APPUNTI DI ENERGIA

European Platforms for Energy Balancing: focus on IN, PICASSO, and MARI

March 2026

What it's about

APE about Euphemia

In the field of energy, the Member States of the European Union aim to create an internal market that guarantees security of supply, promotes competition, and optimizes the use of energy resources through cross-border cooperation. To this end, **the integration of electricity markets at the European level represents a key strategic objective**. The first steps were taken with the PCR (Price Coupling of Regions) initiative, which enables a single solution for the European day-ahead market, as described in the APE dedicated to EUPHEMIA.
A second initiative concerns the unification of balancing markets for procuring the resources necessary to keep the grid frequency within predefined operational limits. This initiative takes shape through the development of specific **European balancing platforms**, which serve as tools through which Transmission System Operators (TSOs) coordinate the dimensioning, procurement, and activation of all resources dedicated to balancing national electricity systems, leveraging the benefits of an interconnected European network.
In this APE we will briefly present the regulatory landscape for European balancing, with a particular focus on the three platforms dedicated to the exchange of Frequency Restoration Reserve, one of the key electricity products for system balancing: IN, PICASSO and MARI.

A note on electrical balancing

Before examining the organizational and implementation structure of the platforms, it is helpful to recall some concepts related to power system balancing.

In a power system characterized by a grid frequency sustained directly by the synchronous rotation of large rotating machines (synchronous generators), under equilibrium conditions (constant frequency) the power drawn by consumption units is equal to the power injected into the grid by generation units. In a real system, however, both the power withdrawn and the power injected may deviate from the scheduled value, thus creating imbalances of varying magnitude and rate of change (ramp). In particular, certain significant fault events (e.g., loss of load units, loss of generation units, loss of an interconnection system) can produce power imbalances capable of compromising the operational stability of the entire electricity system and potentially triggering critical phenomena such as a blackout. **Energy balancing therefore represents one of the key functions performed by TSOs** and aims to ensure, at all times, the correspondence between the energy injected into the grid by producers and that withdrawn by consumers; in other words, the continuous maintenance of the system's grid frequency within a predefined maximum deviation range relative to the nominal value (50 Hz), as well as the availability of adequate reserves necessary for system control. These reserves constitute the Ancillary Services (AS) that the TSO procures from qualified providers sufficiently in advance of their possible use (real time). The balancing process is structured into three main phases, in which TSOs:

1. determine the reserve requirements,
2. procure sufficient reserve capacity to meet those requirements, and
3. order, in real time, the activation of reserve capacity with the resulting exchange of balancing energy.

How it works in our country: Balancing markets in Italy

In Italy, since the launch of the electricity market (31 March 2004), the procurement of Ancillary Services (AS) for balancing has always taken place through the **Dispatching Services Market (MSD)**, managed by the TSO (now Terna). RSE has published an APE providing detailed insight on this topic.

Ape su MSD-MB

In summary, unlike energy markets (the Day-Ahead Market – DAM; the Intraday Market, which includes auction sessions and a continuous Cross-Border Intraday session – IDM/XBID) dedicated to trading energy quantities aimed at meeting consumption demand, the MSD is the market in which authorized operators exchange with the TSO the availability of their regulating units to adjust (in one or in both directions, upward and downward) their production or consumption. This allows the TSO to use such availability as a resource to maintain the real-time balance between injections and withdrawals, as previously mentioned, as well as to resolve grid congestions.

