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Part 1

Balancing markets series

By Alessandro Armenia - February 2025

Contents

List of abbreviations

ALPACA	Allocation of Cross-zonal Capacity and Procurement of aFRR Cooperation Agreement
ASDP	Ancillary Service Dispatch Platform
BOA	Bid Offer Acceptance
BESS	Battery Energy Storage Systems
BSC	Balancing and Settlement Code
BSP	Balancing Service Provider
BM	Balancing Mechanism
BMU	Balancing Mechanism Unit
BSAA	Balancing Service Adjustment Actions
CBMP	Cross-Border Marginal Price
CCGT	Combined Cycle Gas Turbine
CHP	Combined Heat and Power
COBRA	Common Optimisation of Balancing Reserves and CZC Allocation
CRM	Capacity Remuneration Mechanism
CZC	Cross-Zonal Capacity
DC	Dynamic Containment
DER	Distributed Energy Resource
DFS	Demand Flexibility Service
DM	Dynamic Moderation
DNO	Distribution Network Operator
DR	Dynamic Regulation
DESNZ	Department for Energy Security and Net Zero
EAC	Enduring Auction Capability
ERPS	Enhanced Reactive Power Service
FCR	Frequency Containment Reserve
FR	Frequency Response
FRR	Frequency Restoration Reserve
aFRR	automatic Frequency Restoration Reserves
mFRR	manual Frequency Restoration Reserves
FPN	Final Physical Notifications
GCC	Grid Control Cooperation
IGCC	International Grid Control Cooperation

List of abbreviations

IN	Imbalance Netting
LCM	Local Constraint Market
LFC	Load-Frequency Control
LMP	Local Marginal Price
MARI	Manually Activated Reserves Initiative
MC	Market Committee
MEAS	Mutual Emergency Assistance Service
MFR	Mandatory Frequency Response
NESO	National Energy System Operator
OBP	Open Balancing Platform
OCGT	Open Cycle Gas Turbines
OPA	Outage Planning Agents
ORPS	Obligatory Reactive Power Services
PICASSO	Platform for the International Coordination of Automated Freq Restoration and Stable System Operation
PCIs	Projects of Common Interest
RDP	Regional Development Programme
RR	Replacement Reserve
RSP	Restoration Service Providers
SA	Scheduling Agents
SFFR	Static Firm Frequency Response
SMP	Single Markets Platform
TERRE	Trans European Replacement Reserves Exchange
TSO	Transmission System Operator
TYNDP	Ten-Year Network Development Plan
VSP	Voltage Service Providers
WG	Working Groups

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1. Executive summary

The **Balancing Market Series** is a **dual report** unfolding the complexity of **European balancing and capacity markets**.

Part 1 provides a global perspective on **balancing and capacity markets in Europe**, with a focus on ENTSO-E's role, legislative framework, and market design. Moreover, **Germany and Belgium** are examined in-depth, exploring their unique balancing products beyond ENTSO-E's framework. Additionally, the report examines **Great Britain's capacity and balancing markets**. Despite Brexit, Great Britain remains deeply tied with the continental Europe and Norwegian power grid with 8.8 GW of interconnection capacity across seven interconnectors and an additional 3.9 GW expected by 2030.

The ENTSO-E balancing framework is structured around **FCR, aFRR, and mFRR**, which is entirely independent from wholesale market dynamics. FCR continuously follows grid imbalances, aFRR provides asymmetric and automated support to counteract larger deviations, and mFRR, manually activated by the TSO, addresses longer-term imbalances. In contrast, Great Britain's balancing design differs fundamentally. The **GB Balancing Mechanism** maintains a connection with wholesale markets and is supported by a vast web of ancillary services, the most important being **Frequency Response and Reserve services**. Beyond ENTSO-E's framework, Germany's rising reserve market costs and fragile power grid coverage are driving the adoption of new services like "use instead of curtail". Meanwhile, Belgium's approach prioritizes capacity markets and voltage services, facing fewer congestion challenges.

Part 2 will shift to a market analysis, diving into the most **liquid balancing markets** to identify major **cost drivers for TSOs**, bottlenecks that hinder power mix growth, and **investment opportunities for both new and existing assets**. This report highlights the financial and operational challenges facing TSOs while outlining pathways for growth and efficiency.

In part two it is anticipated that, in countries like Germany and the UK, balancing efforts and spending are heavily directed toward grid congestion management. In contrast to Belgium, costs are strikingly high. This stems from a common power system layout: significant northern wind energy production and an energy-hungry southern demand, putting heavy strain on north-to-south transmission lines. However, **grid congestion is a Europe-wide issue**. In 2023 alone, grid congestion cost the EU €4.2 billion, with over 12 TWh of renewable electricity curtailed. That number could skyrocket to 50 TWh by 2030, alongside congestion costs increasing threefold to €13 billion. An estimate that may still be conservative, as redispatch alone could cost €7 billion, according to the EU Joint Research Center. Understanding these dynamics, as well as the impact of common balancing exchange platforms like PICASSO, shed a light on how policies and new services are being shaped, ultimately influencing the liquidity of future markets.

Together, these reports serve as a definitive guide to understanding the structure, costs, and opportunities of balancing markets, with actionable insights to navigate an evolving power landscape.

2. Introduction to European balancing markets

Power markets are a complex ecosystem. Given the numerous players involved, the variety of perspectives adds layers of complexity to how these markets are portrayed. However, there is a general consensus that **power markets can be divided into three main categories: wholesale, balancing and futures markets**. In recent years, a **fourth category**, the **capacity market**, has emerged, though it is not yet globally adopted across all European countries. This report will include a discussion on capacity markets.

Most electricity volume is traded in wholesale markets for next-day (day-ahead) or same-day (intraday) delivery. Balancing markets address near-time scheduled deviations and are the central topic of this report. They also include imbalance markets, which are not covered in this report. These reflect the costs ("system price") incurred by the Transmission System Operator (TSO) to balance the grid, with participation limited to market players whose actual production or consumption deviated from their scheduled commitments. Futures markets enable electricity trading for weeks, months, or years ahead, allowing price hedging and risk management.

With a foundation in wholesale markets, **this series focuses on balancing and capacity markets**, exploring their evolving dynamics.

As wind and solar power grow, the **ecosystem is becoming more weather-dependent and decentralised**. This shift from traditional power plants makes maintaining grid stability much more challenging. While renewables are essential for achieving decarbonisation goals, **rapid fluctuations in solar and wind output** could cause significant grid imbalances. Solar alone could contribute to grid imbalances of up to 5 GW in Germany by 2030, according to the 'Grünbuch Regelreserve' projections drafted by German TSOs. This issue is further compounded by **rising transmission and congestion problems**, more **frequent extreme weather events, limited energy storage capacity**, and unplanned outages, making it harder than ever for TSOs to manage last-hour fluctuations. Meanwhile, incentivising demand-side flexibility offers crucial support but also adds complexity to grid management. Therefore, **balancing markets are rapidly growing and playing an increasingly vital role**.

Capacity markets serve a twofold purpose: they **secure sufficient generation stack to meet future demand at all times,** particularly during extreme system events, ultimately preventing national blackouts. Simultaneously, they **act as a subsidy mechanism for new or existing projects through long-term fixed contracts** characterised by an availability fee, reducing investment risk.

