

Electricity markets in transformation: best practices, lessons learned, and challenges in adapting market designs

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NORD POOL

A EURONEXT COMPANY

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At a glance

- Nord Pool offers day-ahead and intraday trading, clearing and settlement services
- More than 400+ customers from 20 countries trade on Nord Pool's markets
- Operates in 16 European countries
- Serviced' markets in 5 countries
- ~170 employees, 35 nationalities, offices in Oslo, Stockholm, Helsinki, Tallinn, Paris, and London



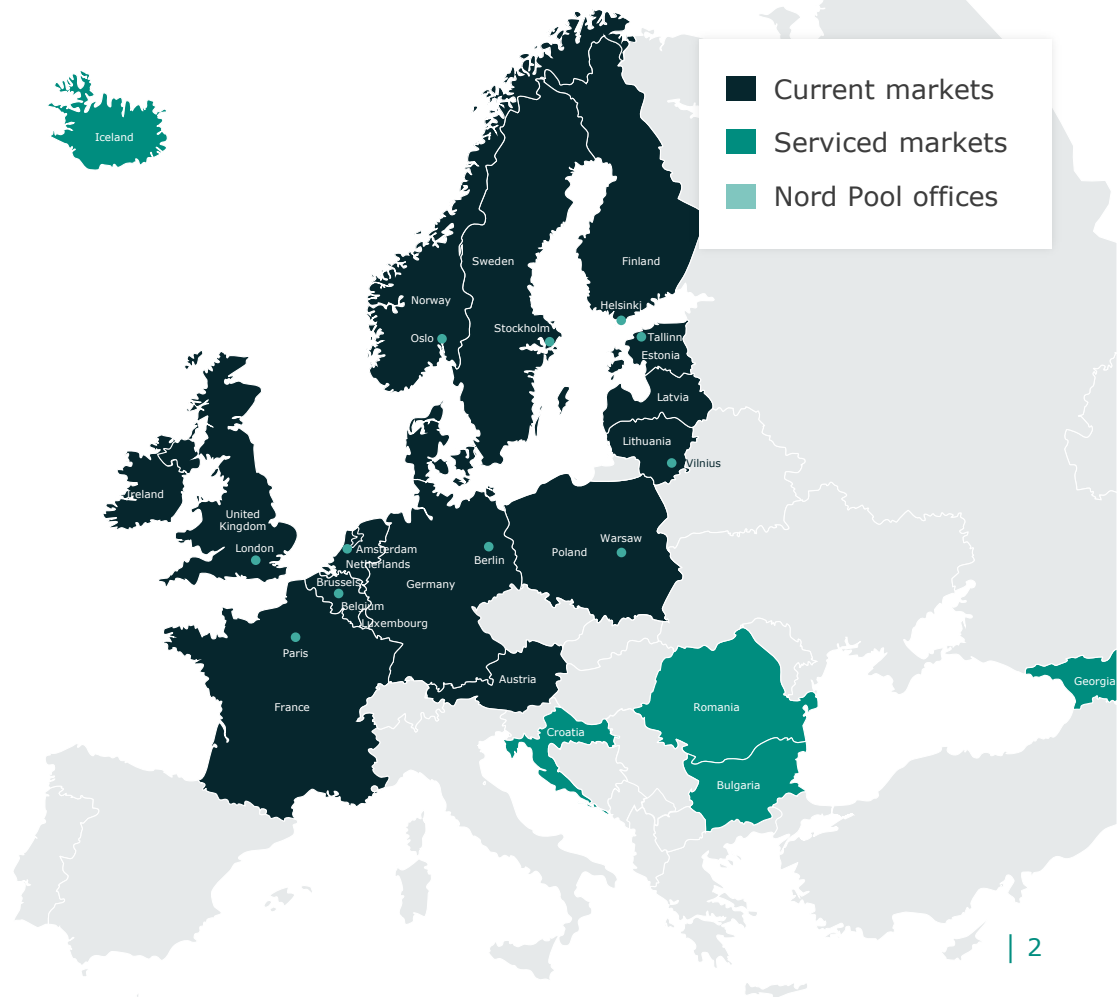
1037 TWh
day-ahead



194 TWh
intraday



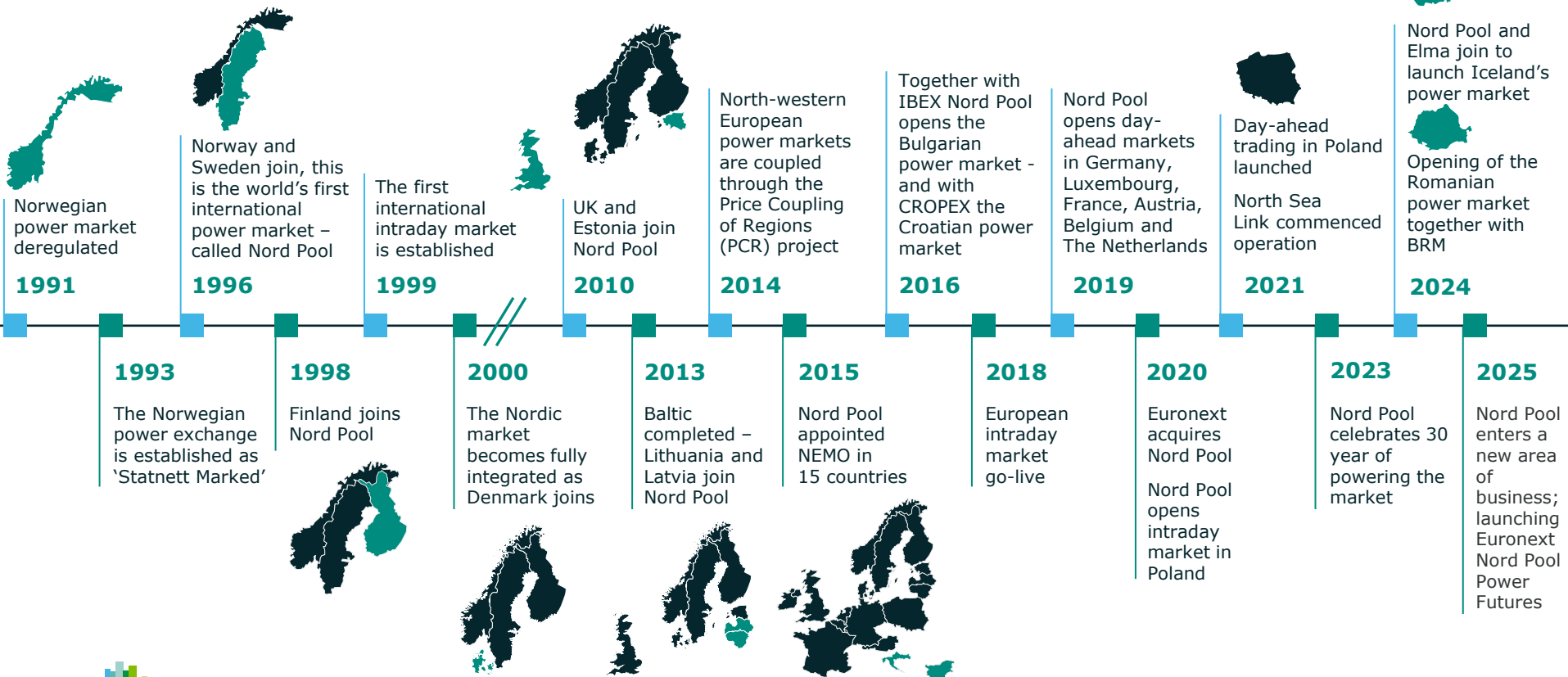
400+
customers



First of its kind..



Towards a European electricity market



Nord Pool's part in the wider electricity market

How the power markets fit together.

Financial markets

10 years



System price



System price

The financial power market consists of derivatives used for e.g. hedging and speculation.