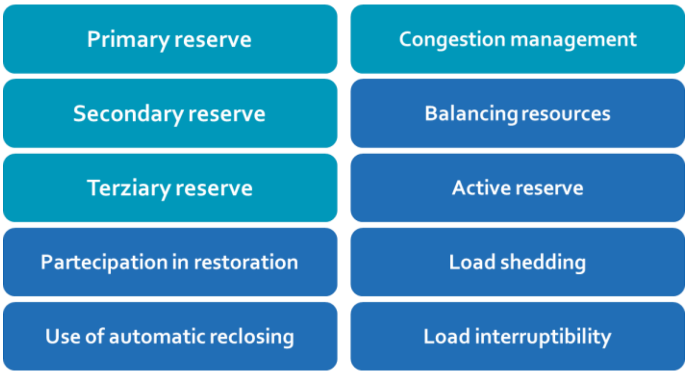


Figure 1 - Ancillary Services

This market is divided into two time phases: the ***ex-ante* MSD**, in which Terna procures the reserves required for the following day on the basis of the injection and withdrawal schedules resulting from the energy markets, and the **Balancing Market (MB)**, which represents the "last-resort" market activated in real time to correct residual imbalances. Several types of energy products referring to specific Ancillary Services (AS) used by Terna are traded in these markets. The figure below shows a list of the Italian AS historically adopted by Terna. In particular, the **services dedicated to balancing** are primary reserve, secondary reserve and tertiary reserve, balancing resources, and congestion-management resources; all of these, except for primary reserve, have always been procured and activated through products traded on the MSD and are shown in purple in the list. Primary reserve, mandatorily provided by relevant dispatchable units (i.e. units larger than 10 MW), has been remunerated on a voluntary basis, starting from 1 April 2014, through a dedicated mechanism outside the MSD.

APE about TIDE

From an economic standpoint, the MSD uses a ***pay-as-bid* pricing** mechanism, meaning that each accepted offer is remunerated exactly at the price submitted by the operator. As for resource activation, secondary reserve follows a ***pro-rata* approach**, meaning that the energy required for balancing is allocated proportionally among the selected resources. The other resources, by contrast, are activated according to merit-order logic, with the exception of primary reserve, whose activation is based on a local signal—the measured frequency deviation from the reference value.

It is noted that the structure of the AS shown in the previous figure was modified as of 1 January 2025, following the entry into force of the new Integrated **Electricity Dispatching Code (TIDE)**.

Why balancing Europe is difficult: different approaches to balancing

The balancing process is highly complex and involves several aspects, such as the technical characteristics of the various services, their activation methods, their procurement and remuneration mechanisms, as well as the rules governing imbalance-settlement calculations. All these elements are generally implemented differently by the various TSOs, depending on the characteristics—and resulting needs—of the power systems they manage.

For example, the Italian MSD–MB model mentioned above is not implemented with the same operational features in other European countries. Some countries adopt a uniform pricing scheme for products traded in balancing markets, while others do not rely on market mechanisms to procure certain resources that, in Italy, are instead traded on MSD–MB. Differences may also concern the characteristics of the products traded in these markets, such

a power system

as activation times, minimum or maximum contractable capacity, and other technical requirements.
These differences have led TSOs to traditionally procure the necessary resources exclusively within their own systems, without sharing Ancillary Services with other TSOs, except for mutual assistance actions in exceptional emergency situations. As a result, the security of the entire interconnected European system was ensured, but without an optimized use of the resources available overall. This is why the decision was made to initiate a process of integration and coordination of these resources through their sharing on common market platforms.

