REPORT ON THE FORMATION OF IMBALANCE PRICES, FOLLOWING THE START OF THE ITALIAN TSO OPERATION ON THE EUROPEAN 'PICASSO' PLATFORM FOR THE EXCHANGE OF AFRR

Courtesy translation: in case of discrepancy between the Italian language original text and the English language translation, the Italian version shall prevail

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1. REGULATORY CONTEXT: BALANCING GUIDELINES AND IMPLEMENTATION OBLIGATIONS

Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (hereinafter referred to as the “Balancing Regulation” or abbreviated to the “EBGL”) came into force on 17 December 2017. Its main aim is to foster the integration of European countries’ balancing markets by defining common principles and rules for the procurement, activation and settlement of balancing services, as well as for the allocation of transmission capacity between market zones for balancing purposes.

Through its implementation, the Balancing Regulation aims to ensure that the provision of balancing services is fair, objective, transparent, based on market mechanisms and promotes liquidity while avoiding distortions in the internal energy market.

The main contents of the Regulation can be traced back to:

- Principles and minimum contents for national terms and conditions for Balance Responsible Party (BRP) and Balancing Service Provider (BSP);
- Principles and methodologies for the development of European platforms for balancing energy exchange through standardised products to be activated according to economic merit order and remunerated at marginal price;
- Rules for the procurement and exchange of balancing capacity (“balancing capacity”) between TSOs via market mechanisms;
- Rules for the calculation, allocation and enhancement of cross-border trading capacity;
- Principles for the settlement of all energy exchanges (intentional and unintentional) between TSOs;
- Rules for harmonising certain aspects of the settlement of imbalances.

The elements listed above are implemented either through direct provisions of the Balancing Regulation, thus of direct application in all Member States, or through specific methodologies, developed by TSOs and approved by the national regulators involved, or by ACER, if the scope of the methodology is pan-European, in accordance with Regulation (EU) 2019/942 of the European Parliament and of the Council, establishing a European Agency for the Cooperation of Energy Regulators (ACER).

To date, the process of developing and approving the methodologies foreseen by the Balancing Regulation can be considered almost complete, at least as far as the regulatory framework relating to balancing energy trading platforms, price rules and related settlement is concerned. This excludes certain regional methodologies for capacity calculation in the balancing time frame (currently being finalised), as well as future amendments to existing methodologies, which will require a new approval process. For more details on the status of approval and development of the contents of the Regulation, refer to the Balancing Market Integration Status Reports, prepared by ENTSO-E pursuant to Article 59.2 of the Balancing Regulation[1].

Over the following paragraphs, we will go into the details of the provisions and methodologies most closely related to the topics covered by the fact-finding survey launched by ARERA with Resolution 475/2023/R/eel of 17 October 2023.

1.1. Principles for imbalance settlement

The Balancing Regulation and Regulation (EU) 2019/943 of the European Parliament and of the Council of 05 June 2019 - recast (the Electricity Regulation) establishes common principles for the harmonisation of imbalance settlement rules to be implemented by individual TSOs at national level. Considering that the imbalance price is one of the main elements defining the operations of players in the various markets and that these markets are becoming increasingly integrated, it is crucial to provide common principles for the settlement of imbalances, so as to provide consistent price signals to all market players, avoiding distortions between the various national systems as much as possible.

In particular, Article 52(2) of the Balancing Regulation provides for the development of a pan-European methodology aimed at harmonising certain elements of the settlement of imbalances, including, at least, (i) the calculation of imbalance volumes, (ii) the main components used for the calculation of imbalance prices, (iii) the use of the single pricing mechanism and (iv) the criteria for applying the dual pricing mechanism. Furthermore, Article 53(1) of the same regulation stipulates that within three years of its entry into force (i.e. by 18 December 2020), all TSOs must apply a 15-minute imbalance settlement period to all production and consumption units, unless a derogation period is granted by the competent authority; the derogation may not be granted beyond 31 December 2024. With Resolution 474/2020/R/eel, ARERA granted the TSO an exemption from these obligations, thus setting the new deadline for applying the 15-minute imbalance settlement period to all units at 1 January 2025.

The methodology referred to in Article 52(2) of the Balancing Regulation was finalised and approved by ACER in Decision 18/2020 of 15 July 2020 (hereinafter: ACER methodology) and each TSO was required to implement it nationwide within 18 months of its approval, i.e. by 15 January 2022. This methodology includes the areas of harmonisation required by Article 52(2) of the Balancing Regulation, as well as the general provisions on the imbalance settlement laid down in the Balancing Regulation and the Electricity Regulation; the harmonisation principles included in the ACER methodology concern:

[1] https://www.entsoe.eu/network_codes/eb/

- the imbalance area, i.e. the area within which the Balance Responsible Party (BRP) imbalance is calculated, which must be equal to the market area, except in central dispatching systems, such as the Italian one, where it may be smaller;
- the imbalance price area, i.e. the area for which an imbalance price is defined and calculated, which must be equal to one or more imbalance areas and furthermore, in line with Art. 6(6) of the Electricity Regulation, must be equal to the bidding zone, except for central dispatching systems, for which it may also be smaller than the bidding zone;
- the sign of the imbalance of each imbalance price area, which, in general, must be calculated as the difference between the sum of all downward balancing energy volumes and the sum of all upward volumes activated to meet the TSO's demands;
- the application, as a standard solution, of the single pricing mechanism for all resources and in each imbalance price area, determined from the sign of the imbalance in each area; however, each TSO may make a proposal to apply dual pricing, subject to certain conditions;
- the imbalance price, which must be determined from the prices and volumes for the activation of balancing energy to satisfy the TSO's demand, in compliance with the boundary conditions (understood as minimum and maximum values), defined by Article 55 of the Balancing Regulation, equal to the weighted average of the prices of the activation of balancing energy from Frequency Restoration Reserve (FRR) and Replacement Reserve (RR); the imbalance price may include incentive or scarcity components, defined at national level;
- the value of avoided activations, which each TSO is required to define, using only the prices of balancing energy bids available to it.

Implementing the framework resulting from European regulation, ARERA reformed the national regulation on the imbalance settlement, first by publicly consulting the principles through consultation document 292/2021/R/eel, and then by approving the new regulation with Resolution 523/2021/R/eel.

Specifically, the contents of the ruling covered:

- **Redefinition of the imbalance price area**, defining it as equal to the market area, in line with the provisions of the European framework. However, a mechanism was introduced to identify uncongested areas('dynamic zones'), within which the price would be the same for all zones. Pending the adoption of the aggregation into dynamic zones, a static configuration aligned with the current North and South macro zones was maintained, as these were defined by the TSO according to the zonal congestion profiles most frequently encountered in daily operations.
- **Extension of the single pricing mechanism to all units**, regardless of their characteristics, thus overcoming the dual pricing mechanism applied to qualified units and the scheme applied to units powered by non-programmable renewable sources.

- **Application of a weighted average price** of balancing energy activated to meet the TSO demand, aligned with the boundary conditions set forth in Articles 55(4)(a) and 55(5)(a) of the Balancing Regulation, according to which the imbalance price, including additional components, for negative (positive) imbalances must be no lower (no higher) than the weighted average of the prices of positive (negative) balancing energy activations from Frequency Restoration Reserve and Replacement Reserve. These requirements led to the reintroduction in the calculation of the weighted average price of secondary reserve activations (or aFRR), which had been excluded since July 2012 with Resolution 342/2012/R/eel, later annulled by the Council of State and definitively since August 2016 with Resolution 444/2016/R/eel insofar as this service is activated automatically in real time with dynamics that are faster than the relevant periods for the settlement of actual imbalances and, as a result, its value is considered, at least in the Italian electricity system, to be unrepresentative of the value of energy in real time of which the imbalance price should be an expression.
- **Mandate to the TSO to define the value of avoided activations**, which is representative of the marginal imbalance price if there are no activations of balancing energy. ARERA has identified such situations as those where the sign of the zonal aggregate is zero, or the sign is non-zero but the demand is entirely met by the imbalance netting process with interconnected foreign TSOs.
- **Extension of the macro-zonal non-arbitrage charge also to qualified units**, in order to neutralise the economic advantages that dispatching users could gain, with potentially distorting effects and additional burden on the system.
- **Application of additional charges for non-compliance with dispatching orders**, calculated at the level of the dispatching user’s portfolio in each area, to prevent combined strategies between several units, which may occur, for example, by not complying with a dispatching order of one unit in order to favour the more expensive call of another unit of the same user.

The principles set forth in Resolution 523/2021/R/eel were subsequently integrated and implemented by the TSO in its own Network Code, which was positively verified by ARERA in Resolutions 123/2022/R/eel and 115/2023/R/eel.

In particular, the new settlement rules provide for:

- positive macro-zone imbalances, a price equal to the average of the prices calculated by the algorithm of each European platform for the exchange of balancing energy (RR, aFRR, mFRR), weighted on the respective quantities in the downward direction activated by the TSO (if any) for each zone belonging to the macro-zone, and of the prices of the accepted downward bids in the same zones in the market for dispatching service for real-time balancing purposes, weighted for the respective quantities;

- negative macro-zone imbalances, a price equal to the average of the prices calculated by the algorithm of each European platform for the exchange of balancing energy, weighted on the respective quantities in the upward direction activated by the TSO (if any) for each zone belonging to the macro-zone, and of the prices of the accepted upward bids in the same zones in the market for dispatching service for real-time balancing purposes, weighted for the respective quantities;

Since the balancing energy demand of aFRR is formulated per load frequency control area (LFC area) and not per zone, it was necessary to conventionally distribute the aFRR demand over each zone, considering that the secondary reserve is activated on an instant-by-instant basis to correct real time deviations, in a diffuse manner over the territory, and that the activations are not functional to restore the balancing of an individual zone but, in general, of the entire system. Given the random and geographically diffuse nature of real-time imbalances and secondary reserve activations, Resolution 115/2023/R/eel deemed it more correct to allocate the demand in equal parts for each zone.

1.2. PICASSO Platforms and Imbalance Netting: operating principles and critical issues

One of the main objectives of the Balancing Regulation is to establish European platforms for balancing energy exchange and imbalance netting process, in order to harmonise and integrate the individual national balancing markets, historically operated by national TSOs independently of each other and with few cooperation initiatives for cross-border exchange. In particular, the Balancing Regulation envisages the implementation of four separate platforms for the exchange of standard balancing products and/or for the netting of imbalances:

- **Platform for the exchange of Replacement Reserves (RR)**, according to Article 19 EBGL; this platform was developed within the TERRE implementation project and involves a small number of TSOs, since the replacement reserve service is not mandatory and is used by a small number of European TSOs;
- **Platform for the exchange of manual Frequency Restoration Reserve (mFRR)**, according to Article 20 EBGL; this platform was developed within the MARI implementation project and has a pan-European scope;
- **Platform for the exchange of automatic Frequency Restoration Reserve (aFRR)**, according to Article 21 EBGL; this platform was developed within the PICASSO implementation project and has a pan-European scope;
- **Platform for the Imbalance Netting (IN) process**, according to Article 22 EBGL; this platform was developed within the IGCC implementation project and has a pan-European scope;

Hereinafter, the operating principles, implementation and critical issues that emerged for the aFRR (or PICASSO) platform and the IN platform are described in more detail, since they are the ones with the greatest impact in the context of the investigation.

According to the respective articles of the regulation, European platforms are to be based on a multilateral TSO-TSO model, i.e. Balancing Service Providers (BSPs, i.e. the entities responsible for bidding for balancing services) will only have to interact with their national TSO, and all balancing energy exchanges or cross-border netting will have to take place via a centralised process between TSOs. The Regulation also stipulates that balancing energy trading platforms shall apply a model of selection and activation of bids by means of a common merit order, with settlement at the marginal price, according to the principles of the uniform price auction.

aFRR process and merit order model

The automatic Frequency Restoration Reserve process (equivalent to the secondary reserve process, according to the nomenclature traditionally adopted also in Italy), is by its nature a closed-loop control process with an almost continuous granularity over time[2] (typically in the range of 3-5 seconds); this means that the selection of resources required by the system can vary with the same granularity. In addition, historically, the aFRR process was performed according to a *pro-rata* activation: a certain number of resources are connected with a certain control band to a central regulator; based on the frequency deviation, the central regulator requests the delivery of a certain percentage of the band to all connected resources, equally and without considering the marginal cost of the delivered energy.

The application of the Balancing Regulation’s provisions on the principles for the selection and settlement of balancing energy led TSOs to propose and develop a platform that combines the very fine granularity typical of the aFRR process, with the common merit order selection model and settlement of energy at marginal price. The result is the current operating scheme of the PICASSO platform, which includes a market optimisation every four seconds. This optimisation is included in the frequency control process of each TSO connected to the platform, as shown by Figure 1:

[2] The electrical system requires a constant balance between generation and load; any deviation from this balance results in a deviation of the grid frequency which, if not properly corrected, can lead to severe consequences. The role of the secondary reserve is precisely to restore the grid frequency instant by instant through changes in the injections and withdrawals of active power into the grid, realigning the foreign scheduled exchange to the relevant set point.