A significantly larger market than the physical, with annual trading representing multiple times yearly production.

Day-ahead

24 hours

Nord Pool

System price

Physical delivery

Day-ahead is the main market, with intraday providing flexibility should variations in supply or demand occur, giving producers and consumers a marketplace to "trade themselves into balance".

Increasing presence of speculative traders.

Imbalance at the time of intraday gate closure (1h before delivery in the Nordics) will result in penalties by the system balance responsible, the TSOs.

Intraday

Intraday

Continuous price

Physical delivery

Reserve markets

Intra-hour

TSO

Regulated price

Physical delivery



Physical delivery

Intra-hour power flow is directly managed by the national TSOs to provide power balancing in real-time to ensure the right frequency of the grid and security of supply.

Day-ahead market - main arena for power trading

Introduction to day-ahead

- The day-ahead market is the main arena for power trading, representing 96% of Nord Pool's traded volume in 2022.
- Hourly contracts with physical delivery
- Auction trading – accumulated bids and offers form equilibrium via an implicit auction that also reflects available transmission capacities between bidding zones

Key order types

Single hourly orders

Price and volume given separately for each hour

Block orders

All or nothing condition in bid for at least three consecutive orders / hours

Exclusive groups

A cluster of sell or buy orders of which only one can be activated

Flexible orders

Bid that may be accepted in an hour given if the price conditions are met (usually high price)

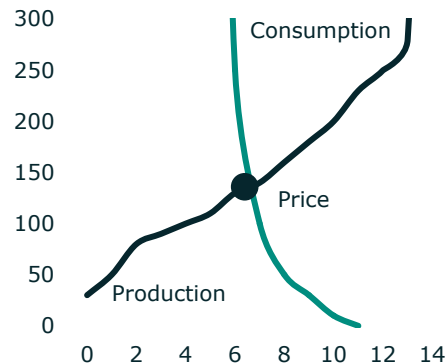
Key factors affecting day-ahead price formation

Introduction to day-ahead

- Variable cost of production
- Plant start-up and shutdown costs
- Carbon price (EU ETS)
- Hydrological situation
- Wind/sun conditions
- New renewable energy
- Politics and regulation
- Guarantee of origin
- Volumes bound to PPAs
- El-certificate prices

Demand / bid

- Mostly inelastic demand
- Retail volumes and delivery obligations
- Weather conditions & seasonality
- Time of day / week
- Industrial activity
- Fixed and variable costs of consumers
- Start-up and shutdown costs
- Politics and regulation
- Electrification
- Cost of alternative sources of energy



Transmission capacity

- Existing interconnectors
- Unavailability of interconnectors (faults, maintenance, etc.)

Self-balancing is a core responsibility of market participants in the european electricity market

Market participants are required to proactively align positions within their portfolios to minimize imbalance risk.

Accurate Forecasting

- ✓ Volumes – own production and consumption
- ✓ Prices – what can they expect to get in the market
- ✓ Renewable energy – what does their weather forecast predict

Risk Management

- ✓ Imbalance price is volatile and difficult to predict
- ✓ Profitability and operational stability impacts

Continuous Position Monitoring

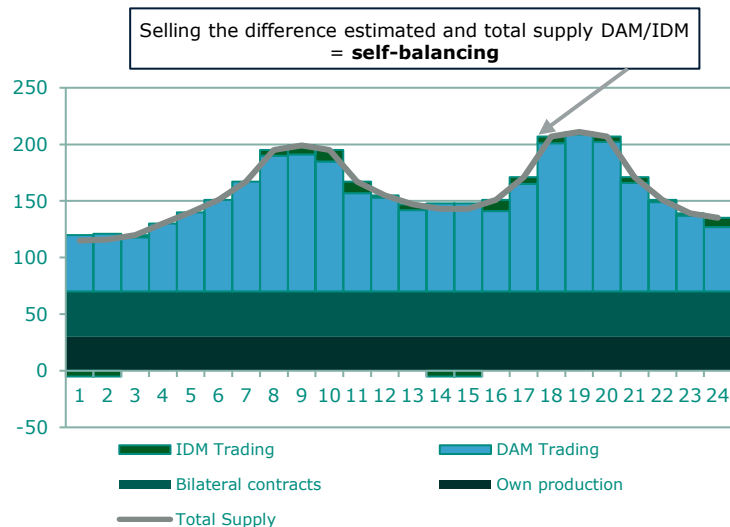
- ✓ Participant's planned net position (scheduled positions in DAM & IDM)
- ✓ Real-time updates (forecasts vs. actual generation and consumption)
- ✓ Market opportunity – does a chance present itself to adjust and profit

Speed & Flexibility

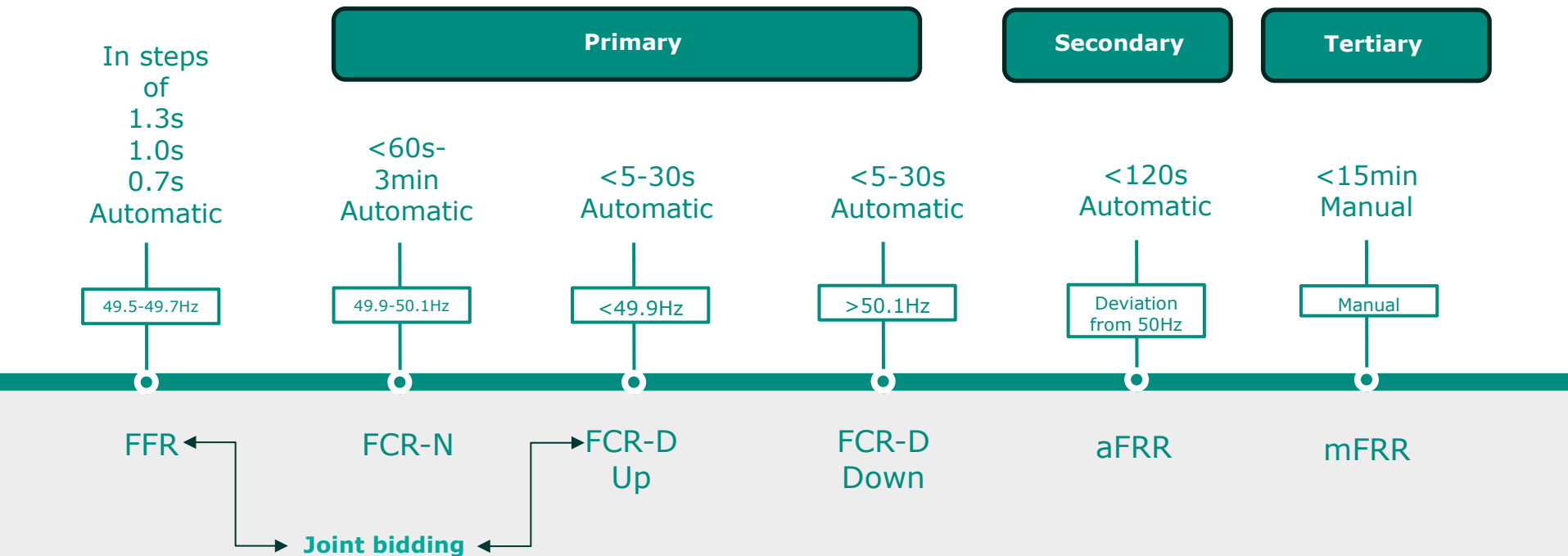
- ✓ Uncertainty management due to wind & solar production
- ✓ Intraday trading adds significant flexibility

Example of daily activity for a self-balancing market participant:

1. First establishes a **baseline position** through **long-term bilateral contracts** or **own production**
2. Then uses the **Day-Ahead Market** to **match expected supply and demand** one day before delivery
3. Closer to real time, forecast **deviations are adjusted in the Intraday Market**,
4. While any **remaining imbalance** is settled through imbalance settlement **by the system operator**.