The solution: establishing common rules. SOGL and EBGL

SOGL

EBGL

The process of integrating markets in general, and balancing markets in particular, has required extensive harmonization work to standardize the various processes by defining standard products and common rules capable of eliminating technical, procedural, and economic barriers. **This has enabled the exchange of balancing resources between different countries and made the various dispatching models compatible with one another**.
This progressive regulatory convergence has been made possible thanks to the guidelines established in two European regulations: the **System Operation Guideline (Reg. EU 2017/1485)** and the **Electricity Balancing Guideline (Reg. EU 2017/2195)**.
The first, known as SOGL, has a broad and overarching function: it focuses on operational management and the security of the transmission system, covering aspects related to frequency control (Load Frequency Control – LFC, Area Control Error – ACE, balancing reserve services FCR/FRR/RR), operational limits of key quantities relevant to overall system functioning (e.g. voltage, grid frequency, current limits), data exchange between TSOs and with DSOs (Distribution System Operators), as well as transmission/distribution grid users (Significant Grid Users – SGUs).
The second, known as EBGL, specifically regulates balancing markets, including the formalization of various elements such as the definition of standard balancing products (FCR, aFRR, mFRR, RR), the activation processes for these products, gate closures and settlement of balancing markets, the rules for calculating imbalance prices, and the responsibilities of the actors involved in balancing-market transactions. Finally, it is precisely in the EBGL—Articles 19, 20, 21, and 33—that the intention to implement cooperation between European countries for balancing the European grid through dedicated common platforms is laid out and operationalized.
Below we provide information on the key aspects defined in the SOGL and EBGL, which form the basis for the implementation of a common balancing market and are essential for understanding the functioning of the European platforms.

The *Load Frequency Control Area* (LFCA)

In the SOGL, the zonal perimeters within which TSOs operate—and on which the platforms are based—are defined, as well as their organizational structure. The broadest perimeter is the *Synchronous Area*, namely a portion of the electrical network in which all generators and electrical equipment operate in synchronism at the same nominal frequency (for example, 50 Hz in Europe or 60 Hz in North America). Italy, like most European states, belongs to the "Continental Europe" Synchronous Area, which includes 26 countries and is one of the largest synchronous power systems in the world. The figure alongside shows the distribution of the four synchronous zones (or Regional Groups – RG) into which Europe's vast interconnected electricity system is divided.

A synchronous area is in turn composed of several ***Load Frequency Control Areas*** **(LFCAs),** which are zones within which load and frequency control, energy-balance maintenance, and frequency deviations are managed. Furthermore, multiple LFCAs that interact to coordinate their balancing activities may form an *LFCA Block*. The perimeter of an LFCA generally corresponds to that of a market zone. However, there are two cases in which the LFCA boundary does not coincide with the market-zone boundary:

1. When multiple market zones exist within the same LFCA.
2. When several LFCAs exist within the same market zone.

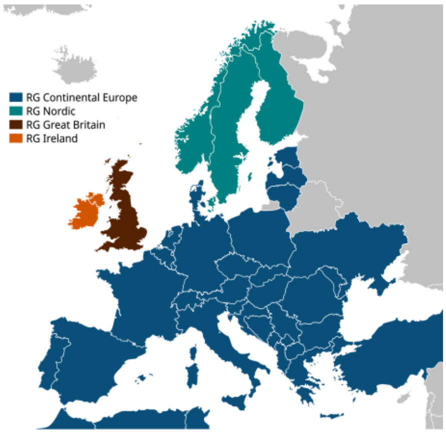


Figure 2 - Synchronous Area of the eletric european network [1]

An example of the first case is Italy, where a single LFCA contains seven different market zones. An example of the second case is Germany, which has a single market zone corresponding to the perimeter of the German LFC Block but containing four distinct LFCAs, each operated by a different TSO.

These various operational perimeters (Synchronous Area, LFC Block, LFCA) are necessary to define the responsibilities of TSOs, with the common objective of maintaining stable operation across the entire synchronous system.

The *Area Control Error* (ACE)

With reference to an LFCA, the fundamental parameter used to estimate a system's imbalance is called the ACE (*Area Control Error*). The SOGL sets a standard and defines the formula for calculating this parameter (equation 1), which is defined as the error in scheduled cross-border exchanges (the difference between the actual delivered power and the scheduled power), plus the error associated with the deviation of the grid frequency from its nominal value under primary-control steady-state conditions (the product of a coefficient and the difference between the measured frequency and the area's nominal frequency). As illustrated in the figure, a system is balanced when it manages to keep its ACE equal to 0.