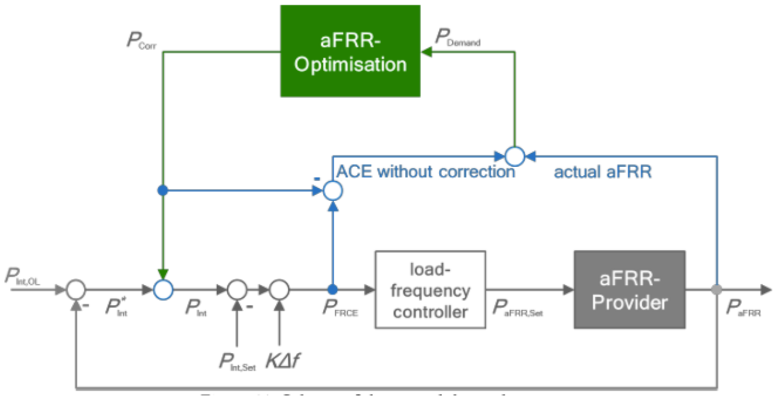

Figure 1 Control and activation scheme of aFRR with the PICASSO platform

- each TSO calculates its aFRR demand (P_{Demand} in Figure 1) at each optimisation cycle, for its own LFC Area (Load-Frequency Control Area), as the sum of the aFRR already activated and the network error, i.e. its own imbalance towards the other control areas (Frequency Restoration Control Error, which in the European synchronous area coincides with the Area Control Error - ACE);
- the aFRR demand is provided as input to the platform which, through an auction constrained by the cross zonal capacities available between control areas, determines which bids to activate from the common merit order. The output of the algorithm is a correction of the aFRR demand for each TSO, which is directly included in the national control scheme;
- through this signal, the controller of each LFC area takes into account the results of the platform. The sum of the aFRR demand and the correction represents the adjusted demand and reflects the volume of aFRR that each TSO must actually deliver.

Figure 2 shows the high-level scheme of how the different TSO control areas interact with the platform and the outcomes of the algorithm[3].

The operating scheme of the PICASSO platform recommended and implemented by the TSOs is in line with the principles laid down in the Balancing Regulation, but nevertheless presents critical issues that the TSOs have to address. Firstly, the recommended model assumes that even at the local controller level, aFRR activations occur according to order of merit (only the cheapest resources are activated, up to the amount required), so as to maintain consistency between the algorithm selections and the actual activations in each LFC area. For most TSOs, this has meant the need to change from a *pro-rata* (i.e. proportional and independent of energy value) to a merit-order mechanism.

[3] For more information about the platform's operating principles, refer to the dedicated section of the ENTSO-E website https://www.entsoe.eu/network_codes/eb/picasso/ and the material shared in the Balancing Stakeholder group https://www.entsoe.eu/network_codes/esc/#balancing-stakeholders-group

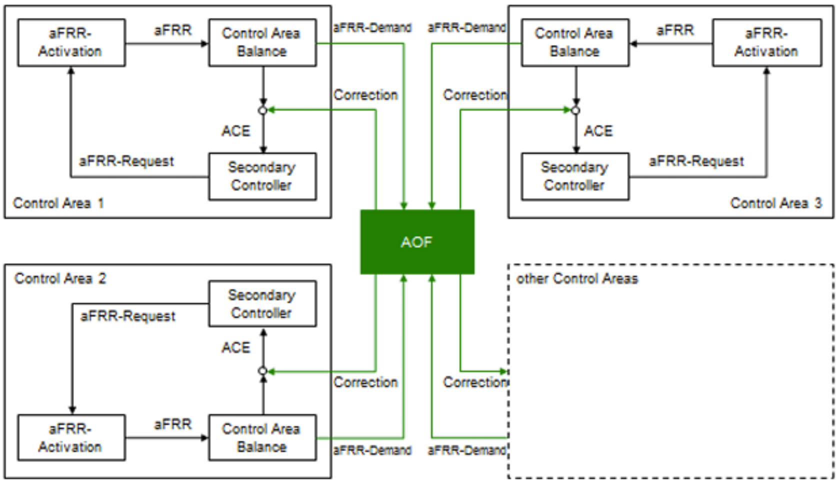

Figure 2 High-level diagram of the interaction between control areas and the PICASSO platform algorithm

Figure 3, extracted from a study[4] carried out for ENTSO-E specifically to assess the impacts of applying the merit order model to the activation of aFRR, shows that in 2015 most TSOs had a *pro-rata* activation scheme. The same study also reports how the merit order activation may worsen the frequency restoration process, in the absence of additional mitigation measures that TSOs must consider when switching to the merit order scheme.

4 https://docstore.entsoe.eu/Documents/MC%20documents/balancing_ancillary/160229_Report_aFRR_study_merit_order_and_harmonising_FAT_%28vs_1.2%29.pdf

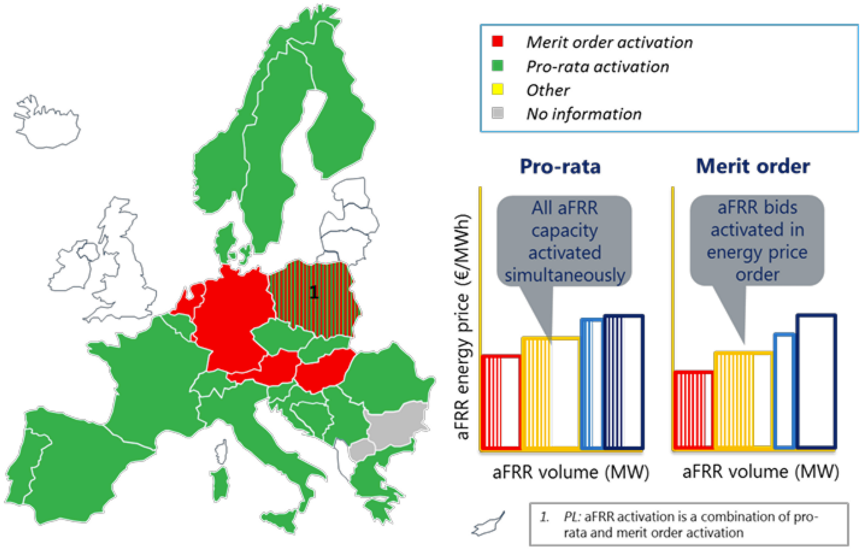

Figure 3 Map of TSOs applying the pro-rata or merit order activation scheme as of 2015 [source: ENTSO-E]

Another critical issue due to the implementation scheme of the PICASSO platform, and in particular the application of the principles of an auction to a process with a very narrow time granularity, is the constant mismatch between the algorithm's solution and the volumes of aFRR actually delivered. In actual fact, the algorithm does not take into account resource dynamics and ramp rates, and the high granularity of the optimisation cycle does not allow the system to align with the market solution before subsequent optimisations. The mismatch between market and system can be very significant, especially when the TSOs' demands are very volatile and there are peaks in aFRR demands for a few optimisation cycles; the market selects resources that cannot be physically activated and establishes a settlement between TSOs for energy volumes that are not actually traded. This misalignment has been known to the TSOs since the definition of the platform model and is subject to constant monitoring, in order to assess alternative solutions in the future, in line with the ACER 2/2020 decision approving the platform implementation framework.

Interactions between aFRR platform and IN

To complement the description of the PICASSO platform's operating scheme, the imbalance netting process carried out by the dedicated platform is also reported, presenting the relationships between the two platforms.

In contrast to balancing energy exchange processes, imbalance netting follows a maximisation of compensated volumes and benefit-sharing approach, i.e., netting does not take into account the value of the energy, but only the volumes that can be compensated with each other within the cross zonal capacity limits. Settlement between TSOs takes place according to a value of avoided activations communicated by them and the expected benefits of avoided activation of aFRR are socialised between TSOs, if negative benefits result for any TSO during settlement. Until the go-live of the PICASSO platform, imbalance netting was considered a stand-alone and independent process, operating in real time, altering the instantaneous aFRR demands of participating TSOs so as to avoid secondary reserve activations in opposite directions, thus saving on TSOs' balancing costs. Figure 4 shows through an example the working principle of the IN platform.

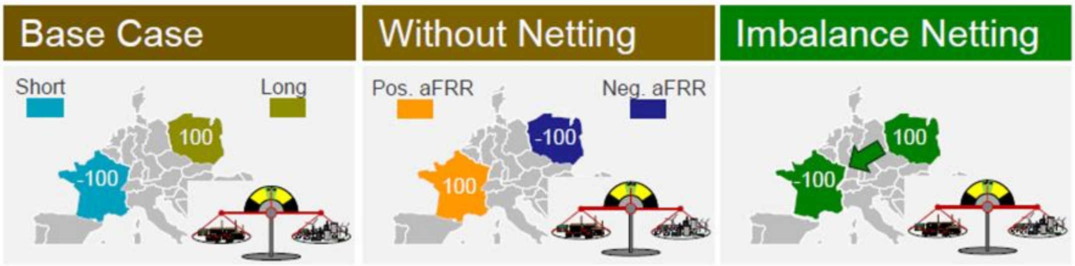

Figure 4 Principle of imbalance netting via the IN platform

Prior to the advent of the PICASSO platform, imbalance netting was the only process that had an impact on the instantaneous demand for aFRR in real time; following the go-live of the PICASSO platform, it became necessary to appropriately coordinate the two processes in order to avoid inconsistencies and de-optimisation. Indeed, by resolving the aFRR market, the PICASSO platform also implicitly performs a netting process between the opposing demands of TSOs, activating aFRR resources only to cover residual demands. For a TSO operating in PICASSO, participation in the IN platform still has added value, as it allows an additional netting opportunity with other TSOs not yet connected to the aFRR platform. The coexistence of both platforms will therefore be guaranteed until all TSOs participating in IN also start participating in PICASSO, at which point the netting opportunities will be implicitly exhausted by the PICASSO algorithm and the IN platform will become useless.
Until then, both platforms have an impact on the TSOs' aFFR demands and therefore require close coordination. The diagram in Figure 5 shows the high-level principle of how coordinated optimisation between the two platforms takes place.

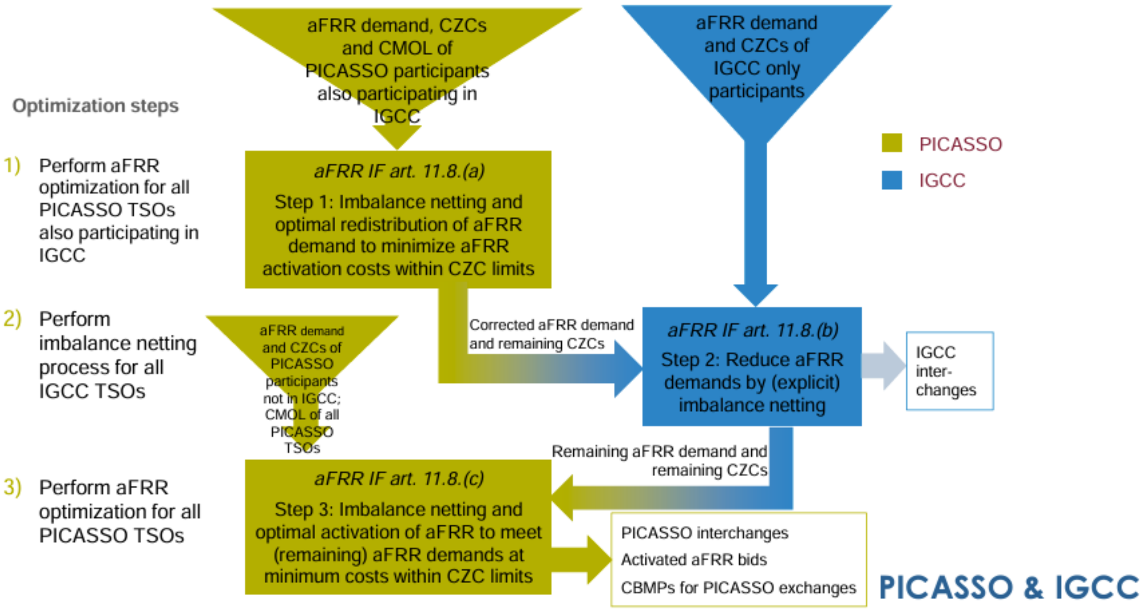

Figure 5 Coordination and optimisation scheme between PICASSO and IN platforms

The process has 3 main steps: (i) optimisation for participating TSOs in PICASSO is carried out, determining the implicit netting and residual aFRR demand for each TSO, (ii) the IN platform offsets, where possible, the corrected aFRR demand of participating TSOs in PICASSO with the aFRR demand of all remaining TSOs, (iii) final optimisation in PICASSO determines the optimal aFRR activations.

On the PICASSO platform, the minimum perimeter for pricing is the LFC Area. Uncongested regions consist of several LFC areas connected by uncongested borders. Thus, an uncongested region is either formed at a minimum by a single LFC area, when all its boundaries are congested, or is formed at a maximum by all LFC areas, when, for example, there is no congestion.

Determining the marginal price

In line with the provisions of the methodology for the pricing of balancing energy, developed pursuant to Article 30(1) EBGL, a price is calculated for each time period (equal to the 4-second optimisation cycle) and for each uncongested region. In the current implementation of the platform, purely economic counter-activations are inhibited, so that in each uncongested region aFFR bids can only be selected upwards or downwards, but never in both directions. Please note that the counter-activations referred to here are selections made by the algorithm on a purely economic basis, i.e. they improve the overall social welfare, but do not lead to any demand satisfaction. Such counter-activations take place, for example, in the event that in the same uncongested area is present a lower priced upward bid than a downward bid. Without further constraints, the algorithm would allow both bids to be accepted, with the sole purpose of improving the value of the objective function.

