Description of concepts for balancing and the balancing markets in Germany

Explanatory document of the German transmission system operators

January 2025

Content

1 Management Summary

To ensure the stable operation of the power system, the electricity feed in and withdrawn from the grid must be balanced continuously. The system balance must be constantly monitored and, where necessary balance the generation and consumption (target/actual deviations), corrective actions must be taken to balance the system. The load frequency control process for the four German control areas is organized by the German transmission system operators (hereinafter "the TSOs").

At the end of 2017, Regulation 2017/2195 (EU) establishing a guideline on electricity balancing (commonly referred to as the Electricity Balancing Guideline [EB Regulation]) entered into force. The EB Regulation aims to create a functioning and liquid cross-zonal internal balancing market. According to Article 60(1) EB Regulation, each TSO has to publish a report on balancing covering the previous two calendar years at least once every two years thus providing a description of developments and market indicators. The TSOs comply with this requirement of the EB Regulation with this explanatory document, which provides a comprehensive overview of the concepts of balancing and the balancing markets established in Germany.[1]

The German TSOs have been organized in the Grid Control Cooperation (GCC) for several years. The GCC is based on the principle of cooperation between the TSOs in all areas of balancing. For example, a joint determination of the necessary reserve capacity (dimensioning) is carried out in Germany, which is procured via a joint platform, as well as a cost-optimized activation if after netting any imbalances remain. It thus appears that the biggest saving potential in the field of balancing at the national level has already been unlocked within Germany. However, the TSOs are constantly working on improving individual processes, such as the opening of the balancing markets for new consumers and suppliers. During the past few years, the imbalance settlement pricesettlement has been further developed and the financial incentives for balancing responsible parties to balance their balancing groups have been tightened. Furthermore, a core element of the EB Regulation was implemented with the connection to the balancing platforms MARI and PICASSO, which are also operated by the German TSOs Amprion and TransnetBW. This leverages further saving potential through international cooperation. Along with the implementation of the associated product and market design the European target market design for balancing energy was largely introduced in Germany, especially 15-minute products, 25-minute gate closure time (GCT) and the marginal price procedure. The level of competition in the integrated balancing energy market did not improve noticeably due to the delayed accession of European TSOs in the period under review. ACER reflected this in its decision

[1]According to the approved proposal of all TSOs of the synchronous area Continental Europe for the determination of load frequency control area blocks (BNetzA decision BK6-18-024), Luxembourg is part of the LFC area Amprion/Creos. Therefore, this report also covers balancing in Luxembourg.

to set an automatically adjusting upper price limit and set a value of 15,000 EUR/MWh temporarily (until July 2026) and as a starting point for the automatic adjustment (from July 2026 onwards). In the area of balancing capacity, the TSOs are taking as well further steps towards the voluntary European market integration and support the exchange of balancing capacity both in the FCR cooperation, in the ALPACA project and with the implementation of a harmonized market-based methodology for the reservation of cross-zonal transmission capacity to ensure the further integration of the European balancing markets. A noticeable effect of the tenders for balancing capacity is increasing costs during sunny times, when negative wholesale prices often lead to high opportunities for the provision of (mostly upward) balancing capacity and thus to high clearing prices. The integration of photovoltaics in the balancing capacity markets may counteract this.

2 Introduction

A constant balance between electricity being fed into and withdrawn from the system is required to ensure the stable operation of the power system. As this balance is subject to fluctuations in both generation and consumption, it needs to be continuously monitored and, where necessary, corrective measures need to be taken to balance the system. The transmission system operators (TSOs) are therefore tasked with balancing it[2]. In Germany, this includes the provision and activation of three types of balancing services: frequency containment reserve (FCR), automatic frequency restauration reserve (aFRR) and manual frequency restauration reserve (mFRR). If balancing is not possible despite the extensive use of these balancing services, TSOs can also use contracted interruptible loads, the capacity reserve and emergency balancing contracts with foreign TSOs (Mutual Emergency Assistance Service, MEAS) as well as trade scheduled energy at the power exchange to support balancing. While the adjustments to electricity generation, electricity transits and electricity withdrawals in accordance with §13 (2) EnWG enables further emergency measures. Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (EB Regulation) was published at the end of 2017 in the Official Journal of the European Union. The guideline aims to establish a liquid cross-zonal internal market, including balancing. It contains direct requirements on the balancing capacity and balancing energy markets as well as the imbalance system to be implemented by the TSOs of the member states.

[2]The terminology "Balancing" is adopted from the EB Regulation. In addition to the term balancing, the topic is often addressed using other terms such as load frequency control, frequency control or balancing energy system.

Article 60(1) EB Regulation requires each TSO to publish a report on balancing at least once every two years covering the previous two calendar years. In 2019, such a report was published for the first time. German TSOs meet this requirement of the EB Regulation with this updated report providing a comprehensive overview of the concepts for balancing and the balancing markets in Germany and deals with European aspects. The quantitative analysis provided covers a period of two years starting in January 2022. The report was, moreover, prepared to provide a compact and complete overview of the subject matter (as of December 2024) to give. In addition, this report includes a description of the current cooperations at a European level as well as an outlook of the future cooperations with other TSOs in the field of balancing and the balancing markets.

3 Legal and regulatory framework

In addition to maintaining the grid infrastructure for the long-distance transport of electrical energy, the provision of system services being indispensable for the secure operation of the power system is one of the most important tasks of the TSOs. Among these system services, system balancing stands out not only because of its technical complexity, but also because of its considerable cost relevance and the interactions with the segments of electricity generation and electricity distribution. As a result, the balancing markets as well as the imbalance settlement price system are subject of intensive regulation.

The regulatory framework for frequency control is currently provided by the following regulations and resolutions:

- At the European level, the requirements for system balancing are based not only from fundamental requirements in the Regulation on the Internal Electricity Market (Regulation (EU)[3]) but also on the guidelines on the topics of "System Operation" (SO Regulation)[4] as well as "Electricity Balancing" (EB Regulation)[5]. Both guidelines entered into force as EU regulations in 2017.
- The guideline on Electricity Balancing (EB Regulation) aims to establish a liquid cross-zonal internal balancing energy market and the harmonization of the national balancing markets. It therefore contains direct requirements for the national balancing markets to be implemented as well as the internal EU balancing energy market. Based on the EB Regulation, numerous methods were developed by the European TSOs and approved by ACER or the national regulatory authorities,

[3]Available at https://eur-lex.europa.eu/legal-content/DE/ALL/?uri=CELEX:32019R0943

[4]Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32017R1485

[5]Available at https://eur-lex.europa.eu/eli/reg/2017/2195/oj

which together form a very narrow legal framework and lead to largely harmonized products and processes. These include in particular:

  - the implementation frameworks for imbalance netting, aFRR and mFRR, which define not only rules for the platforms for the exchange of balancing energy (MARI and PICASSO) but also the standard products for aFRR and mFRR,
  - the pricing methodology for balancing energy
  - the standard products for balancing capacity
  - the terms and conditions for balancing service providers
  - the methodology for the harmonization of the main features of the settlement of imbalances the methodology for harmonized rules on the allocation of cross-border capacities for the exchange of balancing capacity

- The system operation guideline (SO Regulation) establishes harmonized requirements for the grid operation with the objectives of creating a legal framework for grid operation, facilitating electricity trading in Europe, and ensuring system security.
  - The national legal framework deals with issues on the topics of the balancing services and imbalance energy not only in the specialized Electricity Grid Access Ordinance (Stromnetzzugangsverordnung - StromNZV) but also directly in the Energy Industry Act (Energiewirtschaftsgesetz - EnWG). There, in addition to general principles, e.g. For example, the system responsibility of the operators of transmission system is defined as well as specific requirements for the market-based procurement and provision of balancing services specific regulation at the legislation level which stands out in relation to other system services underlines the importance of balancing. On this basis, the StromNZV sets out more detailed requirements for the procurement, provision, and settlement of this system service. The Renewable Energy Sources Act (Erneuerbare Energien Gesetz - EEG) specifies additional regulations on the participation of electricity generation plants in balancing markets based on renewable energies.

In addition to the specified legal provisions and in line with the above methods, the TSOs draft and continuously further develop prequalification requirements. Potential balancing service providers for the different types of balancing services can participate in a non-discriminatory prequalification process, where they demonstrate that they meet the requirements necessary to ensure the security of supply for the provision of one or more types of balancing services.

The concepts (technical concept and IT concept) for all balancing service types (FCR, aFRR, mFRR) are released jointly by the TSOs. The pool is then prequalified by the TSO in whose LFC area the relevant technical units (electricity generation units and/or demand units) are connected to the grid independent of the voltage level (connecting TSO). Since 2018, reserve units and reserve groups have been prequalified. As soon as the prequalified marketable capacity exceeds the respective minimum bid size, the connecting TSO concludes a framework contract with the reserve provider for each balancing service type, which in turn is a prerequisite for participation in the tendering processes for balancing services. A prequalification is possible at any time. The relevant documents such as PQ conditions, model contracts or supporting documents such as guides can be found on the regelleistung.net platform here.

- The EB Regulation also impacts the role of the German Federal Network Agency (Bundesnetzagentur - BNetzA) concerning balancing market rules, which are now largely defined by the European regulations and regulatory authority (Agency for the Cooperation of Energy Regulators - ACER). The EB Regulation provides the framework for TSOs on how to make proposal for changes in the field of balancing, for the consultation of stakeholders as well as for the approval by the competent national regulatory authorities. In the case of national proposals, BNetzA has to approve. Regional proposals must be approved by all concerned national regulatory authorities. Until entry into force of the ACER regulation, all TSO proposals had to be approved by all national regulatory authorities. Since then, ACER has been the competent authority for all TSO proposals.
- The Network Code Demand Response (NC DR) is currently being developed. The TSOs expect the entry into force of the NC DR by the end of 2025 / beginning of 2026. According to Article 59(1)(e) of the Internal Electricity Market Regulation, the NC DR is to establish rules for load response, including aggregation, energy storage and load limitation. The Framework Guideline published by ACER and the consulted draft of the NC DR suggest that the NC DR will contain far-reaching regulations that relate to balancing services and the system services voltage control and grid congestion management.

This demonstrates the complexity of the legal and regulatory framework of relevance for balancing. It also demonstrates procurement, provision, and settlement of these system services being subject to continuous development.

4 Grid access model

4.1 Organization of system balancing

The stable operation of the power system requires to balance between feed-in (generation) and withdrawal (consumption, incl. transport losses) of electrical energy in the overall system at all times, or the restoration of the balance within a few seconds after deviations from the equilibrium. Excess electrical energy that is fed into the grid cannot be stored directly and even the grid itself cannot store energy. While indirect storage in pumped storage power plants, battery storage systems or using other storage technologies is feasible, it can only be realized to a limited extent in the current power system.

The users of the power system are thus dependent on the system balance being monitored in real time and on it being balanced by means of suitable control systems. For this purpose, the control systems must have access to controllable feed-in or controllable consumption to be able to deliberately influence the system balance.

From a technical point of view, keeping the system in balance corresponds to keeping the system frequency in a very narrow range around the target value of 50 Hz, as shown in Figure 1.

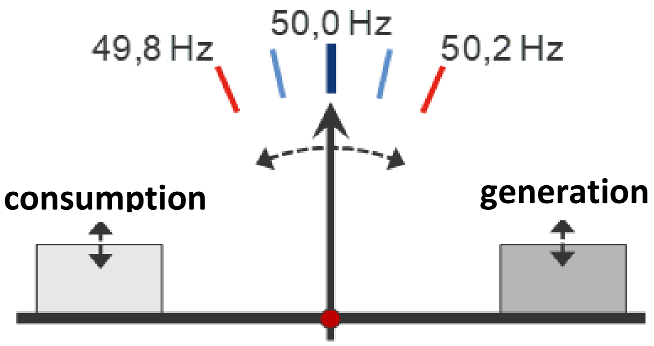

Figure 1: Need to balance consumption and generation in the power system to maintain the target frequency of 50.0 Hz

The occurrence of deviations between feed-in and withdrawals and thus of imbalances in the system balance cannot be prevented by precise advance planning as neither the consumption by individual consumers or collectives of consumers, nor the feed-in by electricity generation units - especially those based on volatile renewable energies (e.g. wind and sun) – can be precisely forecasted. The active continuous control of imbalances is therefore essential for the stability of the power system.

In Germany, the Energy Industry Law specifies that the TSOs operating their load-frequency control (LFC) areas are responsible for the system balance. Therefore, each TSO operates a load frequency control area, within it continuously balances by activating and coordinating various control mechanisms. Chapters 4 and 5 cover the technical implementation of this concept and the procurement of the necessary balancing services in more detail. The optimization of the procurement of balancing capacity is carried out by the ALPACA cooperation. In addition, the TSOs are organized in the Grid Control Cooperation (GCC) , within which they technically and economically optimize the activation of balancing energy and the provision of balancing capacity. The details on this cooperation are described in section 4.3. With the participation in the platforms Imbalance Netting, MARI and PICASSO, TSOs reduce the costs of activating balancing energy by netting and the exchange of balancing energy with their European neighbours. How the platforms work is explained in more detail in section 4.4.

4.2 Balancing system

Electricity balancing is defined within the German energy law framework as a joint task of all German TSOs. Each TSO is responsible for balancing in its control area according to its role defined by the Energy Industry Law. Costs for balancing capacity are settled to all connected grid users and costs for balancing energy are settled to balancing responsible parties by their imbalance energy.

To implement this task and to enable a cause-based settlement of the balancing costs, generation/storage operators, electricity suppliers, large-scale consumers and electricity traders form balancing groups within an LFC area, in which the feed-in, electricity trading quantities and some withdrawals for which they are responsible, or those they supply consumers are bundled. Every feed-in, withdrawal and traded volume in an LFC area must always be assigned to a balancing group to ensure complete balancing. A balance responsible party (BRP) is responsible for the management of each balancing group.

By aggregating the metered values for all feed-ins and withdrawals within a balancing group and considering any mutual deliveries between the balancing groups, the TSO responsible for an LFC area determines the imbalance for each balancing group and for every balancing period (15 minutes) at the end of each delivery month has. A balancing group's imbalance corresponds to the balancing energy which the balancing group has used or supplied.

According to the national Electricity Grid Access Regulation (Stromnetzzugangsverordnung - StromNZV) and the terms and conditions for balancing responsible parties (T&Cs for BRPs - BRP contract), the BRPs are obliged to ensure that they are balanced every ISP. The rights and obligations of the BRPs are fixed in the T&Cs for BRPs, which was approved by the BNetzA in April 2019 and entered into force on 1st August 2020. The T&Cs for BRPs meet the requirements of Article 18(6) EB Regulation. Among other things, this defines the fundamental responsibility of the BRPs to strive to be balanced.

However, due to forecast deviations and other issues, inevitable imbalances occur and consequently a need for balancing energy. A BRP that has withdrawn imbalance energy from the system is referred to as under-supplied. A BRP that has fed in imbalance energy to the system is referred to as over-supplied. The sum of the imbalances of all BRPs in an LFC area equals the imbalance in the LFC area. Like the individual BRPs, the LFC area is identified as undersupplied if it withdraws more imbalance energy than it feeds in; in the opposite case, it is referred to as over-supplied.

The balancing energy utilized by a BSP is settled by the respective TSO with the BRPs based on an imbalance settlement price, determined for each ISP, and multiplied by the respective BRP's imbalance. This price, which can be positive or negative, is applied uniformly nationwide for all imbalance energy quantities (over-supplies and under-supplies). In principle, the imbalance settlement price settles the costs that the TSO incur due to the activation of balancing energy in the respective ISP (see section 7.2).

The volumes of the positive and negative imbalances settled for an ISP are generally far greater than the balancing energy activated during the same ISP, since both positive and negative BRP imbalances occur in practically every ISP. The BRPs therefore provide each other with imbalance energy and balancing energy only has to be activated to cover the remaining imbalance after netting all BRPs' imbalances.

4.3 Grid Control Cooperation

The German TSOs jointly operate the German balancing market. To do this, they use the concept of the Grid Control Cooperation (GCC), which provides four modules of cooperation:

1. Avoidance of counter activations of balancing energy

It is inherent in the system that there are times when individual control areas have a deficit, while other control areas have a surplus at the same time. Without the GCC, the balancing energy in each control area would be activated independently of each other with different signs. The goal of module 1 is to avoid the counter activation of balancing energy through the controlled and targeted netting of imbalances between the German control areas. The saving potential lies in the reduction of the activation of balancing energy (aFRR and mFRR) and the associated costs. The imbalance netting of balancing requirements was extended to our European neighboring countries via the IGCC project. As soon as all countries of the IGCC have joined the PICASSO platform, PICASSO can completely take over the functionality of the IGCC.

2. Common dimensioning of reserve capacity

The objective of Module 2 is the joint, cross-control area dimensioning of reserve capacity and thus the reduction of the balancing capacity to be procured and the associated costs. The dimensioning is identical to an artificial German control area.

3. Joint Procurement

Module 3 enables the German TSOs to procure balancing capacity across the inner-German control area borders. The saving potential lies in the cost reduction through direct competition between the providers in an all-German market as well as in the reduction of the technical effort w.r.t. submission of bids for the BSPs through a joint platform.

This module is also transferrable to our neighboring countries. Using the example of the joint procurement of aFRR balancing capacity with the Austrian TSO APG, the German TSOs have shown that the advantages of joint procurement can also be realized on a cross-zonal basis. You can find more about this under ALPACA.

4. Cost-optimized activation of balancing energy

The objective of module 4 is the cost efficient optimization of the activation of balancing energy across all control areas. The saving potential lies in the reduction of the costs for activated balancing energy. For this purpose, all balancing energy bids from all German control areas are listed in a common merit order list. The imbalances of all control areas are netted and the remaining imbalances (GCC Balance) are covered by utilizing balancing energy bids from the common merit order list. The new European platforms MARI and PICASSO also work according to this principle.

4.4 European platforms

In 2022, the European platforms for the optimization of the deployment of balancing energy were put into operation. The platform for the optimization of the activation of aFRR is called PICASSO (Platform for the International Coordination of the Automatic Frequency Restoration Process and Stable System Operation). The platform for the optimization of mFRR activation is called MARI (Manual Activated Reserves Initiative).

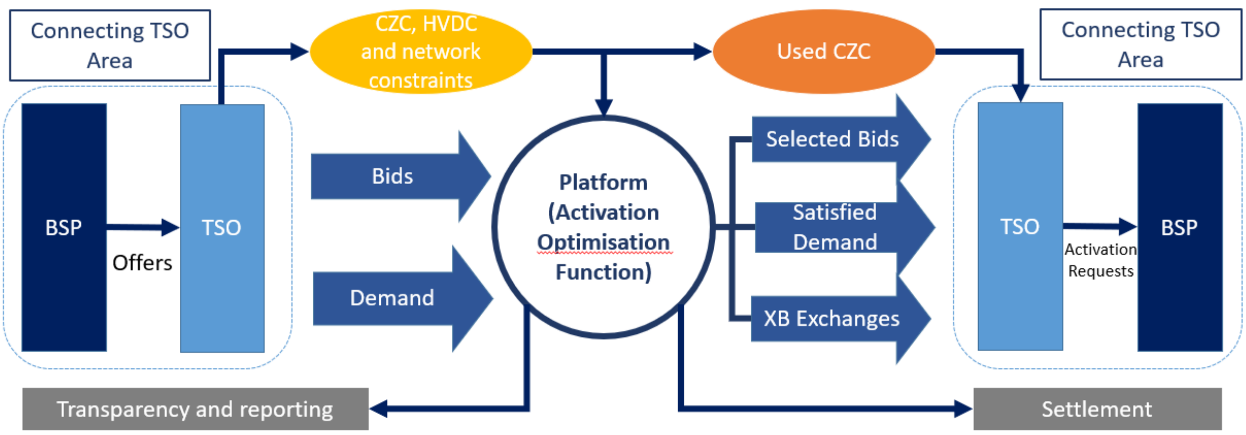

Figure 2: Schematic representation of an optimization platform for balancing energy activation

The European balancing platforms (see Figure 2) are based on the TSO-TSO model. This means only TSOs interact there. Balancing service providers (BSPs) only interact with their connecting TSO – i.e. submit their balancing energy bids and receive activation signals. TSOs forward their local merit order lists, available cross-zonal capacities and demands to the activation optimization function (AOF) of the respective balancing platform. The AOF combines all local merit order lists to a common merit order list (CMOL) and determines the total cost minimum activation volume based on the demands and side conditions (available transmission capacity). The result is the covered demand for each TSO, the volume of the selected bids per TSO and the exchange volumes, which form the remaining cross-zonal transmission capacities. The TSO then activates the set of balancing energy bids according to the results of the respective platform and sends corresponding activation signals to the connected BSPs. The balancing energy exchanged via the balancing platforms is settled between the participating TSOs, the activated balancing energy is settled by the connecting TSO with the connected BSP.

5 Implementation of the load frequency control

5.1 Requirements for the load frequency control

As explained above, the feed-in and withdrawal of electrical energy in the power system must be balanced at all times. In principle, the system balance is achieved by continuously adjusting the activated reserves and is referred to as balancing or load-frequency control.

This balancing works on several levels:

- During system operation, minor disturbances of the system balance occur continuously and unavoidably, e.g. due to the stochastic, uncoordinated feed-in and withdrawal behavior of grid users. However, since the generation capacity of power plants as well as the withdrawal of consumers can only be adjusted with a delay, instantaneous balancing exclusively uses kinetic energy of all rotating inertias in the interconnected system, especially synchronous generators (spinning reserve). In this non-selective automatic process, all inertias are evenly decelerated (withdrawal of kinetic energy, power deficit) or accelerated (feed-in of kinetic energy, power surplus). Due to the fixed-frequency grid connection of synchronous generators, this process is directly accompanied by a decrease or increase in the system frequency. Thus, the system frequency directly correlates with the system imbalance of the entire synchronous area and serves as a trigger for further measures of system control.

- Since a stable system frequency without major deviations from the target value represents an essential characteristic of the quality of the electrical supply and large deviations from the system frequency cannot be technically tolerated, balancing the system solely by using the - in any case limited - kinetic energy of inertias is not acceptable. Rather, the spinning reserve must be replaced as quickly as possible by additional reserves for balancing to return the system frequency to its target value. Only very small deviations of the system frequency within 10 mHz are within the measuring tolerance of the decentralized frequency meters.

The load frequency control (see Figure) o operated by the TSOs to ensure a stable grid frequency - and thus the power balance in the entire synchronous grid - also has a further task: it ensures that the power balance of a control area follows the target values coordinated in advance between the TSOs based on the schedule nominated by the grid users[6]. To achieve this, each TSO operating an LFC area has its own load frequency controller which measures the balance of the LFC area (based on the actual flows on the LFC area's interconnectors) as well as the system frequency. In the case of deviations from target values, balancing services are activated to minimize the difference between actual and target values.

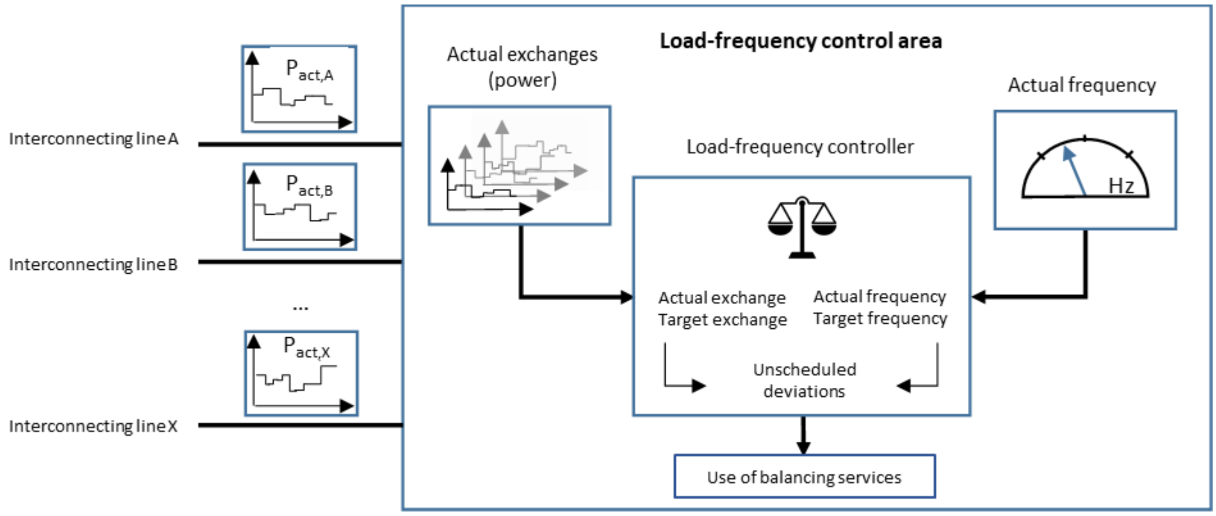

Figure 3: Schematic representation of the load frequency control

[6]For example, the notification of an energy delivery from control area A to control area B leads to an increase in the balance target value in A and a corresponding decrease in control area B. There must be a balance within the entire synchronous area.

5.2 Quality of balancing services

To fulfill the tasks of balancing the system, the TSOs procure balancing services which can be activated at different speeds (activation of balancing energy). The properties and tasks of these different types of balancing services and the interactions between them are described below. Figure 5 also shows the interaction of the different types of balancing services.