The aim of this first report is to unfold the intricacies of European balancing markets, which are largely shaped by the ENTSO-E framework. Moreover, it will deep dive into the balancing services of two key countries, Germany and Belgium, delving into their full suite of ancillary services, and finally offer a comparison with the capacity and balancing markets in Great Britain.

2.1 What is ENTSO-E?

Representing 40 TSOs from 36 European countries, ENTSO-E is a non-profit association governed by an Assembly of 12 elected members, with reach extending beyond the EU. Founded in 2008, its mission is to promote operational collaboration among European TSOs and support the European grid by developing, interconnecting, and integrating infrastructure and services within a shared framework. Moreover, its goal is to ensure the security of the interconnected power system at a pan-European scale, promote the optimal functioning and growth of electricity markets, and enable renewable energy integration while supporting emerging technologies.

ENTSO-E's tasks and responsibilities are outlined in EU regulations, including:

- Regulation (EC) No 714/2009 on conditions for access to the network for cross-border exchanges in electricity.
- Regulation (EU) 838/2010 on guidelines relating to the inter-TSO compensation mechanism.
- Regulation (EU) 347/2013 on guidelines for trans-European energy infrastructure.
- Transparency Regulation (EU) No. 543/2013 on submission and publication of data on electricity markets.

By promoting cooperation and standardisation among European TSOs, ENTSO-E plays a crucial role in ensuring the security, competition, and transparency of the European electricity system. Key initiatives include the Ten-Year Network Development Plan (TYNDP), a blueprint for transmission infrastructure development that identifies European Projects of Common Interest (PCIs). Future goals include providing access to new players in areas such as demand response, storage elements and integrated renewables.

Shifting focus to the balancing market, ENTSO-E has established frameworks for balancing and ancillary services, though none exist for the Capacity market. At the heart of this system are Balancing Service Providers (BSPs), the designated market participants who deliver balancing services to TSOs.

2.2 ENTSO-E framework

ENTSO-E's activities are overseen by the ENTSO-E Market Committee (MC) currently chaired by Kjell Arne Barmsnes from Statnett (Norway's TSO) and Peter Scheerer from TransnetBW (a German TSO) as Vice-Chairman. The Committee reports to the ENTSO-E Board and Assembly. Below the MC, there are six Working Groups (WGs) and three projects directly reporting to the MC. One of them is the Ancillary Service Working Group.

Working Group Ancillary Services (WG AS) focuses on defining and amending pan-European methodologies for electricity balancing markets as required in the EB regulation, also known as **Electricity Balancing Regulation (Commission Regulation (EU) 2017/2195 of 23 November 2017)**. The EB Regulation lays down the principles for the exchange of balancing energy and the associated TSO–TSO settlement and TSO-BSP settlement, regarding the following set of products: frequency restoration reserves (FRR), Replacement Reserves (RR), Imbalance Netting (IN) and a common methodology for the exchange and sharing of reserves, as well as for the procurement of Frequency Containment Reserve (FCR).

Coming to balancing markets, there are 4 main types of ancillary services designed to balance the system:

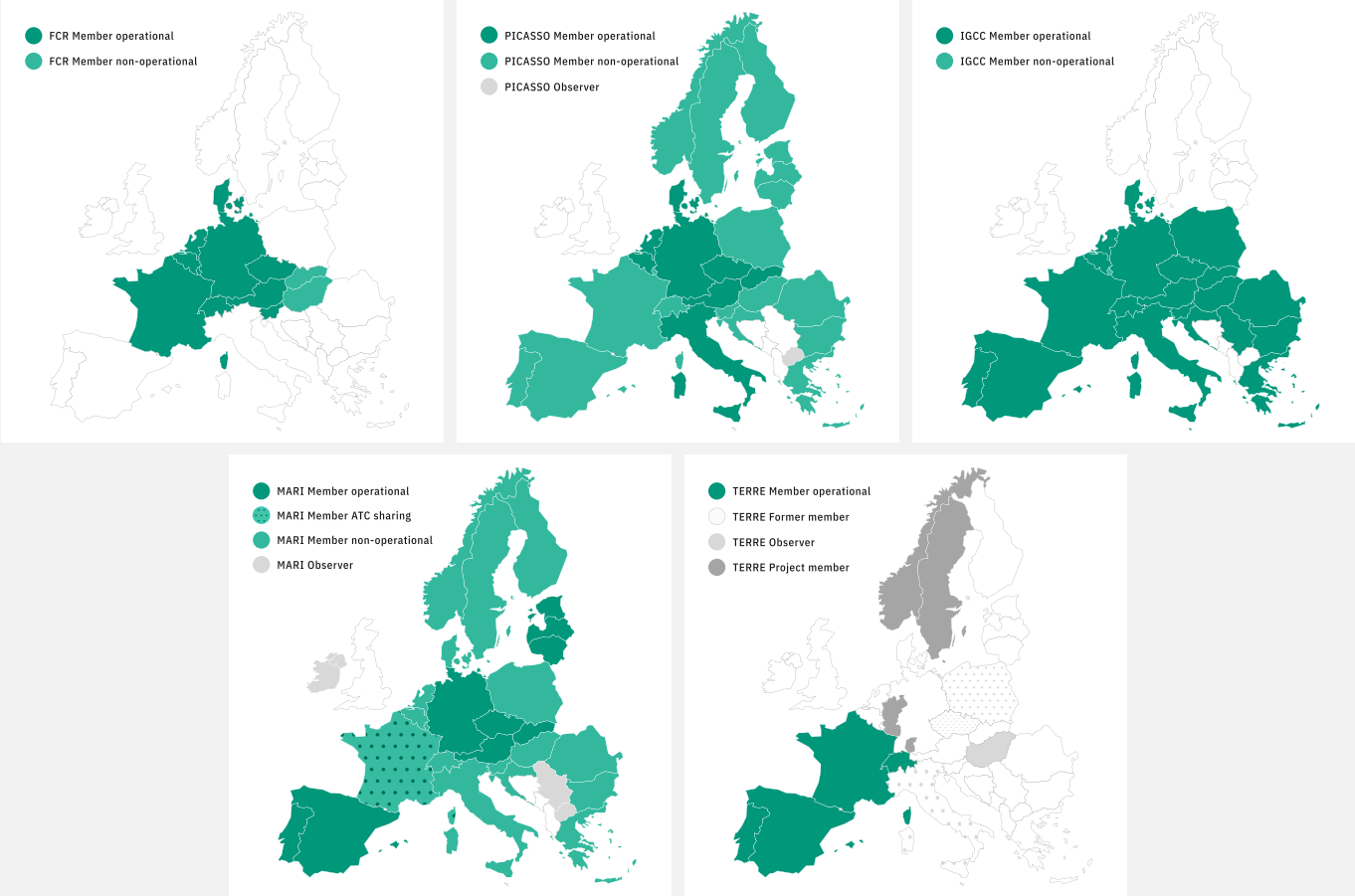
- **Primary reserve** → Frequency Containment Reserve **(FCR)**
- **Secondary reserve** → automatic Frequency Restoration Reserve **(aFRR)**
- **Tertiary reserves** → manual Frequency Restoration Reserve **(mFRR)** and Replacement Reserve **(RR)**