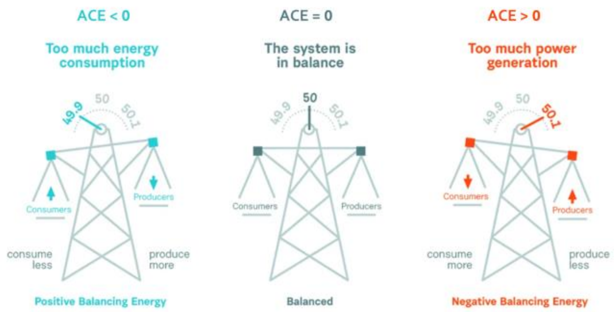


Figure 3 - Balancing mechanism

$$ACE = P_{reale} - P_{prog} + B \times (f_{reale} - f_{nominale}) \quad (1)$$

I Balance Responsible Party and the Balance

In the EBGL, Articles 3(1)(11) and 3(1)(12) define the roles, duties, and responsibilities of the two main actors involved in energy balancing, alongside the TSO:

- **The Balance Responsible Party (BRP)** is a market participant, or a designated representative, responsible for the imbalances they generate in the electricity market. They are therefore financially accountable for any deviations between their portfolio position and the outcome of the spot markets.

Service Provider

- **The Balancing Service Provider (BSP)** is the provider of balancing services that offers reserves and flexibility to TSOs for managing system frequency and system imbalances.

The two roles may, but do not necessarily have to, be performed by the same market operator.

The standard products

Another key element introduced in the SOGL and technically defined in the EBGL is the standardization of the balancing products traded on the various platforms. As mentioned, this standard makes it possible to compare and aggregate bids originating from different countries. These products represent the new categorization of the primary, secondary, and tertiary reserves traditionally used by European TSOs before the entry into force of the European Network Code. Three types of reserves are defined: **FCR, FRR, further split into aFRR and mFRR and RR.** The definition of the corresponding four products concerns their technical characteristics, bidding modalities, response times, and activation rules. These resources intervene in a coordinated sequence, with different activation times and specific functions:

Frequency Containment Reserve (FCR): this reserve, defined in Article 156 of the SOGL, intervenes within a few seconds of the disturbance that causes the imbalance, in order to stop the frequency deviation and stabilize it. FCR is activated automatically through a control signal based on the frequency error of the grid, measured locally and sent to each enabled generation unit.

Automatic Frequency Restoration Reserve (aFRR): this reserve, defined in Article 158, restores frequency to its nominal value and corrects cross-border power exchanges. aFRR is activated automatically through appropriate level signals (setpoints) sent by the TSO to each enabled generation unit via Automatic Generator Control (AGC).

Manual Frequency Restoration Reserve (mFRR): this reserve is activated manually to manage larger or longer-lasting imbalances. Both mFRR and aFRR can be activated upward or downward, depending on whether demand exceeds generation or vice versa.

Replacement Reserve (RR): Replacement Reserve: this reserve has slower activation times and is used to replace previously activated reserves and restore system margins.

The table below presents the main technical operating characteristics for each type of reserve, as defined in the EBGL.

Table 1 - Main technical features of the standard balancing product (aFRR, mFRR, RR)

Feature	aFRR	mFRR	RR
Activation mode	Automatic	Manual	Manual
Response time	~ 0 min	2,5 min	Up to 30 min
Ramp period	5 min	Up to 10 min	Up to 30 min
Activation time	5 min	12,5 min	30 min
Minimum delivery duration	Not required	5 min	15 min
Maximum delivery duration	Not required	20 min	60 min

The *Cross Border Marginal Price* (CBMP) and the *Merit Order*

The EBGL regulation establishes two important economic features in the operation of the European platforms:

1. The price formation process is based on the marginal pricing mechanism (pay-as-cleared). Therefore, the price of the last (i.e., most expensive) standard product offer activated to meet the energy demand within a given area (which may consist of a set of uncongested LFC Areas) becomes the price received (or paid) by all operators whose sell (or buy) bids are accepted at the intersection of the supply and demand curves. This marginal price is referred to as the **Cross-Border Marginal Price (CBMP)**.
2. The activation of resources procured through the platforms must follow a **merit-order approach**, as opposed to the traditional pro-rata approach.