Therefore, in light of the above, only three situations can arise for the definition of the price:

1) In the uncongested region, only upward bids (hereafter also SELL bids) are selected; in this case, the price is the highest of the selected bids;
2) In the uncongested region, only downward bids (hereafter also BUY bids) are selected; in this case, the price is the lowest of the selected bids;
3) No aFRR bids are selected in the uncongested region; this can happen when demand is fully covered by bids from other uncongested regions or when complete netting occurs. In this case, the price is defined as the average between the price of the first upward bid and the price of the first downward bid available in the uncongested region.

The definition of the marginal price for each optimisation cycle and for each uncongested region is entrusted to a post-optimisation that defines the congested borders, identifies the uncongested regions and calculates a single price for each of them. For more information on the definition of the marginal price, refer to the algorithm description document published by ENTSO-E[5].

According to the Balancing Regulation and its methodologies, the marginal price established by the algorithm is used for the settlement between TSOs and towards BSPs, according to the rules defined at national level by each TSO.

Mismatch between quantities selected and quantities delivered

Due to the implementation model chosen by the TSOs (the "control demand"), a systematic mismatch occurs between the quantities selected by the platform algorithm and the volumes physically delivered by the resources. This is due to the fact that the algorithm establishes aFRR exchanges and activations on the basis of the common order of merit, but without considering the ramping constraints and dynamics inherent in the service provision.
In this way, the exchange of aFRRs between TSOs only impacts the local frequency control process as input, so the controllers in each LFC Area do not have to be harmonised and can remain calibrated to the specifications of the local BSPs.
However, the mismatch between the exchange of aFRRs (step signal) and the quantities activated by local controllers has impacts on the volumes settled between TSOs and the volumes settled to BSPs, as shown by Figure 6. In particular, in the case of significant variability in the selection of the algorithm between optimisation cycles, it may happen that a selected resource does not deliver before the algorithm determines its deactivation in a subsequent cycle. Conversely, it may also be the case that a resource continues to deliver even after the algorithm has ceased its activation, due to slower dynamics.
In order to simplify settlement procedures, the TSOs agreed from the outset to base settlement among themselves on the 'theoretical' results of the algorithm and thus to

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5 https://www.entsoe.eu/documents/nc/NC%20EB/2022/20220406_PICASSO_Public_Algorithm_description_v1.0.pdf

assume as volumes the energy blocks and as prices those established by the selected bids. Instead, settlement with BSPs is a matter of national terms and conditions, defined by each TSO at national level.

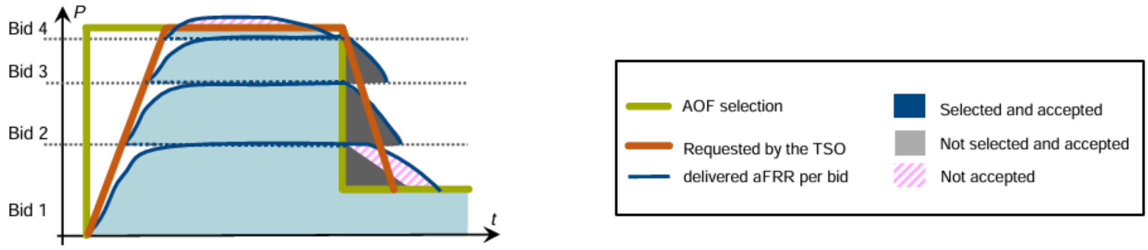


Figure 6 Example of mismatch between algorithm selections and actual volumes delivered [source: ENTSO-E]

1.3. The Terna’s participation

The coordination rules between the MSD and the aFRR platform, included in the TSO’s national terms and conditions and approved by ARERA with Resolution no. 115/2023/R/eel, envisage a process for converting bids submitted in the MSD for the secondary reserve service, in order to define a bid curve consisting of 3 blocks of quantities and prices, for participation in the aFRR platform. The aim of the conversion is to include in each block, which is then shared on the platform, a portion of the band of all the units serving the secondary reserve service, so that if one or more blocks (or a portion thereof) were selected by the platform’s algorithm on the basis of merit order, the activation at national level would produce a parallel response of all the units, effectively guaranteeing the *pro-rata* mechanism. The conversion process and the effect of a hypothetical activation are schematically shown in Figure 7.

In its Resolution 115/2023/R/eel, ARERA considered the bid conversion rules to be a valid prudential approach for the start of participation in the European exchange platform, allowing the obligations to participate in the aFRR platform via a merit order model to be combined with the need to maintain the benefits ensured by the *pro-rata* activation model at local level. In the same deliberation, however, potential downsides were identified; namely (i) an effect of paradoxically rejected bids due to price reallocation during the conversion process and (ii) the missed opportunity for resources not selected for service provision to still participate in the platform and meet any additional demands of participating TSOs (in the example of Figure 7, the fourth bid on the right). The TSO has been given a mandate to monitor the effects of the conversion on BSP operations, and also to propose possible alternative solutions.

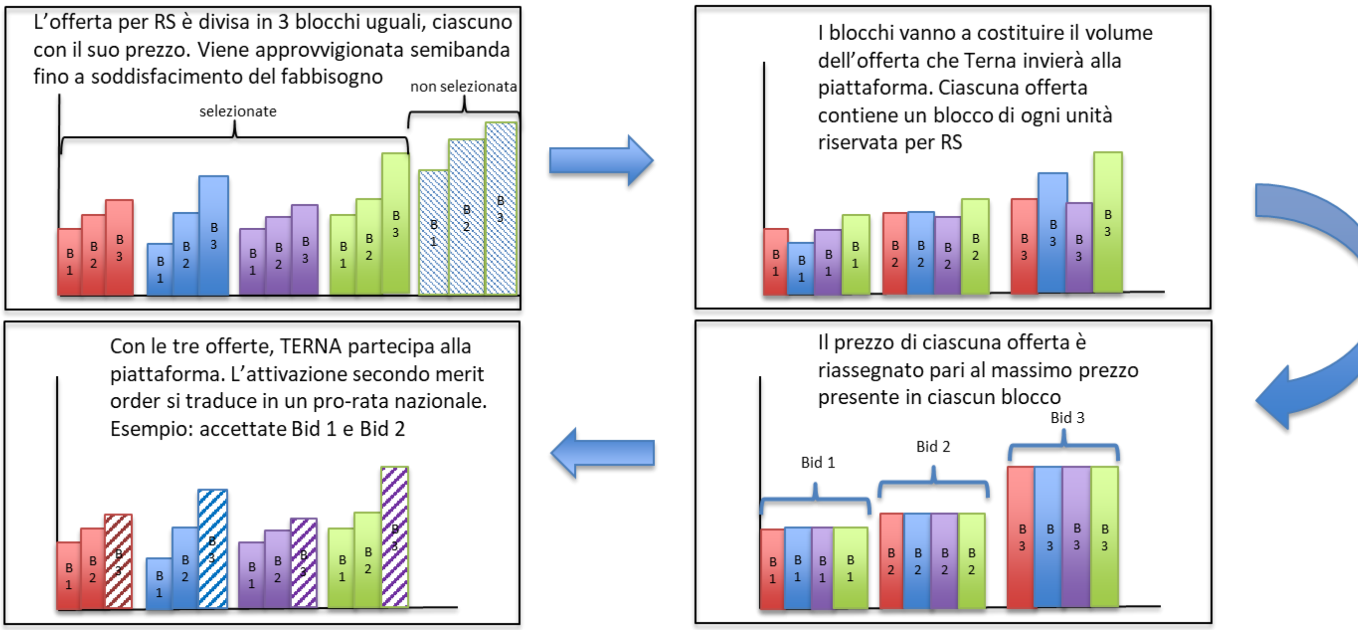


Figure 7 Diagram of the bid conversion process between MSD and aFRR platform

1.4. Marginal pricing on the platform: critical issues emerged and possible impacts in Italy

Even before the official launch of the platform, the European TSOs had expressed concerns about the price limit for balancing bids under European regulation, set at +/- € 99,999/MWh by ACER Decision 01/2020, and the joint effects of its application together with the principle of marginal price assessment in an integrated European balancing market. According to the TSOs, there was a real risk of potentially distorted balancing prices being formed by the BSPs, resulting in the transfer of a fictitious signal of a critical issue into the system, even when such a critical issue is non-existent. Apart from the fact that the aforementioned conduct could constitute a violation of Regulation (EU) 1227/2011 (the "REMIT"), the TSOs, even before the entry into force of this methodology, were already noticing bids submitted by BSPs close to the national market cap at national level; their concern was that, by raising the technical limit at which they could bid, bids close to the market cap would be submitted close to the new limits and, together with the marginal price rule, would lead to additional burdens on the system and unsustainable imbalance prices.

Therefore, in 2021, the TSOs, through ENTSO-E, jointly drafted a proposal for an amendment[6] to reduce the price limits of the balancing market and mitigate the risks of accepting bids at prices close to the cap, also considering new elements in the balancing market such as a new platform for cross-border trading and settlement at marginal price.

[6] https://consultations.entsoe.eu/markets/proposal-for-amendment-of-pricing-methodology/

In their consultation process and submission of the amendment proposal, the TSOs justified their proposal with the new elements of the European balancing market, the need for a period of adaptation by BSPs to adjust their operations in the new environment, and the potential lack of competition that could have led to a high probability of exaggeratedly high (low) prices for upward (downward) balancing bids, with potential risks of disproportionate imbalance prices for BRPs.

In its decision-making process, which ended with ACER Decision 3/2022, ACER did not accept the recommendation to revise the technical limit of +/- € 99,999/MWh, as it would go against the principles of Regulation 943/2019, but did introduce a transitional price limit of +/- € 15,000/MWh until 2026, which should mitigate risks during the start-up period of the new European balancing market.

Since the launch of the platform, following the provision of the ACER decision that introduced the transitional price limit, TSOs are obliged to monitor and report certain indicators relating to the composition of the market merit order, as well as all cases where the price has exceeded 50% of the transitional technical limit. In the context of this monitoring activity, such cases are referred to as “price incidents”; a definition which, however, is not relevant for the implementation of the REMIT regulation. Also according to the ACER decision, TSOs are required to publish a quarterly report with the main analyses and indicators set out in the decision. These reports are available on the ENTSO-E website[7].

Analyses carried out by the TSOs show that the problem can be traced back to the merit orders shared by the German and Austrian TSOs, which are characterised by a ‘hockey stick’ shape, i.e. with a considerable amount of volumes offered at a slightly monotonously increasing price and a small set of volumes offered at exaggeratedly higher prices for upward bids (or lower, for step-down bids), creating a considerable price discontinuity.

When the aFRR demand of the TSOs sent to the platform are sufficiently high, these bids are selected, propagating their price to all contiguous areas not separated by congestion. ENTSO-E’s periodic reports analyse for each price incident the concentration of the balancing market, confirming that at least one pivotal operator is present in each incident.

According to ENTSO-E reports, from June 2023 to October 2023 there were 223 positive price incidents (exceedance of 50% of the positive limit) and 534 negative price incidents (exceedance of 50% of the negative limit); all incidents occurring within a 15-minute interval are grouped into a single incident; therefore, an incident can have a duration of between 4 seconds and 15 minutes.

In the first two quarters of the platform’s operation, most of the incidents occurred either with Austria alone forming the uncongested area concerned or with a combination of two or all three connected countries (Austria, Germany and the Czech Republic). This

[7] https://www.entsoe.eu/network_codes/eb/quarterly-pricing-reporting/

changed as of Q1 2023, with the Czech Republic triggering a price incident as a single uncongested region in between 4 and 35% of cases (see Figure 8, Figure 9 and Figure 10). The graphs show that Austria was involved in a significant number of cases (more than 70% up to Q2 2023), either individually or as an uncongested region with the other countries.

Figure 10 shows the results of the third quarter, including the operations of the Italian system. The graph shows that participation in price incidents always occurs within an uncongested region with 2 or more countries; 21% of the total cases involve a price incident in coupling with Austria.

