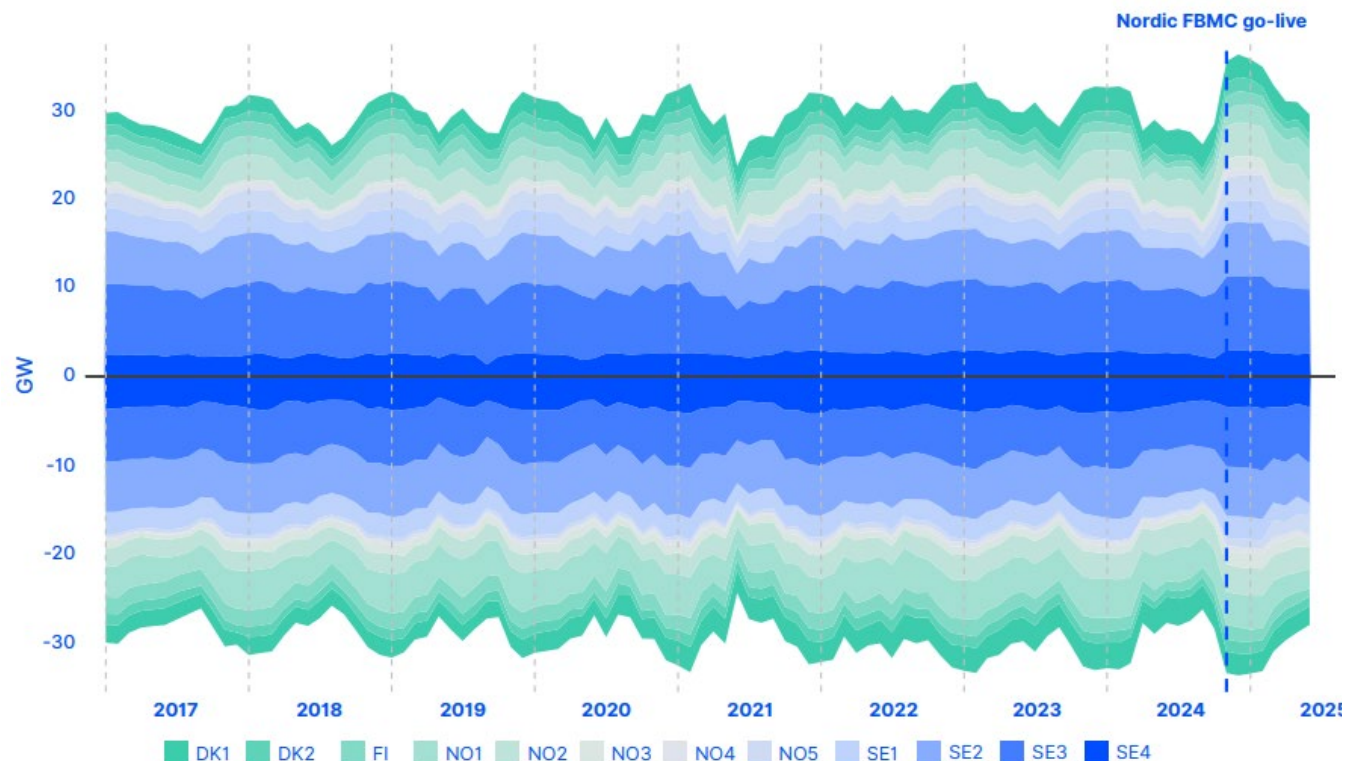
FBMC facilitates cross-border trade in the Nordic

In October 2024, Nordic TSOs implemented flow-based market coupling in the day-ahead timeframe, expanding cross-zonal trading possibilities in the Nordic CCR.

Flow-based capacity calculation models a subset of network constraints, the so-called critical network elements with contingency (CNECs), and provides detailed information on such network constraints to the price coupling mechanism. The price coupling mechanism can then allocate the capacity made available on each CNEC to the electricity exchanges that generate the most socio-economic welfare. This allows for an optimised allocation of cross-zonal capacities at the level of the capacity calculation region.

When analysing the average non-simultaneous minimum and maximum net positions in the bidding zones of the Nordic CCR over recent years, it can be observed that the implementation of **flow-based market coupling has led to an average monthly increase of approximately 10%**, particularly in the export direction.