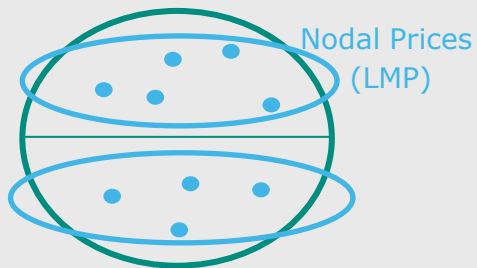


EU balancing markets are organised by TSOs and are separate from the power exchanges



The physical granularity of electricity markets differs depending on how detailed the pricing structure is

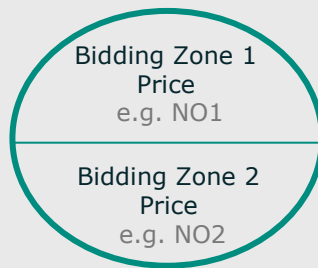
Nodal Markets



- Each physical node has its own price.
- Congestion and losses are reflected directly in that node's price.
- Very precise representation of grid constraints.
- Example: US ISO markets (PJM)

High Granularity

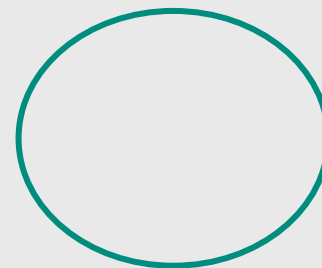
Zonal Markets



- Many nodes are grouped into a bidding zone.
- All nodes within the zone share one price.
- Congestion is only reflected between zones, not inside.
- Internal constraints are managed after market clearing.
- Example: the Nordics

Medium Granularity

Single Price Markets



- Entire country has one price.
- No locational differentiation in the market.
- All congestion handled outside the price mechanism.
- Example: France, Spain

Low Granularity

The design choice influences price accuracy regarding grid constraints, the strength of locational investment signals, market operational complexity, and whether congestion risk is borne by market participants or the transmission system operator (TSO)

A bidding zone is a geographical area where there is assumed no internal congestions in the grid

Market based transmission allocation

Bidding zones promote market-based allocation of transmission capacity, which in turn can help increase market liquidity by incentivising the market over bilateral trading.

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Transmission Efficiency

Bidding zones are created, but can also be continuously modified, to minimise internal grid constraints. This reduces the need for re-dispatching.

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Cross-Border Trading Facilitator

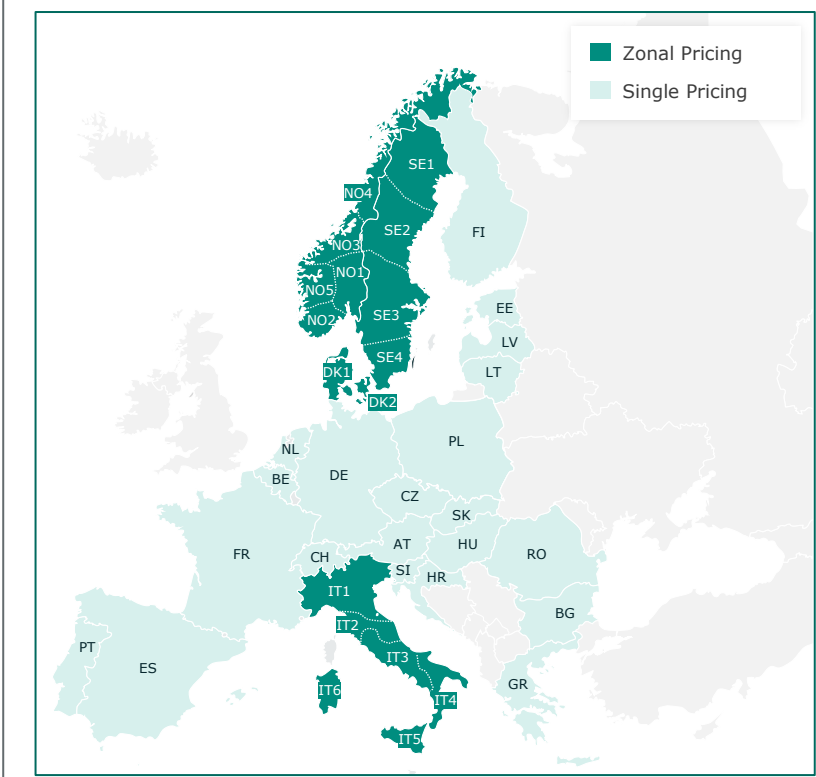
Uniform pricing within zones facilitates cross-border trading and capacity allocation.

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Investment Signals and Stability
Bidding zones signal where investment in generation or grid upgrades is needed through price differences between zones. Price differences can also incentivise large demand to invest in the areas of the grid that are the least constrained.

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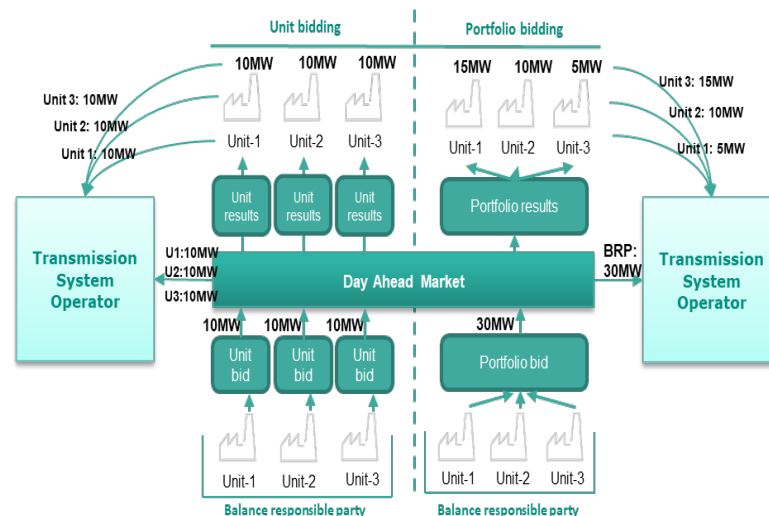
The EU market consists of countries with both unit and portfolio bidding

The key difference lies in the degree to which the market outcome reflects the technical and operational constraints of individual generation units, as opposed to allowing participants to internally optimize their assets and submit aggregated positions that do not reflect plant-level detail.

	Generation Unit	Portfolio Level
Granularity	High - reflects individual plant characteristics	Lower - aggregated across assets
Link to physical Assets	Directly linked to each specific unit	Indirect physical optimization handled internally
Operational Transparency	Greater visibility at unit level	Less visibility of individual units
Commercial Flexibility	More constrained by unit specifics	Higher flexibility through internal netting
Complexity for Participants	More detailed submission requirements	Simpler submission structure
Market Optimization	Physical constraints explicitly embedded	Optimization partly internal to participant

All nodal markets and central dispatch markets use unit bidding

More common in European Markets

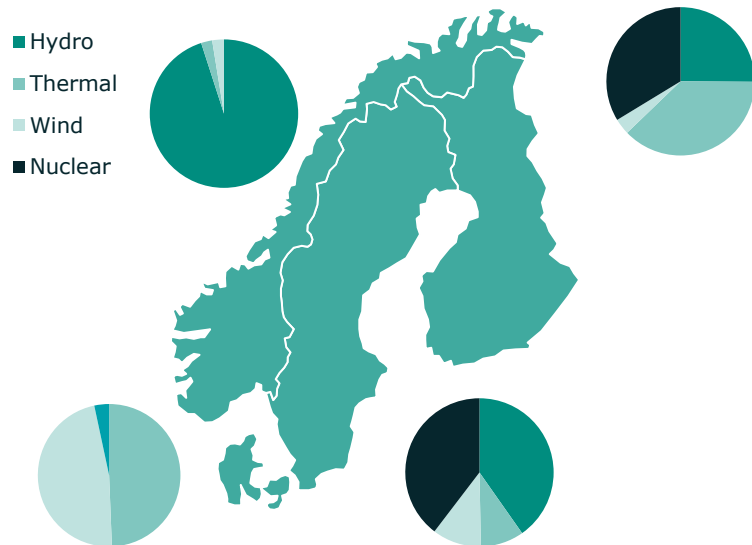


Portfolio bidding offers more flexibility to participants and enables them to find the most efficient outcomes for their entire portfolio, but it also increases the impact of market power and makes market manipulation harder to discover by the market operator