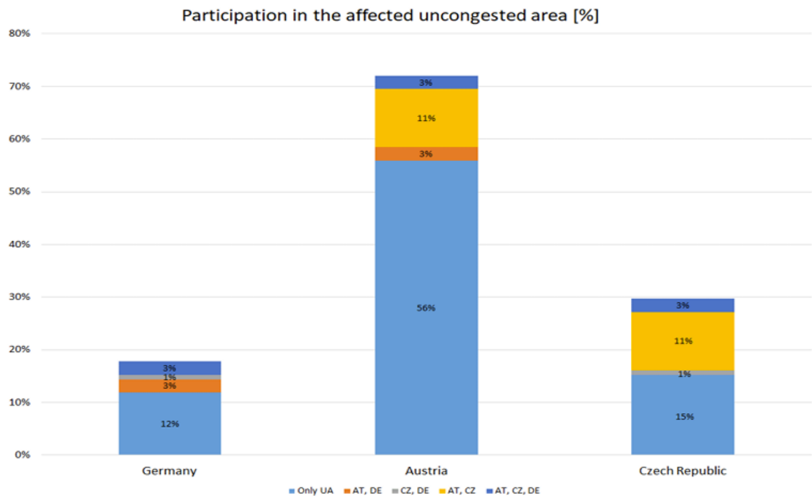


Figure 8 Participation in uncongested regions during price incidents - Q1 2023 [source: ENTSO-E]

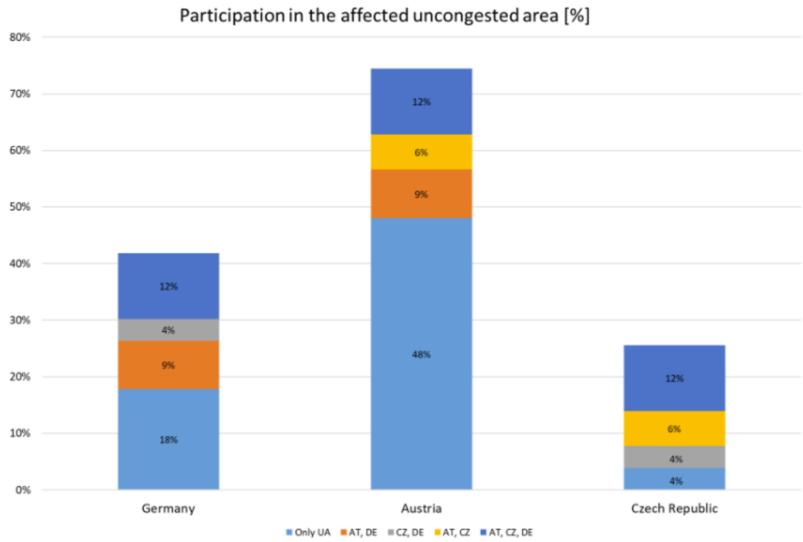


Figure 9 Participation in uncongested regions during price incidents - Q2 2023 [source: ENTSO-E]

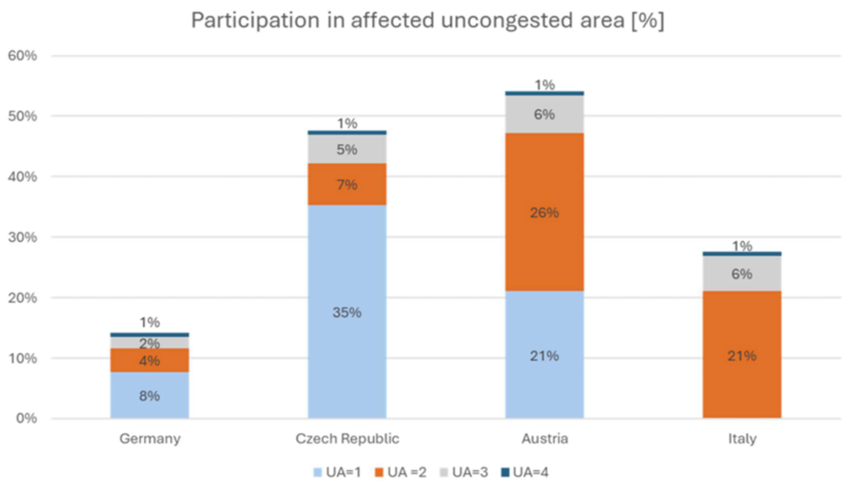


Figure 10 Participation in uncongested regions during price incidents - Q3 2023 [source: ENTSO-E]

Finally, the graph of the weighted average prices of the 5% most expensive bids sent to the platform by each system connected to the platform, for the third quarter of 2023, as published by ENTSO-E, is shown. It can be clearly seen that in the foreign countries connected to the platform, there are bids submitted in the merit order at very high absolute prices ; this is not a direct indication of price incidents, as these depend on the liquidity of the merit order and the supply/demand ratio, but it does provide an indication of the risk of selecting bids at very high prices.

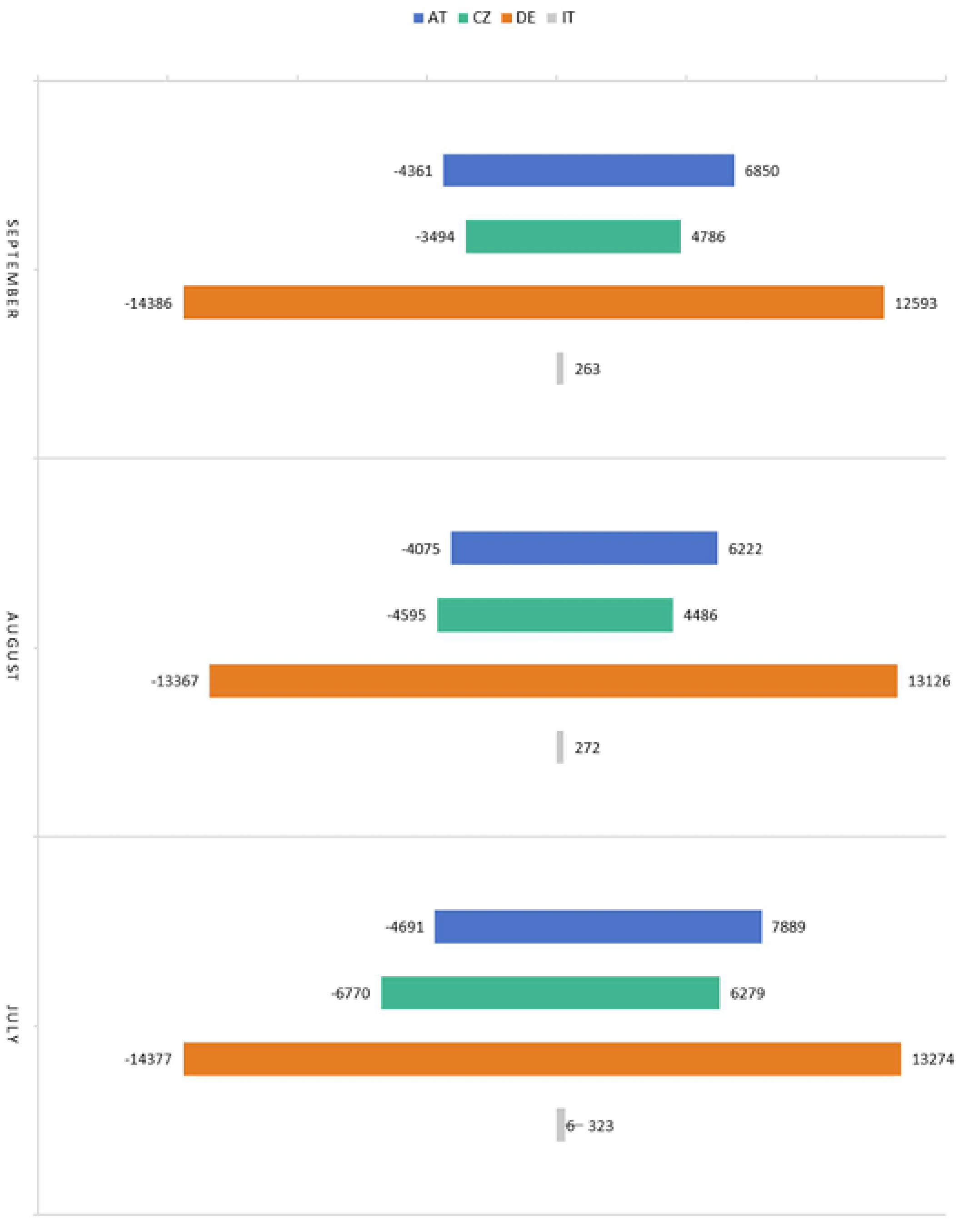


Figure 11 weighted average prices of the 5% most expensive bids submitted in each country [source: ENTSO-E]

Mitigation measures under discussion at European level

In order to mitigate the problem of price spikes (both positive and negative) on the aFRR platform, in February 2024, the TSOs sent to ACER a proposal for amendments to the methodology for pricing balancing energy and to the implementation framework of the aFRR platform, after conducting a public consultation[8]. These amendments introduce measures to mitigate the risk of price incidents and provide for:

- **Introduction of an elastic demand on the aFRR platform**: through this tool, TSOs are allowed to express a price within which the demand can be met by the aFRR platform, thus taking into account the opportunity cost of providing frequency restoration with other types of reserve. This option would only be allowed for the portion of demand exceeding the quantity of aFRR dimensioned in accordance with Article 157 of Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (the "SOGL Regulation").

  This measure stems from the fact that, at present, on the aFRR platform, TSOs have full access to the merit order, even for volumes exceeding the quantities shared by each TSO, as an exception to the provisions of the Balancing Regulation. This ensures a better performance in frequency restoration, but also implies that all aFRR demands are met at any price, regardless of the TSOs' obligations for reserve dimensioning. This design can lead to the activation of extremely expensive bids, even in situations where such activation is not necessary to guarantee frequency quality, resulting (directly or indirectly) in unnecessarily high costs for the system and the BRPs.

- **Price determination on the basis of actually activated bids:** as described above, the current implementation of pricing rules does not take into account the activation dynamics of local controllers and connected resources, with the result that, in the event of strong volatility of demands, the price of the aFRR traded in an optimisation cycle is determined by a bid that is not actually activated locally. The TSOs' proposal is therefore to price each optimisation cycle according to the output signal from the local LFC Area controller, i.e. the resource activation input. In practical terms, for each uncongested region, the price for upward activations is set by the minimum between:

  - the maximum local marginal price, i.e. the maximum among the prices identified by the intersection of the local merit order and the local signal (LFC output) sent to the resources, and
  - the price determined by the algorithm selections, according to the current approach.

  The reverse is true for downward activations.

  Figure 12 shows an example of the proposed new pricing methodology in an uncongested region consisting of two TSOs. It can be seen that during the activation time (red step) the marginal price in the underlying optimisation cycles varies according to the profile of actual activation by the TSOs, while for

[8] https://consultations.entsoe.eu/markets/all-tsos-proposal-amendments-afrr-if-pricing-metho/

deactivation the price follows the current rule (determination according to the instantaneous selection of the algorithm). According to simulations carried out by TSOs, this new rule should reduce the occurrence of short-term price incidents.

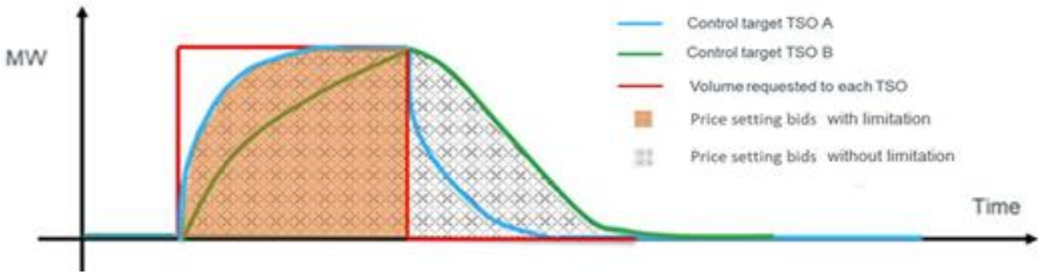


Figure 12 Example of marginal pricing for an uncongested region under the recommended new rules [source: ENTSO-E]

Impacts on the Italian system

As already shown in ENTSO-E’s quarterly reports, following the start of the Terna’s participation in the PICASSO platform, the Italian system became part of the integrated cross-border aFRR market, where the outcomes depend on overall market conditions in terms of BSP bids, TSO demand and trading capacity, with the risk of propagation of the price spikes identified on the platform, despite the fact that locally there are no bids submitted by market participants at excessively high prices (or low, in the case of downward bids).

In an integrated market context solved by uniform auction at the marginal price, there is always the possibility that the price of a market zone is set by bids from adjacent zones, provided that sufficient cross zonal capacity is available in order not to congest the connection between them. In the presence of sufficient cross zonal capacity, two cases can be identified in which the marginal price is set by foreign bids: (i) foreign bids are (all or in part) cheaper than domestic bids and therefore the algorithm provides their activation up to the level of the demands to be satisfied, or (ii) domestic bids are cheaper than the marginal price set, and more expensive foreign bids have to be selected in order to satisfy the demands in the uncongested region. The second case is the relevant one with regard to the risk of price spikes occurring on the PICASSO platform at prices much higher (lower) than the upward (downward) bids submitted nationwide. Such conditions may materialise as a result of:

- Export of bids (BUY or SELL): the TSO’s demand is lower than the Italian volumes procured and shared on the platform, but the overall demand of the uncongested region is such that all Italian bids are selected and the marginal price is set by a foreign bid;
- Import of bids (BUY or SELL): the TSO’s demand is higher than the Italian volumes procured and shared on the platform, so to meet it it is necessary to import aFRR at a higher price, set by foreign bids in the same uncongested region;

These conditions arise under the assumption that the cross zonal capacity between adjacent systems is sufficient to ensure the convergence of areas in the same uncongested region. In this regard, it should be noted that the export of SELL bids or the import of BUY bids corresponds to an export flow; conversely, the import of SELL bids or the export of BUY bids corresponds to an import flow.

These case will be used in chapter 3 to characterise the market conditions of each optimisation cycle and to assess events with a marginal price formation outside the bidding ranges of Italian operators.