Implementation: turning regulations into reality

Now that we have reviewed the main regulatory innovations regarding European balancing, we can examine how these are implemented. The European balancing architecture is structured around platforms, each dedicated to the exchange of a specific standard product or to a specific function.

The platforms for the exchange of aFRR, mFRR, and RR resources are four:

IN

- **IGCC (International Grid Control Cooperation), or IN (Imbalance Netting):** This platform—implemented as an integral part of the PICASSO platform but originally developed as an extension of a phase of the Grid Control Cooperation (GCC) process carried out by the four German TSOs—is dedicated to the Imbalance Netting process. Imbalance Netting allows opposite-sign imbalances between different areas to be offset through the exchange of aFRR resources, thereby reducing unnecessary activation of costly reserves and increasing the overall efficiency of the system.
  IGCC currently includes TSOs from 24 countries (shown in dark blue in the figure). The development of the current platform is the result of a series of progressive evolutions: the first phase, in 2010, as mentioned earlier, was implemented within the Grid Control Cooperation (GCC) between the four German TSOs. The current platform was completed on 24 June 2021.

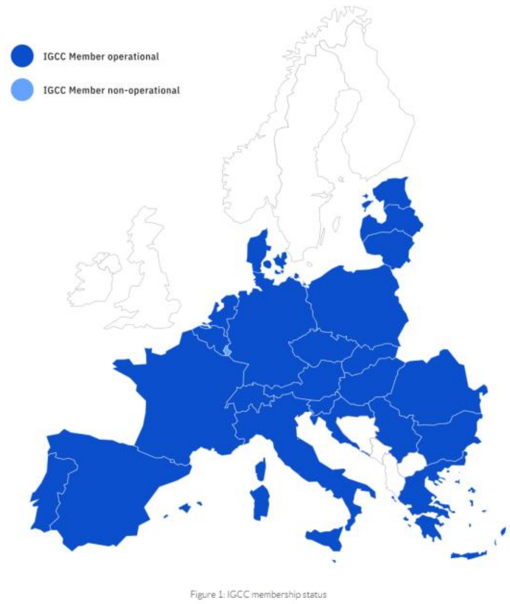


Figure 4 - Operational and non operational IN members [2]

PICASSO

- **PICASSO (Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation)** is the platform for the exchange of balancing energy from automatically activated frequency restoration reserves (aFRR). It enables fast and coordinated interventions to correct frequency deviations and optimize cross-border exchanges. As of mid-2025, the platform includes 17 operational countries (in dark blue in the figure) and 9 non-operational countries (in light blue) that are still undergoing regulatory adjustments in order to join the platform. The platform has been fully operational since 24 July 2022 (full Go Live), and the project is under continuous monitoring and development.

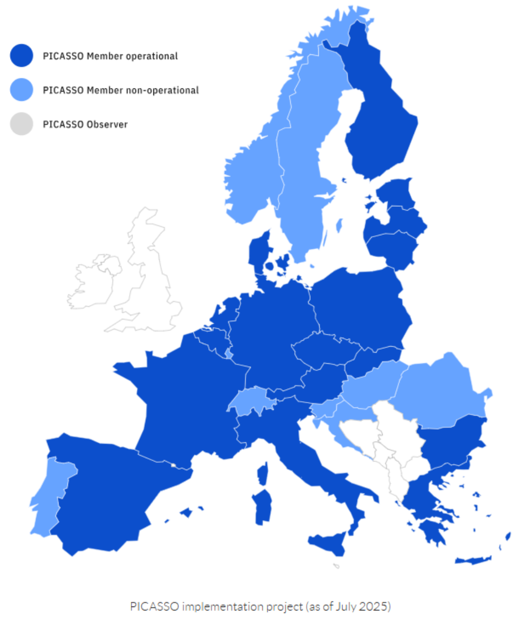


Figure 5 - Operational and non-operational PICASSO members [3]