Cooperating across borders - the Nordic model

Connecting the Nordic countries ensures optimal use of natural resources and more stable prices

Nordic production capabilities



Connecting markets with differing production profiles provides stability to the system



Hydrology

- Wet year: higher hydro production
- Dry year: lower hydro production

Seasons

- Hydropower highly seasonal
- Wind power highly seasonal
- Nuclear neutral
- Fossil power neutral

low reserves



Daily weather

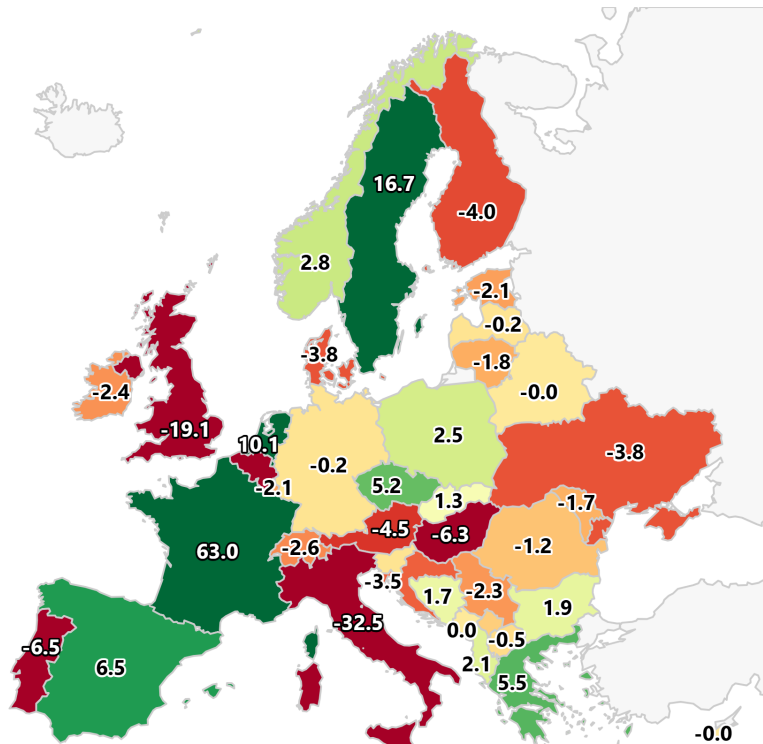
- Wind/solar power is neither flexible nor storable
- All other sources are flexible



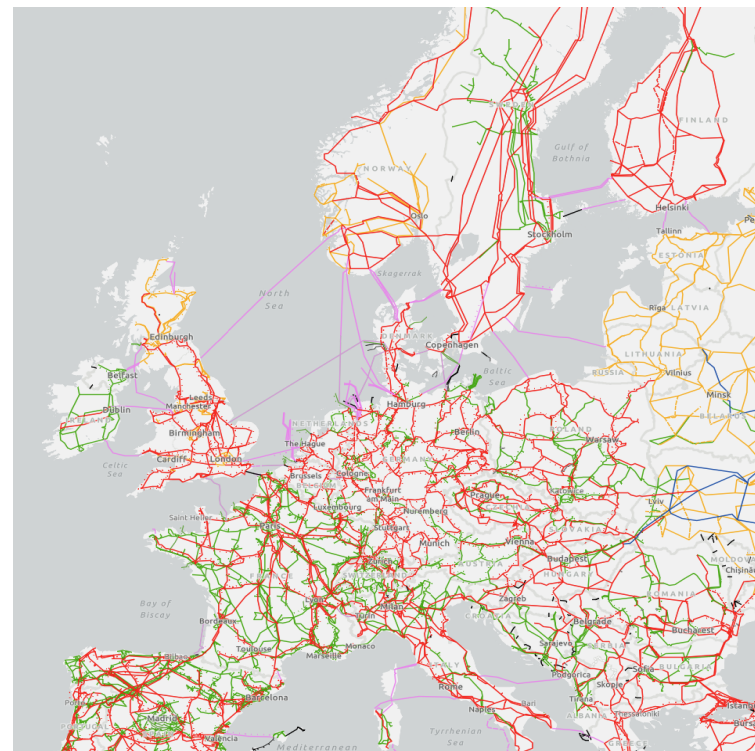
The European power market is deeply integrated

Cross border physical flows in 2026

In TWh, positive values (green) mean exports, negative values (red) mean imports



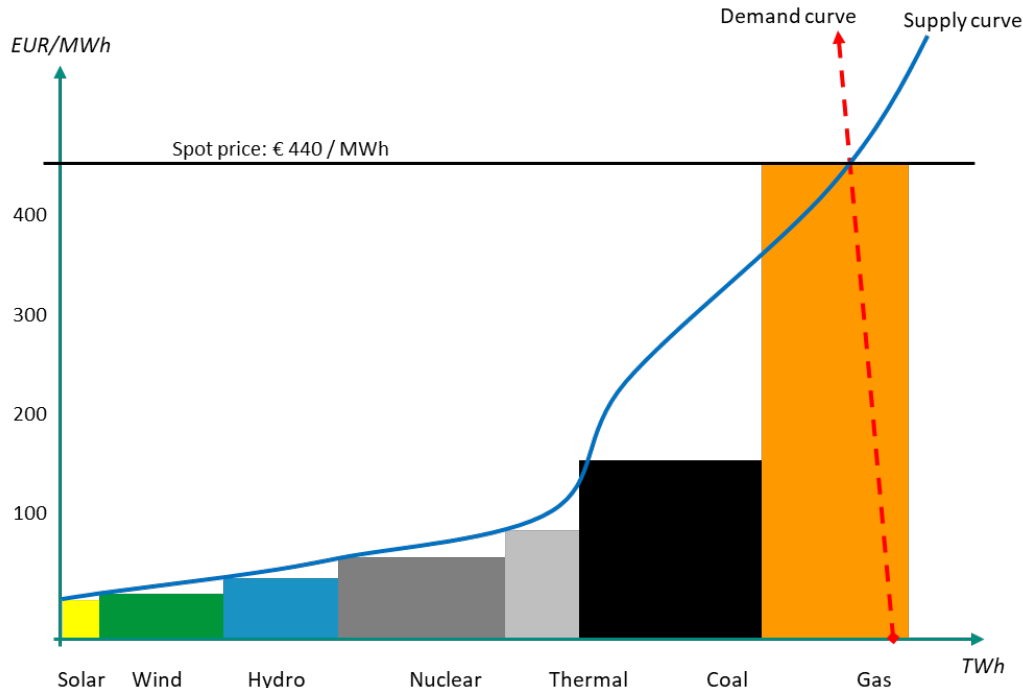
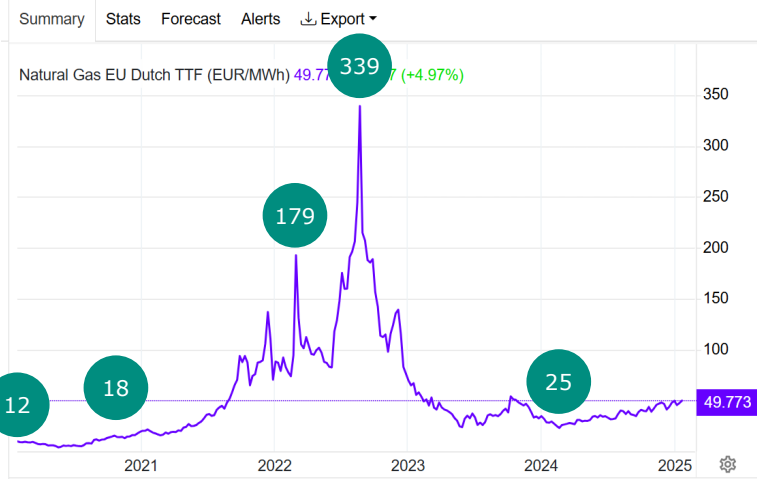
Entso-e transmission system map