2. IMPACTS OF PARTICIPATION IN THE PICASSO PLATFORM ON IMBALANCE PRICES

Based on the provisions of Resolution 475/2023/R/eel, ARERA has carried out quantitative analyses to investigate the nature of the events affecting the formation of imbalance prices, focusing on a time horizon from 1 January 2023 to 31 October 2023.

Figure 13 and Figure 14 show, respectively, the time series of the quarter-hourly and hourly imbalance prices, resulting for each macro zone, over the observed time horizon. For each graph, the maximum and minimum value reached by the relevant price in the period prior to the TSO's participation in the PICASSO platform (which took place on 19 July 2023) is also reported. The qualitative analysis of the time series confirms that since the entry into the aFRR trading platform, events have occurred that have led to the formation of abnormal imbalance prices, compared to the maximum and minimum prices recorded in the pre-PICASSO period[9].

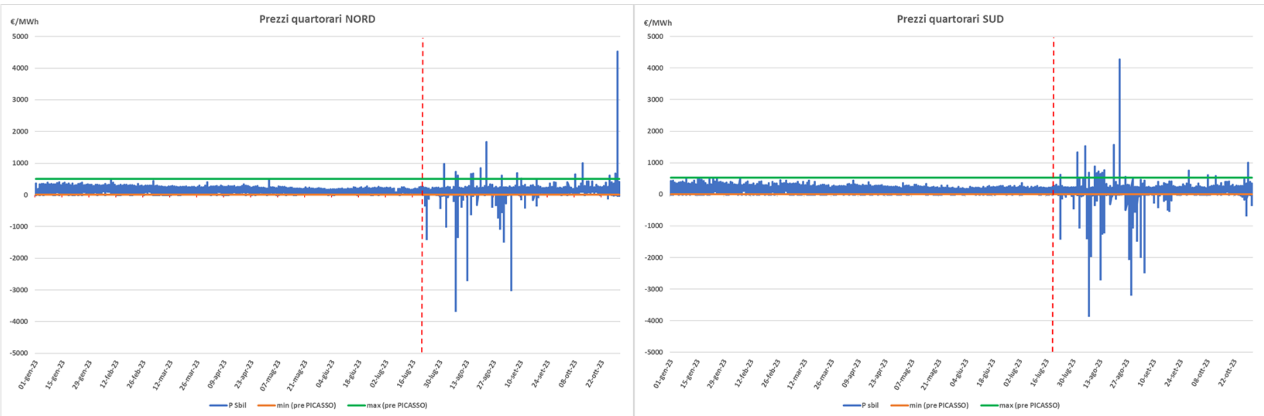


Figure 13- Quarter-hourly imbalance prices by macro zone - [January-October 2023]

[9] This criterion for identifying 'abnormal' prices should not be confused with the approach set out in the ACER Guidance on the application of Regulation (EU) No 1227/2011 of the European Parliament and of the Council of 25 October 2011 on wholesale energy market integrity and transparency of 22 July 2021 to identify potential cases of electricity market manipulation or inadequacy of the electricity system. Therefore, it is not possible to infer from the increase in the frequency of these 'abnormal' prices a parallel increase in cases of manipulation of the electricity market and/or inadequacy of the electricity system, nor even the absence of such cases in the pre-PICASSO period.

Figure 14- Hourly imbalance prices by macro zone - [January - October 2023]

Taking as reference the maximum and minimum prices of the 2023 pre-PICASSO period, imbalance settlement periods (ISP) with a positive (long zone) and negative (short zone) sign were analysed for each macro zone, identifying the events in which the relative price exceeded the lower limit, in the case of the long zone, and the upper limit, in the case of the short zone. Table 1 and Table 2 show, for hourly and quarter-hourly prices respectively, for each macro zone a summary with the breakdown of the relevant periods according to the sign of the imbalance and the number of events in which the price exceeded the limits conventionally set for the analysis, as well as the incidence with respect to the number of relevant reference periods.
The data shows that the number of events exceeding the lower limit, leading to the formation of a negative imbalance price, is significantly higher than the number of events exceeding the upper limit, for both hourly and quarter-hourly prices. Although the incidence of events exceeding the limits considered is rather small, one cannot overlook the impact that such events may have on the settlement of imbalances for BRPs, which depends on the magnitude of the price peak reached.

Table 1 - Hourly imbalance prices - events with lower and upper limits exceeded (19 July - 31 October)

	NORTH macro zone	**SOUTH macro zone**
No. of ISPs with long zone	1239	1228
No. of ISPs with a short zone	1281	1292
No. of out-of-threshold negative price events (% of total periods with long zone)	39 - (3.04%)	65 - (5.03%)
No. of out-of-threshold positive price events (% of total periods with short zone)	9 - (0.73%)	14 - (1.14%)

Table 2 - Quarter-hourly imbalance prices - events with lower and upper limits exceeded (19 July - 31 October)

	NORTH macro zone	**SOUTH macro zone**
No. of ISPs with long zone	5030	5112
No. of ISPs with a short zone	5054	4972
No. of out-of-threshold negative price events (% of total periods with long zone)	126 - (2.49%)	209 - (4.09%)

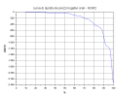
No. of out-of-threshold positive price events (% of total periods with short zone)	27 - (0.54%)	54 - (1.09%)

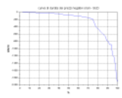
Figure 15 shows the duration curve[10] of hourly and quarter-hourly imbalance prices, for each macro zone, both in the case of negative prices and in the case of positive prices above the threshold value, conventionally established for this analysis.

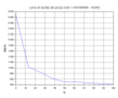
[10] The duration curve indicates the percentage of events in which a given price level was exceeded

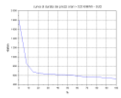
Figure 15 Duration curves of hourly and quarter-hourly imbalance prices, exceeding the set thresholds, in each macro zone (July 2023 - October 2023)

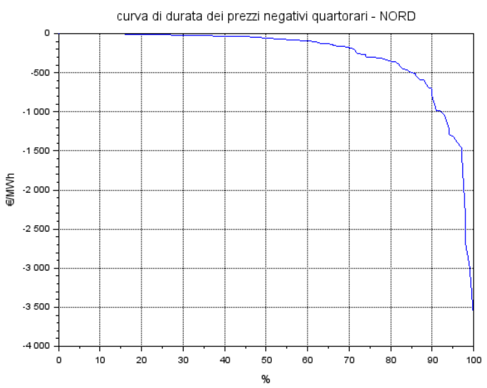
The graphs show how events outside the assumed conventional limits led to significant

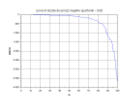


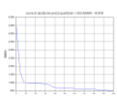


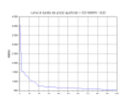












price spikes, both positive and negative, for both quarter-hourly and hourly imbalance prices. To complement the graphs, Table 3 shows the main statistical indicators for imbalance prices exceeding the conventionally assumed limits.

Table 3 - Main indicators for imbalance prices in events exceeding the assumed limits [values in €/MWh]

	Hourly prices				**Quarter-hourly prices**			
	NORTH		**SOUTH**		**NORTH**		**SOUTH**	
	Negative	**Positive**	**Negative**	**Positive**	**Negative**	**Positive**	**Negative**	**Positive**
Max.	-0.37	2888.76	-0.17	1812.43	-0.17	4519.67	-0.07	4280.82
Min.	-2382.64	434.60	-1950.78	525.280	-3655.10	507.00	-3838.62	529.20
Mean	-257.36	859.96	-251.01	699.70	-284.10	891.94	-332.86	796.81
Median	-42.57	503.55	-72.37	612.46	-57.10	672.19	-69.18	654.98

In order to better identify the causes of the abnormal price values, the different contributions of the quantities that contribute to the weighted average of the imbalance price, pursuant to Chapter 7 of the TSO's Network Code, were analysed, separating the share attributable to activations on the national balancing market, activations via the TERRE platform and activations via the PICASSO platform. This further analysis shows that the most relevant contribution to the definition of the imbalance price during events exceeding the limits considered is that of the demand met via the PICASSO platform. By way of example, the most extreme quarter-hourly imbalance prices for the macro-zone SOUTH are shown. Specifically, the data corresponding to the 10th percentile of events with a negative quarter-hourly imbalance price, Table 4, and an imbalance price greater than € 525/MWh, Table 5.

Table 4 Imbalance price components and their ISPs, for values corresponding to the 10th percentile of negative price events [values in €/MWh]

ISP	**Imbalance P**	**MB share**	**RR share**	**aFRR share**
07/08/2023 21:45	-3838.62	0.00	0.00	-3838.62
07/08/2023 17:00	-3295.60	17.87	0.00	-3313.47
29/08/2023 00:45	-3157.08	8.30	3.96	-3169.33
07/08/2023 17:15	-3061.70	16.32	0.00	-3078.01
13/08/2023 10:45	-2675.54	0.00	0.00	-2675.54
07/08/2023 22:45	-2496.50	0.00	0.00	-2496.50
05/09/2023 05:00	-2458.74	6.62	0.00	-2465.36
28/08/2023 21:45	-2039.27	34.85	0.00	-2074.12
07/08/2023 03:15	-2024.08	10.92	0.00	-2035.00
03/09/2023 09:30	-1972.96	0.00	0.00	-1972.96
08/08/2023 18:00	-1946.55	0.00	0.00	-1946.55
07/08/2023 15:15	-1613.74	0.09	0.00	-1613.83
01/09/2023 06:00	-1458.81	0.00	0.00	-1458.81
28/08/2023 21:30	-1435.84	33.37	0.00	-1469.21
07/08/2023 02:15	-1400.40	7.04	0.00	-1407.44

23/07/2023 16:00	-1383.08	0.30	0.00	-1383.39
06/08/2023 17:00	-1380.07	0.00	0.00	-1380.07
08/08/2023 05:00	-1311.46	0.12	0.00	-1311.57
07/08/2023 01:45	-1277.35	7.17	0.00	-1284.51
14/08/2023 09:45	-1229.46	0.00	0.00	-1229.47
13/08/2023 09:45	-1208.43	0.00	0.00	-1208.43

Table 5 Imbalance price components and their ISPs, for values corresponding to the 10th percentile of positive price events exceeding € 525/MWh [values in €/MWh]

Relevant period	Imbalance P	MB share	RR share	aFRR share
02/08/2023 08:45	529.19	0.00	0.00	529.20
10/08/2023 06:00	545.61	20.09	0.00	525.52
14/08/2023 00:00	547.06	59.30	0.00	487.77
12/10/2023 14:45	550.22	90.55	0.00	459.67
12/08/2023 18:15	550.27	33.69	0.00	516.58
12/08/2023 14:15	555.92	0.00	0.00	555.92

In the following chapters, the data relating to the TSO's participation in the PICASSO platform is analysed in order to investigate the reasons for the formation of these prices and to identify possible mitigation measures that could be applied to the way in which the TSO participates in the aFRR platform or to the rules governing the calculation of imbalance prices.

3. Operations on the PICASSO platform during the first few months of participation

As of 19 July 2023, the TSO started participating in the PICASSO platform. In the first months of operation under analysis in this investigation (July - October), the participation rate[11] on the platform was above 90%, with the exception of August, where there was an increase in disconnections (see Figure 16).

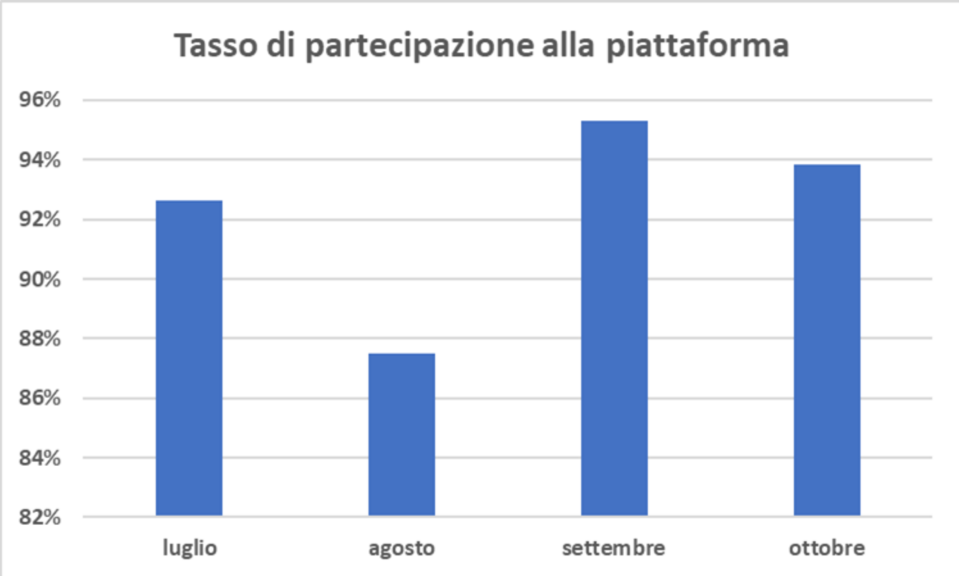


Figure 16 Platform participation rate in the first months of operation

During the months under analysis, the TSO submitted aFRR balancing energy demands up to 361 GWh in upward direction and approximately 617 GWhdownward direction. Figure 17 shows the breakdown of aFRR demand in the different months under analysis. It should be noted that, according to the description of the operation of the aFRR and IN platforms provided in chapter 1.2, the demand sent to the platform can be met, in whole or in part, through:

- implicit netting with other TSOs participating in the aFRR platform;
- imbalance netting with TSOs participating in the IN platform but not in the aFRR platform;
- the activation of resources from the common merit order
-

[11] The participation rate is calculated as the ratio between the number of optimisation cycles in which the TSO was connected to the platform and the total number of optimisation cycles in the month (except for July, where counting starts from day 19)

- of the aFRR platform, which can then be either local or foreign, subject to cross zonal capacity constraints between LFC areas.