2.3 Integrated European balancing network

As mentioned earlier, ENTSO-E's goal is not only to enhance operational energy security within national borders but also to promote a pan-European grid interconnection and integration. To achieve this, the ENTSO-E association has implemented several platforms to facilitate collaboration among TSOs, aiming for a more efficient and cost-effective exchange of electricity services. Currently, there are 4 platforms for the procurement and exchange of balancing services between operational members and 3 cross-border algorithm optimisers:

- **FCR Cooperation:** pools and exchanges FCR capacity
- **PICASSO:** pools and exchanges aFRR balancing energy
- **MARI:** pools and exchanges mFRR balancing energy
- **TERRE:** pools and exchanges RR capacity
- **IGCC:** performs imbalance netting of aFRR balancing energy

Figure 1



Source: ENTSO-E

In addition to the above, ENTSO-E presents two other less known algorithms. **ALPACA** fosters a unified aFRR balancing capacity market, aiming for price convergence and enhanced liquidity post-PICASSO. Hungary, Croatia, the Netherlands, Slovenia and Switzerland are current observers and studying the opportunity to participate in the ALPACA joint procurement. **COBRA** optimises cross-zonal balancing capacity procurement and allocates cross-zonal capacity (CZC), considering its forecasted value for the day-ahead market. The ultimate objective is to promote competition, transparency, while strengthening real-time security at a pan-European scale.

2.4 Balancing markets

The table below provides a detailed overview of the key features of the four services:

Table 1: Major balancing services under the ENTSO-E framework

Ancillary Services	Primary reserve	Secondary reserve		Tertiary Reserves		
	FCR	aFRR capacity	aFRR energy	mFRR capacity	mFRR energy	Replacement Reserve
Purpose	• Responds continuously and automatically to grid imbalances • Limits frequency deviations	• Reserves capacity to support exhausting FCR reserves • Restores system frequency within operational limits	• Supports exhausting FCR reserves • Restores system frequency within operational limits	• Reserves capacity to support exhausting FCR and aFRR reserves • Restores system frequency	• Supports exhausting aFRR reserves • Restores system frequency	• Replaces units utilised as spinning or non spinning reserve, allowing them to return to their original role as operating reserves
Bid submission window	From 11 AM D-14 to 8 AM D-1	From 9 AM D-7 to 9 AM D-1	up until 25 minutes before each delivery period	From 10 AM D-7 to 10 AM D-1	up until 25 minutes before each delivery period	From 10 AM D-7 to 10 AM D-1
Fee rate	€/MW/h	€/MW/h	€/MWh	€/MW/h	€/MWh	€/MWh
Contract length	4 hours	1h France, 4 hours (or daily)	-	4 hours	-	-
[1] Full activation time (FAT)*	Within 30 seconds	-	Within 5 or 7.5 minutes	-	Within 12.5 or 15 minutes	Within 30 minutes
[2] Full activation time limit*	15 minutes	-	5-15 minutes (or 1 hour)	-	15 minutes to 2 hours	Up to 90 minutes
Activation method	• Automatic: Units self-adjust to measured grid frequency deviations.	-	• Automatic, based on TSO signal • Activation is efficient and cost-effective via a merit order list (MOL)	-	• Manual instruction is sent by the TSO to the plant operator	• Manual instruction is sent by the TSO to the plant operator
Common market (Constraints)	FCR cooperation (Core share, Export limit)	-	PICASSO	-	MARI	TERRE
Payment mechanism*	Pay-as-clear	Pay-as-bid	Pay-as-clear mostly	Pay-as-clear (FR, BE), pay-as-bid (DE)	Pay-as-clear mostly	Pay-as-clear
Product (Types)	Symmetrical	Asymmetrical (up and down)	Asymmetrical (up and down)	Asymmetrical (up and down)	Asymmetrical (up and down)	Symmetrical
Min bid size and resolution	1 MW	1 MW	1 MW	1 MW	1 MW	1 MW

Source: Kpler

[1] FAT refers to the product guaranteed response time to reach full capacity after activation.

[2] Full activation time limit refers to the maximum timeframe within which the unit is required to deliver energy at full capacity after activation.

* Row titles or cells with an asterisk can be subject to change based on the country-specific context.

2.5 A focus on primary and secondary reserves

Building on the detailed table of balancing markets, this section highlights Frequency Containment Reserve (FCR) and automatic Frequency Restoration Reserve (aFRR), which play crucial roles in maintaining grid stability.

2.5.1 Primary reserve - FCR

FCR ensures a **rapid and continuous stabilisation of grid frequency through proportional activation of contracted units**. FCR is activated automatically and works through local control systems, removing the need for centralized management. Full activation typically occurs when the grid frequency exceeds the operational imbalance threshold of ±0.2 Hz. At this point, units remain fully active for 15 minutes, providing sufficient time to secondary and tertiary reserves to respond.

Continental Europe must tender at least 3 GW daily. ENTSO-E estimated that the total FCR demand across the nine FCR cooperation operational countries will be less than 1.5 GW per day in 2025. Consequently, the **minimum procured volume of each Load-Frequency Control (LFC) block is set at 30% of its expected demand**. For instance, Denmark West/Germany LFC block had a forecasted demand of 553 MW, with a core share of 166 MW, while Belgium's demand is 86 MW, with a core share of 26 MW.

Operational members of the FCR cooperation experience a common price formation, also known as the **FCR Cross-Border Marginal Price (CBMP)**, unless one of the 2 constraints is hit:

- **Core share constraint**: The core share is a minimum FCR volume set by ENTSO-E that each LFC area must reserve. If an LFC Block's awarded capacity far exceeds its core share volume due to the core share constraint, the Local Marginal Price (LMP) diverges from the Cross-Border Marginal Price (CBMP), primarily caused by indivisible bids used for clearing.

  This has been mostly the case for Belgium and the Netherlands. In 2024, the core share of the Netherlands was 34 MW. During several 4-hour blocks, 33 MW low-priced bids and one 25 MW high-priced indivisible bid were recorded. With the core share constraint, the high-priced bid set the clearing price and 58 MW were awarded. In this scenario, the Dutch LMP decoupled from the CBMP to prevent price distortion.
- **Export limit constraint**: The export limit constraint occurs when a large volume of low-priced FCR bids within an LFC block exceeds both local demand and export capacity. The inability to reach exact limit values while hitting constraints is primarily due to indivisible bids.

  This has mostly been the case in France in 2024, where a high amount of FCR bids priced lower than the CBMP were offered in the market. All bids lower than the CBMP should theoretically be accepted. Yet, limited export capacity leads to a decoupling of the LFC block price from the CBMP.

Both constraints prevent market price distortions across LFC blocks: the core share avoids excessively high prices, while the export share prevents overly low prices.

2.5.2 Secondary reserve - aFRR

aFRR helps the TSO to **restore the frequency to its nominal value after initial frequency deviations have been addressed** by other mechanisms like Frequency Containment Reserve (FCR).

Since PICASSO's launch in July 2022, aFRR balancing energy exchanges between TSOs have continuously taken place. The bids activated follow a pay-as-clear mechanism where the settlement price is calculated every 4 seconds, making it look almost a pay-as-bid system. The algorithm follows a priority order: first, it maximises the satisfaction of aFRR demand in each LFC area. Second, it minimises the volume of selected standard aFRR balancing energy bids. Third, it aims to maximise economic surplus. Finally, it minimises automatic frequency restoration power interchange across aFRR balancing borders.