Gas price (still) impacts power price

Merit Order and Marginal Cost

EU Natural Gas TTF



- The energy source with the lowest marginal cost is produced first
- The last unit of energy that must be produced to fulfill the consumption demand, sets the price for all previous production

Markets

France Slams EU's Single Electricity Market as 'Aberration'

- Finance minister calls for 'top-to-bottom' review of pricing
- Le Maire says he'll call for revisions at ministerial Monday

EU Power Market Not Working Thanks to Putin, Von Der Leyen Says

- Commission chief says electricity market needs changes
- EU power prices soared on limited supplies of Russian gas

Europe at Turning Point to Fix Broken Power Market, Spain Says

- Deputy Prime Minister Ribera says crisis paves way for reform
- Proposal to cap price of Russian oil not mature yet in Europe

During the energy crisis ACER suggested several measures

13 measures for the consideration of policymakers, future-proofing the EU wholesale electricity market design



1. Speed up electricity market integration, implementing what is already agreed



2. Improve access to renewable Power Purchase Agreements (PPAs)



3. Improve the efficiency of renewable investment support schemes



4. Stimulate 'market making' to increase liquidity in long-term markets



5. Better integrate forward markets



6. Review (and potentially reduce, if warranted) collateral requirements



7. Preserve the wholesale price signal and remove barriers to demand resources providing flexibility



8. Shield those consumers that need protection the most from price volatility



9. Tackle avoidable supplier bankruptcies, getting the balance right



10. Tackle non-market barriers, ensuring generation and infrastructure is built at pace



11. Consider prudently the need for market interventions in situations of extreme duress; if pursued, consider tackling 'the root causes'



12. Consider public intervention to establish hedging instruments against future price shocks



13. Consider a 'temporary relief valve' for the future when wholesale prices rise unusually rapidly to high levels

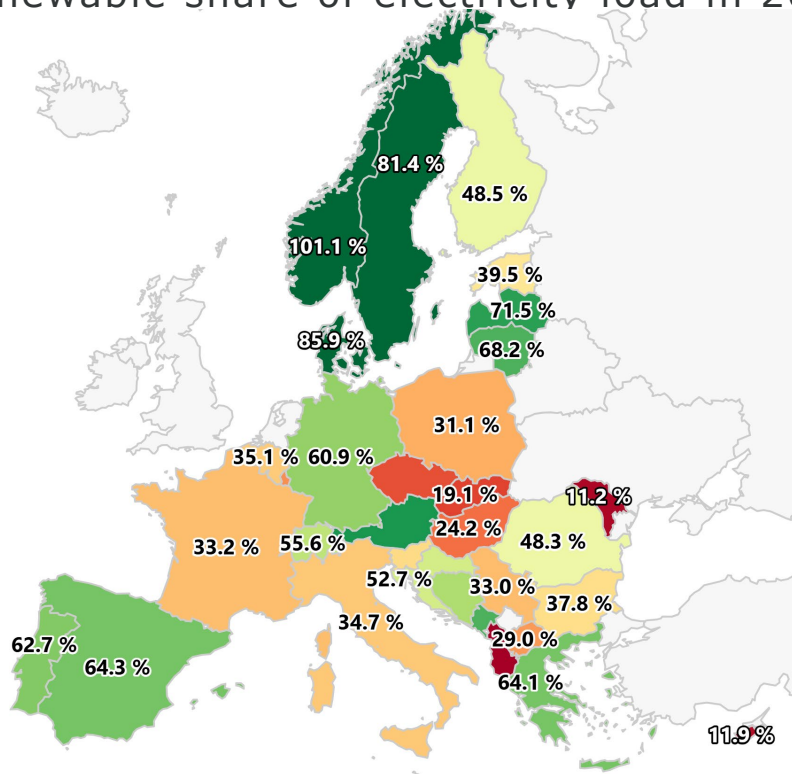


Want to learn more?

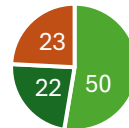
Check out the full report on ACER's Final Assessment of the EU Wholesale Electricity Market Design.

Europe has come quite far in its energy transition

Renewable share of electricity load in 2026



Energy Mix in Europe - 2024 (EU-27, UK, NO, CH)