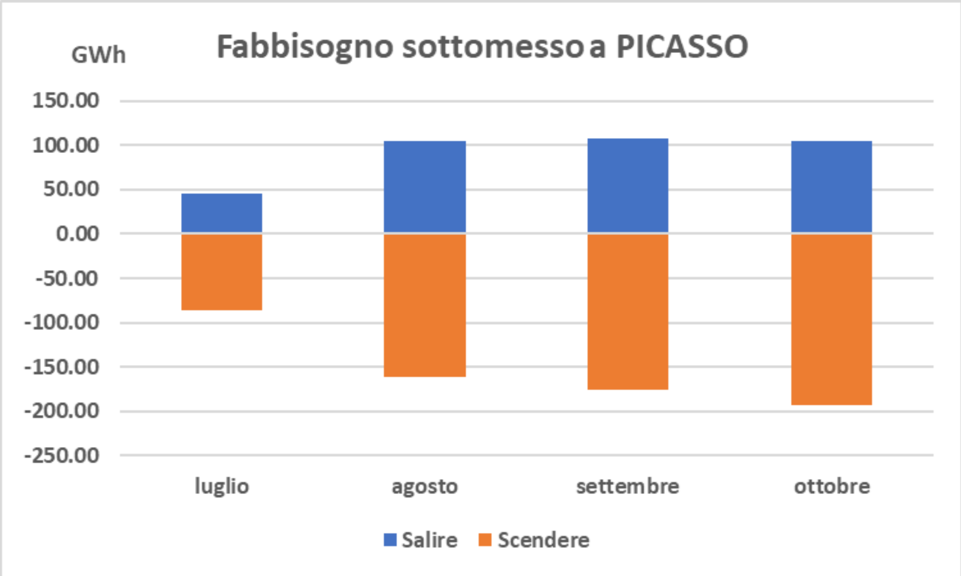


Figure 17 aFRR demands submitted to the platform both in positive and negative direction, in each month analysed

A total of approximately 74 GWh were exchanged with foreign countries in exports and 17 GWh in imports, all through the only border that interconnects the Italian system with the other systems currently operating on the platform, i.e. the Italy-Austria border. Figure 18 shows how the exchange was distributed over the different months under analysis. It should be noted that cross border exchange resulting from PICASSO includes implicit netting, the exchange of aFRR activation, but not the volumes traded through the imbalance netting process.

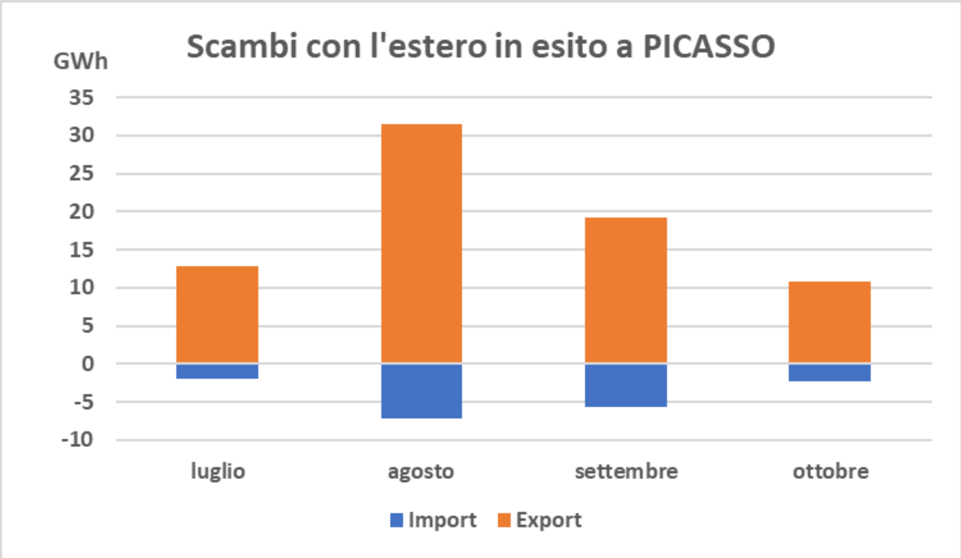


Figure 18 Foreign trade as a result of PICASSO

The major difference between export and import volumes can be attributed both to the type of demand sent by the TSO to the platform and to the values of interconnection capacity (ATC) available in real time for the exchange of aFRR, as leftover after the energy markets. Since the Italy-Austria border is affected by predominantly import flows to Italy as a result of the energy markets, the residual import capacity for balancing is often limited or zero, while the export capacity, ideally equal to the defined export ATC, plus the allocated import quantity, which is theoretically available in counter-flow, is greater. Figure 19 confirms this reading, showing that the average capacity available in export is also four times higher than in import. The significant reduction in capacity in both directions in September and October is attributable to the out-of-service of the Lienz - Soverzene (scheduled periodic maintenance) and Greuth - Tarvisio (extended out-of-service due to a fault) lines, which effectively reduced ATC in both directions to zero between 19 September and 20 October 2023[12].

[12] For details on available capacities see the ENTSO-E transparency platform (https://transparency.entsoe.eu)

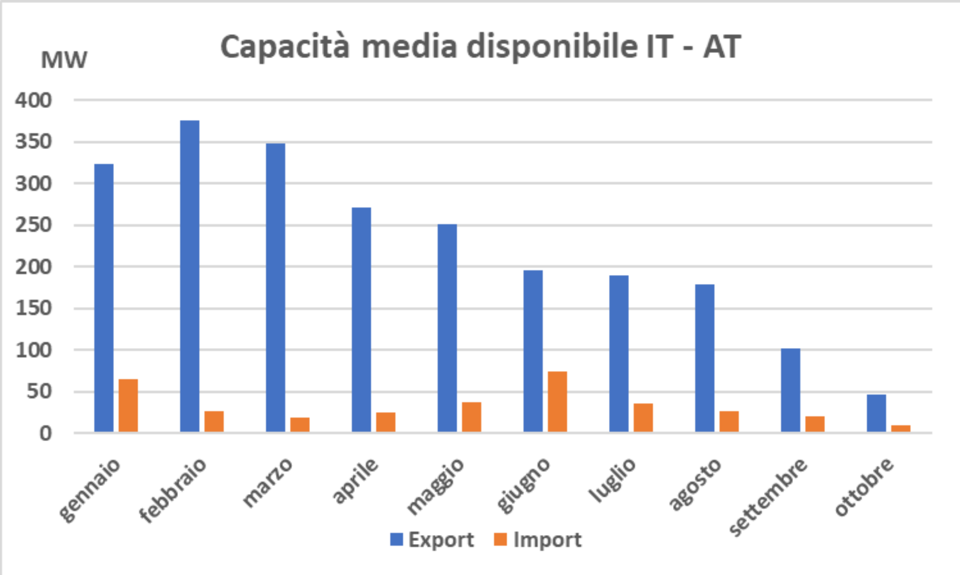


Figure 19 Average ATC available in import and export on the Italy-Austria border

In the July-October period, as a result of platform optimisation, Italian bids were selected for a total of 215 GWh upward and 202 GWh downward (see Figure 21); this selection may have been made indiscriminately to meet the national demand or foreign TSOs demands connected to the platform, in line with the principles of an integrated market. It should be noted that the quantities selected by the PICASSO algorithm to satisfy the demand of TSOs do not correspond exactly to the quantities actually activated and supplied by national resources, due to the dynamics of the secondary reserve regulator and the actual response of resources to the signal, as explained in chapter 1.2.

Finally, Figure 21 reports the difference between the demand submitted to the platform by the TSO and the volumes corresponding to the Italian bids selected by the algorithm; this difference is covered by the implicit netting on the aFRR platform, by the netting with TSOs participating in the IN platform but not in PICASSO, and finally by the import of bids shared by foreign TSOs. The higher volumes in the downward direction can be explained by the greater ATC available in exports than in imports; in fact, both the netting of downward demand and the acceptance of foreign bids in the downward direction correspond to an export flow.

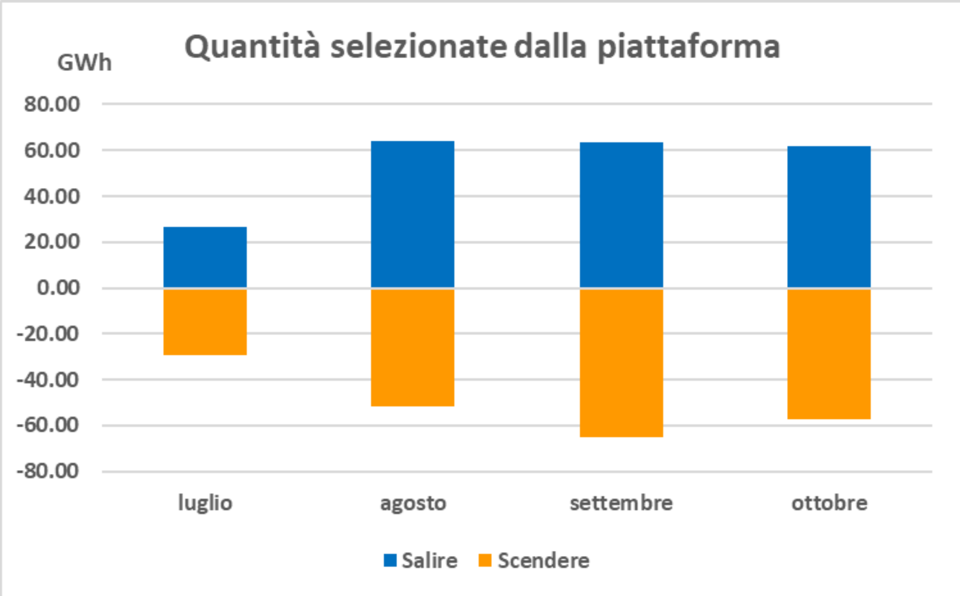


Figure 20 Volumes corresponding to Italian bids selected by the platform upward and downward direction

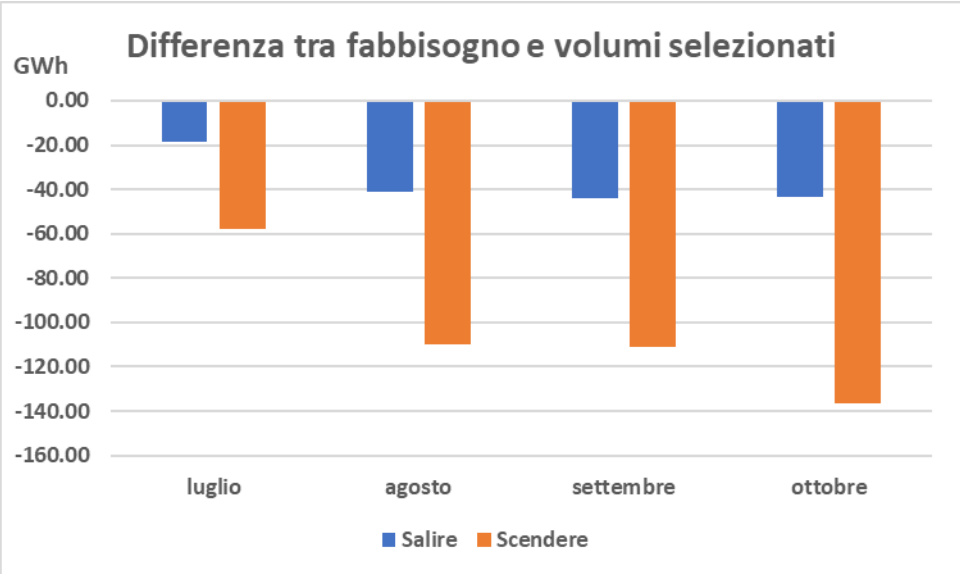


Figure 21 Difference between aFRR demand sent to the platform and bids selected by the algorithm

1.5. Analysis of aFRR market outcomes

Marginal prices resulting from the platform

Marginal prices resulting from the platform were analysed, focusing on situations in which the price was outside the maximum (upward) and minimum (downward) bidding range, with reference to to the bids submitted by Italian BSPs, converted and shared on the platform by the TSO. In the period July - October, this range was € [0 - 445]/MWh.

In the optimisation cycles in which the TSO was connected to the platform (a total of 2,083,665 intervals of 4 seconds each), in 38% of the intervals the price was set by selection of BUY bids, in 40% by selection of SELL bids and in 22% by the netting condition[13].
In the time span analysed, 42,887 intervals with a negative price occurred, corresponding to 5.3% of the intervals with selection of BUY bids. Figure 22 shows the duration curve of negative prices formed for the Italian LFC area as a result of PICASSO. The average value is € -470.87/MWh while the minimum reached is € -9,994/MWh. The values € -16/MWh, € -50.8/MWh, € -161/MWh, and € -950/MWh correspond to the 75th, 50th, 25th, and 10th percentiles, respectively.