The main task of FCR is to stabilize the system frequency as quickly as possible after a disturbance. To ensure this rapid response and at the same time keep contributions provided by every single unit involved as low as possible, FCR is activated on a non-selective (pro rata) basis and according to the principle of solidarity across the entire synchronous area in a decentralized way. Any power flows resulting from the activation are considered by safety margins when determining the cross-zonal capacities in the transmission system.

FCR is designed as proportional control. It is thus activated proportionally to the deviation of the system frequency from its target value. Since the activation of the FCR local control systems of the participating technical units.

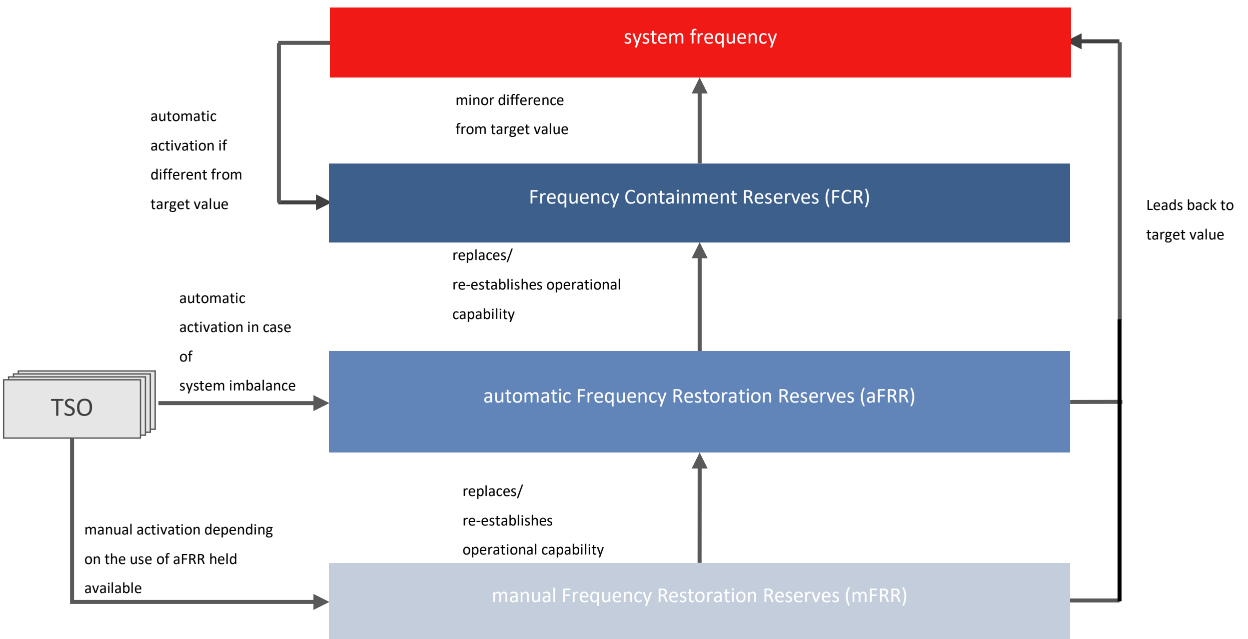

Figure 4: Overview of the deployment and tasks of the different types of balancing services

The prequalification requirements in Germany (section 7.1) and Continental Europe require the complete activation of the requested FCR within 30 seconds. However, FCR is not designed and dimensioned to return the frequency to the target value 50 Hz. For the FCR to be continuously available to balance system imbalances, it is replaced by other types of balancing reserves as quickly as possible.

Due to the nature of FCR as proportional control, it can stabilize the system frequency and the system frequency at a new operating point after an imbalance has occurred (for example due to the outage of a power station). However, a quasi-stationary deviation of the frequency from its target value remains. The return to this target value (and, due to the frequency-proportional activation, the automatic deactivation of the FCR) is the task of the aFRR.

The aFRR is an automatically activated reserve, just like the FCR. Unlike FCR, it is not activated across LFC areas, but in principle in the LFC Area causing the imbalance – as long there is no exchange of aFRR balancing energy. The load frequency controller operated by each TSO for its LFC area is responsible for the detection of the system imbalance that has occurred in an LFC area and the automatic reserve request. This controller operating with an optimisation cycle of few seconds, continuously determines the necessary activation of aFRR by comparing the power transferred from the LFC area to neighboring LFC areas (net position of the LFC area) and the system frequency with the relevant target values and specifies a corresponding target signal the BSPs which are IT-wise directly connected to the LFC. Various activation strategies (for example proportional involvement of all balancing power stations or minimization of the activation costs) can be applied with this setup. German TSOs activate balancing energy at optimal costs based on their common merit order list (MOL), which is an activation order sorted in ascending order by individual bid prices. This practice corresponds to the requirements of the EB Regulation.

In contrast to the exclusively frequency controlled FCR, aFRR aims to minimize the deviation of the system frequency from its target value and ensures compliance with the agreed power exchange with the other LFC areas. Due to its design as a proportional-integral control, no stationary control deviation remains in this secondary control stage. The control variables are therefore returned to their target value. For example, after the outage of a power station, the LFC area in which the outage occurred is over-supplied until the frequency returns to its target value and the FCR is completely deactivated. Only after the FCR has been replaced by the activation of aFRR, it is available again for counteracting any further short-term imbalances. Thus, the activation of the aFRR is also a time-critical process for which the EU regulation has set a time limit for full delivery (aFRR full activation time) of 5 minutes. At the same time, however, the aFRR targets capacity reserves that can be activated not only for a short period of time, but also for an extended period. In Germany, aFRR is procured portfolios-based, within which the deployment of units is optimised for the cost minimal satisfaction of the aFRR demand.

Due to the high technical requirements described for the technical units used for aFRR provision, it is necessary to procure the entire reserve capacity required to counteract even extended imbalances[7]. Therefore, part of the reserve capacity is procured as manual Frequency Restoration Reserve (mFRR). Technical requirements of mFRR are lower than for aFRR (full activation time 12.5 minutes, no continuous/real-time communication, rather it is processed as a scheduled delivery, for example in 15-minute intervals or as direct activation[8]), so that technical units (TU) with limited technical features can be considered. In contrast to aFRR and FCR, mFRR is not activated fully automatically. TSOs decide to activate mFRR on a case-by-case basis depending on the actual activation of aFRR and the expected system imbalance. TSOs aim to replace aFRR activated for longer time periods so that aFRR is made available again for further balancing which might be necessary on short notice. In individual cases, mFRR can also be activated preventively to compensate for expected larger imbalances. In Germany, the mFRR is activated electronically via the MOL server, the retrieval tool for the mFRR-MOL of the bids submitted on the balancing energy market.
FCR and FRR (sum of aFRR and mFRR) are procured by the TSOs both as positive balancing services (to balance imbalances) and as negative balancing services (to balance imbalances). It should be noted that the designations of basically comparable products can vary. For example, mFRR is often referred to internationally as the tertiary reserve.

---

[7] In Germany, according to the StromNZV, the transmission system operators take over the replacement of the lost capacity with balancing services after the outage of a generation unit for up to four 15 minutes, including the 15-minute period in which the outage occurred. According to this, the power station operator is responsible for the activation of its own reserves (for example through the short-term conclusion of electricity trading transactions on the intraday market).

[8] Direct activation of mFRR differs from scheduled activation by the more flexible activation time. Since direct activation only accounts for a very small share of the activation volume of mFRR, the description of mFRR in the rest of the document is based on scheduled activation.

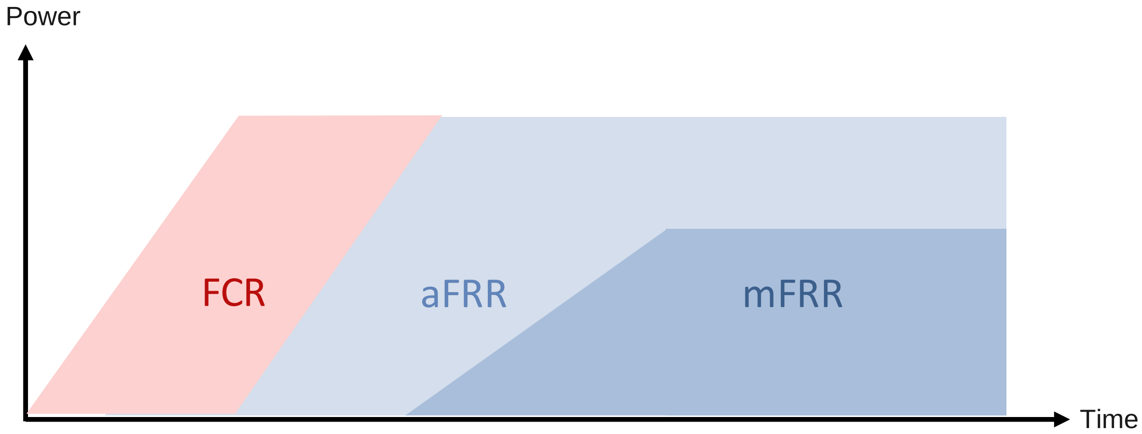

Figure 5: Types of reserves used via a three-stage control concept in Germany (schematic representation)

In Continental Europe (CE), in addition to the FCR, aFRR and mFRR, there is also the reserve type of the replacement reserves (RR), which is not applied in Germany. In addition to the types of reserves shown in Figure 5, which are mandatory for balancing in Germany according to the Electricity Grid Access Ordinance (StromNZV), German TSOs can in exceptional situations, e.g. B. in the case of particularly high imbalances, resort to further measures. These include the exchange of emergency reserves with other TSOs, the activation of interruptible loads or the execution of trading transactions for balancing. These additional measures will be taken at the time of need for up-to-date availability.

6 Procurement and deployment of balancing services

The Electricity Grid Access Ordinance (StromNZV) requires balancing capacity and balancing energy to be procured in the DE/LU bidding zone in a joint, anonymized LFC-cross-zonal auction via an internet platform and to be used according to the results of the auction based on offer curves. The EB Regulation also sets out further requirements for the procurement and activation of balancing services.

This chapter provides a detailed overview of the precise regulations of the procurement and deployment process, starting with the technical prequalification of the providers through to the transparency obligations and the resulting current publication practice.

6.1 Prequalification of balancing service providers

The Electricity Grid Access Ordinance (StromNZV) expressly points out that BSPs must provide proof of compliance with the technical requirements for the provision of the different types of balancing services. Therefore, potential BSPs must go through a prequalification process before they are granted access to the relevant markets. This is as well required by SO Regulation with the obligation to repeat the prequalification regularly.

In addition to the technical compliancy, proper provision of balancing services under operational conditions and the economic capacity of the potential BSP must be ensured. For all types of reserves, the prequalification takes place exclusively with the TSO in whose LFC area the installation to be prequalified is connected to the grid, independent of the voltage level (connecting TSO). Prequalification requirements apply for the level of the pool and the level of the reserve providing unit as well. The unit to be prequalified is also referred to as a technical unit (TU) [9]. The prequalification can be requested for a reserve providing unit (one or more TUs at one grid connection point) or a reserve providing group (aggregated TUs at different grid connection points).

The duration of a prequalification process generally takes a maximum period of three months. The documents that a BSP submits to the connecting TSO to prequalify its installation are transmitted electronically via the prequalification portal (PQ portal - www.pq-portal.energy). If there are changes to the main framework conditions on the BSP's side in connection with the prequalification, the BSP must inform the connecting TSO of this. This may require a new prequalification.

Prequalification has been carried out since 2018 in accordance with the uniform "PQ conditions " of the German transmission system operators (in the current version of 05.07.2024)", which implement the requirements on the prequalification process for balancing service providers of the SO regulation for Germany.

Essential components of the prequalification are

- the submission of an IT concept
- the submission of the service concepts for the pool and for each unit and group
- the successful completion of a service run,
- the submission of necessary certificates from third parties,

[9] Technical unit is the generic term for systems for the provision and provision of balancing services and means both generating units and controllable consumption units.

- and conducting the I&C test.

IT concept

Due to their system responsibility, the TSOs have to meet high requirements for the confidentiality, availability and integrity of their infrastructures as well as information, which are for companies that provide balancing capacity services are defined in the transmission system operators' "IT minimum requirements" and represent minimum requirements for security and availability.

By submitting the IT concept - documentation of the IT technical implementation of the concept for the provision of balancing services - a potential provider proves that it meets the minimum IT requirements of the transmission system operators.

Delivery concept

The service concept is to be submitted for each reserve unit, for each reserve group as well as the pool with the PQ application. It is the document in which the provider describes its provision and delivery. This includes, for example, the documentation of the technical implementation of the respective type of balancing services.

Service run

The service run is a trial provision of balancing services. It is a practical test based on standardized criteria to verify the technical suitability of a provider's units for the provision of balancing services and to quantify the service to be prequalified. It corresponds to the power change that can be activated during the activation period (FCR: 30 seconds; aFRR: 5 minutes; mFRR: 12.5 minutes). The system run is documented in an operating log, which the balancing service provider submits with the application documents. The relevant test profiles for the individual types of balancing services are published on the tendering platform www.regelleistung.net . Figure 6 shows an example profile for the negative aFRR.

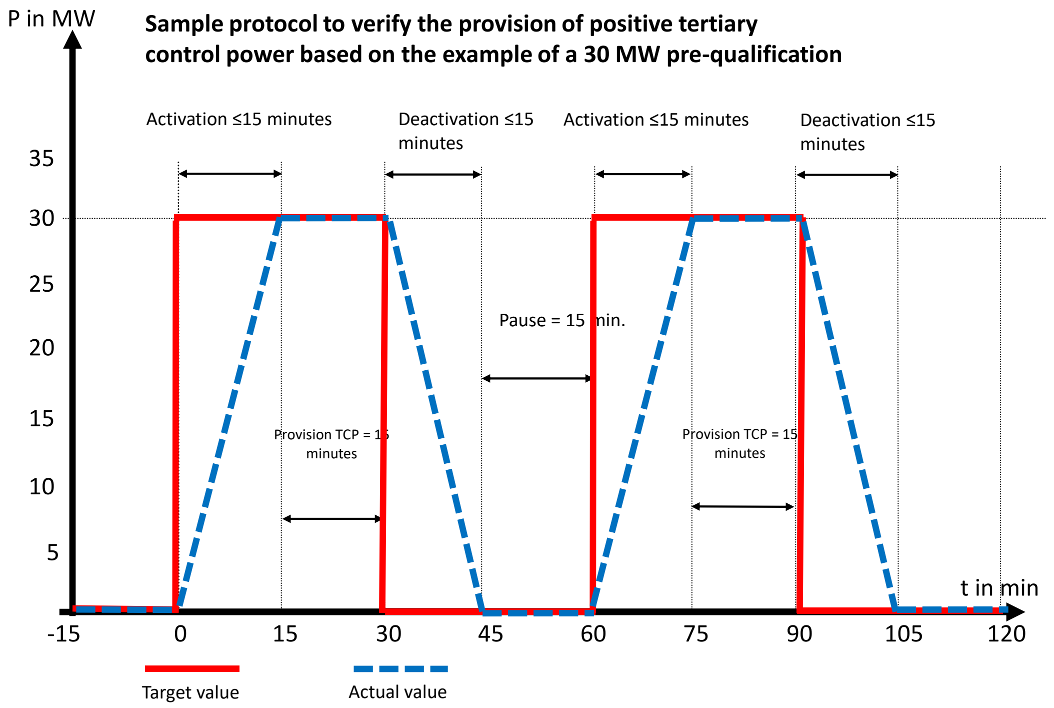

Figure 6: Sample activation for negative aFRR

Certificates

If the market roles involved in or affected by the balancing service provision (the connection system operator, the supplier, the balancing responsible parts and the operator) are not exercised in an integrated manner within one company and are hence identical people, the prequalification process requires a certificate of knowledge and consent of the balancing service provision of a TE by the non-integrated third parties.

I&C test

The control system test then ensures that the IT connection of the provider to the control system of the TSO is working properly. Components of the test are, for example checking the correct acquisition and transmission of the individual data points, the reception and accurate implementation of target value specifications, as well as checking the redundant data connection. The test is performed in close cooperation between the provider and TSO and is intended for all types of balancing services.

If the prequalified capacity reaches the minimum bid size, the connecting TSO concludes a framework contract with the BSP for each balancing service quality (model contracts are available at www.regelleistung.net). For all types of balancing services, prequalified units and groups from a provider are bundled in real operation to form a pool which can be accessed by the connecting TSO in the case of a winning bid for balancing capacity. Pooling enables the provider to optimally organize the provision and provision of the balancing capacity offered.

According to the provider list published by the German TSOs (as of 28/11/2024)[10], 29 providers are currently prequalified for FCR, 30 providers for aFRR and 27 providers for mFRR. Figure 7 illustrates the prequalified capacity in Germany differentiated by generation technology and type of balancing services.

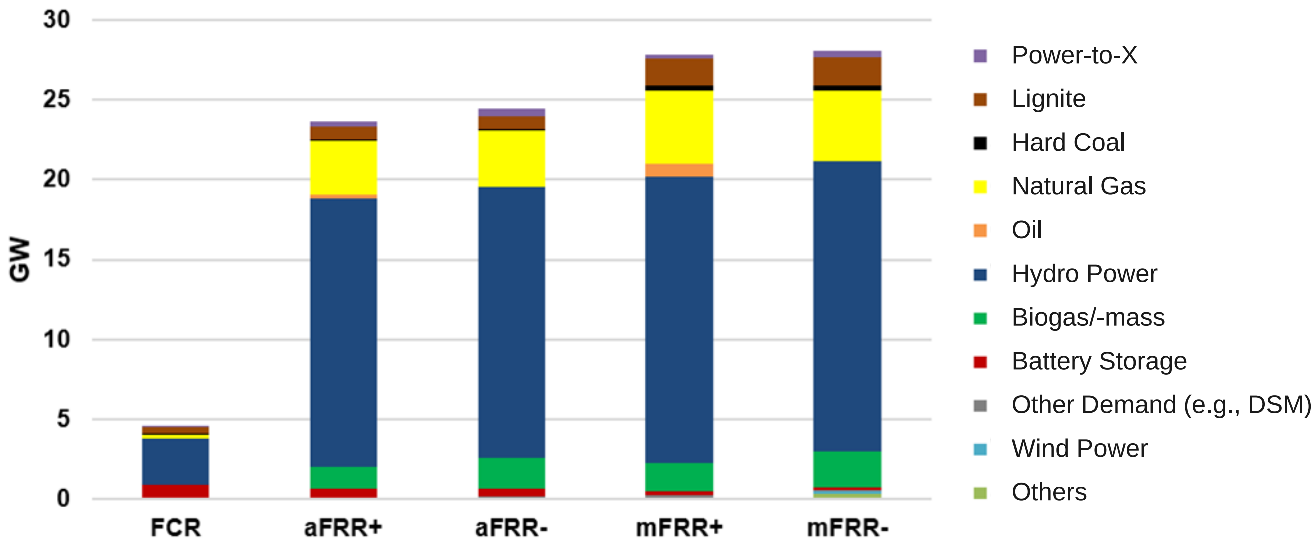

Figure 7: Prequalified capacity (in GW) in Germany differentiated by generation technologies and direction (source: Regelleistung.net - as of: Q4/2024)

The requirements for the prequalification (PQ conditions) are continuously further developed by the TSOs and adapted to changes in the EU law. Over the past two years, this has affected the implementation of decision BK6-19-069 of the German Federal Network Agency (additional properties of FCR) as well as the revision of the requirements with the introduction of the European market design (PICASSO and MARI). The main changes were the shortening of the reaction time of units and groups for mFRR from 15 to 12.5 minutes as well as the requirement that the activation of all must not be artificially delayed, must start no later than 2

[10] See prequalified providers per balancing reserve type (regelleistung.net)

seconds after a frequency deviation, and must increase at least linearly. During this period, reserve operation was also introduced for storage-limited FCR units. i.e. storage limited FCR units that are technically capable of doing so shall ensure that near the upper and lower bounds of energy storage, the remaining capacity is sufficient to maintain an adequate response to short-term frequency deviation (reaction to a zero-mean frequency deviation).

Furthermore, in 2023, the German TSOs met the requirements of the SO Regulation for a limitation of the prequalification of units to five years. Since October 2023, units whose PQ is older than five years and has therefore expired, for which a valid repeat PQ application is submitted by the provider, have been prequalified again for a further five years.

To facilitate the prequalification process as well as the entry of innovative technologies (such as renewable energies or electromobility) for the BSP, the transmission system operators have published additional documents to the existing PQ conditions on regelleisstung.net in addition to the legally required adjustments over the past few years:

- **Guide on the prequalification of wind power** (link): In addition to the PQ conditions, the document provides an overview of the essential requirements and options for prequalification for balancing services for wind power plants.
- **Guide for the prequalification of electric vehicles and other mobile installations** (link): The guide shows the options for BSPs regarding the prequalification of mobile installations.
- **Guide on the collateralization of balancing capacity in case of technical outages of a/mFRR facilities of the balancing capacity provider** (link): The guide describes the different possibilities of securing balancing capacity in the case of technical outages for balancing service providers for aFRR and mFRR.
- **Guidelines for the creation of the delivery concept at pool level** (link): The guide provides an example of an overview of the content that a provider's delivery concept should have at pool level.
- **Concept template for the delivery concept at the unit and group level** (link): The document can be used as a template by providers when preparing the provision concept for RE or RG.

6.2 Dimensioning – Determination of reserve capacity requirements

6.2.1 General

An essential part of the market-based procurement of balancing capacity to cover the necessary reserve capacity is the verifiable determination of demand. A distinction must be made here between the FCR procured and used across the synchronous area and the aFRR[11] and mFRR procured and used in a coordinated manner within the GCC on the other hand.

6.2.2 FCR

According to the regulations of the SO Regulation, an FCR of 3,000 MW is currently to be procured for the Continental European synchronous area. This specification results from the goal of being able to control two overlapping reference incidents with the provided FCR. The largest expected imbalance due to a single cause is referred to as the reference incident. In the current system, this reference incident corresponds to the spontaneous outage of one of the largest power generator units operated in the synchronous area. These are currently large nuclear power plants with a capacity of approximately 1,500 MW, which explains the level of the overall FCR requirement. It is also regulated that each LFC area has to reserve a share of this total FCR demand that corresponds to its share of the total electricity generation and withdrawal in the synchronous area. According to this calculation rule, the FCR provision to be provided by each LFC area is updated once a year. FCR of 564 MW is currently being tendered in Germany (in 2024), in 2022 it was 555 MW and 570 MW in the following year. [12]

6.2.3 FRR

The requirements of ENTSO-E are less relevant for the dimensioning of the aFRR and mFRR. Accordingly, the dimensioning practices of the European TSOs differ. However, the minimum requirements to be met by the TSOs are specified in the EU regulations, especially the SO Regulation. In 2019 the German TSOs revised the process for dimensioning of FRR to be able to adjust to short term requirements. In December 2019, the previous static design method, which was used to determine a reserve capacity need (in practice

[11] For the cooperation between Germany and Austria in the aFRR auction, see section 8.2.5.

[12] It should be noted that TSOs from Belgium, Germany, France, the Netherlands, Austria and Switzerland jointly tender FCR. As a result, the FCR capacity awarded in Germany can vary. (see section 5).

one quarter), was replaced by a dynamic dimensioning method for aFRR and mFRR [13]. In accordance with the requirements of BNetzA decisions BK6-15-158 and BK6-15-159, a situation-dependent design is now performed. The reserve capacity requirement is determined for each rolling 4-hour product time slice. Like the previous process, the dimensioning is carried out based on a probabilistic approach, which leads to significantly more needs-oriented - but also more volatile - values than the previous quarterly dimensioning.

Reserve capacity is dimensioned in such a way that the German TSOs are still able to independently balance imbalances caused in Germany. The dynamic dimensioning therefore also considers imbalances which were netted with the neighboring TSOs and thus did not lead to an activation of balancing energy. This appears to make sense because the historical netting potential of opposite imbalances with neighboring LFC areas cannot be reliably extrapolated into the future, particularly due to the uncertain availability of the cross-border interconnector capacities after intraday trading as well as the existence of opposite imbalances.

Figure 8 shows the quantities of the FRR tendered for the years 2022 and 2023. Overall, a decline can be observed for all four products. The biggest changes are apparent in summer 2022 and result from the dimensioning logic. After a certain time, the events from a considered observation period are dropped. In June 2019, there were high imbalances in Germany. From mid-July 2022, these were no longer included in the database of the dimensioning logic.

[13] A detailed description of the new dimensioning process can be found at https://www.regelleistung.net/ext/tender/remark .