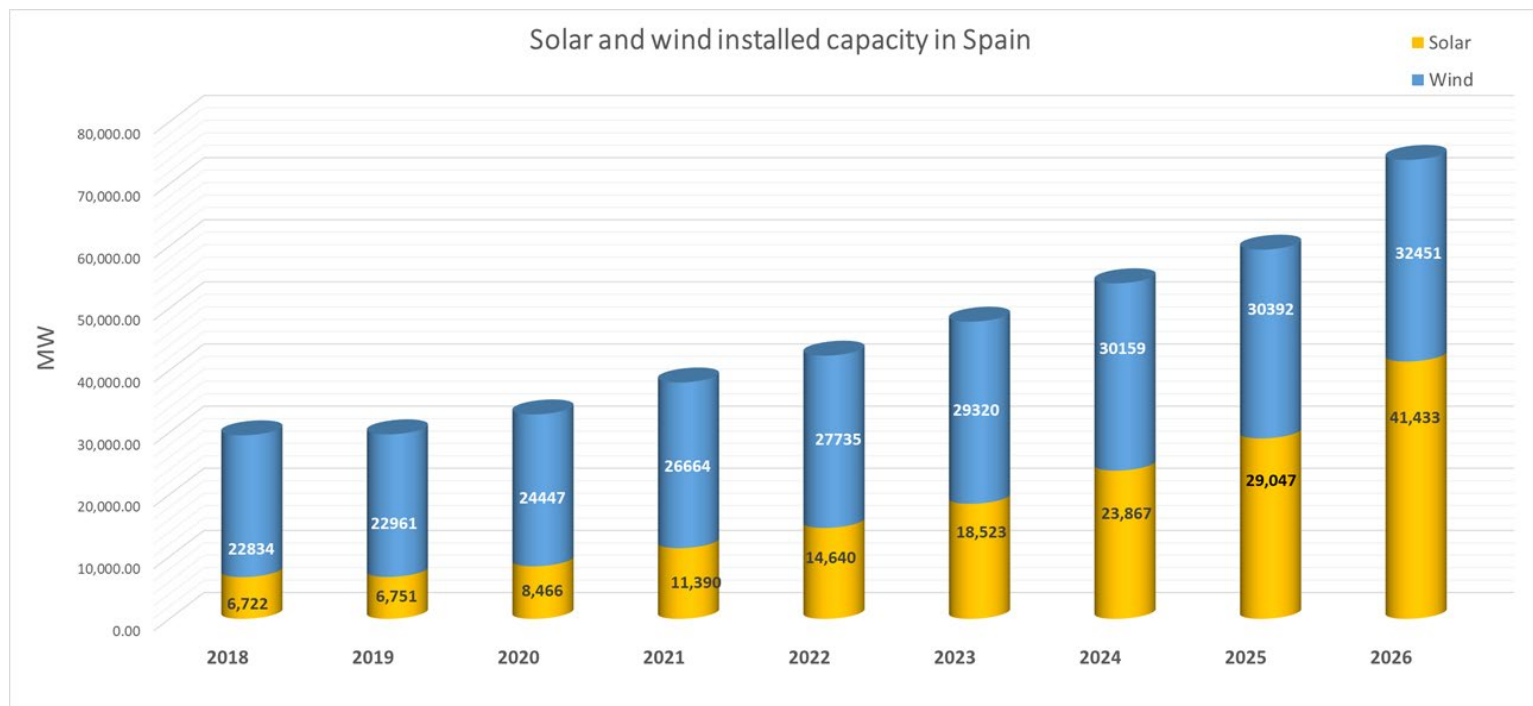


■ Renewable ■ Nuclear ■ Fossil

72% of power generation in 2024 came from "emission free" energy

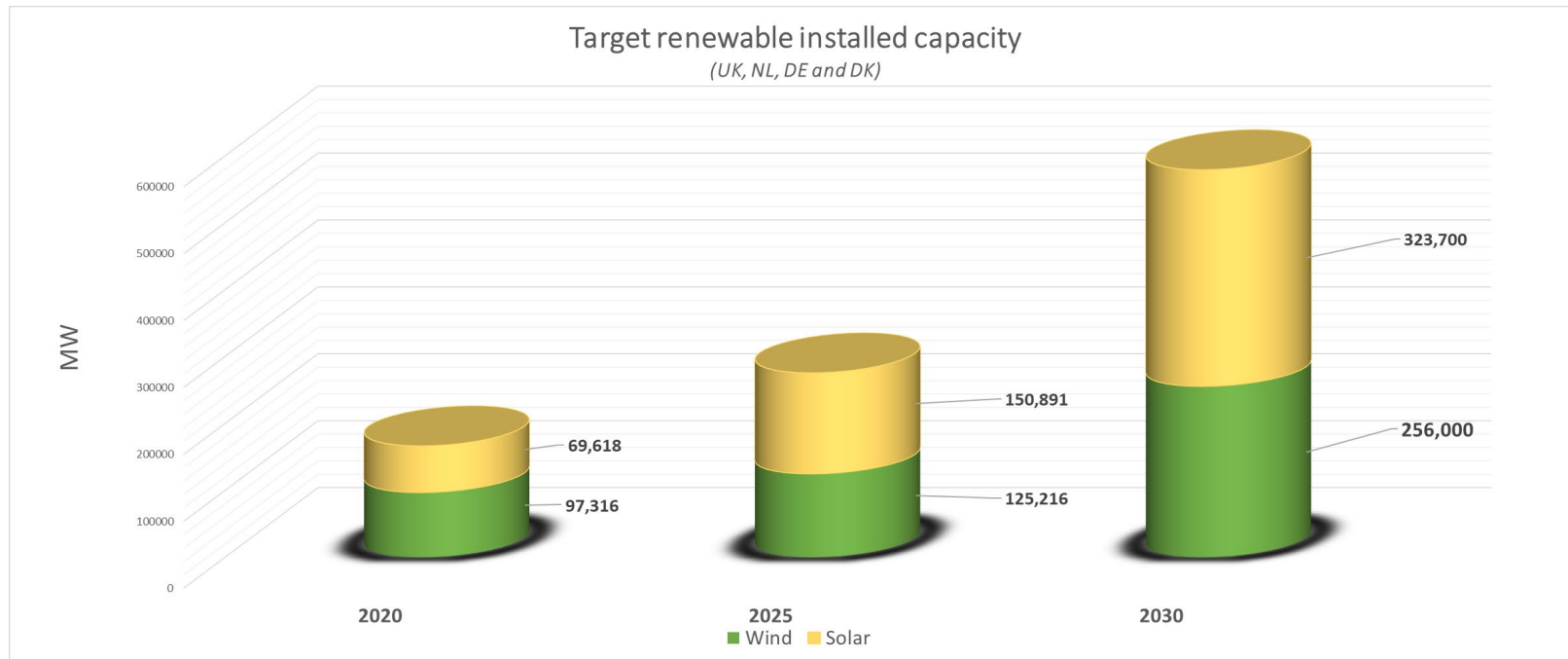
NB: "Renewable share" does not include nuclear