Evolution of the monthly average non-simultaneous minimum and maximum net positions per bidding zone in the Nordic CCR – 2017-2024 (GW)



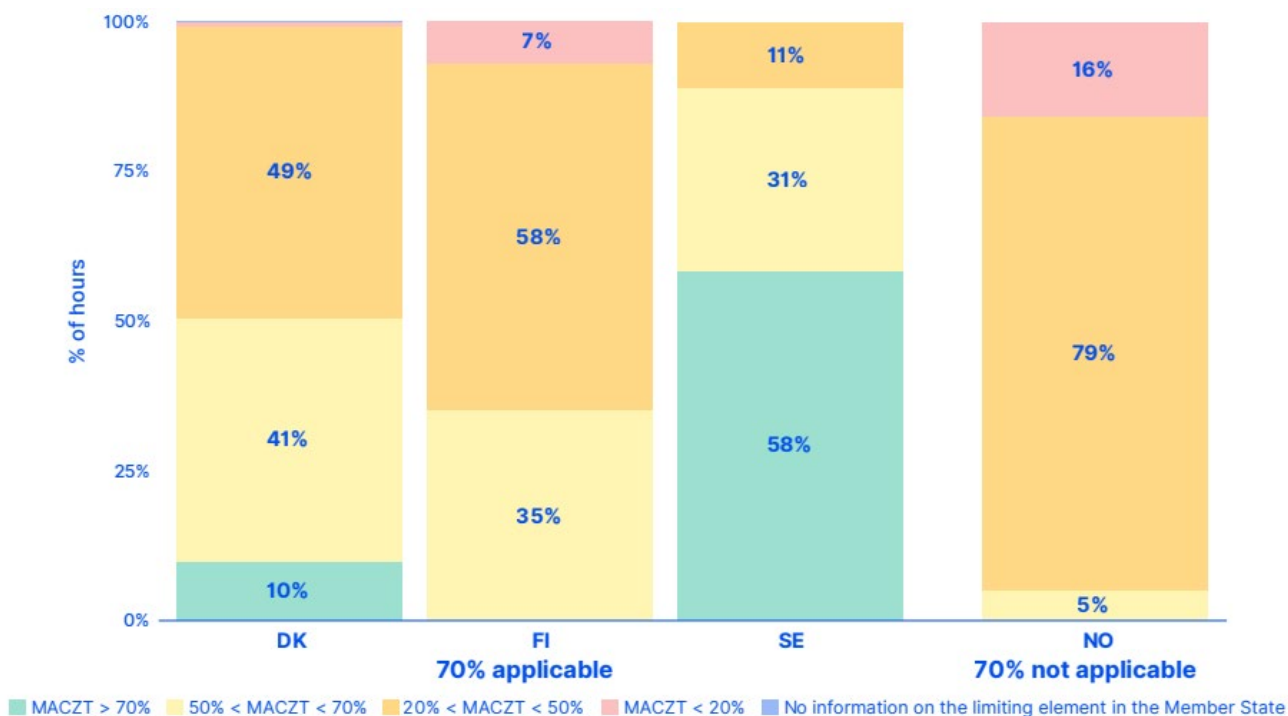
Methodology: In FB, min-max NP is a direct output of the calculation, whereas pre-FB values are calculated as the sum of NTCs in importing and exporting direction per BZ.

For additional information on maximum and minimum net positions, see slide 54.

Data source: ACER elaboration based on JAO Publication Tool and ENTSO-E Transparency Platform data.

The minimum 70% requirement in Nordic FBMC

Percentage of hours when the minimum hourly MACZT was above 70%, or within predefined ranges, in the Nordic CCR for each Member State – 29/10/2024 to 31/12/2024 (% of hours)



The implementation of Nordic flow-based allows for the margin available for cross-zonal trade to be computed, and monitored, on all CNECs defined by Nordic TSOs. As the minimum 70% requirement is to be respected in all CNECs and hours, ACER's monitoring focuses on the CNECs with lowest values of MACZT for every hour.

The go-live of the Nordic flow-based market coupling increases the coordination level when calculating capacities, compared to the previous NTC national calculations. Additionally, Nordic TSOs have implemented advanced hybrid coupling on the external bidding zone borders within SDAC, modelling them as virtual bidding zones, leading to no impact from such borders on MACZT.

Three major differences compared to the Core CCR apply in the Nordic CCR:

1. No derogation nor action plan are in place in the Nordic CCR: The **minimum 70% requirement is fully applicable today**.
2. The **Norwegian TSO is not bound by the minimum 70% requirement**, as Norway has not adopted the Clean Energy Package.
3. The Nordic CCM does **not consider the use of virtual capacities** to fulfil 70%.