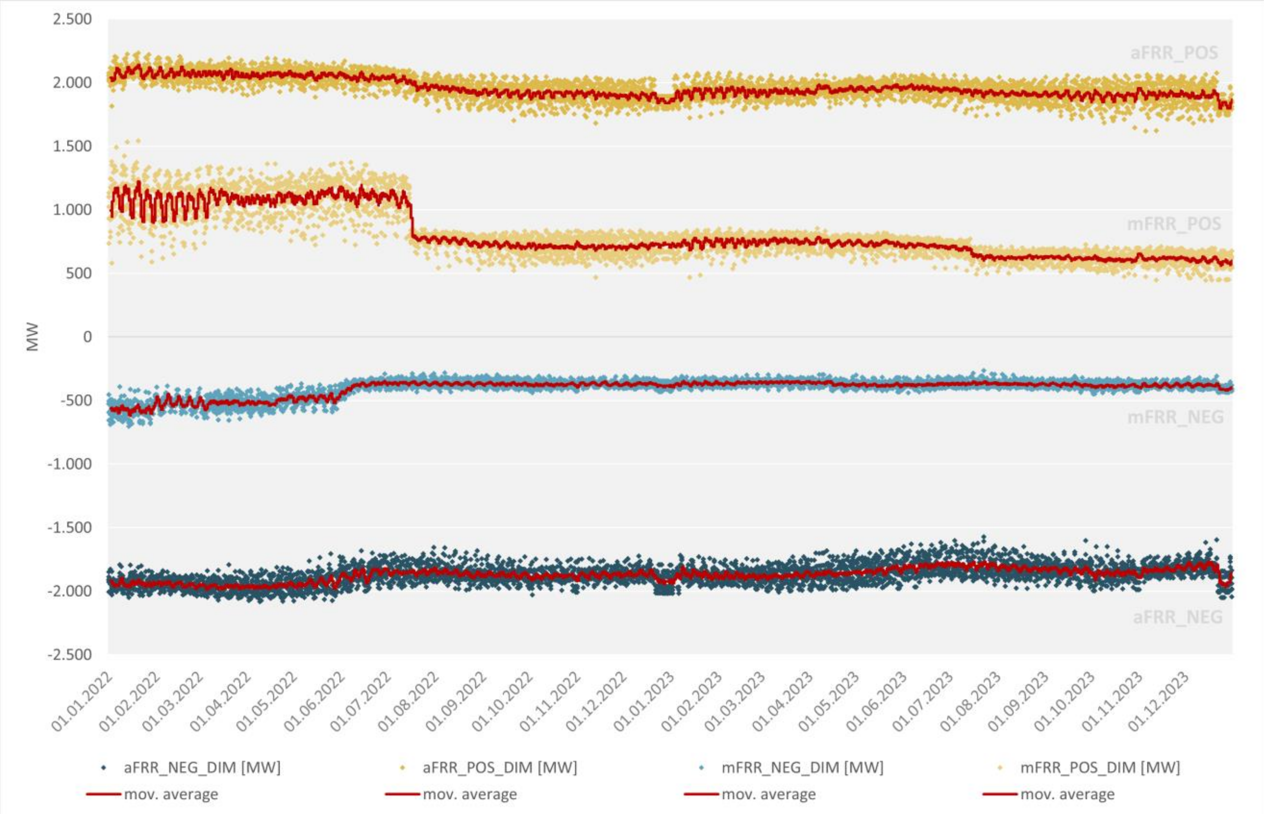

Figure 8: Development of the tendered aFRR and mFRR volumes (4-hour blocks each)

Table 1 below shows the annual average values for the dimensioned FRR. For all products, the values decreased in the second year of the period under review, for the positive direction at 11%, significantly more than for the negative direction at 5%.

year	aFRR	mFRR	FRR	aFRR+	mFRR+	FRR+
2022	-1,901	-432	-2,333	1,995	921	2,916
2023	-1,842	-372	-2,214	1,922	681	2,603

Table 1: Annual average values for the dimensioning in MW

The GCC imbalance presented as a reference in Chart 9 comprises only a part of the historical imbalances. In practice, the NRV balance changes continuously and has e.g. T. significantly higher extreme values than the 15-minute mean values shown.

Figure 9: NRV balance and FRR tendered (¼-hourly values)

The dynamic dimensioning process is currently based exclusively on specificities of the day (for example weekend days, public holidays, time of year). This means that the imbalances in the previous weeks and the same periods last year (reference periods) have an impact on the dynamic dimensioning results. Deviations between the tendered and procured balancing capacity and the actual requirements are always possible since sufficient balancing capacity must be provided for almost all expected imbalances- However, the imbalances in the reference periods can vary widely. With the planned future consideration of external influencing factors such as the forecast errors of the wind and solar generation in addition to the daily characteristics, the balancing capacity tendered should correspond even better to the real requirements in the future.

The analysis also shows that the available FRR (aFRR + mFRR) was sufficient at all but two points in time to balance the imbalances in the GCC. This ensures compliance with the requirements of the SO Regulation on the probability of a deficit/surplus.

During the two points in time, additional balancing options via the European platforms could be used:

- 04/04/2023 12:45 - 13:00

  The GCC balance was approx. 150 MW above the available reserves. During this period, a "weak gradient high pressure system" determined the weather in Germany. The weather models have expected significantly more cloud formation for this period in both the short-term and the day-ahead forecast. However, this did not occur, which means that the forecast cloud coverage and reduced solar feed-in did not occur. As a result, the sky remained cloud-free and a correspondingly high solar feed-in resulted.

- 09/12/2023 07:30 - 07:45

  The GCC balance was approx. 1 GW above the designed capacity. The cause was a management error by a BRP due to an IT error (BRP procured far too much energy on the exchange for a short period of time)

6.3 Balancing markets

The balancing services are tendered via the internet platform www.regelleistung.net (IP RL), which is jointly operated by the TSOs. Each BSP has an individual secure BSP area on the internet platform for the submission of bids and collection of the results.

The market rules and access conditions for the individual types of balancing services are defined by BNetzA and ACER after consultation with the TSOs and providers. While with FCR only balancing capacity is procured, the balancing services for aFRR and mFRR are procured in two stages. The balancing capacity corresponds to the dimensioned reserve capacity per type of reserves and is tendered for on the previous day and a contract is awarded in the amount of the dimensioned demand on the balancing capacity market (RLM). After the closure of the balancing capacity market, the balancing energy market (RAM) opens. All BSPs with bids awarded in the balancing capacity market are obliged to submit balancing energy bids in the amount of the volume on the RAM for which an award has been made on the RLM. In addition, additional bids for balancing energy can be placed in the RAM without being pre-contracted in the RLM (free bids). All balancing energy bids available at the gate closure time are submitted to the respective European platform in a merit order list (MOL). Table 2 provides an overview of the most important product features. Key differentiating features are explained in more detail below.

	combined market	RLM		RAM	
	FCR	aFRR	mFRR	aFRR	mFRR
Tender period	Daily D-1 (8am)[14]	daily D-1 (9 a.m.)	daily D-1 (10 a.m.)	continuously 25 minutes before delivery period	
product time length	6 x 4-hour blocks[15]			15 minutes	
product differentiation	none (symmetric product)	each positive & negative			
minimum bid size	1MW				
increment of supply	1MW				
award	Demand Price Merit Order	Demand Price Merit Order		Commitment price merit order	
remuneration	pay-as-cleared (performance price)	pay-as-bid (performance price)		pay-as-cleared (working price)[16]	

Table 2: Main product features of the balancing services tendered in Germany

- **Tendering period:** FCR, aFRR and mFRR (balancing capacity) are procured in daily tenders. With the FCR, balancing capacity is procured on a combined market (see section 8.2.4) whose gate closure time (GCT), i.e. the closure of the market, is at 8 a.m. the previous day. aFRR and mFRR capacity is procured via the balancing capacity market. Its GCT is each day: for aFRR at 9 a.m. of the previous day and for mFRR at 10 a.m. of the previous day. After the RLM, the balancing energy bids of mFRR and aFRR are collected via the respective RAM (in accordance with Article 16(5) EB Regulation). The RAM opens after the result of the RLM auction is announced. BSPs can submit

[14]Until July 1st, 2020, the D-2 tenders were held Monday to Friday.

[15]A daily product time slice was tendered for the FCR until 1 July 2020.

[16]Pay-as-bid applied here until the introduction of the target market design on June 22, 2022

balancing energy bids up to 25 minutes [17] before the start of the product's delivery period (15 minutes).

- **Product time length:** Procurement at the RLM takes place uniformly for all types of reserves in six separate products each. Each day is divided into time slices of four hours each. On the RAM, the product length is 15 minutes, according to the definition of the relevant standard product for balancing energy.
- **Product differentiation:** While the FCR is procured as a symmetrical product, for aFRR and mFRR positive and negative balancing products are tendered separately. With the FCR, providers must therefore be able to both increase and decrease the power by the same amount as the offered power. However, different TUs can be used for the two control directions.
- **Awarding:** For providers of FCR as well as for providers of FRR on the RLM, the contract is awarded based on the price offered by the BSP. The TSOs will award all offers until the respective demand for balancing capacity is covered. BSPs of FRR that are unsuccessful or have not submitted a bid on the RLM can submit non-contracted balancing energy bids to the RAM. While bids in the form of a capacity price and an energy price can be submitted on the RLM, the energy price is not considered when selecting the bids. It is transferred to the RAM and can be adjusted by the BSP up to the GCT of the RAM. The submission of an energy price on the RLM is therefore voluntary. However, successful BSPs on the RLM are obliged to submit balancing energy bids of the same volume to the RAM. This ensures that sufficient bids are received in the RAM to cover the reserve capacity need of the TSOs.

  With the introduction of the RAM, analogous to the RLM, only bids up to the coverage of the dimensioning were awarded on the RAM - the exceeding balancing energy bids were released. This exemption was initially retained with the introduction of the target market design in June 2022 but was abolished on December 8, 2022. With the reduction of the gate closure time from 60 to 25 minutes and the reduction of the products to 15 minutes, the main argument for the release process, the possibility to use the volume of released balancing energy bids in other markets, became obsolete. Furthermore, the possible release led to a coupling of the balancing energy bids to the intraday price, which had to be considered as an opportunity, and therefore to possible exaggerated balancing energy bids. With the abolition of the release on 12/08/2022, which was also recommended by ACER, the opportunities for the balancing energy market are "sunk costs" from a game theoretical

[17] Until 06/22/2022 the market close on the RAM was 60 minutes n before the start of the product's delivery period.

point of view. Thus, according to market theory, the rational bidding strategy in the balancing energy market is to bid at marginal costs (assuming ideal markets).

With the abolition of the release, neither a significant change in liquidity could be detected on the RAM (see section 6.4.2, in particular Figure 23) nor on the intraday market, which was feared as a risk by some stakeholders. However, it did contribute to a significant decrease in balancing energy prices (see section 6.4.2). Further explanations on this are provided in Section 6.9 .

BSPs active in the RAM must adhere to a price limit when submitting balancing energy bids. It amounts to 15,000 EUR/MWh and is now valid for an unlimited period in all European countries. With the last approval of the pricing methodology by ACER, an adjustment mechanism was also provided. This price limit was introduced to reduce an unreasonable cost risk for the BRPs, as prices of balancing energy must be reflected in the imbalance settlement according to ISHM. Since joining the PICASSO platform, the price limit applies according to the pricing methodology for balancing energy.

- **Remuneration:** With the FCR, the provision of balancing capacity and activation are remunerated via the service fee; there is no separate remuneration for the activation. The price of the highest bid to which the contract is awarded applies to all selected bids (pay-as-cleared). For aFRR and mFRR, all selected bids at the RLM receive its bid price for the awarded capacity (pay-as-bid) and all activated balancing energy bids receive the cross-border marginal price, which is determined by the platforms, for the billable balancing energy (see section 6.6).

Various special features must be considered with regard to the tendering of balancing services:

- Collateralization: With the selection of the bid at the RLM, each BSP enters into the obligation to place balancing energy bids at the RAM in the amount of the volume of its selected balancing capacity bids. If it is not able to do so, it can have a collateral BSP submitting balancing energy bids to the RAM for it to fulfill its obligation.
- Core share: In principle, the TSOs, in consultation with the BNetzA, can set so-called core shares for individual German LFC areas, i. h. limit values for the FRR exchange between the LFC areas. A core share means that balancing capacity bids have to be selected in an LFC area up to the core share independent of the bid price. However, the TSOs currently are not specifying core shares.
-

6.4 Market results

6.4.1 Balancing capacity market (RLM)

This section summarizes the developments on the balancing capacity markets for FCR, aFRR and mFRR in 2022 and 2023.

Development of prices on the balancing capacity market

With the FCR, only the capacity price in the amount of the marginal price of the tender is remunerated. The development of the capacity price in 2022 and 2023 is shown in Figure 10. Based on the moving averages also shown, after a few price peaks in the 2nd half of 2022, in particular due to the increased gas prices and high electricity market prices and the associated opportunities for balancing service providers to be considered, a decrease and a stabilization of the demand price level in 2023 can be seen. Towards the end of 2023, prices rose slightly again.

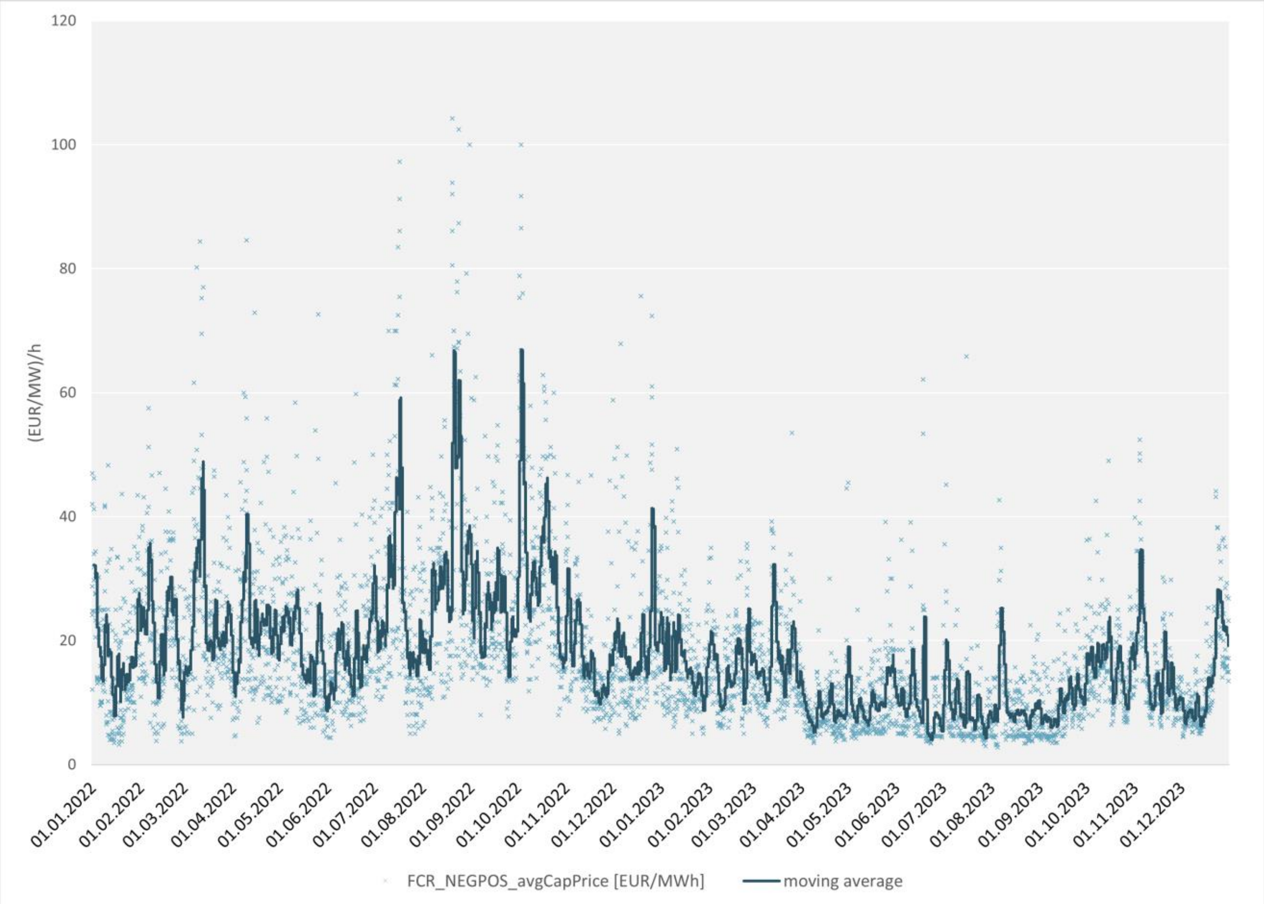

Figure 10: Development of the FCR capacity price and moving average

Figure 11 and Figure 12 show the development of the average capacity prices for mFRR and aFRR in 2022 and 2023.

A significant increase in the price level of negative balancing capacity can be observed over the summer months, which the TSOs attribute to the influence of the increasingly high PV feed-in (see excursus on PV feed-in).

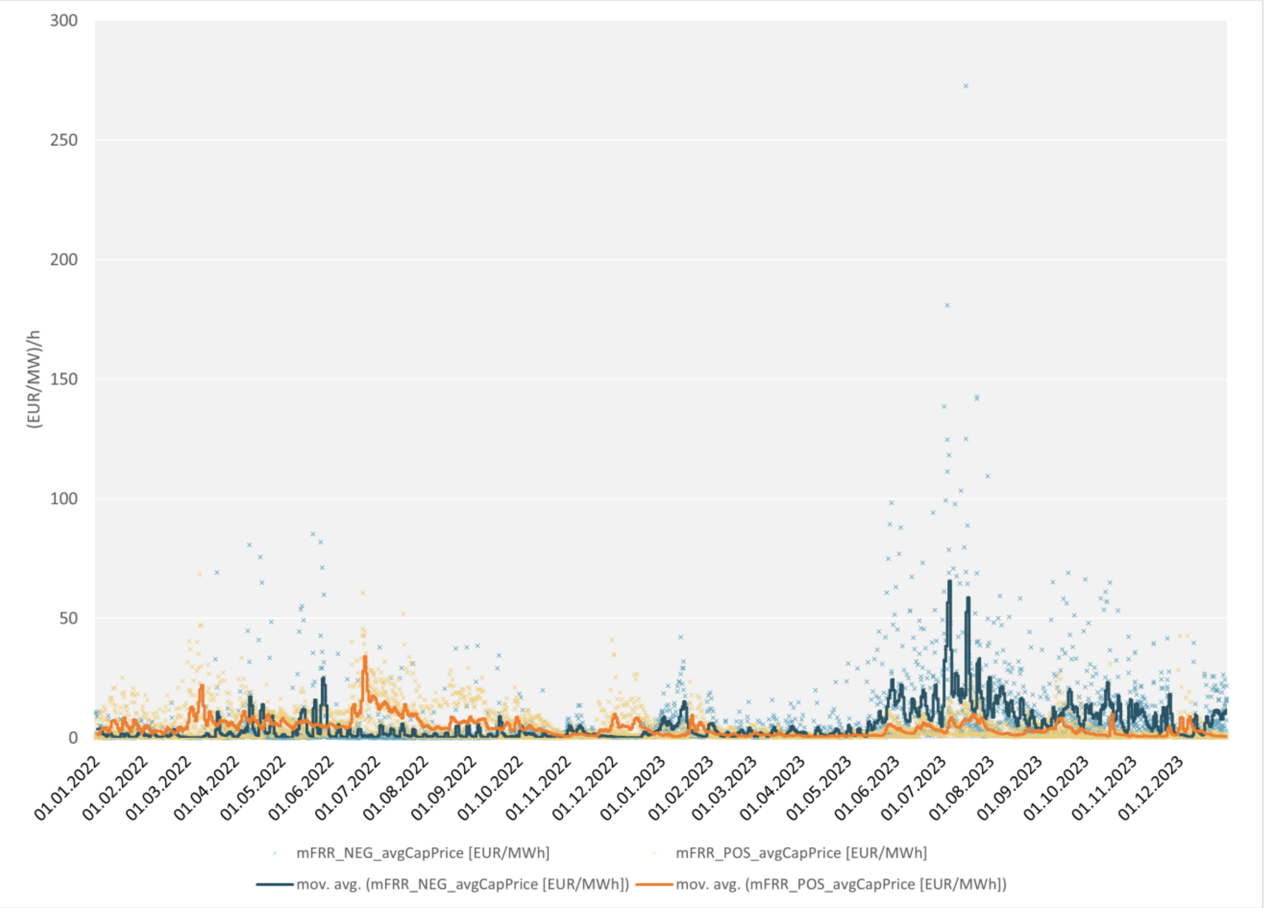

Figure 11: Development of the mFRR capacity price

In 2022, a price increase for mFRR positive balancing capacity (see values displayed in orange) can be observed that does not occur to the same extent in 2023. The TSOs attribute this to the energy price crisis in 2022.

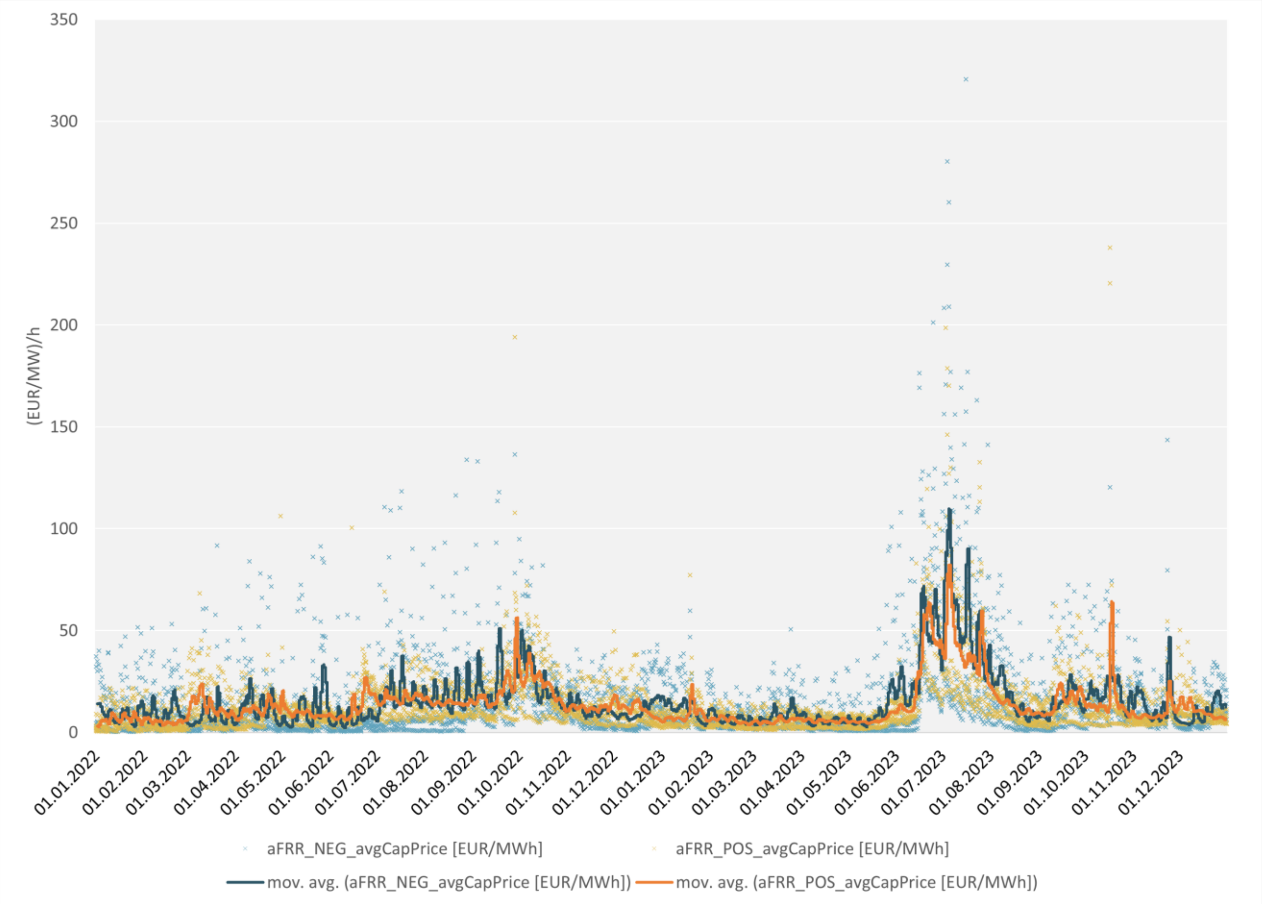

Figure 12: Development of the aFRR capacity price

With regard to aFRR balancing capacity, a slight increase in costs was observed in summer 2022 and in summer 2023 a very strong increase in costs - especially for negative aFRR (see values shown in dark green). From the TSOs' point of view, this is due on the one hand to the unusually high non-availabilities of pumped hydro storages. Significant non-availabilities of the dominating technology in the provision of reserves in Germany mean that this cheap technology has to be replaced by more expensive technologies to cover the reserve capacity needs.

On the other hand, the negative electricity prices on the exchange at noon over the summer months usually lead to high prices for the provision of negative balancing capacity and go (in the summer months) mostly accompanied by a significant (foreseeable) feed-in from PV.

Figure 13 and Figure 14 show the development of the average seasonal balancing capacity prices for aFRR. Here, the average balancing capacity prices are given per hour on a day per month (for example the mean capacity price for aFRR+ for the hour from 09:00 a.m. to 10:00 a.m. of all days in July).