PICASSO has strengthened interconnectivity in the secondary reserve and remains under review by several countries. Slovenia, Denmark, the Netherlands, and Belgium joined in Q4 2024, with France set to follow in Q2 2025. Italy, however, withdrew in March 2024 due to unexpected price spikes.

2.5.3 A clarification on IGCC

IGCC conducts **imbalance netting for aFRR volumes.** This process means that TSOs across LFC areas **prevent simultaneous activation of frequency restoration reserves in opposite directions by exchanging their real-time energy surpluses and deficits**. For example, when two neighboring TSOs face opposite grid imbalances, one with oversupply and the other with undersupply, they exchange power surplus and deficit in real-time to balance the grid, "netting" their position.

2.5.4 TERRE closure: not all projects succeed

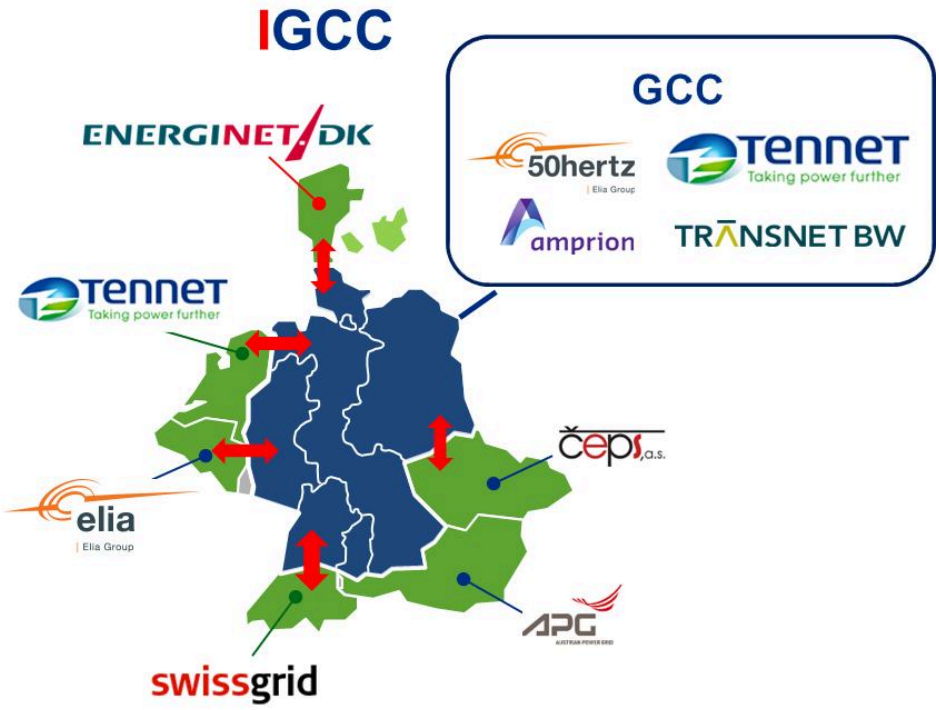
On December 9th, 2024, the TERRE members (CEPS, PSE, Red Eléctrica, REN, RTE, Swissgrid, and Terna) jointly announced the decision to terminate participation in the European platform TERRE. Citing external legislative circumstances, they stated that new requirements under EU Regulation n°2019/943, as amended by n°1747/2024, push the **closure of the platform at the beginning of 2026**.

3. The German balancing market

The German LFC block is an operational member of FCR Cooperation, PICASSO, IGCC, MARI, ALPACA and COBRA, while a TERRE project member in some regions. As of January 2025, **Germany does not have a capacity market** nor the Replacement Reserve (RR) service.

Germany's power grid is managed by 4 different TSOs: Amprion, TenneT, TransnetBW, and 50Hertz (a subsidiary of Belgium's TSO Elia). Each TSO is responsible for managing the regional transmission lines and balancing the grid within his control area. To ensure national coordination, the TSOs formed the **Grid Control Cooperation (GCC)**, optimising power management measures. The GCC coordinates balancing volumes and supports cost-optimised balancing actions through a joint merit order. Currently, 28 BSPs are prequalified for FCR, 30 for aFRR, and 27 for mFRR in Germany, a decline compared to 2022 values.

Figure 2: German TSO's control area and neighbouring countries TSOs



Source: 50Hertz

In Germany, from November 2020, **aFRR and mFRR energy** can be **tendered without prior participation in a capacity auction**. Additionally, energy costs are passed on through the imbalance price to the market participants responsible for triggering the activation of balancing energy.

The **Electricity Grid Access Ordinance (StromNZV)** and the **Energy Industry Act (EnWG)** form the national legal framework addressing balancing services and imbalance markets. These laws outline general principles, including transmission system operators' responsibilities, and set specific rules for market-based procurement and provision of balancing services. FCR, aFRR, and mFRR balancing services are tendered via the Regelleistung platform, jointly operated by the TSOs.

3.1 German ancillary services

In addition to the aforementioned services, Germany provides additional tailored ancillary services and actions to support its balancing operations.

- **Black Start Reserve:** in the case of blackouts or system stress events, TSOs reserve **generation units capable of operating independently to support or restart the power grid**. Until now, TSOs have contracted black start systems through bilateral agreements with operators. In January 2024, German TSOs transitioned to a tender-based procurement process. The second tender is scheduled for June 2025 for the TransnetBW East region. The framework for this new procurement process was established by the Federal Network Agency's BK6-21-023 determination.
- **Capacity Reserve:** serving as a twin substitute to the Replacement Reserve (RR), this service serves a similar purpose but with one major difference: **contracted reserve plants remain outside the electricity market and are activated when market options are exhausted**. Its purpose is to contract additional capacity to ensure sufficient national supply, especially in winter.

  The 2024-2026 tender secured 1.2 GW of contracted capacity, with German TSOs paying around €100k/MW/year, a 50% cost increase from the previous tender. However, the Federal Network Agency raised concerns over insufficient coverage, noting that for winter 2024/2025 the 5.6 GW reserved capacity was not able to cover all demand scenarios. In worst case scenarios, this could leave Germany with 1.4 GW of foreign redispatch plants to cover the imbalance, since the winter capacity reserve demand is forecasted to reach almost 7 GW. Capacity reserve is forecasted to grow to 9.2 GW for the 2026/2027 winter term.
- **Additional reserve:** German TSOs conclude contracts for additional reserves outside of national borders to enhance its potential for redispatch measures. Unlike the capacity reserve, remuneration only occurs via an activation and utilisation fee.
- **Redispatch actions:** to manage grid imbalances and transmission congestions, TSOs may instruct power plants to adjust their output. In Germany, it is not rare to witness northern wind power in-merit exceeding the southbound transmission capacity, requiring TSOs to curtail wind production and import or dispatch additional generation in the south.
- **Switchable loads:** when grid stability cannot be maintained through regular balancing measures, sheddable or switchable loads (typically large industrial consumers) can be **activated to ramp down power demand**. Switchable loads (Abschaltbare Lasten or AbLa) are regulated by the AbLaV Ordinance since 2013, and can be activated remotely within 15 minutes (SNL) or automatically within 1 second (SOL). **TSOs compensate** these loads with 2,500 €/MW **for availability plus a work price**, which in 2024 was recorded to be on average 77 €/MW.
- **"Use instead of curtail":** opposite to the switchable loads concept, this product is intended to incentivise additional demand. Introduced in November 2023, this service incentivises nearby consumers, like electrolysers or power-to-heat plants, to **use excess renewable energy to reduce grid congestion**. Starting in October 2024, a **two-year test phase will offer a fixed '13k-price'** for energy below natural gas costs, reimbursing the difference with the spot price. **Participants are exempt from network charges and taxes**, provided costs remain lower than standard redispatch measures. Competitive bidding is planned from 2026.