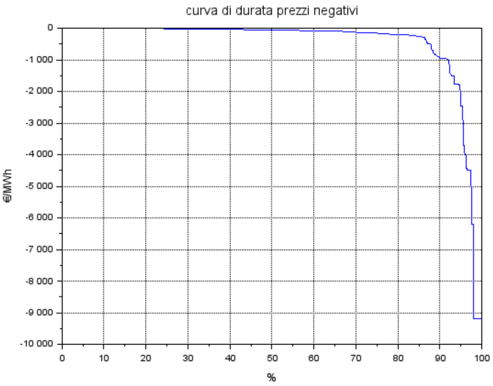


Figure 22 duration curve of negative prices in Italy, as a result of PICASSO

In 1635 occurrences, the negative prices were isolated cases (i.e. they occurred for only one 4s cycle), while the remaining cases are concentrated in 2564 events grouping several consecutive optimisation cycles, the average of which is 16 intervals (about 64 seconds), while the longest event comprises 1183 intervals (about 78 minutes) and occurred on 7 August at 1:42. Figure 23 shows the duration curve of multiple interval events with a negative price (the ordinate scale is limited for ease of reading).

[13] For more details, see the description of the platform's operating principles and its pricing rules

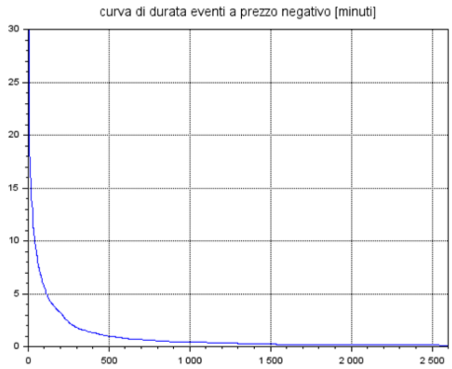


Figure 23 Duration curve of negative price events with a duration of more than 4 seconds

A similar analysis was carried out for the formation of positive prices, above the established threshold (equal to the maximum price of the upward bids shared on the platform, in the July-October period).
In this case, 3,057 intervals with a price above € 445/MWh occurred, corresponding to 0.4% of the intervals with selection of SELL bids. Figure 24 shows the duration curve of prices above € 445/MWh, which occurred for the Italian LFC area as a result of PICASSO. The average value is € 3,108/MWh while the maximum reached is € 15,000/MWh. The values € 5,857/MWh, € 5,070/MWh, € 1,450/MWh, € 560/MWh correspond to the 90th, 75th, 50th and 25th percentiles respectively.
In 384 occurrences, the positive prices above € 445/MWh were valid for only one 4-second cycle, while the remaining cases are concentrated in 371 events grouping several consecutive optimisation cycles, the average of which is 7 intervals (about 30 seconds), while the longest event comprises 56 intervals (about 3½ minutes) and occurred on 12 September at 06:43. Figure 25 shows the duration curve of the events with multiple intervals with a positive price above € 445/MWh.

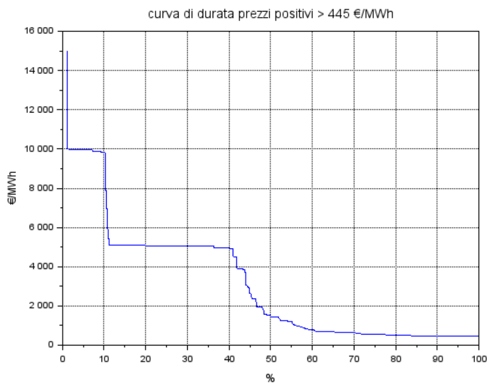


Figure 24 Duration curve of prices above € 445/MWh as a result of PICASSO

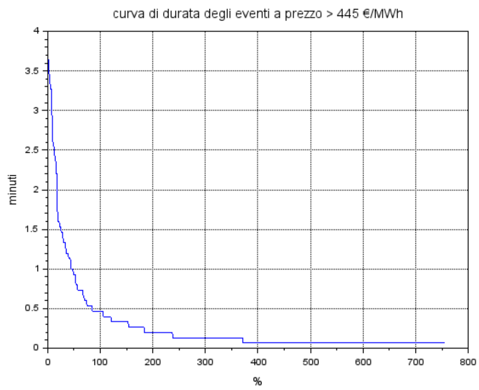


Figure 25 Duration curve of events with a price > € 445/MWh and a duration of more than 4 seconds

Analysis of coupling opportunities

Throughout the time horizon under analysis, coupling possibilities with adjacent LFC areas were analysed in order to identify the intervals in which the marginal price could potentially be set by a foreign bid, at a higher (lower) level than the price of the upward (downward) bids shared on the platform by the TSO, based on the conditions described in chapter 1.4. In particular, for each optimisation cycle in which the TSO was operational on the PICASSO platform, the instantaneous aFRR demand sent to the platform was compared with the aFRR reserve margin procured by the TSO in MSD *ex-ante*[14], in order to assess the residual aFRR margin available for export or the reserve deficit to be imported to meet the aFRR demand, both in upward and downward direction. By then, comparing the residual margin with the ATC available in both directions, it is possible to relate each optimisation cycle to one of the following five conditions: import of SELL bids, export of SELL bids, import of BUY bids, export of BUY bids, 'No coupling', meaning that the conditions theoretically do not allow the Italian system to be included in an uncongested region in which the marginal price is set at a price higher (lower) than the last upward (downward) bid shared by the TSO. Table 6 shows the results of the analyses described.

It should be borne in mind that this characterisation of the intervals is carried out on the basis of the input data to the PICASSO platform and does not take into account the netting opportunities realised with TSOs not yet connected to the aFRR platform but operating on the IN platform (RTE, Swissgrid, Eles), that operates in the intermediate step of the PICASSO algorithm (see chapter 1.2), and which could change the aFRR demands actually satisfied by the aFRR market and thus the final characterisation of the

[14] In this analysis, the term aFRR margin refers to the amount of secondary reserve to be procured as input to MSD *ex-ante* (integrated scheduling process), which may differ from the actual quantities reserved quantities, due to MSD optimisation and unplanned events (e.g. trip of a generator)

optimisation cycle. However, this analysis provides a good indication of coupling opportunities in the aFRR market.

Table 6 Coupling opportunities in an uncongested region with marginal price outside the range of bids offered on the platform by the TSO, based on input data to PICASSO

Type	**Percentage of intervals analysed**
Export SELL bids	6.6%
Export BUY bids	1.3%
Import SELL bids	13.6%
Import BUY bids	25.2%
No coupling	53.3%

Combining this data with the negative price events, it resulted that around 2% of the intervals in which a negative price was formed in Italy were attributable to a condition of exporting BUY bids, while the remaining 98% were attributable to a condition of importing BUY bids, which means that the TSO's demand submitted to the PICASSO platform was higher than the aFRR reserve margin procured in MSD *ex-ante*, and that there was sufficient cross zonal capacity on the Austrian border to import aFRR bids to meet the demand (disregarding the potential effect of the imbalance netting process, which could reduce the aFRR actually required at the last PICASSO optimisation step).

Analysing the exchanges at the Italy-Austria border resulting from the platform (relating only to the exchange of aFRRs or to the implicit netting that occurs in the first step of PICASSO optimisation) in the intervals in which a negative price is formed, it emerges that in 93.6 % of cases the cross border exchange is in export, confirming the prevailing condition of 'import of BUY bids'[15], while in 3% of cases the exchange is in import.

On the other hand, as regards the intervals in which positive prices greater than € 445/MWh occurred, 3% of the cases can be attributed to the condition of export of SELL bids, 47% to condition of import of SELL bids and the remaining 50% to 'no coupling' conditions. In most of the latter cases, the price was determined on the basis of the perfect netting situation, described in chapter 1.2, i.e. within the uncongested region neither upward nor downward bids would be selected; therefore the price should be set by the average of the prices of the first upward bid and the first downward bid available in the uncongested region. The outcomes of the platform seems to be incoherent with the

[15] Importing downward bids results in an export exchange at the border

approved and published pricing rules, and it is unclear how in a netting condition a price above the available bids that should not have been accepted could be determined.

Similarly to what was done for the negatively priced intervals, the transits at the platform were analysed to assess the consistency between price formation and congestions. In 36% of the intervals there is an export cross zonal exchange, in 33% there is an import cross zonal exchangeand 31% of no transit. Compared to the case of negative prices, the number of cases in which the Italian price is set by a foreign bid in the presence of zero transit is significantly higher, confirming the need for further investigation into price formation mechanisms.

1.6. Analysis of aFRR demand and dimensioning of reserves

In light of the fact that almost all of the negative-price events and a large portion of the positive-price events above the maximum price offered in Italy occur in a situation in which the TSO sends to the PICASSO platform a demand for aFRR exceeding in the aFRR reserve margin procured in MSD *ex-ante,* the events in which this occurs were analysed, to understand the magnitude of the deviation and its duration over time. The deviation in each optimisation cycle is calculated as the difference between the absolute value of the demand and the aFRR reserve margin procured in the same direction of the demand.

Over the time horizon analysed, in 43% of the intervals where the aFRR demand was negative, this demand was higher than the aFRR reserve margin procured (Figure 26). The average value of the positive deviation is 307 MW and the maximum value is 2165 MW. With regard to the intervals in which the aFRR demand is positive, a surplus with respect to the aFRR reserve margin procured in MSD *ex-ante* occurred in 33% of the cases. The average value of the positive deviation is 260 MW and the maximum value is 1871 MW.

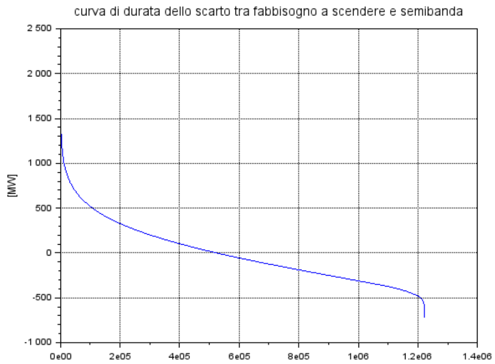


Figure 26 Deviation duration curve between downward demand and relative aFRR reserve margin

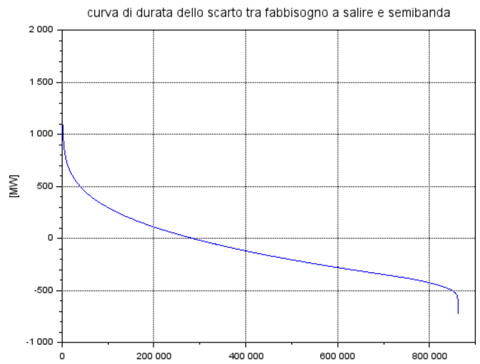


Figure 27 Duration curve of the gap between upward demand and relative aFRR reserve margin

Analysing the events (an event consists of a single 4-second interval or a set of consecutive intervals), in which the negative demand exceeds the reserve margin, 21,547 events were identified, of which 7,384 were single intervals and 14,163 events with multiple intervals; the average duration of events with multiple intervals is about 2 min., while the maximum duration is about 157 minutes, which occurred on 4/08/2023 starting at 21:27. In total, 246 events with a duration of more than 30 minutes occurred during the months under analysis (average duration of events 45 minutes).

Similarly, for situations in which the demand is positive, 33% of cases were identified in which the demand sent by the TSO exceeded the reserve margin, grouped into 13,991 events including 5,043 events with single intervals and 8,948 events with multiple intervals, the average duration of which is about 2 minutes and the maximum duration of 75 minutes, on 4/08/2023 from 14:03. A total of 69 events with a duration of more than 30 minutes were identified (average duration of events 38 minutes).

Focusing on situations in which the demand sent to the platform is negative, no specific correlation was identified between the value of the negative prices determined on the platform and the value of the gap between demand and reserve margin, confirming that the market outcome depends on many external factors, including the demands of other TSOs, available bids, available ATCs and netting opportunities.

In view of the large number of cases in which the aFRR demand is greater than the half-band value as an input to MSD, it is deemed appropriate to examine in greater detail how the secondary reserve and, more generally, the reserves aimed at balancing are dimensioned, in order to verify that the minimum requirements established by the SOGL Regulation and the LFC Block Operational Agreement (LFCBOA) according to Article 119 of the SOGL Regulation are met. A preliminary analysis carried out on the amount of aFRR reserve margin in input to the MSD *ex-ante* procurement process shows that, at least over the past three years, there has been a general reduction in the average reserves procured, at least for the aFRR (Figure 28) and the total upward reserve (tertiary reserve + aFRR) upward (Figure 29).

This aspect is not negative per se, and could be a consequence of the optimisation of dispatching costs implemented as a result of the incentive scheme under Resolution 597/2021/R/eel, provided that the reserve margins dimensioned and procured are in line with the criteria of the SOGL Regulation. In this regard, however, it seems appropriate to proceed to investigate the reasons for this trend and to verify compliance with the regulatory framework.