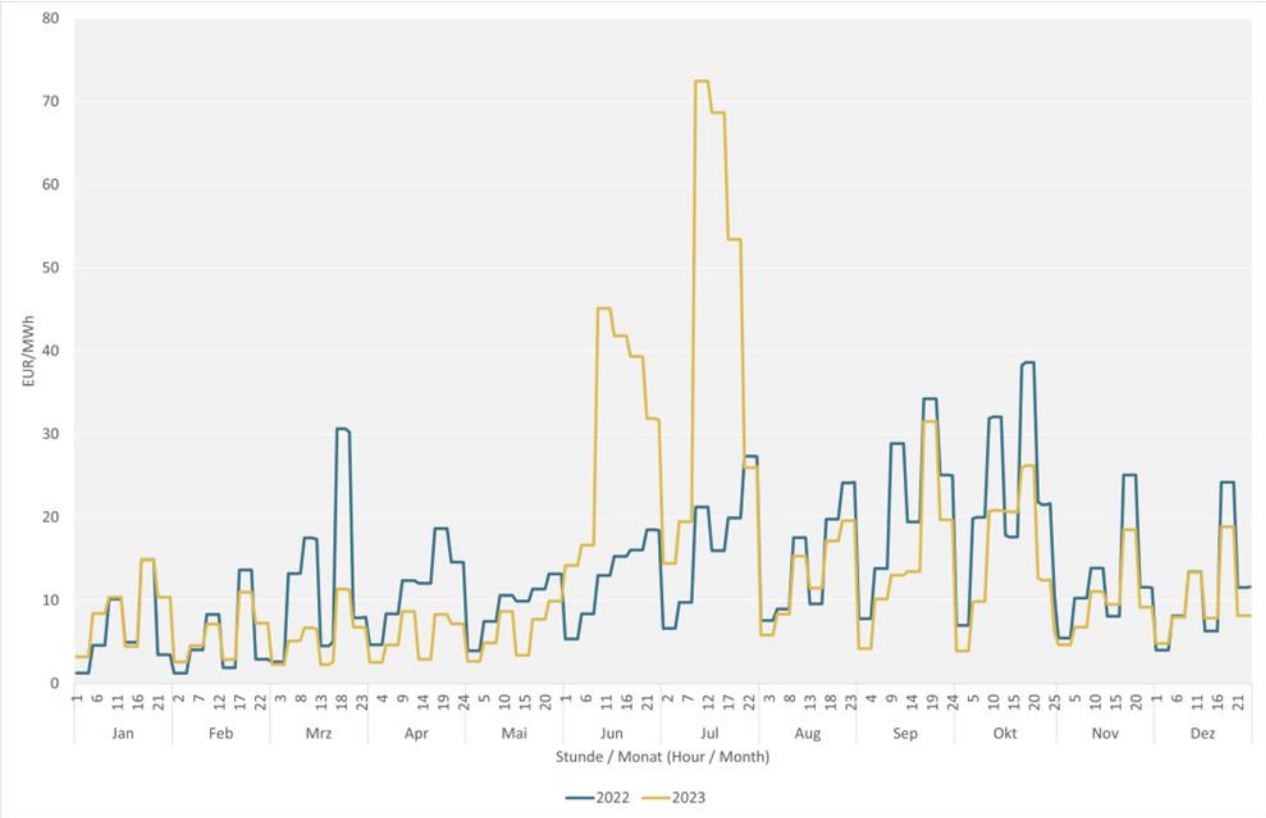

Figure 13 : Average seasonal balancing capacity prices (aFRR+)

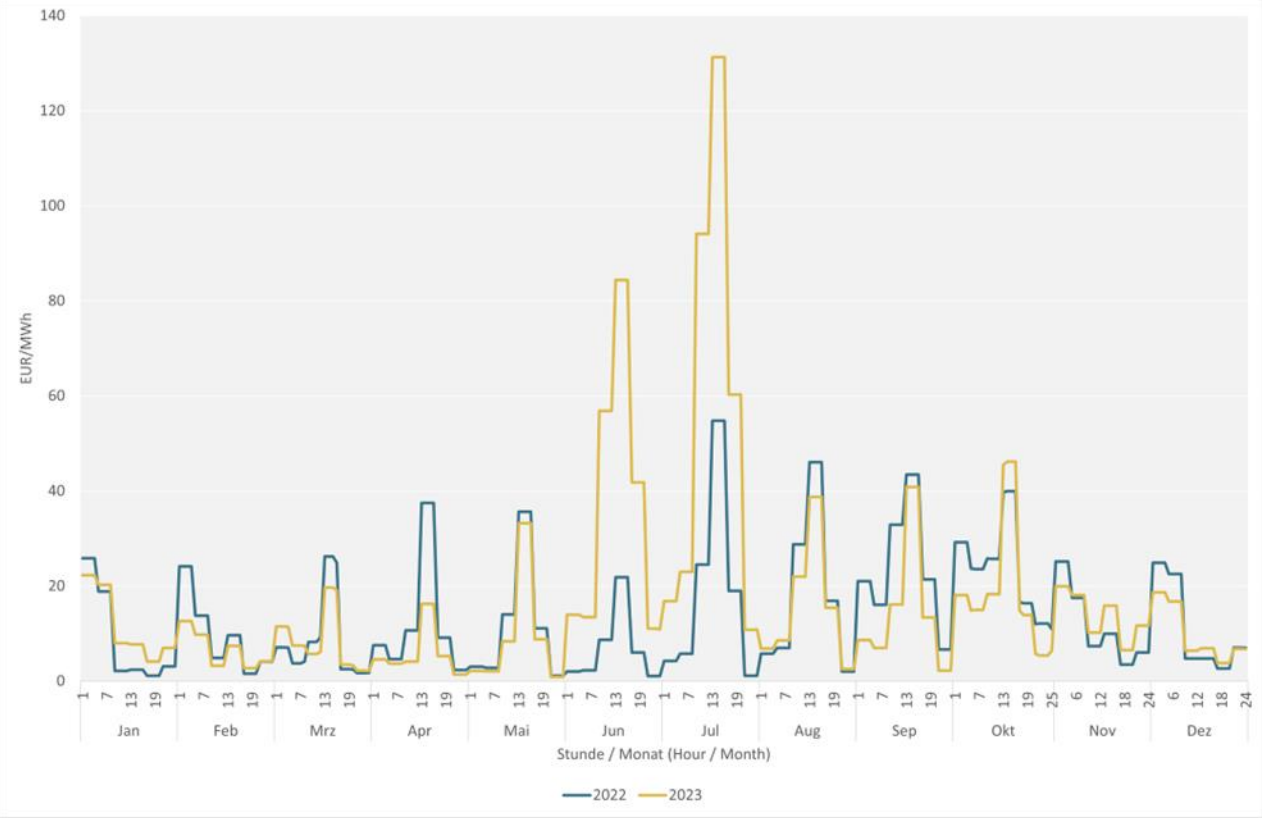

Figure 14 : Seasonal average balancing capacity price (aFRR-)

PV feed-in

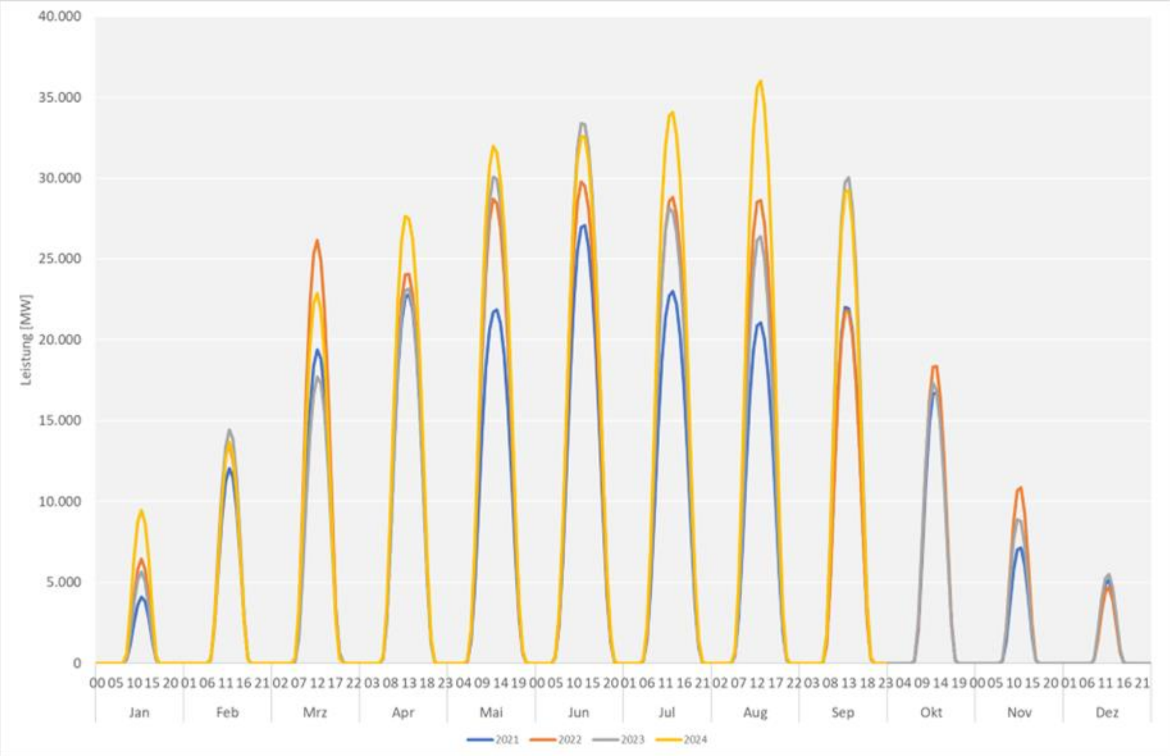

Figure 15 : Average seasonal PV feed-in in Germany (data: ENTSO-E)

Figure 15 shows the average seasonal PV feed-in. This clearly demonstrates that the strong expansion of PV in Germany is leading to an increasing feed-in power of PV, which keeps reaching new highs during the day in the summer months. This effect has increased significantly over the past few years and means that the residual load during days with high PV feed-in tends to zero or even becomes negative (see Figure 16). During these times, the PV feed-in is forcing out of the market prequalified and reducible generation capacity for the provision of reserves, which causes the provision costs to increase significantly, especially for negative balancing capacity, since PV is not participating in the balancing capacity market to date and the costs (for example start-up costs or must-run costs) of the units active in balancing services cannot be covered by other markets. If it is possible for the PV, which is sometimes the cause of the price peaks, to make a significant contribution to the negative aFRR, at least in time slices with the maximum number of sunny days, these price peaks could be reduced. The TSOs are therefore giving specific consideration to how renewables (especially PV) and available flexibilities (for example battery storage) could be better integrated into the balancing services.

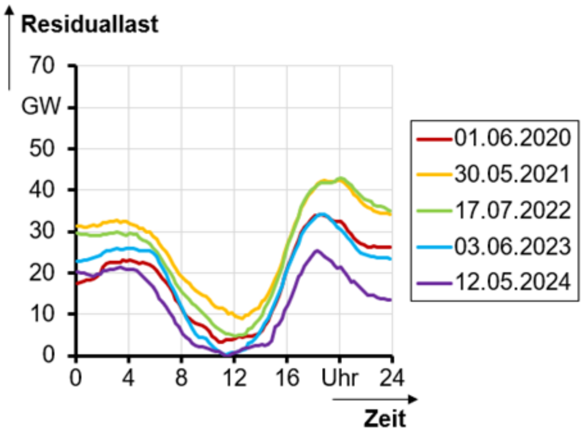

Figure 16: Exemplary comparison of the residual load in Germany on days with high PV feed-in

Development of the balancing capacity market

The analysis of the demand and bid surpluses for balancing capacity provided below (Figure 17 for FCR, Figure 18 for aFRR and Figure 19 for mFRR) shows that the offered bid volume for the procurement of balancing capacity was higher than the demand for all three types of reserves at all times and a clear surplus of bids has occurred, even with slight changes in demand. Table 3 shows the relative averaged annual bid surplus based on the dimensioned capacity.

year	FCR	aFRR	aFRR+	mFRR	mFRR+
2022	140%	101%	127%	504%	306%
2023	117%	81%	109%	412%	356%

Table 3: Relative average annual bid surplus

Except for mFRR+, the bid surplus in 2023 is significantly lower than in the previous year. Nonetheless, it can be seen from this that in Germany the market for FCR as well as the market for FRR balancing capacity can apparently be regarded as sufficiently liquid. Therefore, no negative repercussions on the availability of sufficient balancing services are currently foreseeable.

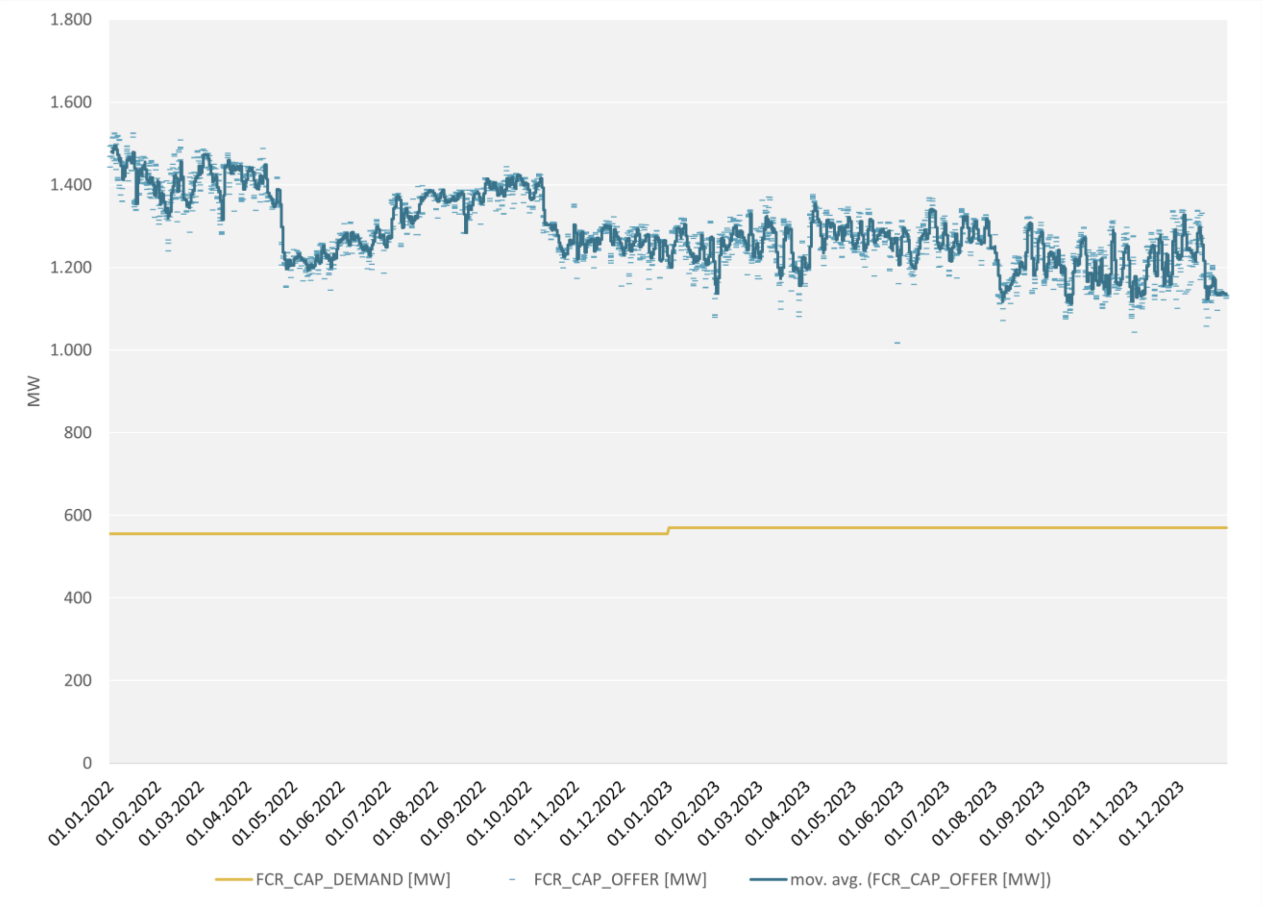

Figure 17: FCR demand and offer (symmetric product)

Figure 17 shows the FCR demand (yellow line) and bid surplus (blue) in 2022 and 2023. In 2023 compared to 2022, the bid surplus decreased. The TSOs have no explanation for the jumps in spring 2022 and autumn 2022.

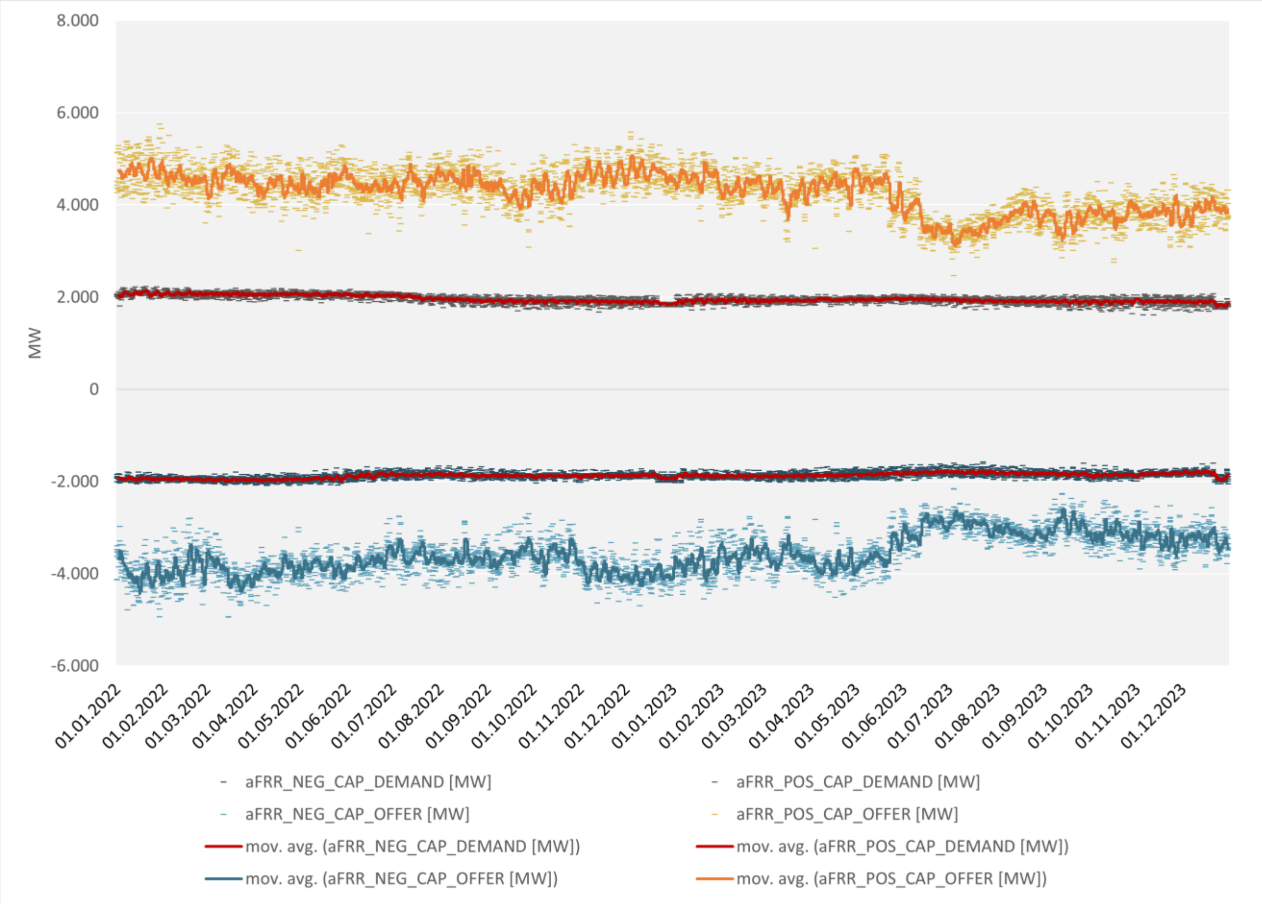

Figure 18: aFRR demand and offer on the balancing capacity market

Figure 18 shows the aFRR demand (red) and surplus bids (aFRR+ orange, aFRR- blue) on the aFRR balancing capacity market in each direction. The dimensioned volume (= procured volume) will decrease slightly over the years 2022 to 2023 from (absolutely) over 2,000 MW below 2,000 MW. It can also be observed that the supply volume is usually twice the demand. From the second half of 2023, a slight decrease in the bid surplus can be observed.

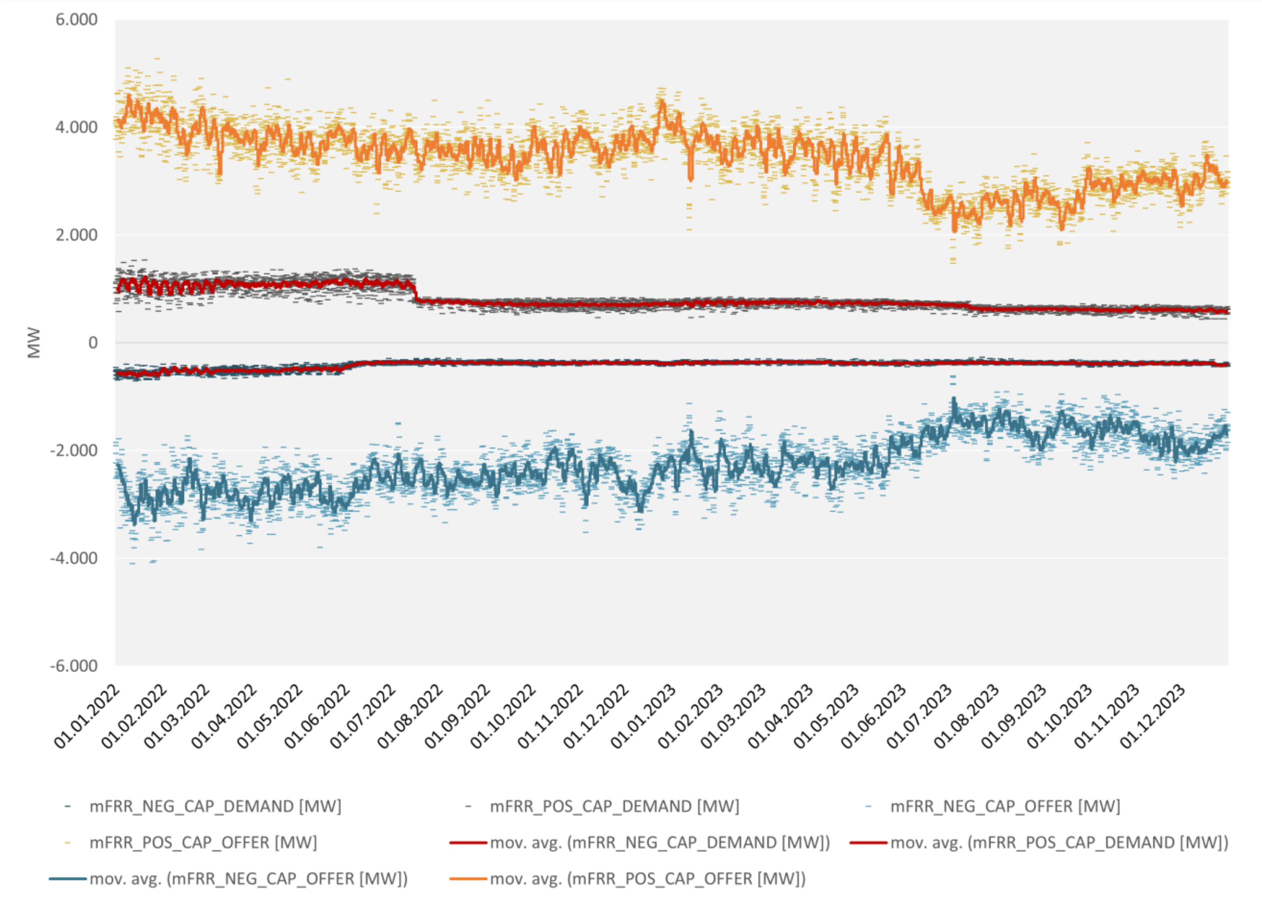

Figure 19: mFRR demand and offer on the balancing capacity market

Figure 19 shows the mFRR demand (red) and the supply (mFRR+ orange, mFRR- blue) on the mFRR balancing capacity market in each direction. In addition to the decrease in mFRR+ demand due to the dimensioning method used (consideration of special events in the last three years), it can be observed that the supply volume usually exceeds demand many times over. From the second half of 2023, a slight decrease in the bid surplus can be observed.

6.4.2 Balancing energy market (RAM)

Development of prices on the balancing energy market

Figure 20 and Figure 22 show the development of the average balancing energy prices for aFRR and mFRR for 2022 and 2023. The development of the median balancing energy prices for aFRR and mFRR for the same period can be seen in Figure 21 and Figure 23.