Solar and wind installed capacity in Spain



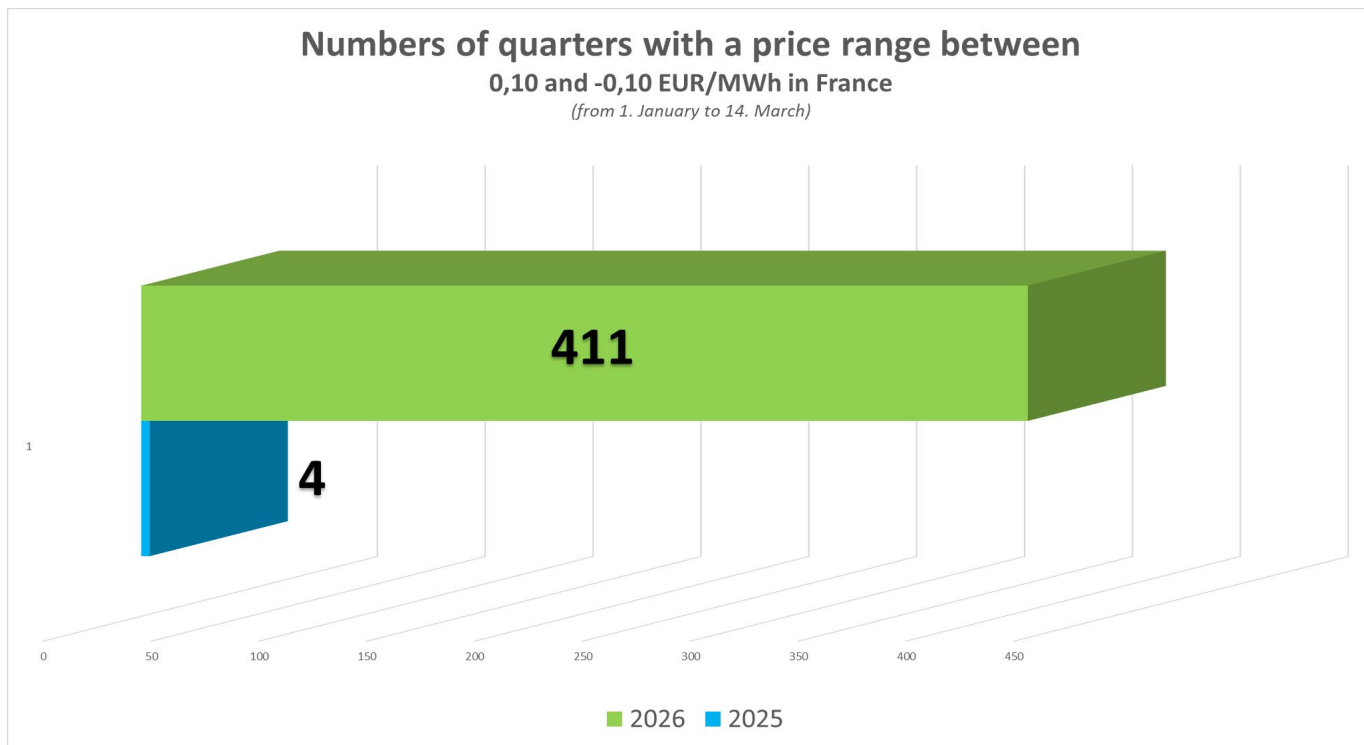


Doubling of renewable energy next 4 years in key EU countries



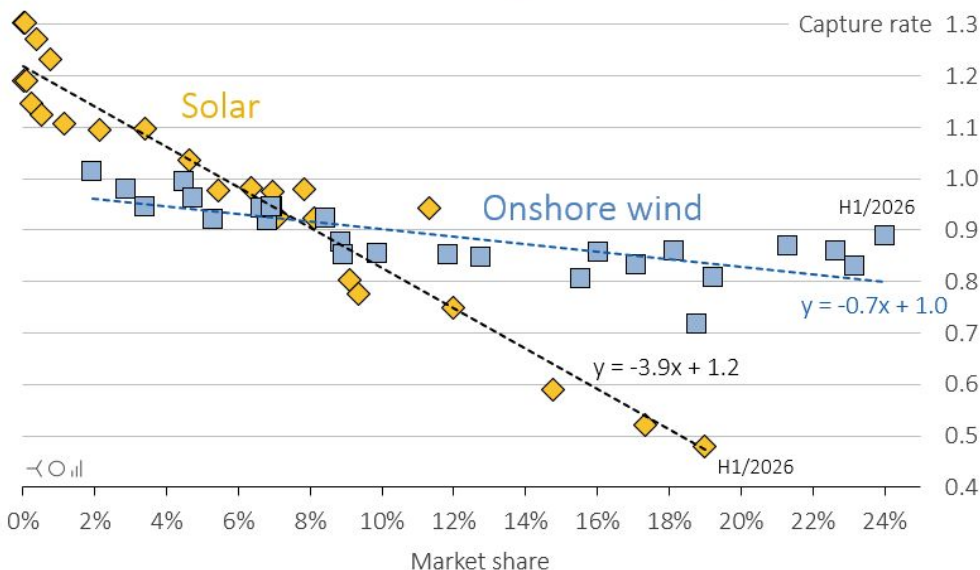


Many more hours close to zero in France in the beginning of the year

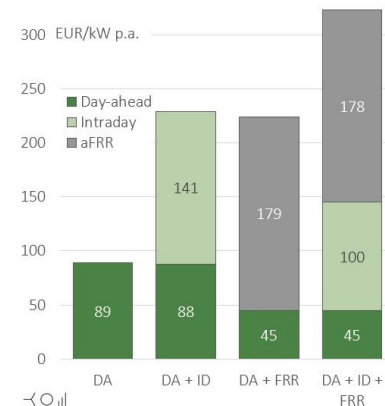


Increase in renewables leads to new challenges for investment

The Value of Wind & Solar Energy in Germany



Battery profits by market segment



Germany, 2025 prices, 2h discharge time, 95% one-way efficiency, 2 cycles per day max

Hitzevlaute and dunkelflaute is the new reality

Flaute – German for "lull", a state of little wind

Dunkelflaute – Dunkel, meaning "dark" in German

- **Supply drops:** Wind turbines slow down. Solar panels don't produce in the dark, and during the winter there are few hours of sunlight per day.
- **Demand surges:** Low wind periods during winter often coincide with low temperatures, increasing the demand for heating.
- Unlike hitzevlaute (the summer equivalent), dunkelflaute can lead to consistently high prices throughout the day, without the intraday price spreads associated with hitzevlaute.
- **Country-specific effects:** Germany is severely impacted due to the high combined penetration of both wind and solar power.

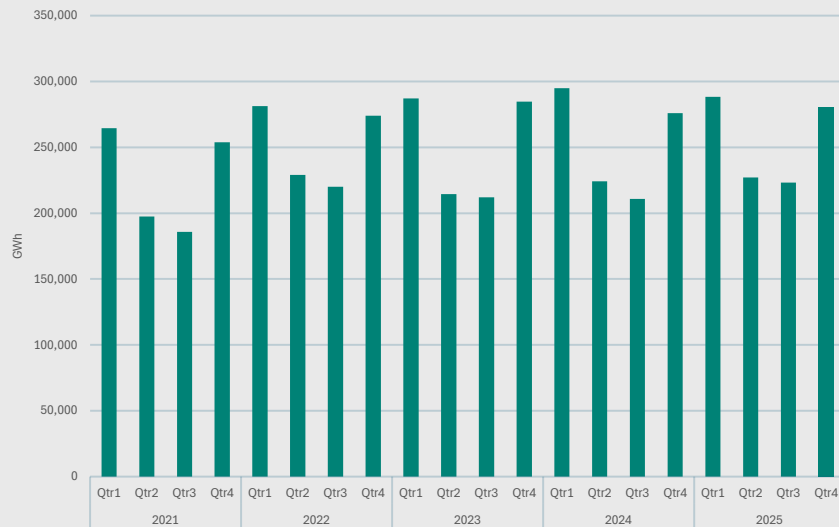
Hitzevlaute – Hitze, meaning "heat" in German

- **Supply drops:** Wind turbines slow down. Nuclear plants cut output as cooling water gets too hot. Gas plants lose efficiency above 30°C. Solar panels produce less when overheated.
- **Demand surges:** increased use of air conditioning and cooling pushes consumption up.
- **Ramping costs:** as the sun sets, solar output drops sharply — in Germany, up to 1 GW every five minutes — forcing gas and coal plants online at premium cost.
- **Huge spreads:** midday prices often collapse to zero or negative, while evenings spike to €200–250/MWh.
- **Country-specific effects:** France struggles as nuclear plants along rivers face cooling restrictions. Germany sees extreme evening price ramps due to heavy solar penetration.

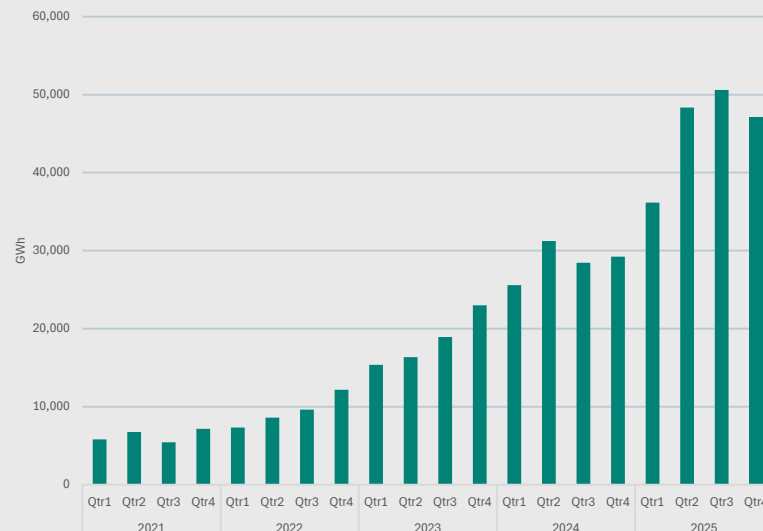


Traded volumes traded closer to delivery, hence massive growth in Intraday volumes