- **Grid Loss:** German TSOs tender power to compensate for power transmission losses. Tenders take place via a procurement portal and according to non-market-oriented criteria. There is a **long-term and short term procurement:** the short-term component accounts for the difference between the predicted short-term energy loss and the already acquired long-term component. The **capacity fee** remuneration is based on a **pay-as-bid mechanism**, while the **utilisation fee** is determined from the **hourly EEX spot market price**. When activation is required, TSO will inform the service provider the energy quantities to be delivered by 10 AM on the day before delivery. The tendering process and the determination method for grid losses is published under the specification BK6-08-006.
- **Reactive Power:** the Federal Network Agency has initiated a procedure under BK6-23-072 in order to establish rules and technical requirements for the future market procurement of reactive power. Grid operators will procure reactive power via market-based tenders, starting within 12 months of regulatory approval if needed, and covering all regions within 36 months. Initial tenders will appear on Netztransparenz.de by mid-2025, with some TSOs starting in Q1, and contracts awarded by the end of 2025.
- **Inertia:** the Federal Network Agency has initiated a procedure under file number BK6-23-010 to define the specifications and technical requirements for the future market-based procurement of inertia.
- **Mutual Emergency Assistance Service (MEAS):** these represent emergency balancing contracts with foreign TSOs.

4. The Belgian balancing market

Elia, Belgium's TSO, is solely responsible for managing the country's power grid and owns 50Hertz, a subsidiary that operates as one of Germany's four TSOs.

Belgium features a capacity market and a balancing market, all aligned with the EU Network Codes. We will discuss capacity markets more in depth in Great Britain's section. In 2018, Elia also launched the iCAROS project to enhance the coordination of assets for system operations and market procedures in compliance with EU regulations. In doing so, the TSO organised the system services for grid balancing into four categories:

- **Outage Planning Agents (OPA) and Scheduling Agents (SA):** every grid user must provide a weekly availability schedule as an OPA and a daily power schedule as an SA.
- **Balancing Service Providers (BSP):** operating under ENTSO-E frameworks, Elia incorporates key balancing reserves like FCR, aFRR, and mFRR. As of the writing of this report, Belgium is not connected to the TERRE platform, became an operational PICASSO member at the end of November 2024, and remains a non-operational MARI member.
- **Voltage Service Providers (VSP):** while frequency on the grid is influenced by the behaviour of active power, voltage is affected by reactive power. VSP providers offer their assets to absorb or inject reactive power.
- **Restoration Service Providers (RSP):** in the event of extreme system stress events or a grid blackout, Elia relies on RSPs to restore the high-voltage transmission system.

4.1 Belgian capacity market and ancillary services

4.1.1 Capacity Remuneration Mechanism (CRM)

Belgium's capacity market is called Capacity Remuneration Mechanism (CRM).

The CRM presents similar features to the GB Capacity Market, featuring **Y-1 and Y-4 auctions**. The most recent Y-4 auction, held in October 2024 for the Delivery Period 2028-2029, resulted in a **weighted average bid price of 3.2 €/MW/h**. A total capacity of 4.44 GW was secured across 30 units, with Combined Cycle Gas Turbines (CCGTs), Open Cycle Gas Turbines (OCGTs), and Combined Heat and Power (CHP) units contributing 75% of the volume, while large-scale Battery Energy Storage Systems (BESS) accounted for 10%.

4.1.2 Voltage services

The supply of reactive power is governed by a contract between Elia and the VSP. Every year, Elia launches a tender to which only qualified candidates can participate. Awarded VSPs enter into a **5-year contract** duration. The TSO activates the reserve on a merit-order basis, remunerating with a **utilisation fee in €/MWh**.

4.1.3 Restoration (or Black Start) services

Similar to the voltage services, Elia launches a yearly call for tenders to qualified providers. Elia closed the latest tender in November 2024, seeking to award Black Start Services contracts from 01/01/2027 to 31/12/2038.

5. The GB balancing market

Great Britain offers its own take on balancing markets, presenting a scheme that differs from the ENTSO-E framework while retaining certain parallels. This section explores its design.

5.1 Main actors

Great Britain's balancing market present three main actors: National Energy System Operator (NESO), Elexon, and the market operators:

- **National Energy System Operator (NESO)** is the new **state-owned TSO**, responsible for planning and operating the transmission networks for electricity and gas markets in GB. On September 1, 2024, the government took over the privately owned National Grid ESO, transforming it into the publicly owned National Energy System Operator (NESO). As any TSO, NESO operates the transmission network and ensures that power supply and demand are physically balanced at all times within Great Britain's electricity system. Coming to balancing markets, NESO is the entity recalling balancing actions. Moreover, NESO leads the integration of new energy technologies via the capacity market and supports the UK's 2030 clean power goals.
- **Elexon** is an independent entity responsible for administering the Balancing and Settlement Code (BSC). The **BSC is a code** with a set of rules that **define the rules and governance for the Balancing Mechanism and imbalance settlement processes of electricity** in Great Britain. Elexon doesn't physically balance the system or make operational decisions like NESO, but covers regulatory and administrative roles and ensures financial settlements for energy trading and government schemes. For example, Elexon is in charge of the registration and validation of Balancing Mechanism Units (BMUs), and is responsible for providing settlement services for government initiatives such as Contracts for Difference.
- **Market players** refer to any entity actively involved in electricity trading, generation, distribution, or consumption. These include generators, suppliers, traders, aggregators, and large consumers.

5.2 Capacity market

In Great Britain, the **Capacity Market is an auction-based system** designed to shape and secure the country's future generation stack.

It issues new capacity contracts annually based on power demand forecasts and serves two key purposes: first, it **ensures sufficient supply to meet future demand at all times**, with adequate power reserves to handle extreme system events and prevent blackouts. Second, it provides a **subsidy mechanism for new or existing projects through long-term fixed contracts** marked by an availability fee, reducing investment risks.

Capacity providers are paid an **availability fee in £/MW/h** and must guarantee the promised capacity within four-hours of a Capacity Market Notice, which is an early indication that a System Stress Event could occur. Since the Capacity Market started in 2014, 15 Capacity Market Notices have been issued, but there have been no System Stress Events. Unless a System Stress Event occurs, participating assets will continue to operate as normal. This winter 2024/2025, three Notices have already been issued, the most recent one on January 8, 2025.