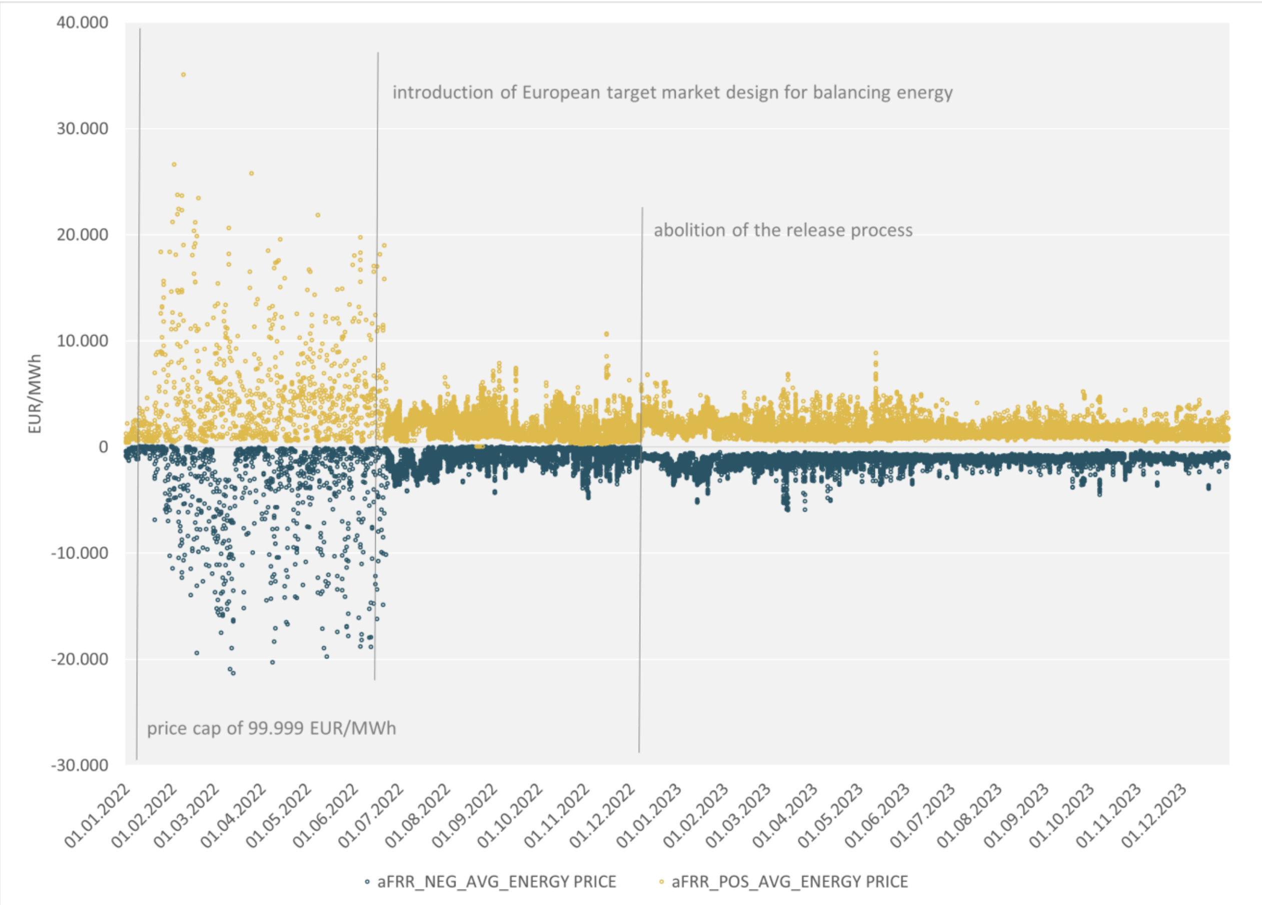

Figure 20 : Development of the aFRR energy price (average)

The average aFRR energy prices were mainly characterized by three things in the reporting period:

- The changes in the price upper limit with an increase in January 2022 and the most recent reduction to 15,000 EUR/MWh in June 2022 according to the pricing method.
- When the release was abolished, a sharp increase in the average aFRR balancing energy price of the bids in the MOL can be observed. This is due to the high-priced bids being considered (and no longer released) in the calculation of the average aFRR balancing energy from then on.
- With a decreasing level of wholesale prices over the course of 2023, the dispersion of the average aFRR balancing energy price of the balancing energy bids in the MOL will also decrease.

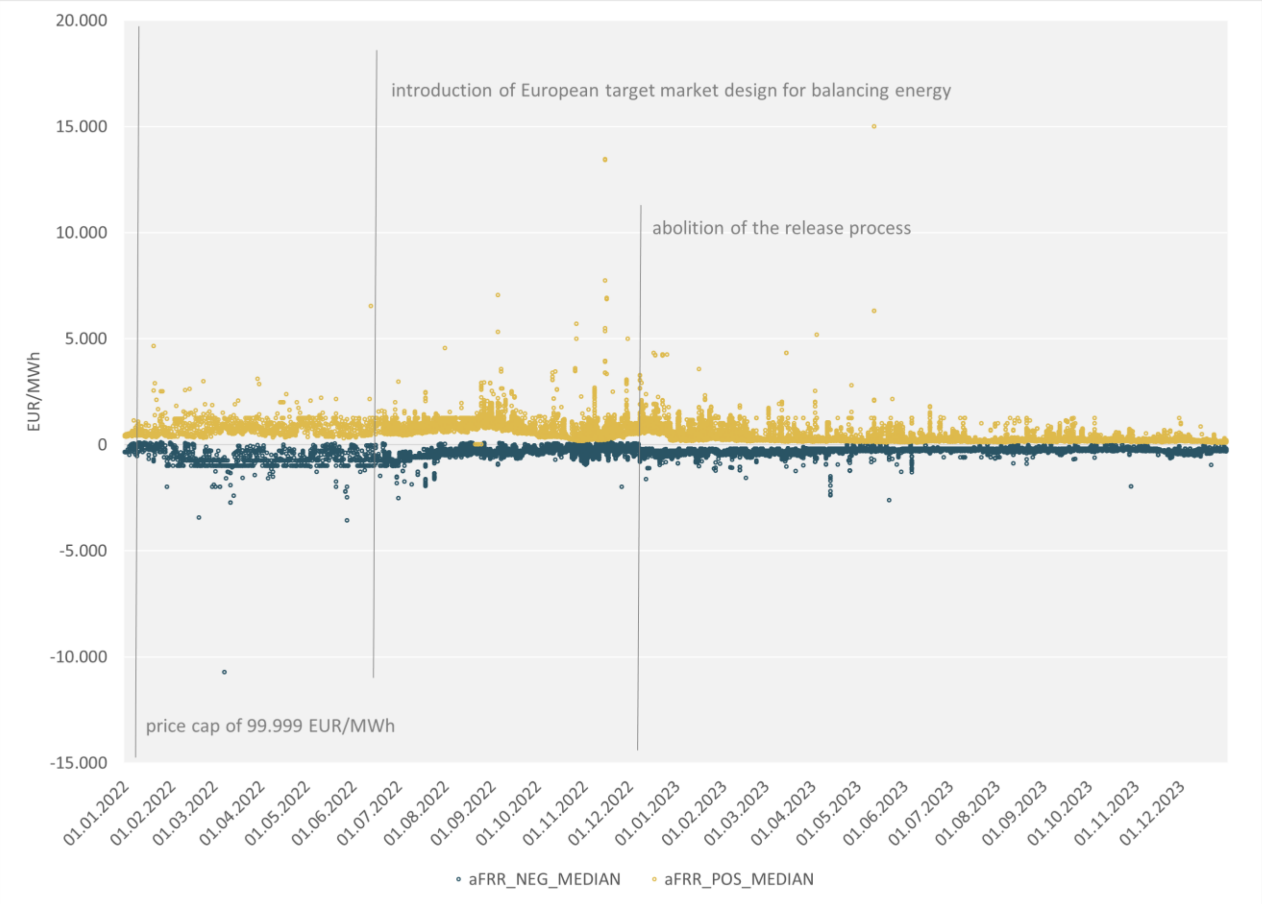

Figure 21 : Development of the aFRR energy price (median)

A comparison of Figure 20 and Figure 21 shows that the average balancing energy prices are at a higher level and the median also has fewer effects, which is due to the changes made essentially having an impact on the end of the MOL. From the TSO's point of view, considering the median is more suitable for presenting the development of balancing energy prices since with the abolition of the release, the MOL contains a higher additional volume at high prices and the median is therefore more informative about the level of balancing energy prices. In the long-term observation, the median tends to decrease, which suggests a lower bid price level of the more frequently accessed balancing energy bids in the first half of the MOL.

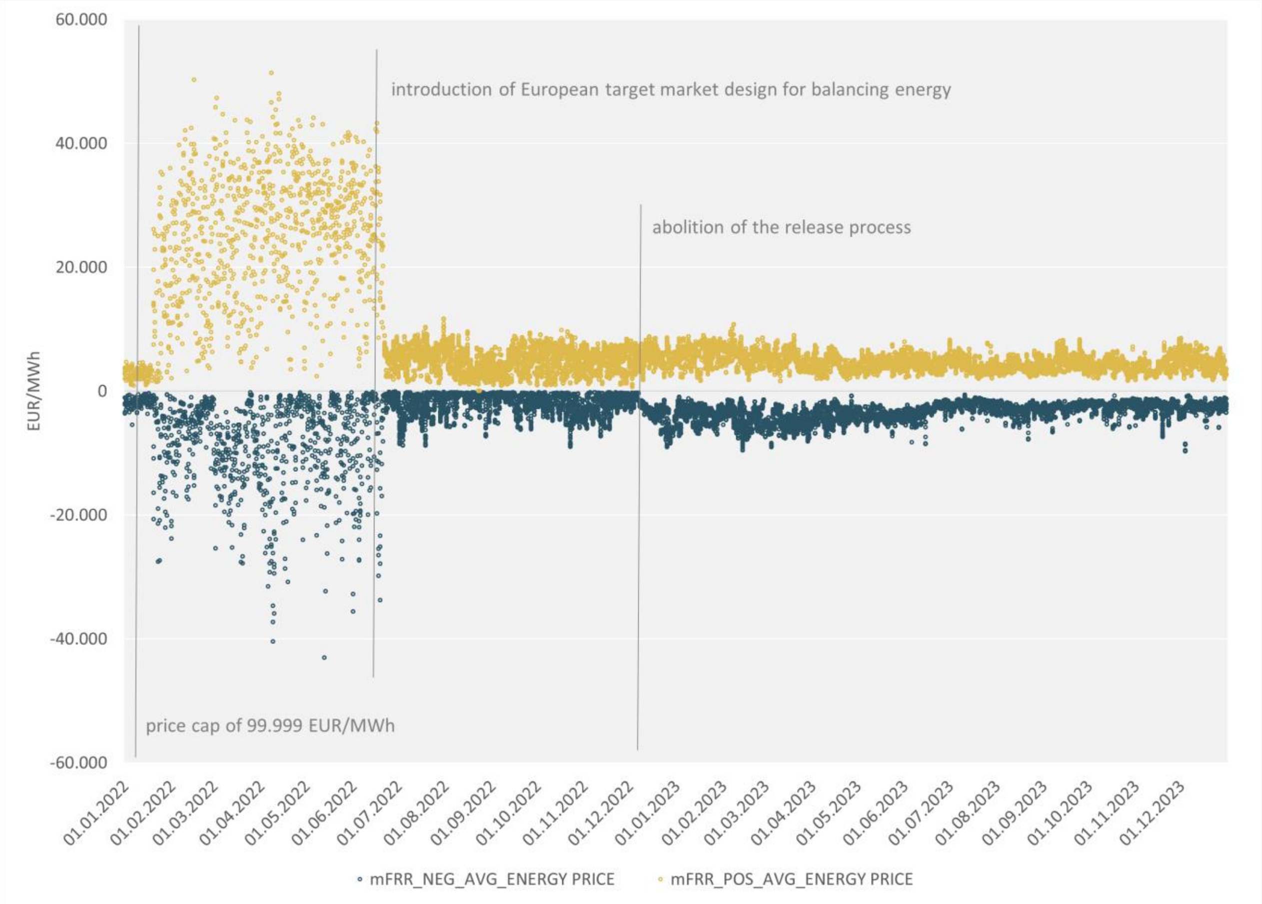

Figure 22 : Development of the mFRR energy price (average)

Similar to the developments for aFRR, it can be seen in Figure 22 that the mFRR balancing energy bids in the MOL increased sharply after the abolition of the release. This is due to the high-priced bids being considered (and no longer released) from then on.

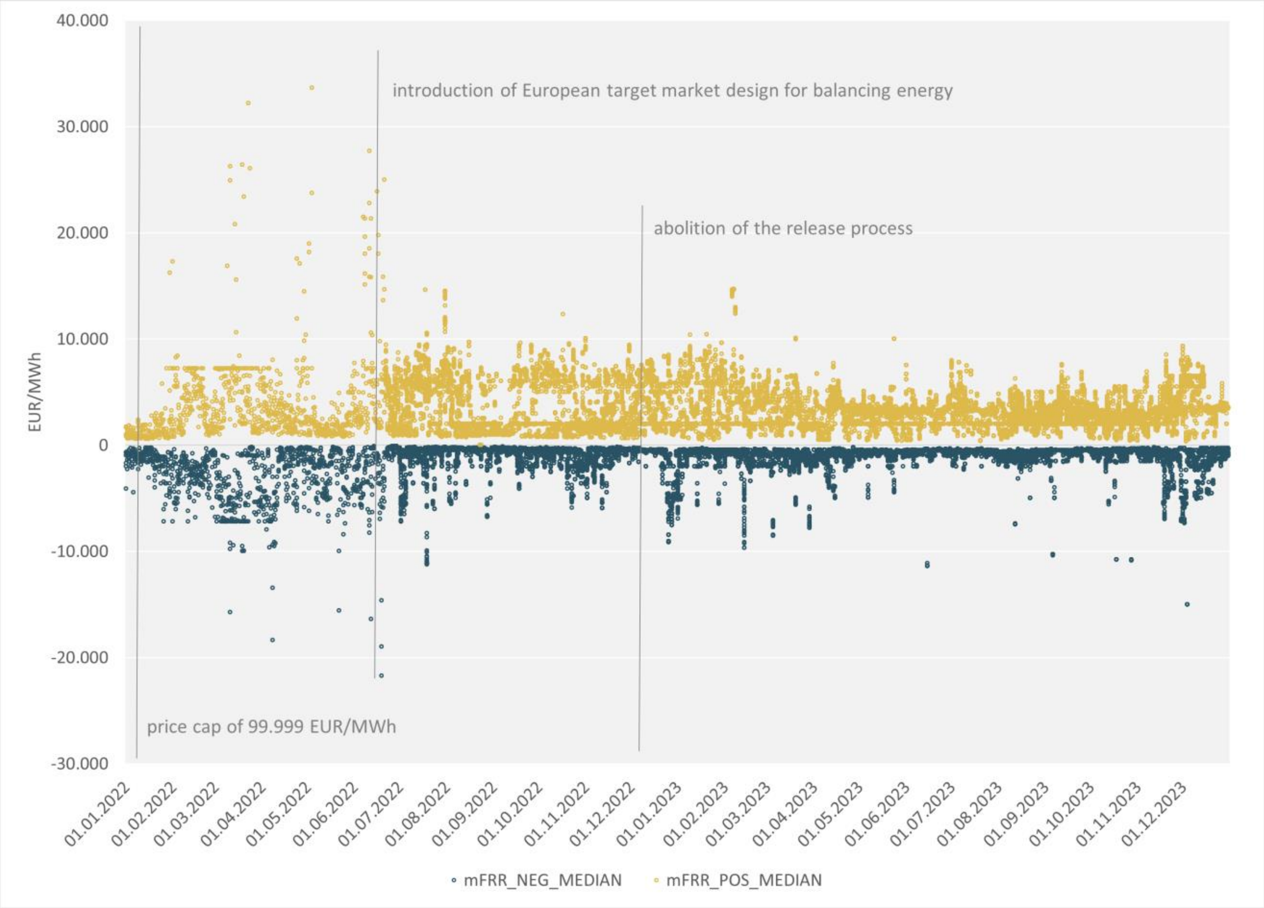

Figure 23 : Development of the mFRR energy price (median)

With the introduction of the EU target market design for balancing energy, the highest prices have been reduced to the new upper price limit and an accumulation of prices at the upper price limit can be observed. Basically, the prices for negative mFRR initially decreased, but later returned to the level at the beginning of the observation period. A decrease in the price level in the second quarter of 2023 can be observed for both the positive and the negative mFRR.

The frequency of deviations from the average price level is interesting. With the introduction of marginal pricing, a decrease in prices to the level of the respective marginal costs would be expected. However, there are some very high positive and negative prices. A direct effect of the abolition of the lay-off cannot be inferred from the prices.

Development of supply in the balancing energy market

When considering the offer at the RAM for aFRR and mFRR in Figure 24 and Figure 25, it can be seen that there is not always a bid surplus or that it is significantly lower than for the balancing capacity. It can be determined that since the RAM went live, there have been only a few additional bids without a prior award in the balancing capacity tender. The volume offered by the RAM is obviously well below that of the RLM.

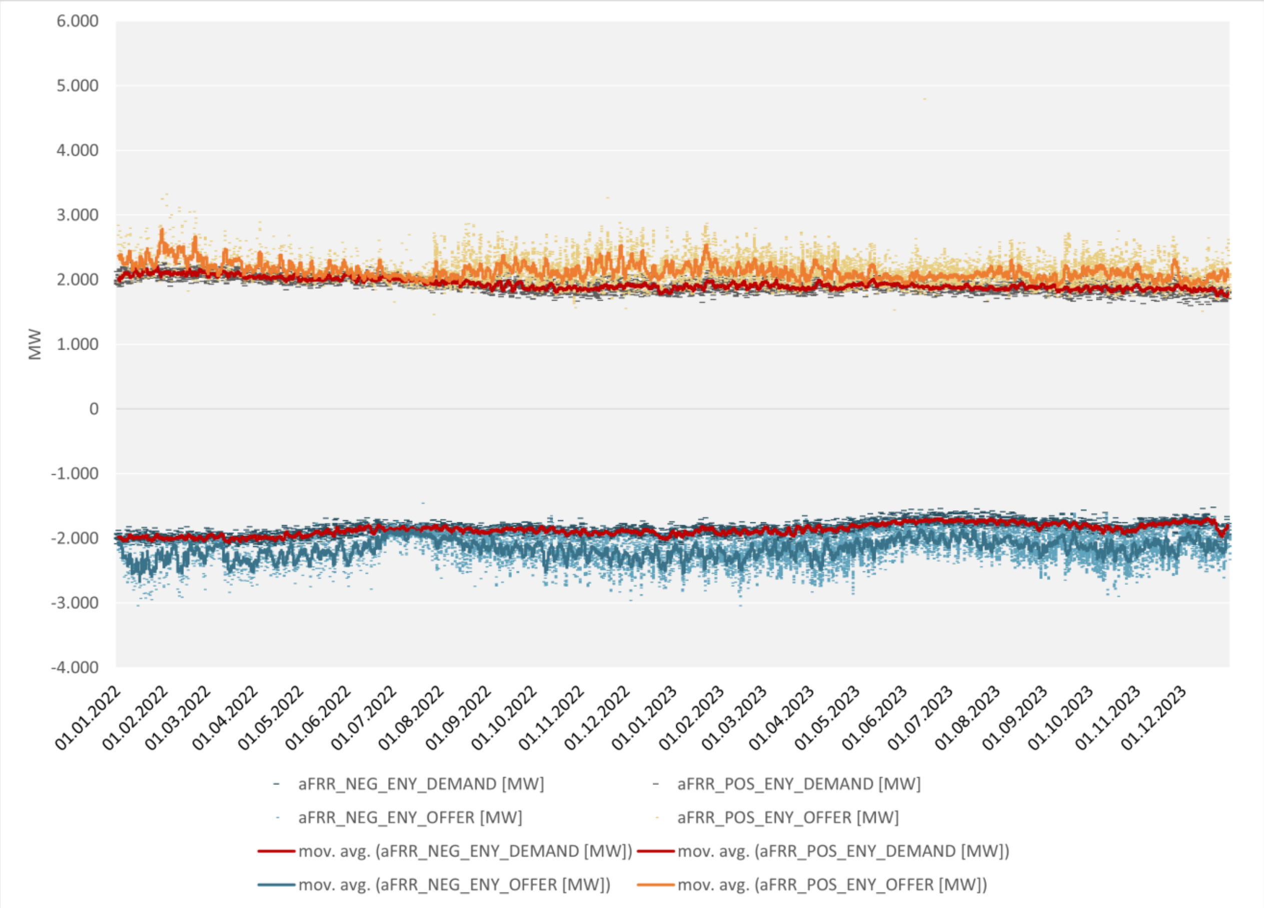

Figure 24: aFRR need and offer on the balancing energy market

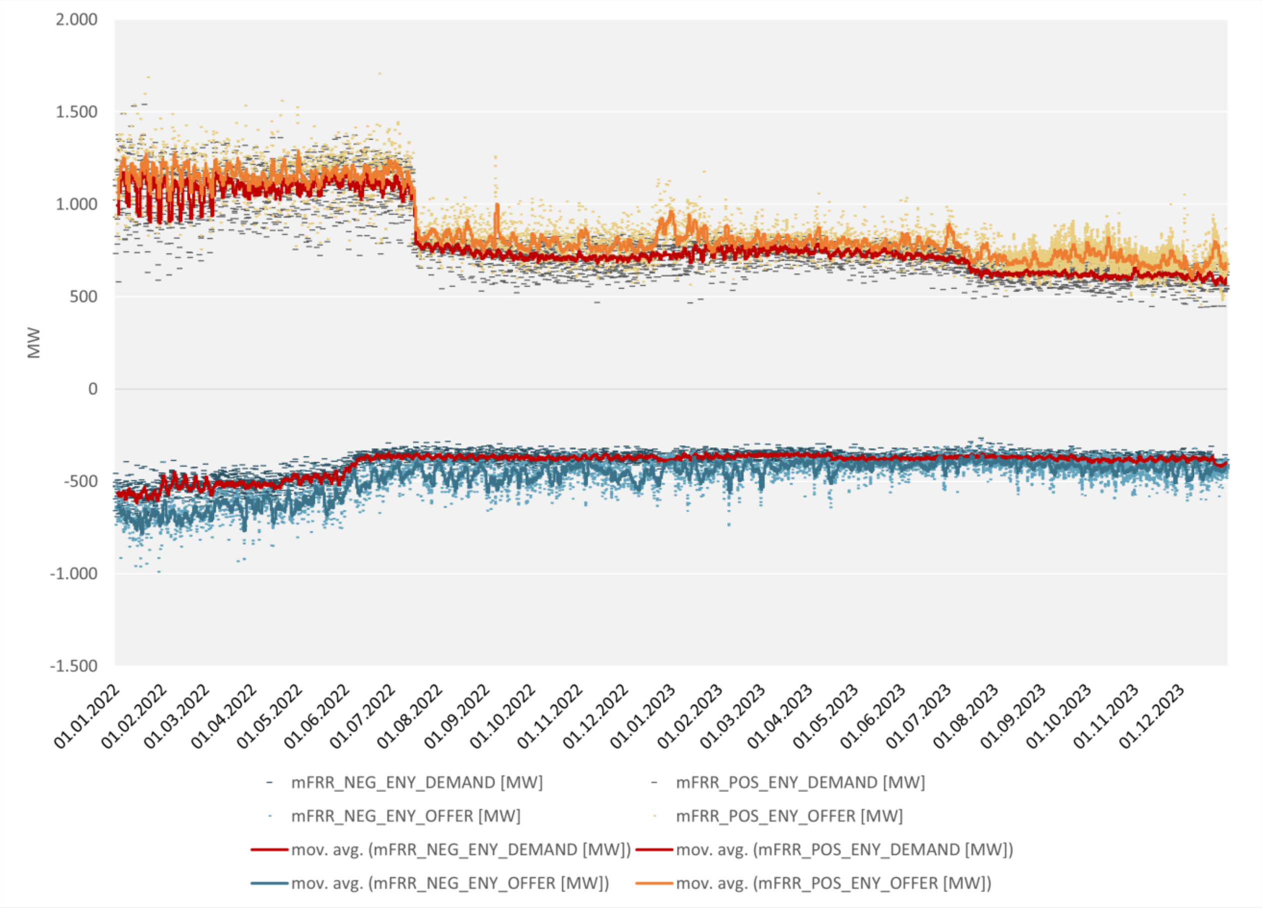

Figure 25: mFRR need and offer on the balancing energy market

Note: In cases in which bids could not be submitted to the RAM by the regular gate closure, the selected volume from the RLM was considered in the analysis. This service must be provided by the BSPs according to the terms & conditions and thus be offered at the RAM. Thus, one can generally assume that this service would have been offered at least. During the reporting period, the aFRR was up to 39 15 minutes and the mFRR up to 45.

In cases in which bids could be submitted up to gate closure but other problems led to a fallback, the service actually offered in the RAM is displayed.

6.5 Activation of balancing services

FCR is not activated centrally; rather, the providing technical units provide FCR according to the system frequency, measured on a decentralized basis, and the provided FCR.

For aFRR, the activation is performed automatically by the LFC of the connecting TSO, which considers the deviations of both the transferred power of the marginal integral and the frequency from their respective target values when making its activation decision. Deviations from the requested and provided aFRR are booked as imbalance energy. The activation is based on the merit order of the aFRR energy price bids, with the NRV ensuring a Germany-wide merit order - independent of the power plants connected to the LFC.[18] The aim of this procedure is to minimize the costs of activation of the required aFRR balancing energy. The requirements of the MOL correspond to the requirements of the EB Regulation. Providers are obliged to provide the TSOs with suitable evidence of the provision of requested aFRR upon request. Furthermore, the TSO can check the provision by means of test activations.