MARI

- **MARI (Manually Activated Reserves Initiative)** is the platform designed to optimize the exchange of manually activated frequency restoration reserves (mFRR). It is used to manage imbalances of greater magnitude or duration by integrating the resources available across different areas. At the beginning of 2026, MARI includes 12 operational members (in dark blue in the figure), one member (France) which, although not yet operational, already shares its available transmission capacity, 12 non-operational members (in light blue), and 2 observer members (in grey). MARI has been active since 5 October 2022.

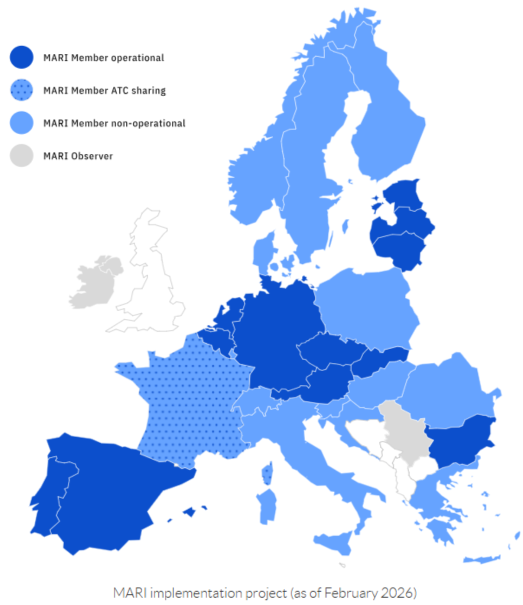


Figure 6 - Operational and non-operational MARI members [4]

TERRE

- **TERRE (Trans European Replacement Reserves Exchange)** was the European platform for the exchange of Replacement Reserves (RR). The TERRE project, operational since 29 September 2020, was one of the first European initiatives aimed at integrating electricity balancing markets. However, subsequent developments in market dynamics introduced by Regulation (EU) 2024/1747—Electricity Market Design Reform (EMDR), adopted on 21 May 2024—led to the decision to discontinue the platform due to several technical incompatibilities. As a result, TERRE has no longer been active since the end of 2025.

The following sections provide a concise overview of how the three platforms currently in operation function.

IGCC

Imbalance Netting is the process that enables TSOs from different LFCAs to coordinate in order to avoid the simultaneous activation of aFRR in opposite directions, compensating each TSO's request whenever sufficient interconnection capacity is available. The approach is based on maximizing volumes by considering only the physical flows and not the value of energy, while respecting cross-border transmission capacity.

The IN receives the following inputs from participating TSOs:

- the aFRR demand, calculated as the difference between the aFRR already activated and the ACE;
- the existing limitations in terms of available transfer capacity (ATC) between the LFC Areas participating in IN (both for import and export);
- the participation status, which may be active or inactive depending on whether the TSO is connected to or disconnected from the platform.

At each optimization cycle, which takes place every 4 seconds, the platform processes these inputs and returns to each participating LFCA the corresponding correction value (P_{corr}), which is activated whenever TSOs present opposite aFRR needs. P_{corr} represents the amount of energy of the LFCA participating in IN that is "netted" with the other LFCAs. A negative P_{corr} results in a power import, while a positive value results in a power export.
The signal is then processed by the local controller (Grid Regulator) of each TSO, potentially reducing the activation of local aFRR. Integrating the netting process therefore requires that, once P_{corr} values are provided to the TSOs, they recalculate their own ACE to determine their imbalance:

$$ACE = P_{reale} - P_{prog} + B \times (f_{reale} - f_{nominale}) - P_{corr} \qquad (2)$$

PICASSO

The operational structure of the PICASSO platform consists of a process organized mainly into two phases:

1. an Imbalance Netting process as the one used in the IN platform.
2. a centralized optimization process, executed through the **Activation Optimization Function (AOF)**, which selects and activates aFRR reserves based on economic and technical efficiency criteria, maximizing overall welfare while respecting network constraints and cross-border capacity limits.