5.2.1 Capacity market auctions

Since the first Capacity Market auction in December 2014, two separate two-day auctions have been held each February:

- **T-4:** a 4-year ahead capacity auction. It is the main auction with the longest contracts, awarding the highest volumes.
- **T-1:** a "year-ahead" auction, with capacity to be delivered starting from October. T-1 acts as a top up auction for extra capacity to cover the previously held T-4 auction.

Contracts awarded through the 2 auctions are known as Capacity Market Agreements. **Contracts awarded in the T-4 auctions** can last up to 15 years for certain asset classes and **represent a way to de-risk long-term investment by providing a first fixed and steady revenue stream**. They serve as a crucial tool for investors and **can determine final investment decisions**.

The Department for Energy Security and Net Zero (DESNZ) sets the capacity auction volumes based on Great Britain's future power demand. Target capacities are announced by DESNZ a month ahead of the auction and the delivery year runs from October to September. The two-day event operates on a pay-as-clear basis: it starts with a price cap (last year was about £8.5/MW/h) and lowers each 30-minute round. The auction clears at the round where the remaining auction capacity is less than the target capacity, also known as clearing round. In 2024, DESNZ set the capacity requirements at 44 GW for the T-4 auction and 7.7 GW for T-1. While gas secured most capacity agreements, representing two-thirds of the target volumes in the T-4 auction, Battery Energy Storage Systems (BESS) emerged as the frontrunner for new-built contracts.

Participating in the Capacity market is not limited to power generators. Any large energy consumer or demand aggregator can take part as well. However, to ensure fair competition, a de-rating factor is used. The de-rating factor is a percentage applied to the maximum capacity of the asset and reflects the likelihood that the asset will be available and able to respond under a Capacity Market Notice. For example, conventional power plants like gas or coal usually see high de-rating factors given their high capacities per unit and ability to operate on demand. Wind or solar have lower de-rating factors due to their intermittent nature. Storage technologies are de-rated based on their discharge duration and reliability. Demand-side response is de-rated based on how reliably it can reduce demand when needed.

5.3 Intro to the GB Balancing Market

Terminology within the GB balancing markets can often be confusing. This is true also among energy experts, mainly because different services and markets share the same terms and synonyms. This section unravels the GB balancing market structure and provides an in-depth explanation of its ancillary services.

Before gate closure, all market participants must submit their Final Physical Notifications (FPNs), which serve as the final confirmation of each supplier's delivery commitments. The aggregate FPNs summarise the expected supply injection into the grid, and provide to the TSO an hour-ahead view of the supply-demand imbalance. Here is where the balancing markets come into play: after gate closure, the TSO calls on balancing services and actions to ensure grid stability.

The TSO has various ways of balancing the grid. Whatever mechanism the TSO uses, it is trying to balance the transmission system as efficiently as possible. We can divide GB's balancing market in three main blocks:

- **Balancing Mechanism (BM)**
- **Ancillary services**
- **Balancing Service Adjustment Actions (BSAAs)**

5.4 The Balancing Mechanism (BM)

To qualify as a Balancing Mechanism Unit (BMU) and participate in the Balancing Mechanism auction, a generation unit must register with Elexon, achieve certification, and accept the Balancing and Settlement Code (BSC). Before gate closure, market participants provide two key pieces of information to the TSO:

- **Physical Notification (PN):** providing the expected generation or demand for each 30-minute settlement period. At Gate Closure, it becomes the **Final Physical Notification (FPN)**.
- **Bid/Offer Data:** specifying how a unit can deviate from its FPN after Gate Closure in exchange for payment. An **Offer Price** is the amount the market player is willing to be paid for increasing generation or reducing demand, while the **Bid Price** is the amount the market player asks for decreasing generation or increasing demand in £/MWh.

The system functions via a new online platform, the **Open Balancing Platform (OBP)**. Ultimately, the TSO compiles a collection of bids and offers, organised by prices and volumes, commonly called a Bid/Offer ladder. Once a bid or offer is accepted, NESO notifies the operator by issuing a **Bid Offer Acceptance (BOA)**.

Deviations from FPNs or BOAs by market players can occur due to several reasons such as the unpredictable nature of wind and solar generation, outages in units or interconnections, or intentional "NIV-chasing". These deviations incur additional costs on the TSO, crafting the system price of the imbalance market, a market this report will not address.

Knowledge pill

Initially launched in December 2023, the Open Balancing Platform (OBP) introduced an algorithm designed to automate the selection of bids, ensuring the required action is met at the lowest cost. The platform can send bulk Bid Offer Acceptances (BOAs) to market participants, replacing the previous manual process. Future development stages aim to integrate additional services into the OBP. By 2027, NESO anticipates that this iterative approach will enable the OBP to fully replicate and replace the existing Electricity Balancing System, Balancing Mechanism, and Ancillary Services Dispatch Platform.

5.5 Ancillary services

Ancillary or balancing services are a range of national services used by NESO to maintain grid stability. These services support the Balancing Mechanism by addressing grid stability issues beyond simple supply-demand balance. It is not rare to see BM units activated out of merit, with the TSO justifying this action through a "BOA reason".

Some services are exclusive to BM units, while others also accommodate non-BM units. The **Single Markets Platform (SMP)** is the designated platform for registering and obtaining qualification to deliver ancillary services. In Great Britain, we can currently identify 5 types of macro-services:

5.5.1 Frequency Response Services

Frequency Response (FR) services are among the most widely utilised balancing services. These services can be divided into the following categories:

- **Dynamic Services** include Dynamic Containment (DC), Dynamic Moderation (DM), and Dynamic Regulation (DR).
- **Static Services** include Static Firm Frequency Response (SFFR) and Mandatory Frequency Response (MFR).

In the same way, services can also be categorised as **pre-fault** or **post-fault** services. **Pre-fault** services act as preventive measure services, with generators constantly fine-tuning to adjust frequency deviations at 50 Hz, while **post-fault** services take actions after major deviations. BMUs and non-BMUs can participate in frequency response services. The table below summarises the key features of each frequency response service as of January 2025.

Figure 3: GB Frequency Response Service

Dynamic Containment (DC)

Scope: prevents large frequency deviation losses

Type: post-fault

Response time: 1 second

Duration: up to 1 hour

Contract length: 4 hours (EFA block)

Payment mechanism: pay-as clear

Procurement: day ahead

Products: asymmetrical

- **DCH** - ramp down generation / higher demand
- **DCL** - ramp up generation / lower demand

Dynamic Moderation (DM)

Scope: assists to keep frequency within operational limits

Type: pre-fault

Response time: 1 second

Duration: up to 30 minutes

Contract length: 4 hours (EFA block)

Payment mechanism: pay-as clear

Procurement: day ahead

Products: asymmetrical

- **DMH** - ramp down generation / higher demand
- **DML** - ramp up generation / lower demand

Dynamic Regulation (DR)

Scope: fine-tune continuous, small deviations in frequency

Type: pre-fault

Response time: 10 seconds

Duration: up to 15 minutes

Contract length: 4 hours (EFA block)

Payment mechanism: pay-as clear

Procurement: day ahead

Products: asymmetrical

- **DRH** - ramp down generation / higher demand
- **DRL** - ramp up generation / lower demand

Mandatory Frequency Response (MFR)

Energy source: thermal plants only, predominantly CCGTs. not available to BESS

Response time: 10-30 seconds

Contract length:

- Low frequency 30 minutes
- High frequency: indefinite

Payment mechanism: Pay-as-bid

Procurement: real time

Products: symmetrical bids

- Primary: 350 MW/month ; prices: £0-5 MW/h
- Secondary: 250 MW/month ; prices: £0-5 MW/h
- High: 500 MW per month ; prices: £2-10 MW/h

Static Firm Frequency Response (SFFR)

Type: post-fault

Response time: 30 seconds

Duration: 30 minutes

Contract length: 4 hours (EFA block)

Payment mechanism: pay-as clear

Procurement: day ahead

Product: lower frequency only (ramp down generation)

* Tender closes at 11 AM, so results become an input for DCL auction. Providers can tender for both SFFR and DCL.