If it appears sensible and necessary for operational reasons, the TSOs activate mFRR balancing energy. In particular, mFRR balancing energy is activated to replace the higher-order aFRR because it can be activated more quickly in the case of foreseeable long-term imbalances and to make aFRR available again for counteracting further short-term imbalances. In Germany, there is no economic balancing between the use of aFRR and mFRR. However, the activation of the mFRR balancing energy bids to be triggered is in turn based on the Germany-wide merit order of the mFRR balancing energy bids to minimize the costs of the mFRR activation itself.
The mFRR is requested electronically via the Merit Order List Server (MOLS). mFRR balancing energy is activated as scheduled delivery or as direct activation. This means that in the case of an mFRR request between the provider's balancing group and the mFRR balancing group of the connecting TSO, a corresponding schedule is agreed. The activation must be at least 7.5 minutes before the start of the timetable. Deviations from the requested and provided mFRR are booked as imbalance energy. In addition,

[18] Only in exceptional cases can there be deviations from the Germany-wide merit order. For example, in the event of grid bottlenecks within Germany, individual TSOs can restrict their participation in the NRV to the extent that aFRR is preferably activated within their own LFC area, independent of the Germany-wide merit order. Process control malfunctions in the GCC or events such as test activations can also lead to deviations from the merit order. These deviations are documented by the TSOs).

the balancing service providers are obliged to provide the TSO connecting TSO can check the provision by means of test activations.

It is important for an understanding of the activation of balancing services to know that the balancing services activated in 15 minutes do not necessarily have the same sign for various reasons:

- The course of the demand for aFRR can show a high volatility with frequent changes of sign within a 15-minute period and even within a few minutes, so that aFRR work can be activated positively and negatively within the same 15-minute period. In addition, due to the inevitable inertia of the TUs providing aFRR, the target signal and actual provision of aFRR may differ from aFRR, subject to a minimum ramp. Therefore, especially when there is a change of sign in the aFRR demand, e.g. For example, a positive aFRR may be requested as a target signal while a negative aFRR is provided at the same time, or positive and negative aFRR may even be provided at the same time.
- The activation of the slower mFRR naturally follows the aFRR demand with a time delay and with a lower activation speed. It cannot follow all movements (and sign changes) of the secondary control. Thus, the activations of the two types of balancing services can also have opposite signs within a 15-minute period.

6.6 Settlement and cash flows between providers and TSOs

As explained in section 6.3, with the balancing service types FCR, aFRR and mFRR a power price-based payment for the provision of balancing capacity and in the case of the balancing service types aFRR and mFRR an energy price-based payment for the balancing energy actually used. The remuneration for the provision of balancing capacity always represents a payment from the TSOs to the balancing capacity providers. Depending on the sign of the balancing energy and the energy price for a bid used, the remuneration for activated balancing energy can be a payment by the TSOs to the providers or vice-versa represent.

The remuneration for the provision of balancing capacity and for the activation of balancing energy is settled according to the following principles:

- The level of remuneration is based on the volumes to be settled (i.e. services or energy volumes) and the service or energy prices offered by the providers for the respective bid as well as the marginal prices determined by the platforms (cross-border marginal price).
- by the 15th working day of the following month.

- The settlement is always done by the TSOs, regardless of whether this results in a payment from TSOs to the providers (i.e. a credit from the TSOs' point of view) or a payment from the providers to the TSOs (i.e. an invoice from the TSOs' point of view).
- Each TSO settles the balancing capacity provided and the activated balancing energy with the BSPs whose TUs used for the provision of balancing energy are connected in its LFC area, regardless of where the balancing services are based on the activation for a given balancing amount has been created. The TSOs refer to this allocation as the "connecting TSO principle". Thus, each TU is assigned to exactly one TSO which is also responsible for settlement. In the internal relationship between the TSOs, this results in the need for balancing payments both for the provision of balancing capacity and for the use of balancing energy.

With the payment for the provision of balancing capacity of the qualities FCR, aFRR and mFRR, the quantities to be settled (i.e. the services provided) result directly from the awards within the framework of the balancing capacity tenders. These quantities only need to be corrected in exceptional cases, for example if BSPs change, e.g. due to technical unavailability after the award time.

The energy quantities of relevance for the payment for the activated balancing energy of the qualities aFRR and mFRR are determined separately for each activated bid of each BSP and for each settlement interval of the delivery month[19] and after multiplication by the respective energy prices, are totaled to form monthly settlement amounts. The individual amounts and thus the monthly totals can be positive or negative depending on the sign of the balancing energy and the energy prices and thus represent payments in different directions between the TSO and providers.

The balancing energy quantities relevant for settlement are determined during the delivery month at the end of a delivery day and coordinated between the TSO and the providers. The procedure for aFRR and mFRR is different:

- The aFRR works with a cycle time of one or a few seconds. In every cycle, the actuating signals for the control systems of the respective connected TU are updated and transmitted. These aFRR set points are archived in the TSOs' control systems. In addition, the control systems receive
  The settlement quantities are determined for each pool from the archived yield values. To do this, the TSOs calculate the acceptance and under-delivery quantities for each settlement interval based on the target and actual values of the BSP as well as additional acceptance and tolerance criteria.

[19] In Germany, this is one second for the aFRR and 15 minutes for the mFRR.

Both quantities are then distributed to the bids being called off. At this level, the acceptance quantities are then multiplied by the respective settlement price to get the settlement amounts to determine. The settlement price corresponds to the maximum of PICASSO's marginal price and the provider's bid price for the positive direction. The minimum of these two quantities is used for the negative. The under-performance quantities, on the other hand, are multiplied by the marginal price of PICASSO, with the direction of payment always being to the TSO. The results are aggregated for each bid into 15-minute values and made available to the BSP by 10 a.m. the following day for the purposes of daily coordination. The BSP can lodge an objection within 5 working days. More information on this process can be found in the aFRR model description.

- In contrast to the aFRR, the mFRR is not metrologically delimited so that a separate recording of the actual use is not possible here. Rather, the mFRR is considered in the balancing system by generating an exchange schedule every 15 minutes for each activation between the mFRR provider's balancing group and the mFRR balancing group of the TSO concerned. If the provider provides the mFRR exactly as requested and thus in accordance with the schedule generated for the purpose, the schedule exactly balances the changes in the provider's generation or consumption meters associated with the provision. If, on the other hand, deviations occur, these are automatically determined during the balancing group settlement and treated as balancing energy which the provider has used. The 15-minute values of the activation schedule transmitted by the MOL server of the TSO to the provider are therefore decisive for the settlement of the balancing energy quantities provided within the framework of mFRR between the TSO and the provider. These volumes are settled using the cross-border marginal prices of the European activation platform MARI, which can differ for the "direct" or "scheduled" activation types.

6.7 System balancing cost

In the past, cooperation in the NRV has significantly reduced the costs for the provision and activation of balancing services through the cost-optimized aFRR and mFRR activation. Figure 26 illustrates this development. In contrast, these costs have increased significantly in the past few years (2021 to 2023) in connection with the energy price crisis. A key factor is the further significant increase in wholesale prices, which provide an orientation for the balancing costs. The partially declining costs for balancing services in 2023 are due to the balancing service cooperations as well as lower energy exchange prices (see also section 6.4).

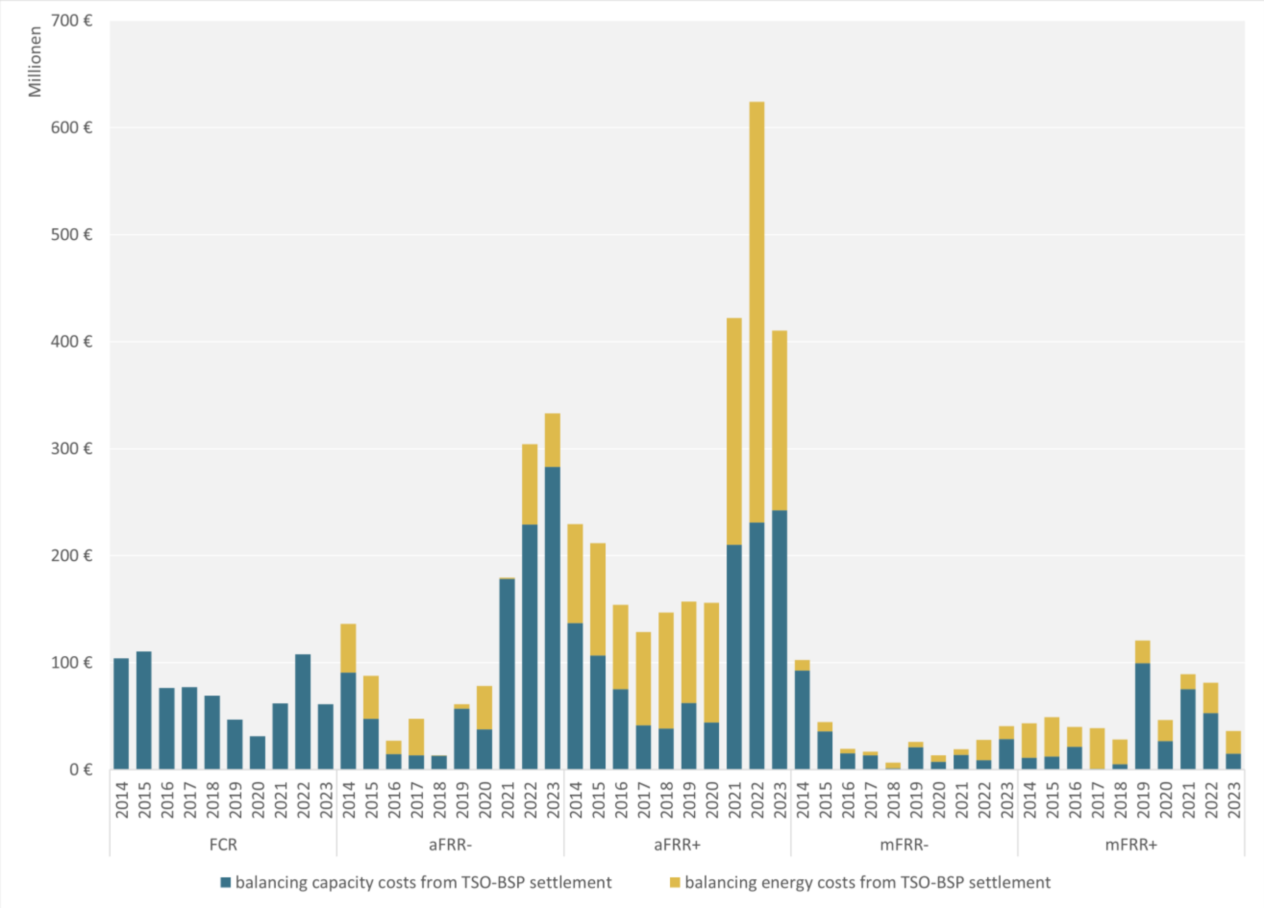

Figure 26: Development of the costs settled with balancing service providers for the provision of balancing capacity and the activation of balancing energy in Germany

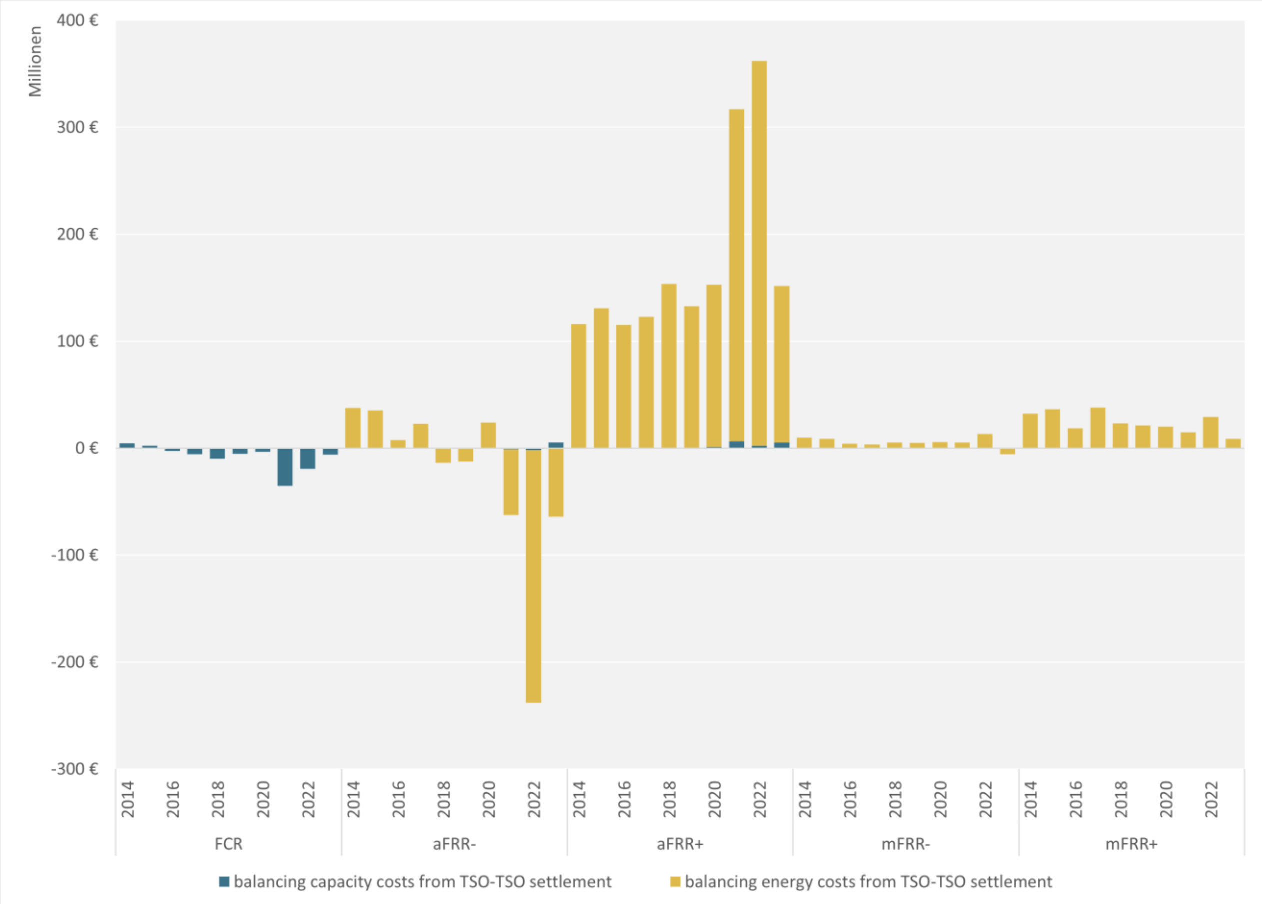

Figure 27: Development of balancing costs in Germany with int. TSO cooperations for balancing capacity and energy

Figure 27 above shows intra-TSO payments for balancing capacity and balancing energy between the German TSOs and the foreign country. Negative values are payments from other TSOs to German TSOs due to deliveries or provisions on behalf of other TSOs. The graphic illustrates the positive effects of the European balancing service cooperation. As already described above, this graphic also shows the effects of the high spot market prices - especially in 2022 - on the balancing markets.

6.8 Transparency obligations

For various reasons (including the opening of market entry barriers and intensity of competition in the balancing markets, the possibility of a comprehensive assessment of the offer situation on the electricity wholesale markets, the traceability of imbalance pricing) the greatest possible transparency in the tendering, procurement and use of balancing services is desirable.

BNetzA from 2011 on the tendering of the different types of balancing services [20] as well as the European Regulation 2013/543/EU on the transmission and publication of data in electricity markets (Transparency Regulation) as well as the Guideline on balancing - EB Regulation. Specifically, the publication of various information on www.regelleistung.net and partly on the ENTSO-E Transparency Platform is required. These include

- for FCR
    - the amount of the total requirement within Germany and abroad,
    - an anonymized list of the FCR bids for which funding was awarded (incl. service and price),
- weighted mean service price (for pay-as-bid) and marginal service price,
    - for FRR (aFRR and mFRR each)
    - the amount of the requirement per product and LFC area, including any approved core shares,
    - an anonymized list of the awarded FRR bids (incl. service offer, capacity bid and, where applicable, energy price bids (on the RAM)) and, where applicable, an identification based on the core portions of the awarded bids,
    - weighted mean price and marginal price per product,
    - the balancing energy used (separately for positive and negative FRR) with a resolution of 15 minutes across the entire Grid Control Cooperation and differentiated by the LFC area and
    - the period of deviation from the merit order and the reason for it.

Since the introduction of the balancing energy market in 2020, an anonymized list of all awarded aFRR and mFRR balancing energy bids, separately for positive and negative FRR, which contains the service offer and the energy price for each bid (balancing energy merit order), has also been published. The FRR work applied will continue to be published with a resolution of 15 minutes, separated into the positive and negative directions for aFRR and mFRR, for the NRV and all four LFC areas. Likewise, the period of the deviation from the merit order is to be published and the reason for it.

---

[20] See BNetzA decisions BK6-10-097, BK6-10-098, BK6-10-099

LFC areas and the entire NRV[21], also with a 15-minute resolution, as well as the names of all providers prequalified for the provision of balancing services for all types of balancing services are to be published on www.regelleistung.net .

Since September 2021, the TSOs have also been publishing an NRV balance traffic light for market participants. [22] The NRV balance traffic light signals gradually indicate either an under-supply or an over-supply of the system and give market participants the opportunity to identify indicators of imbalances in their balancing groups at an early stage and to take appropriate countermeasures.

The data necessary to fulfill these transparency requirements is available in full at www.regelleistung.net and www.netztransparenz.de . In the process, find yourself

- Lists of prequalified providers
- Information on the requirements for the individual balancing services and the results of the tender under the menu item "Tenders" and
- Information on the use of balancing capacity, LFC area and NRV balances and deviations from the merit order under the "Data center" menu item. Information on the exchange within the framework of the cooperation as well as on the exceeding of the 80 % threshold relevant for the imbalance settlement price-system (see section 7.2) is also published there. It should be noted that precisely due to the short publication times, individual data represent operational values and therefore not yet quality assured, which may be corrected later in the settlement and processing process.

Furthermore, in addition to the publications on www.regelleistung.net, the aFRR work deployed can be made available to providers or potential providers over a period of at least 12 months with a resolution of every second. A corresponding provision is made on request via the website of the German TSOs.

6.9 Competition on the balancing reserve markets

Numerous market and product adjustments have been made over the past few years, also aim to ensure greater competition and reasonable prices. While at the RLM the bid surplus is comparatively high and the

---

[21] In accordance with BNetzA decision BK6-12-024 on the further development of the imbalance settlement price-system, the TSOs have been publishing the balance of the GCC since 1 December 2012 at the latest 15 minutes after the end of a settlement interval at www.regelleistung.net.

[22] The ‘NRV-Saldo-Ampel’ is published at: https://www.netztransparenz.de/weitere-publications/NRV-Saldo-Ampel

prices have undergone understandable developments, RAM is characterized by less supply and a price level which cannot in all cases be explained with variable costs or opportunity costs of the provision or provision.

Nevertheless, price spikes, when they occur due to scarcity, signal critical situations in the system balance and provide a financial incentive for balance responsible parties to improve balancing group management. Challenging, however, is that price peaks due to the high balancing energy bids were observed, which occurred without a lack of available flexibility and without any conspicuous need and thus posed unreasonable risks for the balancing groups due to the influenced imbalance settlement price, which necessitated the introduction of price upper limits for balancing energy.

The low RAM supply leads to pivotality of the largest four pools in almost all balancing energy tenders. The European platforms and the target market design were also aligned to strengthen competition in the balancing energy market through European market integration and to establish an incentive-compatible market design. An auction design is considered incentive-compatible if the optimal bid strategy is bidding at marginal costs (including opportunity costs), i.e. no bid strategy exists that leads to the expectation of a higher profit. In general, auctions with the standard price method are attributed this property, however, further requirements must be met for it [23] :

- The auction must auction homogeneous goods.
- This is a one-time auction.
- There are as many bidders as possible.
- The bidding calculations of the other bidders are unknown.
- Bidders only own part of the property.

The fewer of these requirements are met, the less likely it is that an auction using the marginal price method will lead to the desired auction results. And so, in the specific case of the balancing energy market according to the EB Regulation, there are

- Due to the different activation probabilities at different points in the merit order, the goods are not assumed to be homogeneous.

[23] https://eepublicdownloads.entsoe.eu/clean-documents/nc-tasks/210826_Appendix%201%20of%20Explanatory%20document_Report%20(1).pdf

- The auction is repeated every 15 minutes with the same bidders (prequalified bidders). This allows bidders to test and adjust bid strategies. The risk of not earning any revenue with the wrong bidding strategy is limited to a very short product duration.
- Due to the very low minimum bid size (1 MW) in comparison to demand, it is very far from a "single good auction".
- The high market concentration theoretically enables individual providers to influence the price level.

In addition to these theoretical considerations, practical aspects also play a role. Providers who can only provide limited balancing services due to limited availability and only want to be activated above a certain price level, adjust their bidding behavior accordingly and regularly bid at (or near) the upper price limit. The provision obligation from an surcharge on the RLM must not be violated. However, a corresponding contractual arrangement between the balancing service provider and the system operator may be the basis. In these cases, bidding at the marginal price does not always appear to be the optimal bidding strategy. For many pools, a distribution of balancing energy bids along the demand MOL can be observed. This distribution can be an indication of strategic bidding.

In principle, higher energy prices are also justified when demand is high, even if the imbalance settlement price with the scarcity component ensures a financial incentive for balancing responsible parties to manage the balancing groups in a balanced manner. However, when demand is low, the imbalance settlement prices should also be at an appropriate level and not pose a risk to the existence of BRPs.
Together with Consentec, the TSOs examined the bidding behavior on the balancing energy market and are, among other things, came to the following conclusions:

- The balancing energy prices can be calculated, for example T. cannot be explained by marginal costs or provision costs (opportunities).
- With aFRR, more balancing energy bids are offered in the lower price segment than before the switch to the marginal price system.
- More balancing energy bids are bid in the high price segment than before the switch to marginal pricing.

Two time periods were considered for the analyses: the period before the introduction of the RAM in Germany (01/2019 to 11/2020) and the period since the introduction of the RAM in Germany (11/2020 to 08/2023).
Overall, it can be observed that the number of active pools, especially for mFRR and aFRR+, has decreased in the time range analyzed. Only the number of active pools for aFRR- remains at a comparable level. The

introduction of the RAM target market design and the end of the release do not show a clear impact on the bid size of aFRR; however, the mFRR bid size decreases over the period.

Analysis of price developments after the introduction of ZMD

The high bid prices in the period under review due to the Ukraine war have meanwhile fallen significantly again. Nevertheless, the observations described below must be classified against this background in relative terms. Overall, it is evident that when the MOL is exhausted, very high clearing prices and thus imbalance settlement prices are possible. However, the risk of high prices is significantly higher on mFRR, since clearing prices of €15,000/MWh are possible there for even 65% of the capacity provided. The analysis of bid data at the pool level shows that some providers systematically offer high energy prices. This is particularly pronounced for the positive products, although this observation is more applicable for mFRR than for aFRR. The following analysis refer to an analysis of all bids for each balancing service quality.

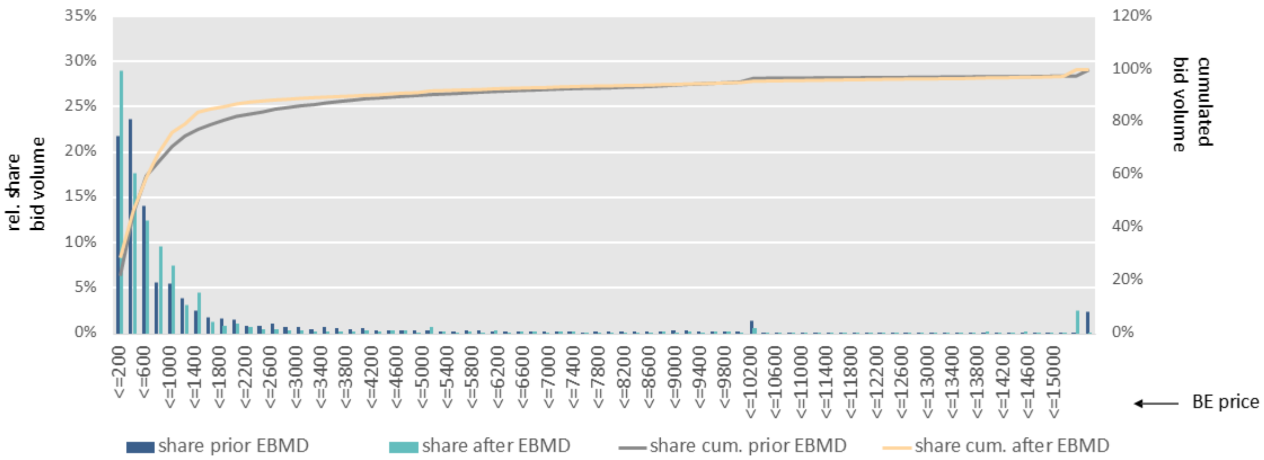

Figure 28 : Price structures of awarded RAM BE bids of all pools for aFRR+ prior and after implementation of EB Regulation market design (EBMD)

aFRR+ (see Figure 28): If you look at the bids of all pools, it is also seen here that prices have fallen on average after the introduction of ZMD. This is evidenced by the yellow curve (cumulative relative bid volume after the introduction of the ZMD) increasing faster than the gray curve (cumulative relative bid volume before the introduction of the ZMD), which shows that the volume of low-priced bids in aFRR+ has increased (e.g. (e.g. green bar in the area of the energy prices <= 200 €/MWh larger than the blue bar).