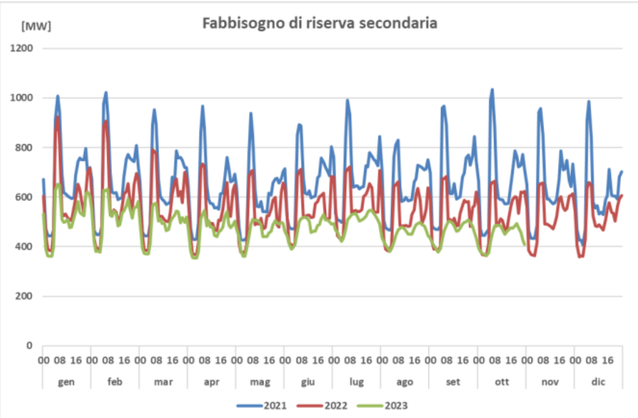


Figure 28 monthly average of aFRR hourly reserve margin procured over the last three years

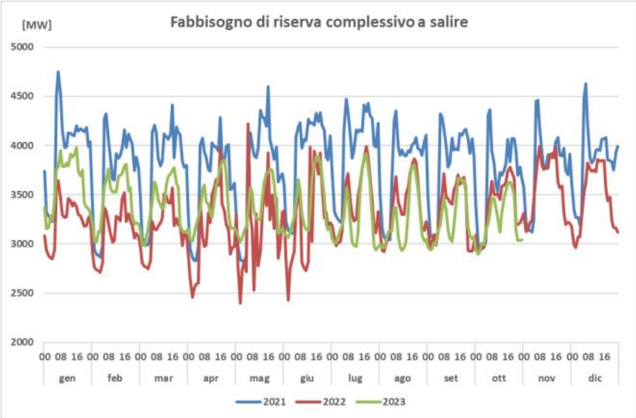


Figure 29 monthly average of total upward hourly reserve margin over the last three years

Pursuant to Article 157 of the SOGL Regulation, the TSOs of an LFC block must establish, within the LFC Block Operation Agreement (LFCBOA), the criteria for dimensioning the overall FRR reserve margins (which includes aFRR and mFRR) and the ratio between automatic and manual reserve such that:

- the target frequency quality parameters defined in Article 128 of the Balancing Regulation are met;
- FRR reserve margins are at least equal to the dimensioning incident (both positive and negative);
- they are sufficient to cover the imbalance of the block 99% of the time;

According to Article 160 of the SOGL Regulation, the TSOs of an LFC block may establish sizing criteria for the RR reserve, if the use of this process is envisaged. The RR reserve must be such that:

- there is sufficient margin to restore the required FRR;
- there is sufficient margin to comply with the frequency quality targets of Article 128 if the RR is taken into account for the dimensioning of the FRR.

In the Italian context, the LFC Block corresponds to the LFC Area and the only TSO responsible for dimensioning is Terna . The LFCBOA was approved by ARERA with Resolution 202/2020/R/eel.

In particular, the LFCBOA provides for the minimum sizing of the aFRR in accordance with what is prescribed in the synchronous area operational agreements (under Article 139 of the SOGL Regulation) and in line with the recommendations therein, according to the empirical formula:

$$aFRR = \sum_i \left(\sqrt{a * L_{max,i} + b^2} - b\right)$$

Where $L_{max,i}$ is the maximum expected load for aggregate i belonging to the LFC block in the period under consideration, a is a parameter equal to 10 MW and b is a parameter equal to 150 MW.

The dimensioning of mFRR shall be based on a probabilistic methodology such that, for both positive and negative reserve capacity, the overall value of FRR (understood as the sum of the value of mFRR and the calculated value of aFRR (positive and negative)) is sufficient to comply with the FRCE target parameters set out in Article 128.

In accordance with Article 160(3)(a), the RR reserve capacity of the aggregation of zones pool is dimensioned to be sufficient to restore the required amount of FRR. Furthermore, in accordance with Art. 157(2)(h), the FRR and RR reserves are sized to cover the positive imbalances of the LFC block in at least 99% of the cases, based on the historical data referred to in Art. 157(2)(a).

Even assuming that the dimensioning is fully in line with the provisions of the SOGL Regulation, the way in which the total reserve is allocated between aFRR, mFRR and RR may have totally different effects on the PICASSO platform outcomes.

Prior to the start of operations on the PICASSO platform, an instantaneous demand of aFRR in excess of the aFRR reserve margin procured would have resulted in the total activation of the procured margin and the inability of the system to restore to zero the network error (i.e. the deviation of scheduled exchanges at the border, or area control error - ACE), in the absence of further balancing actions (e.g. through the activation of manual reserves). In the time in which the network error is not driven to zero, deviations are counted as unintended exchanges at the border and settled between TSOs according to the methodology developed under Article 50 of the Balancing Regulation. The participation in the IN platform, launched by Terna in January 2020, can mitigate this deviation to some extent, as in real time the aFRR demand is instantaneously reduced by the netted quantity, reducing possible unintended deviations. Thus, in the past, the reduction of aFRR reserve margins (still in the respect of the dimensioning principles) and the increase of situations with demand exceeding the reserve margin would only have led to a potential increase in unintended exchanges, which could be managed with timings longer

than the aFRR activation time, by activating manual reserves.

On the contrary, with participation in the PICASSO platform, the Italian system is no longer isolated, but participates in an integrated market in which demands and bids are satisfied through common merit orders; in the event of demand exceeding the reserve margin procured, the surpluses do not automatically increase the network error as unintended exchanges, but the TSO automatically finds further bids to meet its own demand, until the common merit order is exhausted. In this new context, the choice of margins procured and shared on the platform can impact the market outcomes, and the choice between how much demand to be met instantaneously with automatic reserves and how much through slower manual reserves, which can be activated within the frequency restoration time-frame, can no longer be a mere operational management choice of the system by the TSO.

4. CONCLUDING REMARKS

From the analyses carried out on the reference period (July - October), it clearly emerges how the occurrence of abnormal imbalance prices with respect to the first months of the year, and in particular with respect to the period prior to the start of operations on the PICASSO platform, are due to positive and negative price spikes as a result of the aFRR platform. The formation of abnormal imbalance prices affected both macro-zones, with a greater impact on prices for macro-zone with long conditions, which also became strongly negative.

Analysing the TSO's operations on the PICASSO platform during the reporting period, it emerged that:

- the TSO sent to the PICASSO platform a higher downward demand than the upward and, from the conversations held, the TSO confirmed that this is a rather generalised trend (and therefore not limited to the months under investigation), due to the growing penetration of non-programmable renewable energy sources and distributed generation, which tend to create surplus in the transmission grid. This asymmetry in aFRR demands, however, is not reflected in the profiles of unintended exchanges at the border (i.e. the Area Control Error - ACE, which is monitored for frequency quality in accordance with the SOGL Regulation), since the opportunities for netting a downward demand are greater for the Italian system, thanks to the larger availability of cross zonal capacity in export (please note that the netting of a downward demand corresponds to an export flow; since Italy is an importing system, following the energy markets the capacity available in exports is much higher than that in imports). The effect of real-time netting is an immediate reduction in the residual aFRR demand, which has to be covered by reserve activations. This effect is also confirmed by the operating data of the IN (Imbalance Netting) platform.
- The formation of negative marginal prices for the Italian LFC area always occurs as a result of the convergence in the same uncongested region of two or more LFC areas (please note that the only border that interconnects Italy with the other countries on the aFRR platform is the Italy-Austria border); almost all of the events are due to the situation of downward demand higher than the reserve margin procured and shared on the platform, with the consequent import of foreign bids, purchased at any price (at the moment TSOs cannot express a price indication for their demand). The greater the demands of TSOs within an uncongested region, the higher the risk of selecting bids in the merit order queue with very negative prices.

- By contrast, the formation of positive marginal prices above the maximum price of Italian bids is more complex to characterise. In around half of the events, the price appears to be determined under perfect netting conditions (no selected bids within the uncongested region), but this is inconsistent with the availability of unselected bids at lower prices. This evidence calls for further investigation into the pricing rules on the PICASSO platform and their implementation in practice.
- In most of the optimisation cycles in which the Italian system was connected to the platform, the aFRR demand sent by the TSO was higher than the reserve margin procured in MSD ex-ante and shared on the platform (over 40% of cases in which the demand was negative and over 33% of cases in which it was positive). These situations occur either in single isolated intervals or as prolonged events over several consecutive intervals. The latter case seems more relevant and lasting when the demand is negative, reaching in many cases more than 30 minutes with peaks of more than one hour.
- Considering the decresing trend in the reserves procurement, as identified in the preliminary analyses, the competent offices of ARERA should be mandated to investigate this aspect in more detail, checking the reserve margins procured as a result of ex-ante MSD and their use in real time over a sufficiently long period, to analyse in detail the aforementioned trend as well as the punctual compliance with the provisions of the Electricity Regulation, the Balancing Regulation, the SOGL Regulation, the LFCBOA and/or the national Terms and Conditions;
- It is also deemed necessary to ask the Terna to provide additional information on the phenomenon of persistent deviations of aFRR demand, on the possible impact of the reduction in the secondary reserve procured, and on possible mitigations through a different dimensioning of reserves and/or a different use of reserves during real time operations (e.g. prompt activation of manually activated reserves); the analysis must take into account the ongoing analyses carried out at Continental Europe synchronous area level, concerning the definition of the minimum activation time for limited energy systems;
- The presence of bids sent by foreign BSPs to their respective TSOs at very high or very negative price levels cannot be the subject of this investigation and of direct rulings by ARERA towards foreign BSPs, but may be the subject of a report to the responsible parties (foreign regulators, ACER) also in accordance with Article 16.2 of REMIT.
- The formation of abnormal prices on the platform, both positive and negative, is not in itself an indication of a shortage of reserves in general, but rather would seem to be the consequence of applying a market model to a process historically conceived and managed by the majority of European TSOs with different logics.

In actual fact, a TSO is allowed to size the ratio between automatic reserve aFRR and manual reserves (mFRR and RR) such that the SOGL criteria are met; the exhaustion of the automatic reserve does not implicitly mean that resources are scarce, as the TSO can proceed with manual activations with a slower activation time.

- In the past, ARERA had defined the rules for calculating imbalance prices by excluding prices and volumes activated for aFRR, considering them not indicative of the value of energy in real time, given the TSO's operating methods, which dispatch the system in a centralised and proactive manner on the basis of the expected imbalance in real time. The implementation of the Balancing Regulation and the methodology for harmonising the components for the imbalances settlement required the reintroduction of prices and volumes of aFRR activations, in order to comply with the boundary conditions laid down in Article 55 of the Balancing Regulation. However, in the light of the investigations carried out, it is clear that the imbalance price determined in this way risks to transfer an incorrect signal: the possible price spikes do not in fact signal an actual scarcity since they do not take into account the availability of other types of reserves available to the TSO.

1.7. Possible mitigation measures

On the basis of the evidence that emerged during the inqury, measures were identified to mitigate the formation of positive and negative price spikes on the aFRR platform and their impact on the settlement of national imbalances. They are aimed at minimising situations of excess demand over bids shared in the platform, which, as seen, constitute the majority of the events analysed.

- **Increased sharing of national resources on the PICASSO platform** - a first approach to implement this measure is to increase the dimensioning of the aFRR procured, ensuring higher margins out of MSD ex-ante which will then be converted into standard aFRR products on the PICASSO platform. Another approach, potentially complementary to the first, is to allow the participation in PICASSO platform also to resources not reserved in ex-ante for the procurement of reserve margins; in fact, as described in chapter 1.3, the bid conversion process currently implemented by the TSO envisages only the sharing on the aFRR platform of the quantities reserved in the ex-ante MSD; all other resources are in fact precluded from offering on the platform and competing to meet TSOs demands, as additional bids in addition to those normally procured by TSOs (referred to as "free bids"). This aspect had been considered by ARERA when approving the coordination framework between the MSD and the aFRR platform, and for this reason, Resolution 115/2023/R/eel mandated the TSO to monitor the impact of the participation methods adopted on market participants , also assessing different implementation solutions for the future, such as a full implementation of the merit order model at national level.

A larger availability of resources on the platform would lead to a larger supply pool, mitigating the risks of activation of resources in the queues of the merit order. A similar effect could result from the entry of additional TSOs into the platform, which would bring additional liquidity into the common merit order and additional cross zonal capacity on several borders. However, this measure is not under control of ARERA or the Terna and depends solely on the implementation time-line of foreign TSOs whose accession deadline would be 24 July 2024, but who, also in light of the prices recorded on the platform, are in some cases delaying the go-live, pending the adoption of the mitigation measures proposed at European level.

- **Lower aFRR demand sent to the platform** - reducing demand on the platform mitigates both PICASSO outcome prices (with lower demand there is a lower probability of selecting bids in the merit order queues) and the related effect on national imbalance prices, as activation prices are weighted by the relative demand. The proposed amendment to the aFRR implementation framework drawn up by the TSOs at the European level, which envisages the possibility of using an elastic demand for the portion exceeding the locally dimensioned aFRR, could be a good solution and allow many price spikes, especially negative ones, to be mitigated. Through this instrument, the TSO could purchase from the platform without a price indication only a volume equal to the shared bids; any exceeding demand could be met through the platform, if economically viable, or remain with the network error and be met through manual reserves. The measure makes it possible to apply the logic of dimensioning and substitutability between reserves, preventing a TSO from having to meet its instantaneous aFRR demands at any price. It should be pointed out that this measure does not systematically prevent price spikes from occurring, as there is still the possibility of converging within an uncongested region with a price set abroad (e.g. the ‘export BUY’ situation). However, coordinated use by all or many TSOs operating on the platform could effectively contribute to risk mitigation.