Source: Kpler

5.5.2 Reserve Services

A range of services is offered to ensure reserve power for sudden supply or demand changes. Except for the Optional Fast Reserve, payments comprise an availability fee in £/MW/h and a utilisation fee in £/MWh. These services include Balancing Reserve, Quick and Slow Reserve (new solutions replacing the STOR and Operating Reserve services), and Optional Fast Reserve. The table below summarises the key features of each frequency response service as of January 2025.

Figure 4: Reserve Services

Balancing Reserve (BR)

Type: pre-fault

Response time: 10 minutes

Duration: 30 minutes

Contract min size: 1 MW

Procurement: day-ahead, part of the Frequency Response Services auction which run at 2 PM.

Participants: Only BMU

Payment mechanism: Availability fee (in £/MW/h) + Utilisation fee (in £/MWh)

Products: asymmetrical

- Positive
- Negative

NESO plants to stack BR with FR services

Quick Reserve

Scope: replace old Fast Reserve service

Launch date: Nov-2024

Type: pre-fault

Response time: 1 minute

Duration: 15 minutes

Contract length: 30 minutes block

Procurement: day-ahead, part of the Frequency Response Services auction which run at 2 PM.

Payment mechanism: pay-as-clear

Products: asymmetrical

- Positive Quick Reserve (PQR)
- Negative Quick Reserve (NQR)

Slow Reserve

Scope: replace old STOR service

Launch date: Q2 2025

Type: post-fault

Response time: 1 minute

Duration: 15 minutes

Contract length: 30 minutes block

Procurement: day-ahead

Payment mechanism: pay-as-clear

Products: asymmetrical

- Positive Slow Reserve (PSR)
- Negative Slow Reserve (NSR)

Optional Fast Reserve

Scope: manage pre-fault and post-fault imbalances

Response time: 1 minute

Duration: 15 minutes

Contract length: 30 minutes block

Procurement: 4h ahead - real time

Payment mechanism: pay-as-clear

Products: asymmetrical

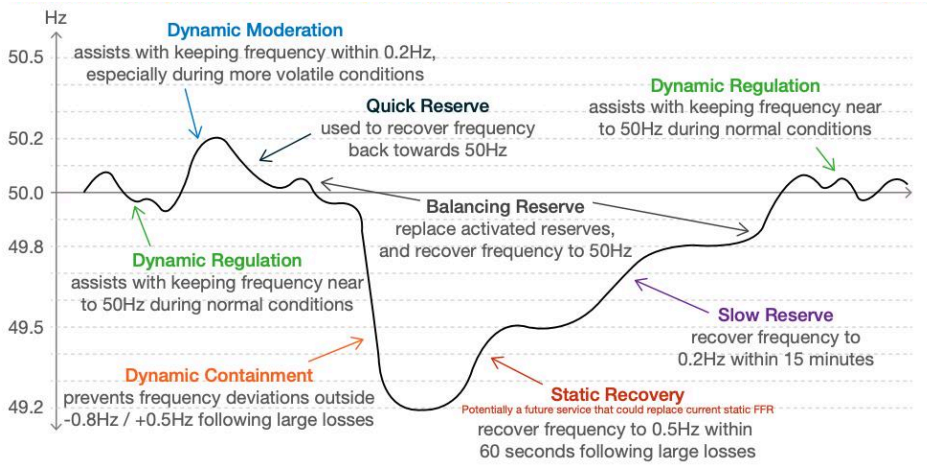
- Operating Reserve
- Negative Operating Reserve

* Operating Reserve is being gradually replaced by the BR service.

Source: Kpler

Below is a figure outlining different frequency imbalance domains, highlighting which services are typically activated and when.

Figure 5: GB Frequency Response and Reserve services typical activation dynamics



Source: NESO

Dynamic Containment, Dynamic Moderation, Dynamic Regulation and the new Reserve services Quick Reserve, Slow Reserve (starting from Q2 2025) are procured simultaneously in a single, pay-as-clear auction in the **Enduring Auction Capability (EAC) platform**.

5.5.3 Network Services Procurement (NSP)

These services can be further divided into voltage services, stability market, and transmission constraint management services to target specific issues within the system.

a. Voltage services

Services that allow generators or other asset owners to absorb (to decrease voltage) or generate reactive power (to increase voltage). These include Obligatory Reactive Power Services **(ORPS)** and Enhanced Reactive Power Service **(ERPS)**.

Generators are generally instructed to reach a target MVAr level within two minutes. The procurement is designed across three timescales:

- Y-4 auctions
- Y-1 auctions
- Day-ahead auctions (D-1)

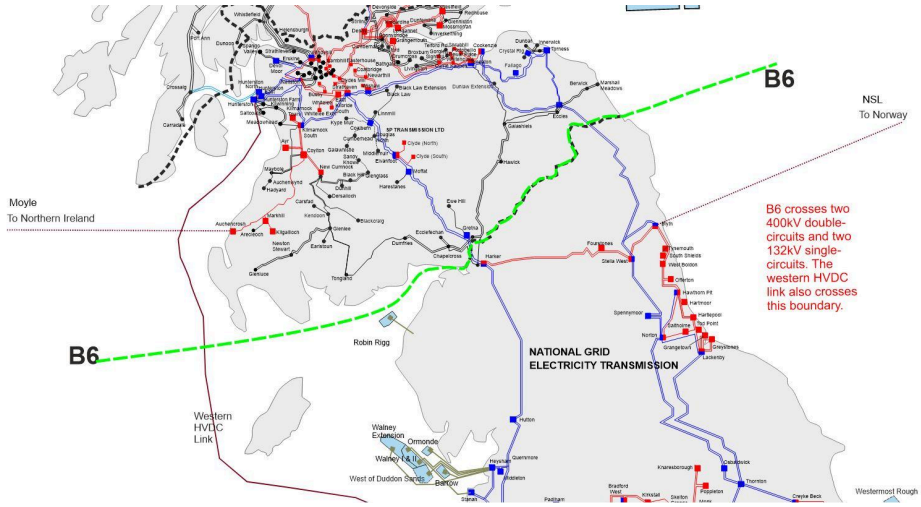
b. Stability services

A stability market is designed to provide grid inertia. The purpose is to slow down the rate of frequency change when there is a sudden imbalance like an unplanned unit outage, buying time for corrective actions. Similar to voltage services, it features Y-4, Y-1, and Day-ahead auctions (D-1).

c. Constraints Management Services

The rapid growth of Distributed Energy Resources (DERs) is creating significant challenges for the distribution network, particularly in managing transmission constraints caused by limited line capacity. This issue is persistent at the Anglo-Scottish B6 border, specifically when high offshore wind production in the north coincides with concentrated demand in the south. In 2024, Great Britain's most congested boundaries were constrained 85% of the time.