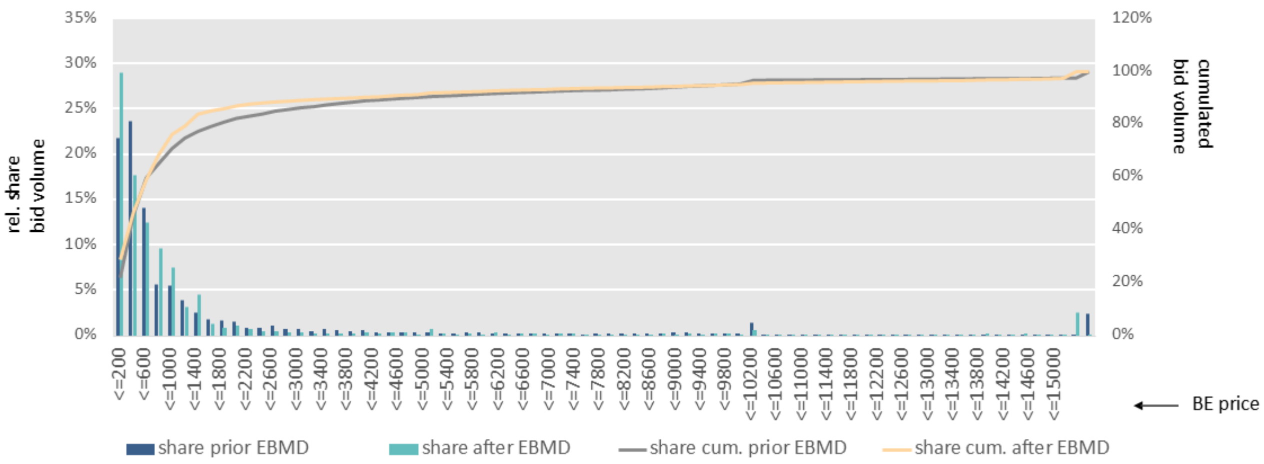

Figure 29: Price structures of awarded RAM BE bids of all pools for aFRR- prior and after implementation of EB Regulation market design (EBMD)

aFRR- (see Figure 29): Over 50% of the bids are in a range ≥ 200 €/MWh. Only 10% of the bids are below €2,000/MWh.

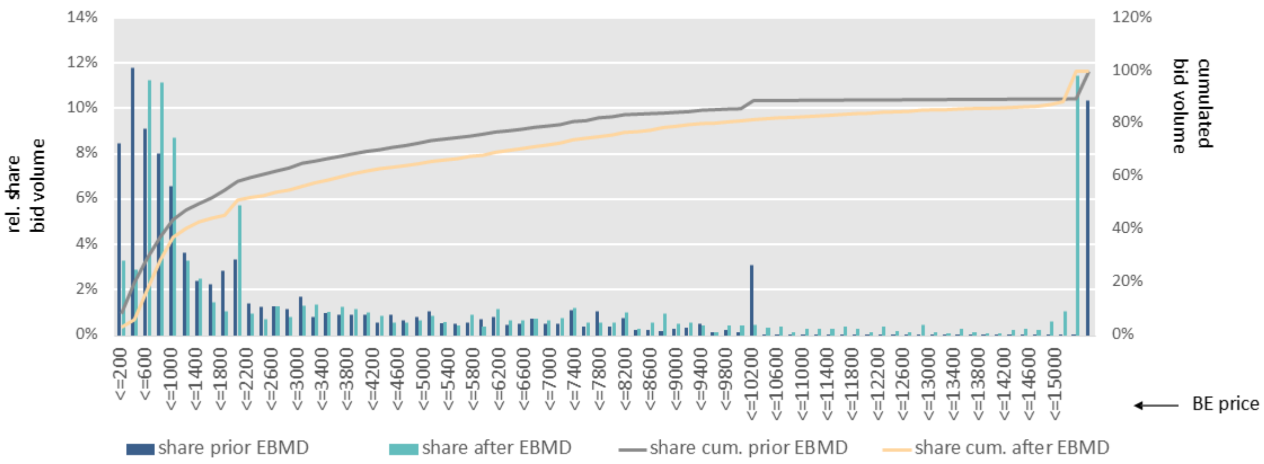

Figure 30: Price structures of awarded RAM BE bids of all pools for mFRR+ prior and after implementation of EB Regulation market design (EBMD)

mFRR+ (see Figure 30): The average price of the bids is higher for mFRR+ than for aFRR. Around 50% of the bids are offered at a price above €2,000/MWh (after the introduction of the ZMD). 10% of the bids are offered at a price of €15,000/MWh. In addition, after the introduction of the ZMD, a lower low-price bid volume is evident from the display of the cumulative bid volume (grey curve crosses the yellow curve), which contradicts the market-theoretical assumption of the price development. After the introduction of the ZMD, fewer bids below € 400 /MWh are submitted than before.

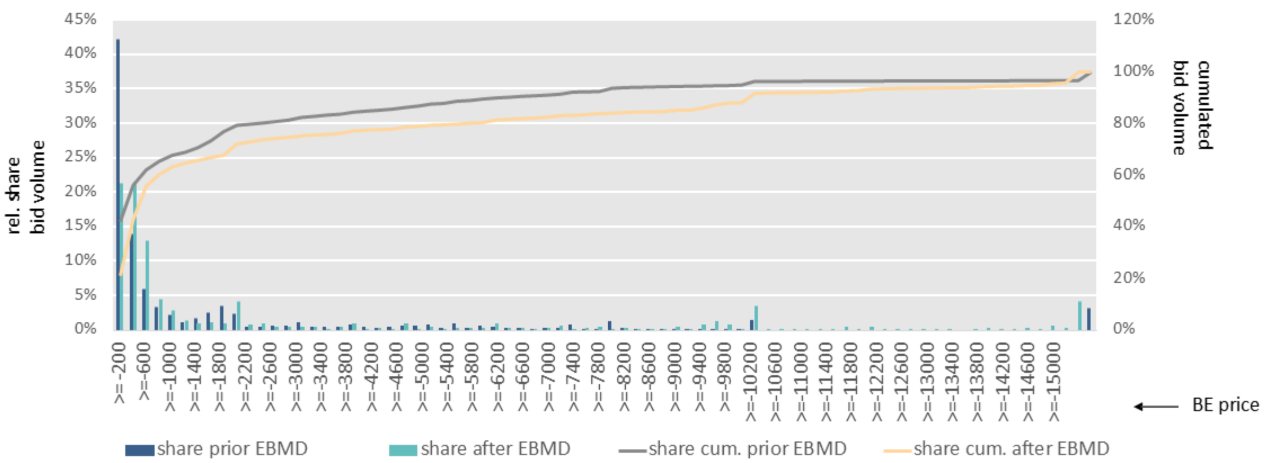

Figure 31: Price structures of awarded RAM BE bids of all pools for mFRR- prior and after implementation of EB Regulation market design (EBMD)

mFRR- (see Figure 31): Price level significantly lower than for mFRR+ (analogous to between aFRR+ and aFRR-). Contrary to the expectation of market theory, an increase in the price level after the introduction of ZMD can also be observed here - albeit more moderately than for mFRR+.

While the decrease in prices at the start of the merit order is due to the incentives of the marginal pricing system and is expected (see in particular the yellow curve in Figure 28) and the bidding at the upper price limit is due to the interest in avoiding activation, the shift of balancing energy bids in the higher price segment is an indication of higher marginal and opportunity costs or more pronounced strategic bidding.

The price level observed on the RAM partly leads to the assumption that the bids submitted are very likely to be higher than the variable costs of BSP. Furthermore, RAM is not classifiable as a perfect market.
Table 4 shows key figures on the competition for RAM before and after the introduction of the target market design. In addition to the number of active pools in the examined period, the Herfindahl-Hirschmann index and the cumulative market shares of the four largest pools are provided. The key figures show that RAM is significantly determined by a few providers.

	Data before the introduction of RAM (from 01/19)				Dates after RAM introduction (11/20-09/23)			
	aFRR+	aFRR	mFRR+	mFRR	aFRR+	aFRR	mFRR+	mFRR
number of pools	33	34	34	37	34	36	33	33
HHI	2 181	1 364	1 279	1 076	2 147	1 249	1 292	1 215
CR1	29%	24%	22%	19%	31%	22%	24%	26%
CR2	56%	44%	42%	37%	60%	40%	43%	44%
CR3	78%	58%	54%	49%	76%	53%	56%	50%
CR4	88%	67%	65%	60%	85%	63%	65%	56%

Table 4: Key figures on the competition at RAM

The four largest pools active in Germany have significant market shares in RAM. This has not changed significantly with the introduction of the target market design. Further analysis showed that the capacity offered by the pools with the largest market shares is higher than the capacity advertised in the RLM for the relevant time slice of the RAM in almost every 15-minute period. As a result, the two largest providers together are pivotal at these times (without their offerings, the necessary service could not be covered).

Using the example in Figure 30, after the introduction of the ZMD, bids along the entire merit order can be observed after the introduction of the target market design, while before that, hardly any bids could be observed in the second half of the merit order. In addition, there is a high bid volume at the upper price limit, which, in the case of a full activation, exploits the fact that there is no price elasticity in the case of balancing services. The POG represents a fixed point that the market participants seem to use for their orientation. This behavior is to be expected in the context of the introduction of price caps in imperfect markets.

The higher the price of the last activated balancing energy bid, the higher the marginal price for all balancing energy bids already activated in the MOL. In general, a distribution of bids across the entire MOL can be observed. This results on the one hand from different marginal costs as well as strategic considerations (for example only activation above a defined price level).

especially for the positive mFRR.

The competent supervisory authorities are responsible for the assessment of the bidding behavior to be observed on the balancing market.

7 Determination and settlement of imbalance energy

7.1 Determination and settlement of imbalance quantities

As explained in section 4.2, the TSOs are responsible for determining and settling the balancing energy quantities used by the balancing groups operating in their LFC area. The necessary exchange of information, the obligations to cooperate and the deadlines to be observed for this process known as balancing group settlement are regulated in the market rules for the implementation of balancing group settlements for electricity ("MaBiS") set out by a resolution of the BNetzA. The process includes the following key steps before and after the delivery time:

- The BRPs operating in an LFC area inform the TSO, whose role in connection with balancing group settlement is also referred to as the balance coordinator (BIKO), of all planned exchange transactions between the balancing groups within the LFC area as well as across LFC area borders, as well as forecasts for the expected physical feed-in and withdrawals. With the report before the delivery time, the BRP demonstrates an overall balanced management of the balancing group. These communications are made using electronic, automated processes; the exchanged messages are referred to as schedules. After the delivery time, the BRPs can still notify coordinated changes to these exchange programs within an LFC area until 16:00 on the following day.
- All system operators (transmission system operators and distribution system operators) in an LFC area record the 15-minute meter values as well as the standardized load profiles, which are used for the balancing of small customers without registering load profile measurement, from the suppliers and consumers connected to their grid after the delivery time, and sum these for each balancing group on, differentiated according to different types of feed-in and consumption. The BIKOs receive these balancing group-specific time series and pass them on to the BRPs. This process and the entire balancing group settlement each take place for one delivery month. The reconciliation of the balancing group-specific energy balances every 15 minutes between the respective grid operator and the BRP must be completed by the 29th working day after the delivery month at the latest. This data is relevant for the imbalance settlement according to the market rules, that the BIKO must establish 42 days after the end of the delivery month.
- To be able to retrospectively consider corrections to the balancing group data which the grid operators and/or BRPs still recognize as necessary and which are communicated to BIKO, a corrective imbalance settlement takes place eight months after the delivery month, for which the MaBiS also specifies deadlines for data exchange and clearing.

- The imbalance settlement prices, which are used later to settle the determined imbalance energy of the balancing groups, must be calculated by the TSOs by the 20th working day after the delivery month – i.e. even before the reconciliation of the balancing group balances - which is decisive for the first balancing group settlement -, publish it and transmit it electronically to each BRP.

Similar to the settlement of providers of balancing capacity and energy, the invoices for imbalance settlement are always raised by the TSO and transmitted to the BRP, independent of whether in the individual case there is a payment from the BRP to the TSO or vice versa.

7.2 Determination of the imbalance settlement price reBAP

Imbalance energy is settled in accordance with the requirements of the Electricity Grid Access Ordinance (StromNZV) as well as the EB Regulation and the method for the harmonization of the main components of the imbalance settlement price (ISHM) derived from it, using symmetrical imbalance settlement prices every 15 minutes. This means that the imbalance settlement price determined for a 15-minute settlement period is used equally for withdrawals of an under-supplied balancing group from the system (i.e. positive imbalance energy) and for feed-ins of an over-supplied balancing group into the system (i.e. negative imbalance energy). This symmetrical imbalance settlement price, which is specified in Euro per MWh, has also been determined as a uniform nationwide price since the introduction of the Grid Control Cooperation and has since been referred to as the "uniform imbalance energy price across all control areas" (reBAP).

Just like the electricity market or balancing energy prices, the reBAP can be positive or negative. A positive reBAP means that BRPs pay money to the TSO for balancing energy withdrawn from the system (i.e. if their balancing group is under-supplied) and receive money from the TSO for balancing energy fed into the system (i.e. if their balancing group is over-supplied). A negative reBAP results in the opposite cash flows. Table 1summarizes the effects for the four possible combinations of the signs of the balancing group balance and the reBAP.

balancing group	Withdrawal/feed-in of balancing energy	Sign of reBAP	Financial impact for BRPs
underfed	withdrawal	positive	invoice
underfed	withdrawal	negative	credit
over fed	feed-in	positive	credit
over fed	feed-in	negative	invoice

Table 1: Financial effects of the use of balancing energy depending on the sign of the balancing group imbalance and reBAP

- The reBAP is determined for the 15-minute period with the maximum, if the NRV balance is positive (total of all balancing groups, insufficient balance) from the three modules, or with the minimum for the other direction. The modules are module 1, the main component of the reBAP, module 2, a reference price derived from intraday trading acting as incentive component and module 3, a scarcity component (see Figure 32). The ISHM also permits other components to strengthen the incentive effect of the imbalance settlement price-system.

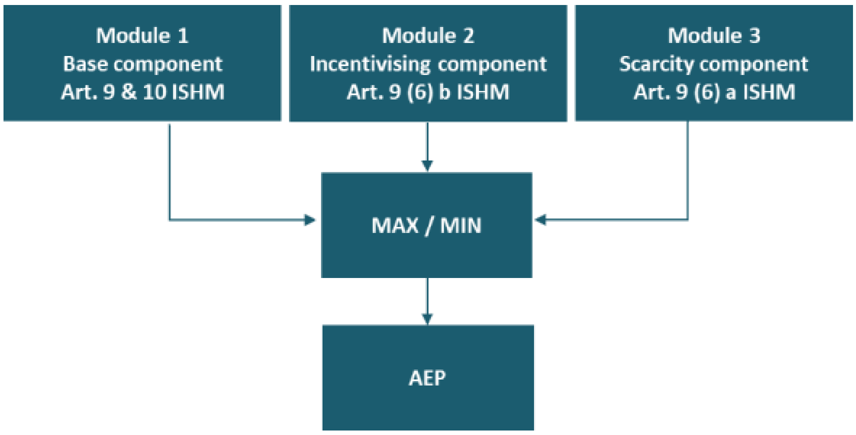

Figure 32: Schematic image of reBAP calculation

- Module1: Basic component

  Until 21st of June 2022, the reBAP was calculated on the basis of costs. In principle, the balancing energy costs that occurred in a 15-minute period were divided by the balance of the balancing energy quantities used. The rules of the EB Regulation required an adjustment of the main component, which the TSOs also refer to as "module 1". The basis is still provided by the prices for balancing energy formed on the market, however, in accordance with the requirements of the EB Regulation, a cost-based calculation was changed to a price-based one. Since then, the imbalance settlement price has no longer been determined on the basis of the costs and volumes of the activated balancing energy bids as well as other measures to balance the German Grid Control Cooperation. Instead, the prices and volumes of the balancing energy are the same as on the European platforms MARI for mFFR and PICASSO for aFRR to be used as a basis. To implement these requirements, the TSOs submitted a corresponding application to the BNetzA in March 2021.[24] As part of this, the TSOs also revised the provision on the determination of the GCC balance in line with the European requirements. In particular, the introduction of the target market design, the TSOs also consider the volumes of unintended exchange with neighboring control areas (Article 8 (1a) ISHM) and the FCR (Article 8 (1c) ISHM). Capping of reBAP is also no longer done since the risk of high prices no longer exists by dividing the costs by very small quantities. Furthermore, §55 EB Regulation prohibits a reduction of the imbalance settlement price below the average energy prices of the bids activated in the affected 15-minute period.

- Module 2: Spot Market Price Coupling

  Even before the switch to the price-based model as part of the introduction of the balancing target market design, there was a coupling with an Intraday price index in Germany. This was last revised in 2020 and has already been implemented in accordance with the rules of the EB Regulation and ISHM.

- Module 3: Scarcity Component

  A scarcity component was also established in the old reBAP, in the form of price surcharges at a balancing capacity utilization of 80% (80% criterion). This was replaced in 2021 by a continuous function, which was also introduced in line with the new regulations.

The spot market price coupling unfolds its effect in 16% of the settlement ISPs and the scarcity component in 0.01%. The reBAP is therefore primarily determined by the balancing energy costs and volumes. However, there is no simple relationship between these two variables, e.g. a monotone increase of balancing energy costs with increasing activation of balancing energy (or vice versa). Instead of that prices are impacted by the independent procurement of reserve qualities aFRR and mFRR and therefore strong differences in price structures may occur. As explained in section 6.4, the two types of balancing services can also be used simultaneously with opposite signs. Therefore, the balancing energy costs can be high even when there is a

[24] See BNetzA procedure BK6-21-192

small imbalance volume or can be subject to strong fluctuations even during periods when the imbalance has remained the same, since the distribution to the different types can change. The level of reBAP and its development over time can therefore only be explained by considering both the cost developments and the volume developments of both types of balancing services and any additional measures taken for balancing.**Fehler! Verweisquelle konnte nicht gefunden werden.**shows the imbalance settlement prices and the associated GCC balances for the years 2022 and 2023. High imbalance settlement prices in the four-digit range only occur occasionally 0.7% of the time and in combination of - both low and high GCC imbalances.

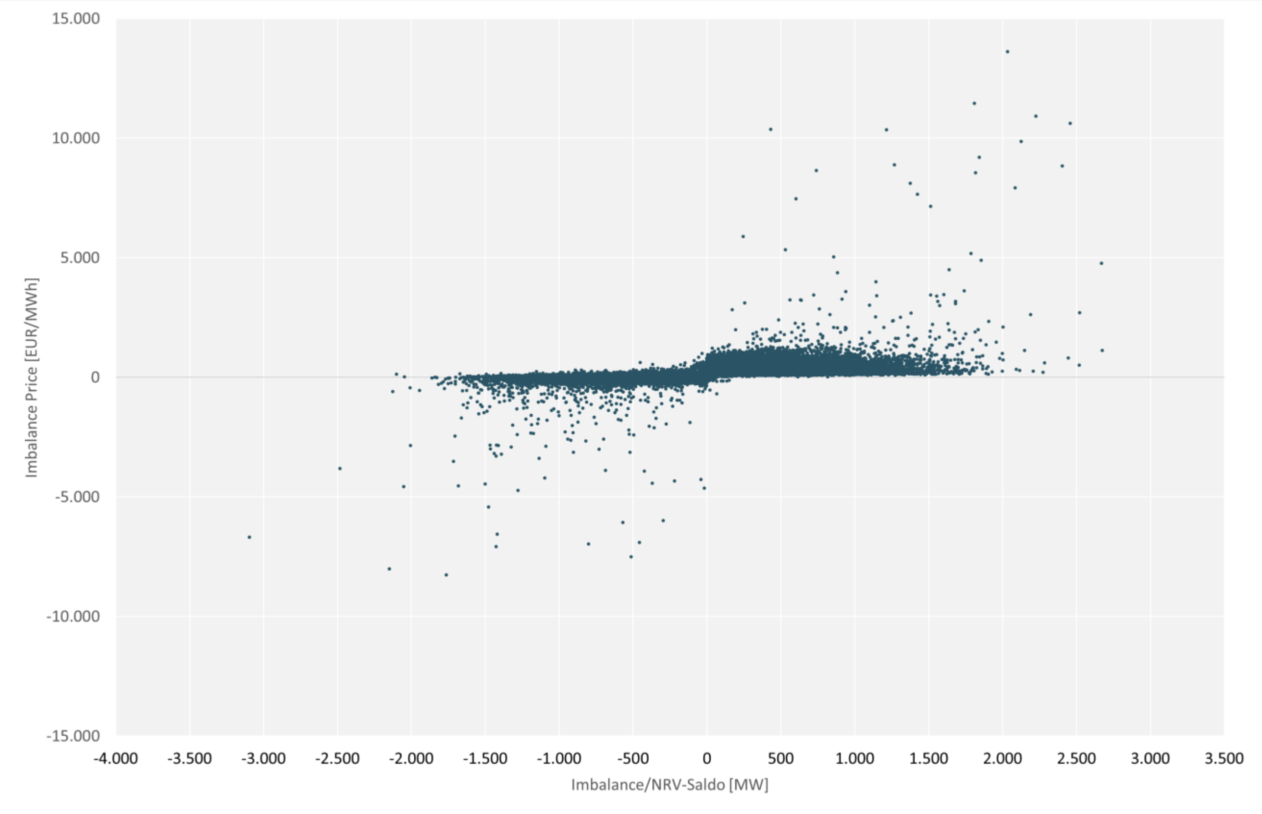

Figure 33: Correlation of the imbalance settlement price reBAP with the balance of the German Grid Control Cooperation (GCC) between 2022 and 2023; each point represents the values for a 15-minute period; the correlation coefficient is 0.5

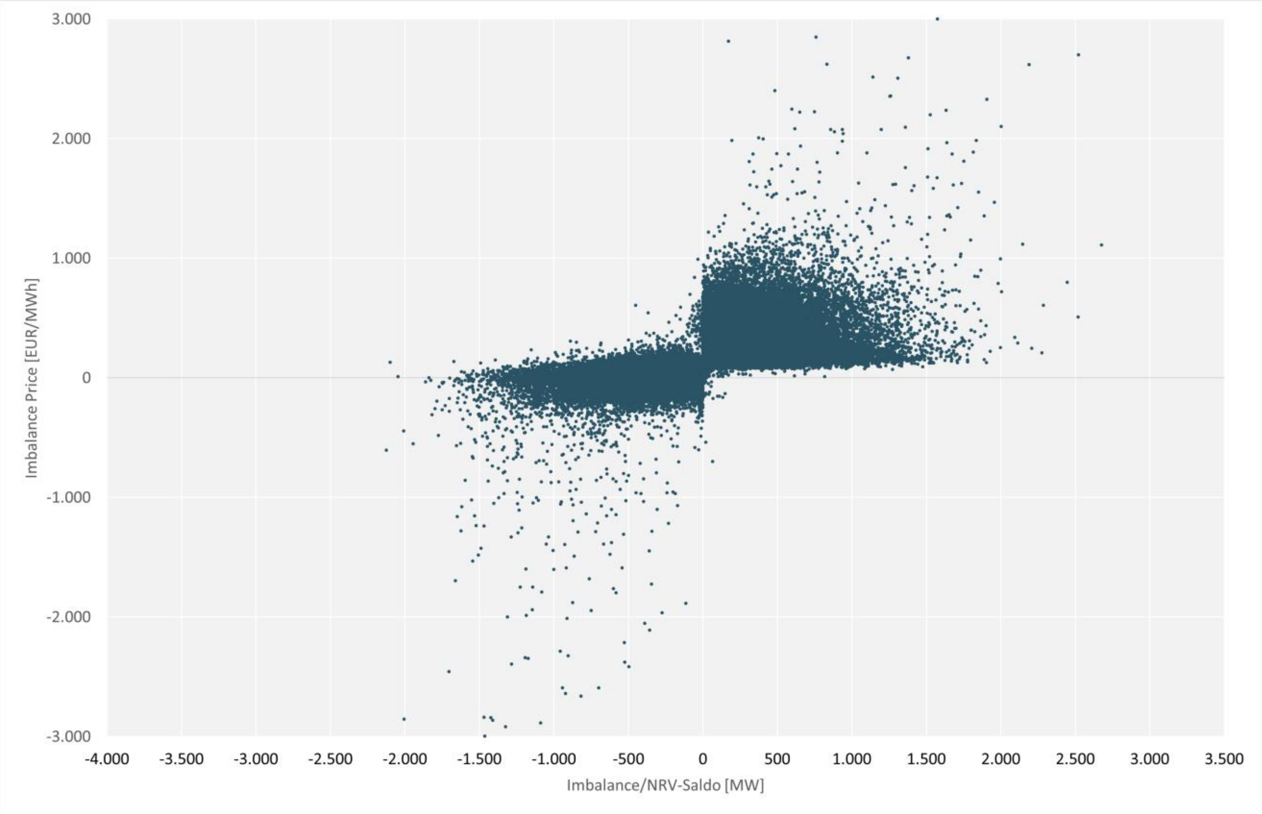

Figure 34: Correlation of the imbalance settlement price reBAP with the balance of the German Grid Control Cooperation (GCC) between 2020 and 2021; each point represents the values for a 15-minute period, detail of imbalance settlement prices between ± 3,000 EUR/MWh, the correlation coefficient is 0.5

The price adjustment mechanisms described above mean that the costs settled via imbalance settlement do not match the balancing energy costs exactly every 15 minutes. Since December 2012, these deviations have been settled in the TSOs' grid costs, which form the basis of the grid fees. Previously, such deviations were only caused by the first of the three described mechanisms (price capping). They were referred to as "non-rollable costs" and accounted for by a uniform surcharge/discount to the reBAP values of the respective billing month.