Netting

Since the netting process involves Member States participating only in IGCC, others only in PICASSO, and still others participating in both, the netting and optimization process in PICASSO takes this overlap into account by evaluating netting through a step-by-step procedure, as illustrated in the accompanying figure.

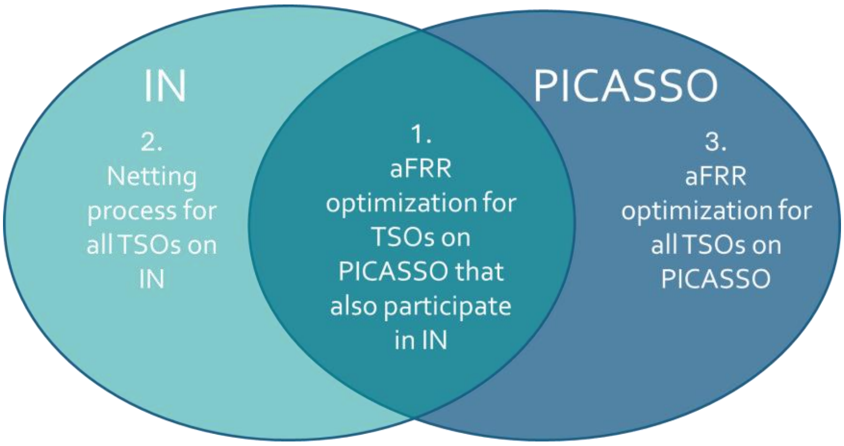


Figure 7 - Relation between netting in IN and PICASSO

The optimization process

PICASSO algorithm

The PICASSO AOF, in line with Article 30(1) of the EBGL, determines a single CBMP every 4 seconds for each uncongested region. Bids can be selected only in one direction: upward or downward. Unlike other market sessions, such as the day-ahead market (MGP) or the MARI and TERRE platforms, where the algorithm explicitly determines the fulfilled requirements and the BSP bids selected, the PICASSO platform algorithm does not directly return the selected quantities. Instead, it sends a correction signal to the amount of aFRR that each TSO will activate. For example, if a TSO has an upward aFRR requirement of 100 MW and the algorithm determines that 20 MW can be covered through the activation of cheaper resources from another TSO, the correction signal sent will be –20 MW. This means the TSO will activate only the remaining 80 MW using its internal resources.

Transparency platform

The optimization process unfolds across six steps, shown in the figure, the first two of which occur before real time, steps three to five occur in real time, and the final step takes place afterward.

Demand Elasticity in PICASSO

Until mid-2024, the PICASSO platform operated with inelastic demand from the TSOs. This demand reflected the volumes required to ensure the stability and operational security of the power system, as established by the SOGL Regulation. In this sense, TSOs were obligated to guarantee the availability of sufficient reserves regardless of cost. However, following episodes of extreme prices and the resulting temporary suspension of Italy from the platform, ACER revised the operational rules. With Decisions 08/2024 and 09/2024, ACER introduced the possibility for TSOs to use a share of elastic demand (i.e. dependent on price) allowing them to more effectively reflect the trade-off between additional costs and system frequency stability.