Day-ahead volume development 2021-2025



Intraday volume development 2021-2025

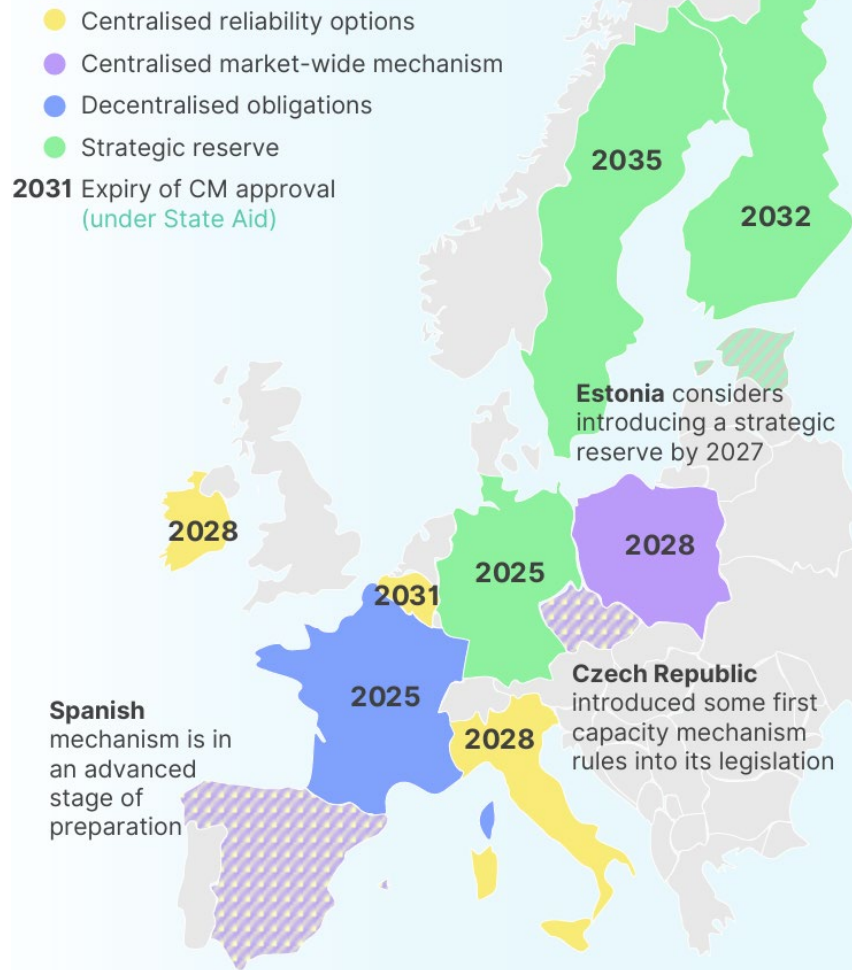




Capacity mechanisms are on the rise

- The European market has historically been “energy only”
- Sentiments gradually changed over last years, fuelled by the energy crisis in 2022
- Several countries are considering, or actively developing capacity mechanisms
- Challenge remains in creating capacity mechanisms that are technology agnostic to enable low emission capacity sources

Capacity mechanism in the EU, 2025



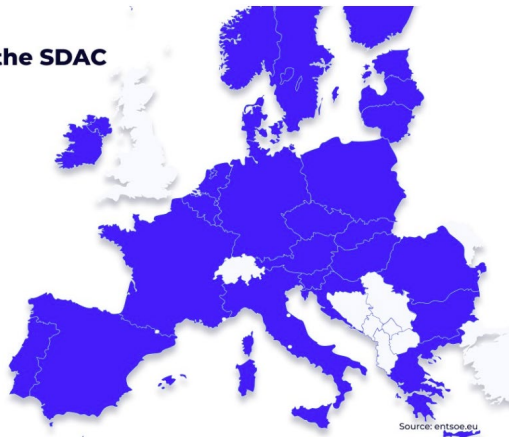
Our biggest strength: The European power market - deeply interconnected and integrated

Countries a part of the SDAC

Single Day-Ahead Coupling

Legend:

-  Coupled via SDAC
-  Not coupled

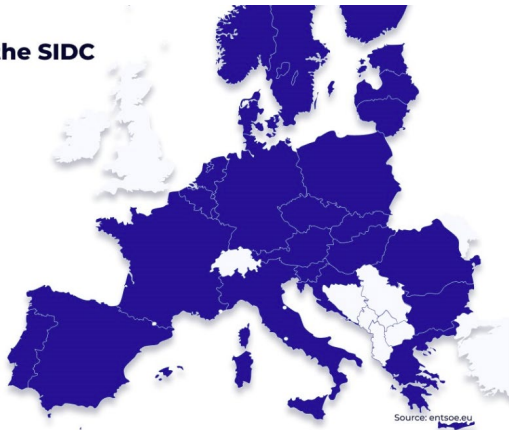


Countries a part of the SIDC

Single Intraday Coupling

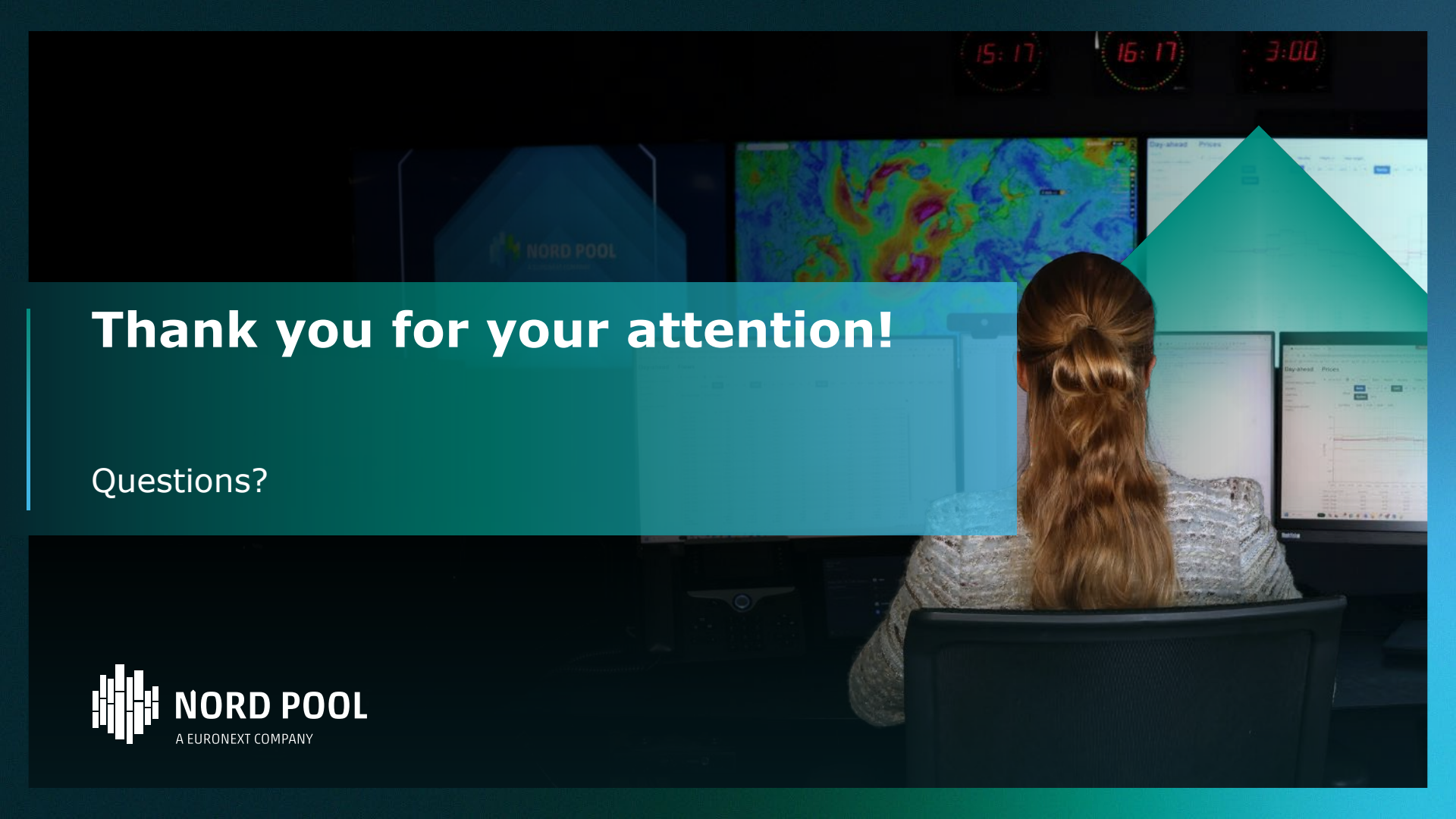
Legend:

-  Coupled via SIDC
-  Not coupled



- European countries are interconnected within single day-ahead and intraday markets.
- The European electricity market is the largest integrated electricity market in the world.
- An **integrated EU energy market is the most cost-effective way to ensure secure, sustainable and affordable energy supplies** to Europeans.
- The EU internal energy market saves consumers €34 billion annually (2022 data) and with deeper integration, this could rise to €40-43 billion by 2030*.
- Broad Geographical Scope • 77 bidding zones (including virtual Bidding Zones), • 30 TSOs • 16 operational NEMOs. Large Traded Volume and Value • 1 840 TWh traded in 2024 → 5 TWh daily (on average)

Source: *[European Commission](https://ec.europa.eu/economy_finance/electricity-market-integration)



Thank you for your attention!

Questions?



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