With the implementation of the price-based method according to ISHM, the number of price adjustment mechanisms has been reduced. Nevertheless, it is still the case that in addition to the remaining price adjustments of the spot market price coupling and the scarcity component, the revenue from balancing group settlement deviates from the actual costs, in particular due to the price-based approach of the basic component "module 1" (AEP1). The main reasons for this are that in some cases large volumes are balanced via the IGCC, which are settled at a separate price which, according to the ISHM, may not be used for the AEP1. The same applies for the amounts of unintended exchange or FCR.

The size of the effects in individual 15 minutes in 2022 and 2023 is shown in Figure 35 with the values every 15 minutes. The cumulative annual costs for all three modules are also shown on the secondary axis. For the TSOs, positive values mean a monetary surplus from imbalance settlement, which reduces the costs covered by grid fees.

In contrast to modules 2 and 3, module 1 can generate both a surplus and a deficit in individual 15-minute periods. However, there is a surplus in the long run. The reason for the differences from the actual costs is,in particular, that only the prices of aFRR and mFRR may be used, but physical balancing also takes place with other products and at their prices. Furthermore, within a 15-minute settlement interval, there can be deviations in both directions, resulting in a small 15-minute balance of imbalances and correspondingly low balancing group payments remaining with the TSO. In any case, modules 2 and 3 generate surpluses.

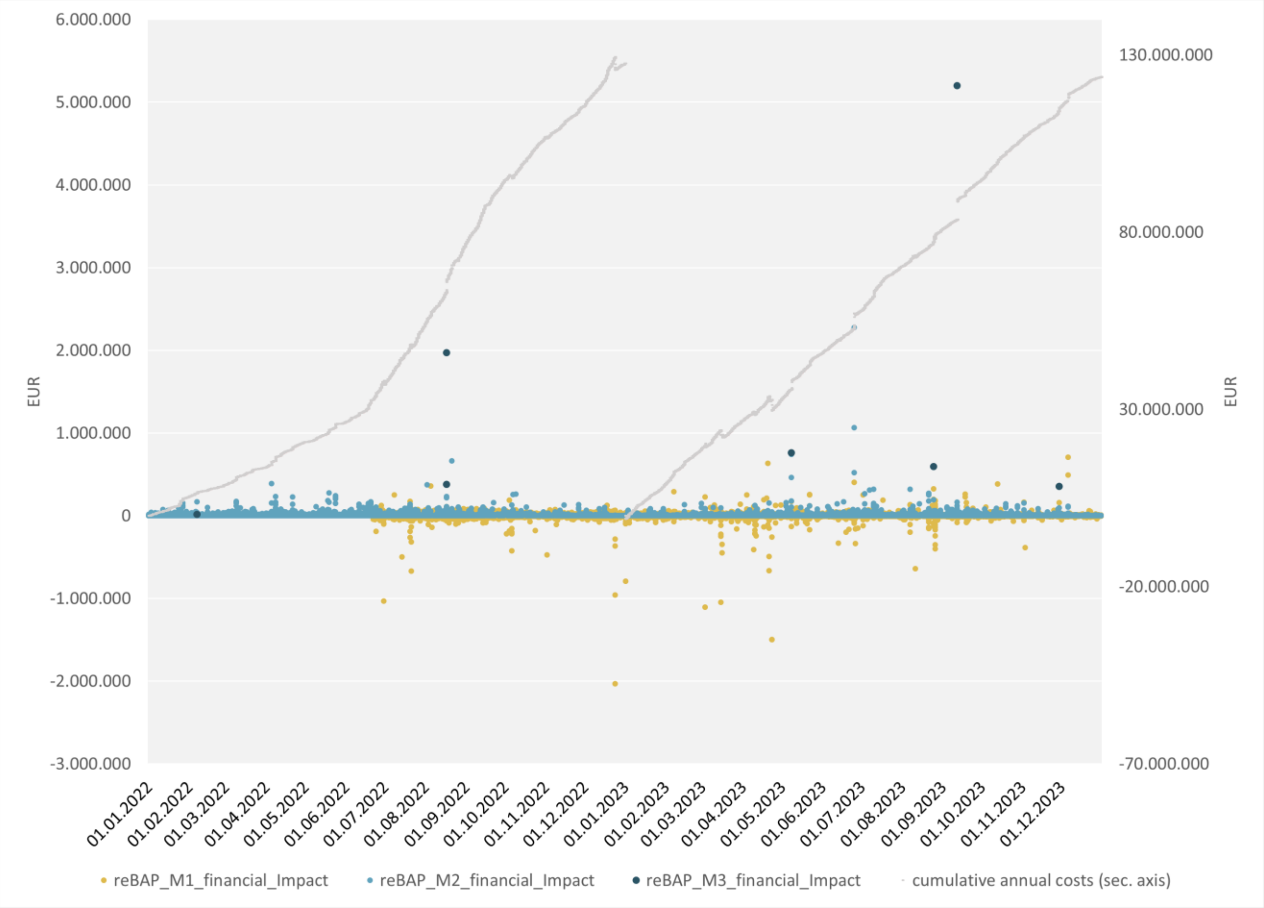

Figure 35: Financial effect of the imbalance settlement price modules

In terms of the process, the reBAP is calculated in such a way that after the settlement with the balancing service providers and the contracting parties for any additional measures taken, the four TSOs provide each other with complete information on the resulting costs/revenues and the energy quantities used. After agreeing any need for correction, which in practice only occurs when there are changes to the calculation system or data exchange modalities, the TSOs publish the reBAP values for the delivery month on the internet by the 20th working day of the following month at the latest. Since the implementation of the ISHM, the values for one day from modules AEP1 to 3 have been made available on the internet within 8 working days.

As an indication for the final imbalance settlement prices, the TSOs provide an estimated value at www.netztransparenz.de.

The explained steps for the calculation of the reBAP are listed in detail in the model description for reBAP calculation coordinated between the TSOs and the BNetzA and published at www.netztransparenz.de.

7.3 Balancing markets

As explained in section 4, the concept of system control by the TSOs, in contrast to a theoretically conceivable completely decentralized control responsibility of the individual electricity suppliers, leads to considerable savings for all grid users as a whole, since it dispenses with the time-consuming real-time recording of the feed-in and consumption of all grid users and the Demand for balancing services minimized by making maximum use of mixing effects. With this concept, by using balancing energy, the individual BRPs only incur a small fraction of the costs that they would otherwise incur by providing and using their own balancing services for their own customer collective.

However, the costs and revenues of the individual BRPs balance each other out over time due to the constantly changing direction of the use of balancing energy. On long-term average, each BRP bears part of the balance of the TSOs' balancing energy costs. The level of this share depends heavily on how strongly the imbalance energy demand of the individual balancing group is statistically correlated with the imbalance energy demand of all balancing groups as a whole. Purely random fluctuations that do not show any systematic connection with the fluctuations in demand in the overall system do not lead to significant imbalance costs on average.

This concept of the solidarity-based sharing of the balancing energy costs among the BRPs requires the acceptance of all parties involved of the fact that the part of the costs attributable to a balancing group depends not only on its imbalance energy demand, but also on the imbalance energy demand of the other balancing groups. For example, an imbalance settlement price can be higher or lower than the electricity market prices for a balancing group that experiences an under-supply in 15 minutes, depending on whether the balancing groups as a whole show under-supply or over-supply. In addition, due to the merit order activation, the imbalance settlement price shows at least a tendency to be related to the overall imbalance energy demand of all balancing groups.

Another essential feature of this concept is that the causes for the imbalance energy demand of the individual balancing groups do not, in principle, play any role in the balancing group settlement. Notwithstanding the fundamental obligation of BRPs to the balanced management of their balancing groups every 15 minutes - it is accepted that within plausible limits, there may be an imbalance energy demand and that the amount of the settlement is solely determined by the level of the imbalance energy demand. The causes for individual deviations or the drivers for their magnitude - such as e.g. the quality of forecasts, the intensity of the information exchange between BRPs and their customers as well as the used measures for balancing – are not considered here.

According to the balancing group contract, BRPs can only be sanctioned in the case of an unacceptably extensive use of balancing energy. By contrast, a fundamental obligation to BRPs to justify the level of their imbalance energy demand is not provided for and would also be difficult to reconcile with the fundamental principles of the imbalance concept. Only if the TSOs identify significant balancing deviations do they clarify with the affected BRP to what extent these deviations could have been avoided by the BRP (see, for example, the June 2019 issue).

7.4 transparency requirements

In addition to the publication obligations of TSOs on the procurement and use of balancing capacity and energy explained in section 6.7, the transparency requirements in connection with balancing group settlement mainly include:

- imbalance settlement prices (reBAP)
- calculation methodology
- Values of the incentive and scarcity components (modules 2+3)
- provisional imbalance settlement price (within 30 minutes after fulfilment)

The balances of all four LFC areas and the GCC imbalance dissolved after 15 minutes as well as the prices of the European platforms PICASSO and MARI as an input variable in Module 1 are also to be published. Information on the utilization of balancing energy by the individual balancing groups is treated confidentially and is therefore not published.

8 Cooperation in the balancing services

8.1 stages of cooperation

Over the past few years, the TSOs have significantly intensified and advanced their cooperation in the field of balancing. In some cases, the EB Regulation is already calling for closer European cooperation in the exchange of balancing energy from all balancing capacity products [25]. Next to that there are also voluntary cooperations for the exchange and procurement of balancing capacity. Cooperation takes place both in initiatives with all ENTSO-E member states and within the framework of bilateral cooperation. In general, balancing services can be cooperated in different areas and intensities:

- **Imbalance netting:** This form of optimization aims to prevent or reduce the activation of balancing services in opposite directions. For the netting of imbalances, opposite balancing needs of the individual LFC areas (or blocks) are identified and the required exchange capacities are determined from this. In this way, opposite activation is avoided and balancing energy is saved.
- **Harmonisation:** Harmonisation of the balancing service products as well as the market rules is necessary for many forms of cooperation. The necessary degree of harmonization of products and activation of balancing services depends on the intensity of the cooperation. Intensified cooperation is only possible if the cooperation partners implement identical regulations on balancing services and system operation in general.
- **Cost-optimized activation**: The goal of this optimization level is to balance demand by means of activation based on a common (cross-control area) MOL, which is stored in the optimization system and includes all awarded balancing offers of the participating LFC areas. The requirements of the participating LFC areas are considered summarily, i. e. reverse activation is also avoided. In addition, the entire balancing services of all participating LFC areas are available to all LFC areas involved.
- **Joint tendering:** This is a form of cooperation in which the balancing capacity is partially or fully tendered jointly. Provided that any restrictions are complied with, a provider can procure its balancing capacity for any LFC area. The request can be either directly by the requesting/contracting TSO (TSO-BSP model) or indirect by the connecting TSO (TSO-TSO model). According to the EB Regulation, the TSO-TSO model is preferred.
- **Joint dimensioning:** The controlled exchange of capacity in the form of temporary activation or cost-optimized activation enables a joint dimensioning of the balancing capacity of the participating LFC areas. Joint dimensioning allows the total balancing services to be provided by all LFC areas to be

[25] All cooperations in which the German TSOs participate are described below. In addition, there is the **T** rans **E** uropean **R** eplacement **R** esserves **Exchange** (TERRE) for replacement reserves that are not used in Germany.

determined. In particular, it enables the consideration of reduced coincidence of e.g. forecast errors of load or RES production, leading to a decreased balancing capacity demand.

- **Sharing of reserves:** In addition to joint dimensioning, so-called reserve sharing, i.e. joint access of different control areas to the same reserves, is also possible. General requirements for the sharing of reserves are sufficient available transmission capacity and its appropriate consideration in the dimensioning process, the consideration of a reference accident that corresponds at least to the probabilistic dimensioning, as well as harmonized products. Joint dimensioning is thus the most complex of all cooperation levels. Accordingly, cooperation between the TSOs is only to be expected here when sufficient experience is gained in the other fields of cooperation.

  As a result, the joint dimensioning would enable a reduction in the balancing services provided and thus a cost reduction. The possible cost saving potentials through the sharing of reserves as well as the joint dimensioning are offset by the interactions with the trading of scheduled products with regard to the transmission capacities. This means that there is a tension between the use of transmission capacity for the sharing of reserves and the use by the trading markets, and the effects on welfare gains must be considered. In addition to the resulting power flows which must always be considered, the regulatory requirements must also be considered, especially at this level of cooperation. In practice, the sharing of reserves is therefore currently used in particular between small LFC units, the dimensioning of balancing services in which is determined by the outage of a single component (for example power station or HVDC terminal).

8.2 Existing cooperations with German participation

Regarding the savings from the cooperations, we refer to the reporting at the EU level.

8.2.1 IGCC

Germany is working together on the netting of imbalances at the European level with various TSOs in the International Grid Control Cooperation (IGCC).[26] In addition to the previously participating TSOs from Austria, the Czech Republic, Switzerland, Belgium, the Netherlands, Denmark, France, Croatia and Slovenia, joined the IGCC. In June 2021 is the European platform for the imbalance netting (IN platform) has been fully implemented in accordance with the requirement of Article 22 EB Regulation. Greek (ADMIE) and Romanian (Transelectrica) TSOs also joined the platform in 2021.

---

[26]See: https://www.entsoe.eu/network_codes/eb/imbalance-netting/

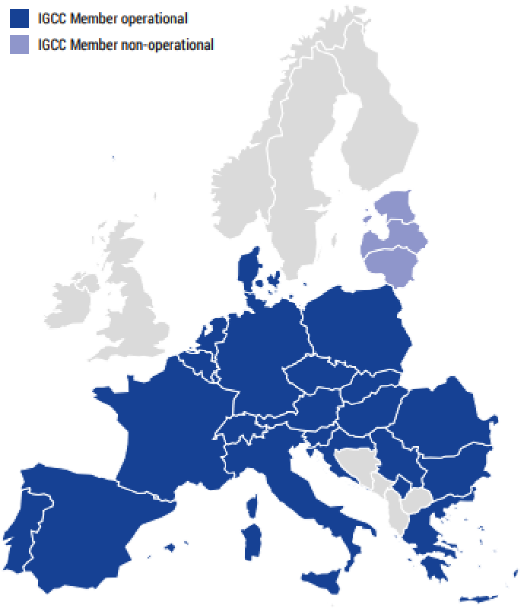

Figure 36: Geographical extent IGCC as of December 2024

Technically, the IGCC is integrated into the PICASSO aFRR optimization system. The aim of the IGCC is - comparable to the effect of the GCC within Germany - to avoid opposite activations of aFRR provided sufficient transport capacities are available for the balancing of surpluses and deficits between control areas. The resulting cost savings are shared between the participating TSOs. Cooperation in the IGCC reduces the costs for the use of balancing energy across the entire cooperation area. In 2024, the cumulative savings across all participants since the IGCC went live amounted to more than EUR 3 billion for the first time. For Germany, this amount comes to around EUR 570 million after 13 years of participation.

However, due to significantly different pricing systems for balancing services, these cost savings are not automatically divided between the cooperation partners in a way that is generally considered fair and provides sufficient incentives for participation in the cooperation. Therefore, a pricing system was established when the IGCC was introduced, which is used as the basis for the settlement of IGCC deliveries between the participating TSOs

This form of cooperation is comparatively easy to implement as it neither requires the harmonization of products and markets, nor does it require separate treatment of transmission capacity. The transmission capacity is used according to ability and ability in real time.

8.2.2 PICASSO

For a europe-wide aFRR cooperation, European TSOs have joined forces and developed the **P**latform for the **I**nternational **C**oordination of **A**utomated Frequency Restoration and **S**table **S**ystem **O**peration (PICASSO).[27] The project implements the requirements of Article 21(1) EB Regulation, which calls for the implementation of a European platform for the exchange of balancing energy from aFRR. The aim is to create a technically and economically efficient model. The goal is a European platform providing a multilateral TSO-TSO model with a common MOL for the exchange of all aFRR balancing energy bids. In December 2018, the European TSOs presented a proposal for the implementation framework for an aFRR platform. This proposal contains the high-level structure of the platform, timelines for implementation, proposed provisions on management, operations and responsibilities, as well as a definition of the standard products for balancing energy from aFRR and the balancing energy gate closure timing for all aFRR standard products. The proposal was processed by ACER and adopted in early 2020.[28] According to the EB Regulation, the platform had to be implemented by July 2022. The PICASSO platform went live on 22nd of June 2022. In 2023, the theoretically calculated savings from the cooperation (economic surplus) amounted to EUR 137 million. Further information on the PICASSO platform can be found on the project website.

[27] Project website: https://www.entsoe.eu/network_codes/eb/picasso/ .

[28] See BNetzA procedure BK6-18-110.

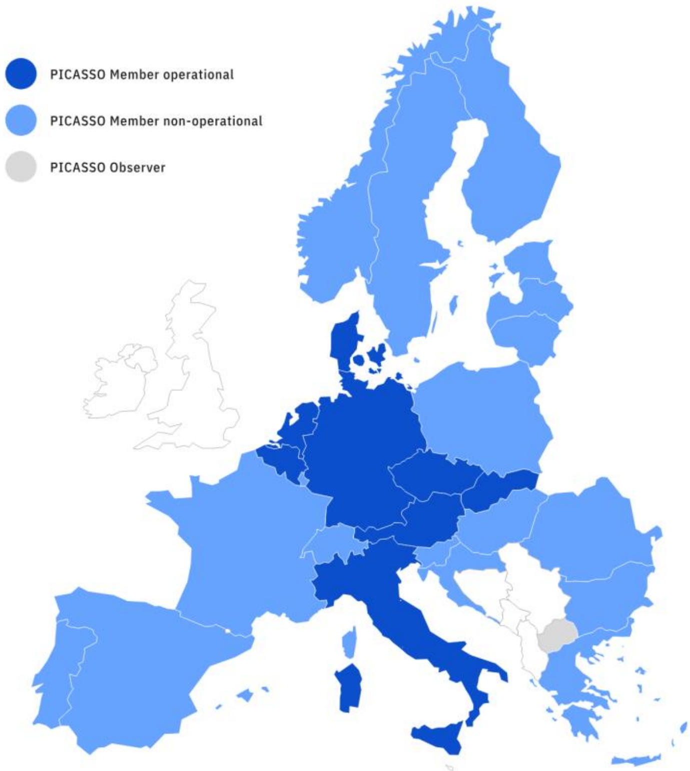

Figure 37: Geographical extent of PICASSO as of December 2024

8.2.3 MARI

Manually **A**ctivated **R**eserves **I**nitiative (MARI)[29] is responsible for cooperation on the mFRR and implements the requirement of Article 20(1) EB Regulation to create a Europe-wide platform for the exchange of balancing energy from mFRR. MARI thus represents the counterpart to PICASSO for the mFRR. Here, too, the European TSOs presented a proposal for the implementation framework for an mFRR platform in December 2018. This proposal provides the high-level structure of the platform, timelines for implementation, proposed provisions on management, operations and responsibilities, as well as a definition of the standard products for balancing energy from mFRR and the balancing energy gate closure timing for all mFRR standard products. The proposal was also processed by ACER and adopted in early 2020.[30] According to the EB Regulation, the platform had to go live on July 24th, 2022. The German TSO joined in October 5th,

[29]See: https://www.entsoe.eu/network_codes/eb/mari/

[30]See BNetzA procedure BK6-18-139.

2022. In 2023, the theoretically calculated savings from the cooperation (economic surplus) amounted to €9 million.

Further information on the MARI platform is available on the [project website]to find.

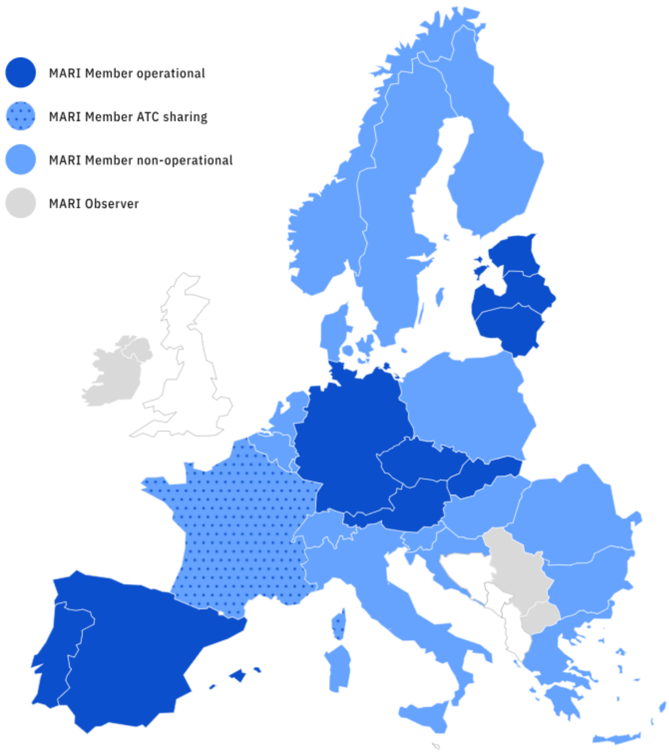

Figure 38: Geographical extent of MARI as of December 2024

8.2.4 FCR cooperation

Since March 2012, the Swiss (Swissgrid), Austrian (APG), Dutch (TenneT NL), Belgian (Elia) and French TSO (RTE) have been successively participating in a joint FCR auction with the German TSOs as part of the FCR cooperation. The Danish grid operator (Energinet) and the Slovenian grid operator (ELES) have been participating in the joint FCR tender since January 2021. In addition, the Czech system operator (CEPS) has been part of the cooperation since March 1, 2023. The Slovak, Hungarian and Croatian system operators (SEPS, MAVIR and HOPS) are currently active as observers in the cooperation. A total of around 1,500 MW FCR (as of December 2024) will be procured, which corresponds to around 50% of the total FCR procured in Continental Europe. The auctions consider permitted FCR exports of a maximum of 30% of the FCR demand of the respective country, Belgium fulfills this requirement of the SO Regulation by means of a separate national tender, where necessary. All cooperation partners observe the limit values for the FCR exchange according to SO Regulation Annex VI. According to this, it must be ensured that at least 30% of the FCR obligations must be fulfilled within its own LFC block.

This cooperation in the field of FCRs represents voluntary European cooperation within the meaning of Article 33(1) EB Regulation in the procurement and exchange of FCRs. In 2024, the theoretically calculated savings of the FCR cooperation (Economic Surplus) amounted to EUR 120 million. EUR .

A daily auction as well as a procurement of 4-hour products has been taking place since July 2020 (see also section 6.3).

Figure 39: Geographical extent of the FCR cooperation as of December 2024

8.2.5 aFRR cooperation between Germany and Austria

EB Regulation for the economic optimization of aFRR activation has existed between the German TSOs and the Austrian grid operator APG since 2016. Within the framework of a TSO-TSO model, the cooperation is based on a common merit order list (CMOL). As long as there are no operational restrictions in the grid between the two countries, national balancing energy costs can cross-zonal activation of the cheapest bids. Since both countries joined the PICASSO platform, aFRR has been exchanged via the platform.

In addition to the joint aFRR activation, there has been cooperation in the procurement of balancing capacity for aFRR across the national borders since the beginning of February 2020. For this purpose, the Austrian balancing capacity products were harmonized with the German ones in 2017. The cost-benefit analysis (CBA) developed by APG and the German TSOs determines which cross-zonal transmission capacities are allocated in advance for the exchange of aFRR. The CBA, conducted monthly and adjusted via weekly updates, compares the welfare gains of cross-zonal transmission capacity on the day-ahead market with the value of this transmission capacity for aFRR reserve markets. This comparison is carried out before the monthly cross-zonal capacity auction. Transmission capacities that are not needed for the aFRR exchange will be returned to the intraday market.[31] This cooperation addresses the tensions discussed above of the use of the limited transmission capacities for the purposes of balancing and electricity trading by the CBA. With regard to the treatment of transmission capacity, this cooperation thus assumes a pioneering role in Continental Europe.

In 2023, the savings of the DE-AT aFRR cooperation amounted to approx. EUR 24m (see Figure 40).

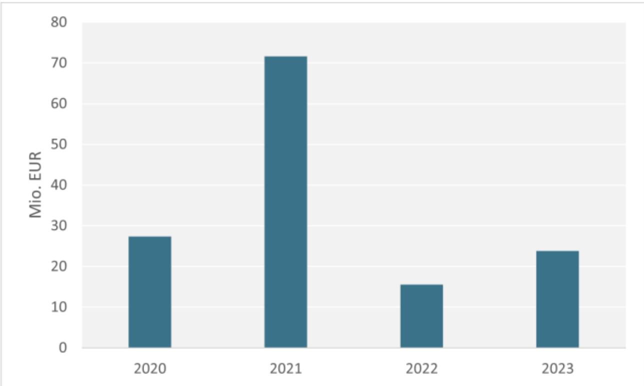

Figure 40: Savings from aFRR cooperation

To expand the cross-zonal procurement of balancing capacity, the German TSOs are involved in the voluntary ALPACA cooperation with Austria and the Czech Republic.

[31]Further information at https://www.apg.at/de/markt/netzverordnung/sekundaerverordnung/Kooperation /.