MARI

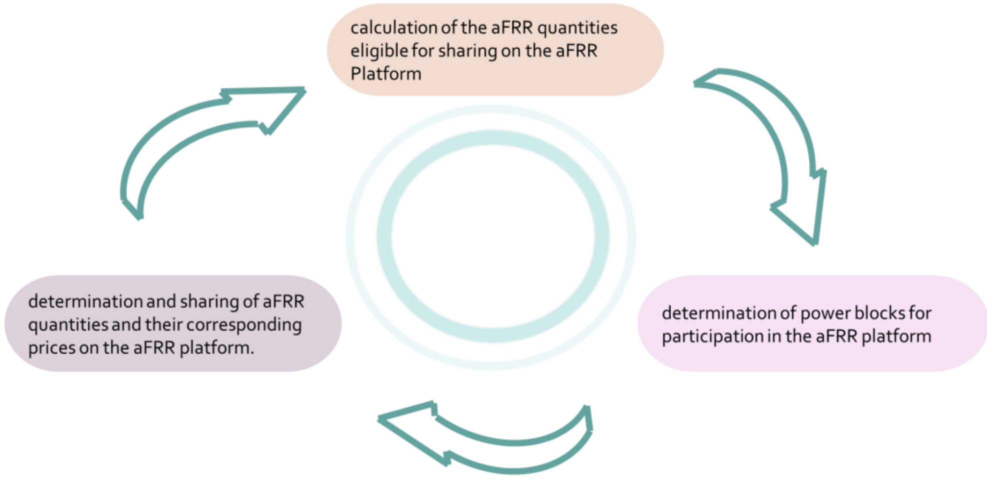
MARI is based on the LIBRA platform for managing the data and information exchanged with the TSOs and relies on the AOF for the optimization algorithm used for activations and the calculation of marginal prices.

The optimization process followed by the MARI platform mirrors the same steps as the PICASSO optimization process shown in the previous figure, with the following differences: the AOF for MARI not only determines marginal prices but also calculates cross-border exchange capacities based on the merit order for each quarter-hour. As defined in Article 11 of the mFRR Implementation Framework, the function is designed to maximize economic surplus and minimize flows between the various zones. The primary objective of the function is to satisfy all inelastic demand. As in PICASSO, TSOs in MARI also have the option to submit a demand that, in addition to the inelastic component, may include an elastic component.

Returning to our country: Italy and the platforms so far

We conclude this overview of the operation of the main European balancing platforms by returning to the Italian context. As a Member State of the European Union, Italy actively participates in the collaboration among European TSOs within ENTSO-E and in the projects it promotes. Terna, as the Italian TSO, participates in various balancing platforms to different extents. It became an active member of the IGCC platform in 2020 and has fully participated since then. With regard to PICASSO, it joined as an active member in July 2023, but temporarily suspended its participation in March 2024 due to the above-mentioned imbalance-price

anomalies that occurred following its entry into the platform. On 25 November 2025, after the earlier-mentioned adjustments, Terna re-joined the platform and currently participates in the exchange of aFRR on PICASSO. In particular, during its first phase of participation, Terna used the European aFRR platform through a process that converted the aFRR bids submitted to MSD into standard products, following the sequence illustrated in the figure below.
The three steps enabled coordination between MSD and the platform for the exchange of aFRR, allowing for a pro-rata activation of the resources accepted on the platform. In the second phase of participation, however, this conversion process is no longer necessary, as Terna has shifted to



a merit-order activation of the bids accepted on the platform. In any case, unlike other TSOs, Terna still retains the national platform, in addition to the European one, for aFRR resources (see ARERA Resolution 364/2025).
With respect to MARI, as of early 2026 Italy is not yet an active member but is planning to join the platform.
Finally, it should be noted that Italy's integration into the European framework is also reflected in the TIDE, the regulatory text that defines the new rules for the national dispatching system. TIDE was primarily introduced to address the operational challenges arising from the massive penetration of Non-Programmable Renewable Energy Sources (FRNP). A key element of TIDE is technological neutrality, namely the possibility for ancillary-service provision to be opened to resources previously excluded due to being non-relevant (i.e., below 10 MW) or non-programmable, such as FRNP plants, distributed generation, storage systems, and loads, all of which may also participate in aggregated form. Additionally, TIDE provides for integration between the MSD and the European platforms for balancing-service exchange—an integration that, over time, will progressively reduce the role of the national platform.

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