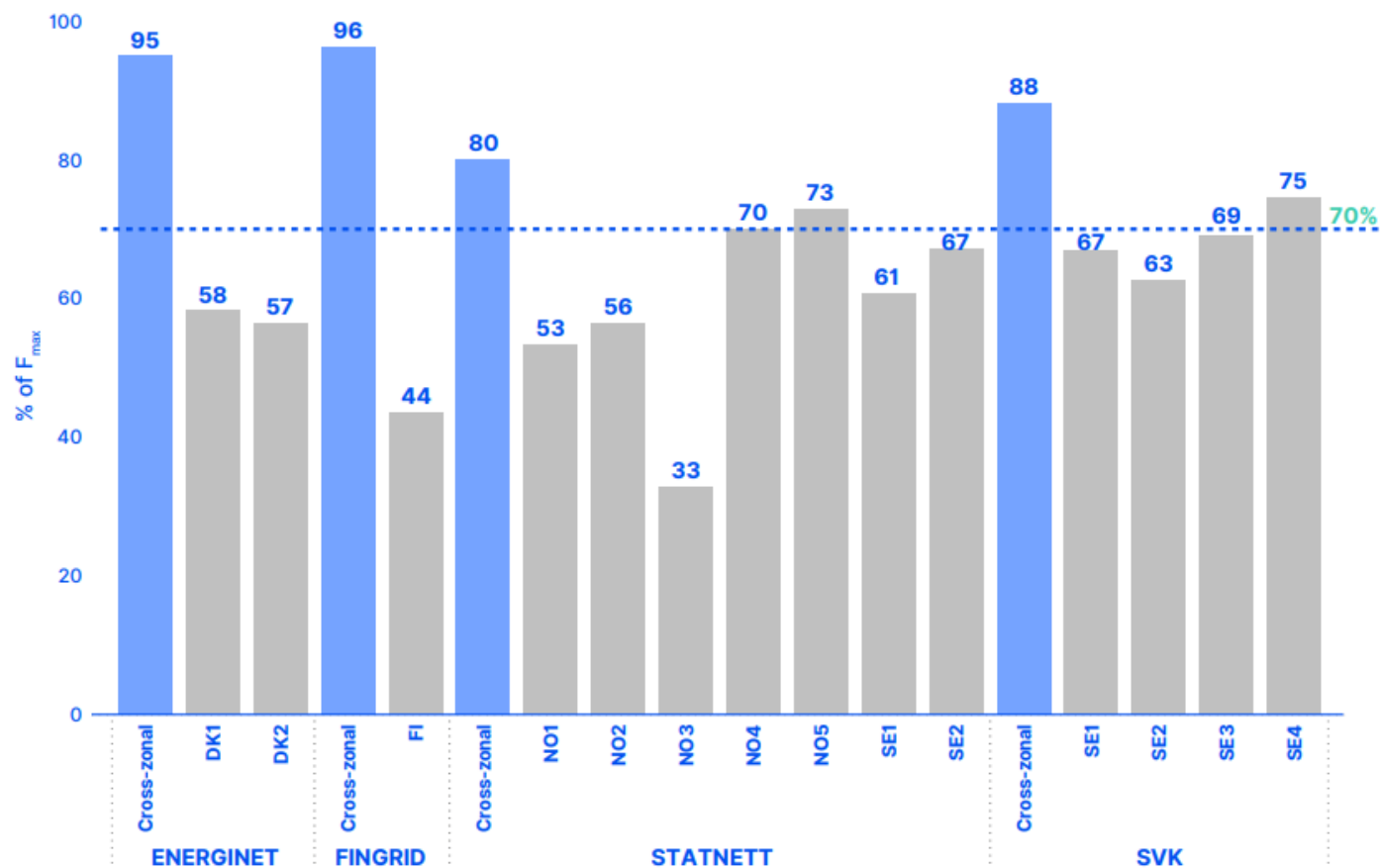
Differences between cross-zonal and internal CNECs

Data reported from TSOs allows to group the CNECs introduced by Nordic TSOs in the flow-based capacity calculation, and thus the share of physical capacity offered to the day-ahead market for cross-zonal exchanges, by whether they are internal to a given bidding zone or cross-zonal.

Such analysis indicates that loop flows in the cross-zonal network elements appear to be negligible, leading to cross-zonal CNECs offering high levels of MACZT (above 80% on average).

However, **some bidding zones appear to have significant flows not stemming from cross-zonal exchanges**, such as NO3 or FI, limiting the values of capacity offered to the day-ahead market.

Average minimum hourly margin available for cross-zonal trade in the Nordic capacity calculation region per TSO and constraint location – 29/10/2024 to 31/12/2024 (% of F_{max})



Drop in intraday capacities after Nordic FBMC

Cross-zonal capacities offered to intraday markets (both auctions and continuous trading) in the Nordic CCR are based on leftovers from day-ahead, as there is no specific intraday flow-based calculation implemented yet.

Since the implementation of Nordic FBMC in day-ahead, leftover capacities are extracted from the day-ahead flow-based domain using an ATC-extraction algorithm, similarly to the process used on Core IDCC(b).

Average cross-zonal capacities offered in the Nordic CCR at 15:00 and 22:00 day-ahead (corresponding to the timings of IDA1 and IDA2), following the go-live of Nordic FBMC in day-ahead, **have seen a significant drop**, revealing similar inefficiencies as in the Core process, and stressing once again the need for the implementation of flow-based calculation and allocation in the intraday timeframe.

Average intraday cross-zonal capacities at 15:00 and 22:00 day-ahead in the Nordic CCR before and after Nordic flow-based market coupling go-live – 2023-2024 (MW)