Figure 6: GB Anglo-Scottish B6 border (SP Transmission to NGET)



Source: NESO

The B6 boundary capability is limited to 6.3 GW due to a thermal constraint on the Harker–Moffat 400kV circuit. To tackle regional problems, NESO has developed the Regional Development Programmes (RDPs) to implement new products, markets, and services that provide an economic route to connection for Distributed Energy Resources (DER):

- **MW Dispatch service:** is the first market-based product to be developed through RDPs, and ancillary service to manage transmission pre-fault thermal constraints. It is based on a tri-lateral contract between DERs, the Distribution Network Operator (DNO), and NESO. NESO may issue an instruction to the DNO to request that the DER curtails its production to zero in exchange of a utilisation fee in £/MWh. NESO activates assets with a "pay-as-bid" principle, with price covering the full duration of the curtailment instruction. The duration is bespoke to need.
- **Transmission Constraint Management service:** NESO offers an optional contract to market participants to manage forecast constraint costs and volumes caused by asset health, planned outages, and forecasted system conditions. The most recent contract, awarded to VPI Rye Power House Station, secured 410 MW for the East Anglia/North London zone and has been extended until December 12th, 2024.

The Local Constraint Market is a second product also being developed to address congestion issues, as we will discuss in the next section.

5.5.4 Demand Flexibility Service (DFS)

The DFS incentivises domestic consumers, industrial users, and commercial entities to voluntarily reduce or adjust their energy demand. This is typically achieved through suppliers or demand aggregators. With a pay-as-clear principle and a within day only procurement, DFS turned into a year-round product starting from winter 2024.

5.6 Balancing Service Adjustment Actions (BSAAs)

The Balancing Services Adjustment Data (BSAD) is used to submit balancing actions under the Balancing and Settlement Code (BSC) framework. However, BSAD covers actions taken outside of the Balancing Mechanism. These actions are still a component of the electricity imbalance price calculation, as defined in section T, paragraph 4.4 of the BSC. Balancing Service Adjustment Actions (BSAAs) encompass a range of services, such as:

- **Forward contracts**
- **Restoration Services (formerly known as Black Start):** service used to restore power in the event of a total or partial shutdown of the national electricity transmission system.
- **Local Constraint Market (LCM):** NESO is developing a market for non-BM providers, where Flexibility Service Providers (FSPs) can engage in day-ahead and intra-day auctions to resolve local constraints, particularly targeting the B4 and B6 boundaries in Scotland. The market offers services such as generation turn-down or demand turn-up, with pricing focused on operational savings and promise to be competitive with BM pricing. In this stackable and non-exclusive service, FSPs will use the Piclo platform to place bids.
- **Non-BM Fast Reserve:** as of January 2025, key market players in this space include Habitat Energy, UKPR, and ENWL.
- **Commercial intertrips services:** automatic control systems that reduce or disconnect generation in response to system fault events. Commercial intertrips contracts are negotiated on an ad-hoc basis and can enable higher levels of generation during periods of system stress or tight margins.

Daily bids of the aforementioned services, like the non-BM Fast Reserve, can be submitted through the Ancillary Service Dispatch Platform (ASDP), which is the system used by NESO to procure operational reserves and contingency resources. NESO also publishes non-BM instruction data via the ASDP system once these instructions are confirmed by service providers.

6. Conclusion

By the end of this read, you are equipped with a solid **understanding of ENTSO-E balancing regulations, main European balancing markets (FCR, aFRR, mFRR)**, and attained the full spectrum of **ancillary services in Belgium and Germany**. In parallel, you've gained insight into **Great Britain's capacity and balancing markets**, mastering the terminology nuances between concepts like the Balancing Mechanism, Balancing Reserve, or Balancing Service Adjustment Actions.

Understanding these differences is crucial for asset operators, traders, or portfolio managers. For instance, technologies like BESS thrive in fast-response services such as Dynamic Containment and Quick Reserve. The next report (Part 2) will focus on **balancing market dynamics**, exploring the most **liquid markets**. It will explore which services are mostly spiking during extreme events, what are the biggest costs incurred by the TSO and how are they planning to manage grid and market bottlenecks. The **ultimate goal of Part 2** is to outline a detailed **market analysis** and **unfold opportunities for traders, flexible operators and aggregators, and power market players**.

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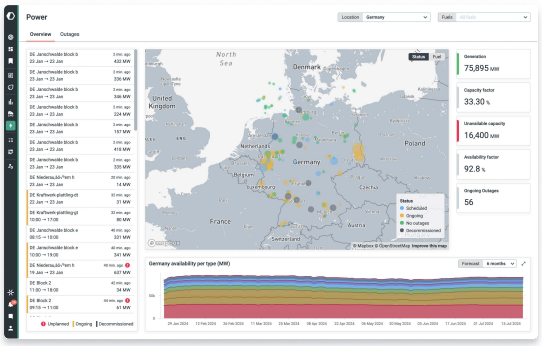
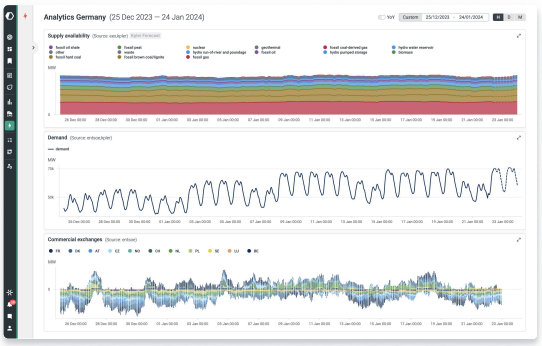
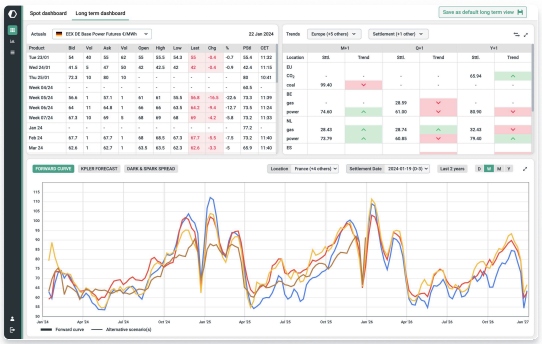


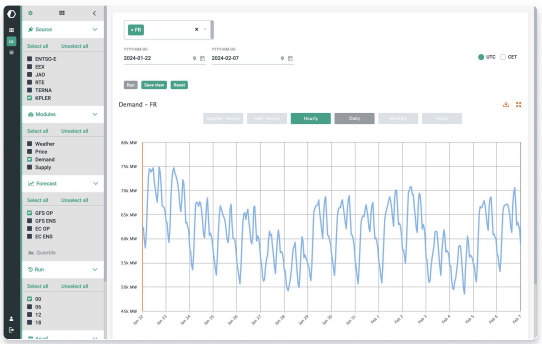
Supply and demand modelling



Proprietary fundamentals forecasts



Post-processed market data



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