Description of the balancing process and the balancing markets in Germany

Explanatory document

on behalf of the

German transmission system operators

05 August 2022

This English translation is for information purposes only. The text is based on the original study of Consentec (in German).

consentec

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Management Summary

To ensure the stable operation of the power system, the energy fed into and withdrawn from the grid must be balanced continuously. The system balance must be constantly monitored and, where necessary to counter fluctuations in the power generation and consumption, corrective actions must be taken to balance the system. The load frequency control process is organized by the transmission system operators (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 GL]) was published in the Official Journal of the European Union. The guideline aims to create a functioning and liquid cross-zonal internal market, including system balancing. According to Article 60(1) EB GL, the TSOs are obliged 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 GL with this explanatory document, which provides a comprehensive overview of the concepts of system balancing and the balancing markets.[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 instance, a joint determination of the necessary reserve capacity (dimensioning) is already implemented in Germany, which is procured via a joint platform, as well as a cost-optimized activation if after netting any imbalances remain. While it appears that the biggest saving potential in the field of balancing has been unlocked within Germany, the TSOs are constantly working on improving individual processes, such as the opening of the balancing markets for new consumers and suppliers. During the last two years, the imbalance price-system has been further developed and the financial incentives for balancing group managers to balance their balancing groups have been tightened. Furthermore, with the introduction of the balancing energy market in November 2020 in line with the EB GL, a separate procurement of balancing capacity and balancing energy was introduced. This lays the foundation for the timely implementation of the cooperation with foreign TSOs required by EB GL and the expansion of voluntary cooperation.

Over the past few years, in line with the EB GL, the TSOs have also intensified their cooperation with foreign TSOs, resulting in the merging of the balancing markets at an international level. For example, further TSOs were included in the International Grid Control Cooperation (IGCC), which focuses on imbalance netting and thus reduces simultaneous activation of FRR in opposite directions. The Frequency Containment Reserves (FCR) cooperation was expanded and further developed. The German TSOs are closely cooperating with the Austrian TSO both for the aFFR and the mFRR. The commissioning of the European platforms MARI and PICASSO, which will enable the exchange of balancing energy, is planned for 2022. The participating member states hope that this will lead to further cost reductions in the activation of balancing energy. The platforms will be hosted by the German TSOs. Accordingly, the German TSOs will join at the same time as the platforms go live.

[1] According to the approved proposal of all TSOs' proposal for the determination of LFC blocks for the synchronous area continental Europe (BNetzA stipulation BK6-18-024), Luxembourg is part of the LFC area Amprion/Creos. This report therefore also covers balancing in Luxembourg.

Contents

1 Introduction

A constant balance between energy 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 TSOs operating the system are therefore tasked with balancing[2] it. 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 (Abschaltbare Lasten – AbLa), the capacity reserve (Kapazitätsreserve) 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 enable further emergency measures.

In the end of 2017, Regulation 2017/2195/EU establishing a guideline on electricity balancing (commonly referred to as the Electricity Balancing Guideline [EB GL]) was published 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.

Article 60(1) EB GL 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 GL with this updated report providing a comprehensive overview of the concepts for balancing and the balancing markets in Germany. The quantitative analysis provided extend over a period of two years. The report was, moreover, prepared to provide a compact and complete overview of the subject matter (as of April 2022) against the background of the numerous developments in the field of system balancing. In addition, this report ultimately affords 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.

2 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 – in relation to the costs of certain other system services as well as the overall transmission grid costs – and the interactions with the segments of electricity generation and electricity distribution. As a result, the balancing markets as well as the imbalance price system have long been subject of intensive regulation, which extends from general guidelines and laws to technical regulations and specific anti-trust law and regulatory requirements.

At present, the regulatory framework for the balancing is defined by the following regulations and stipulations:

[2] The "balancing" terminology is taken from the EB GL. In addition to the "balancing" term, the issue is often also addressed using other terms, such as load-frequency control, frequency stability or imbalance system.

- At the European level, the requirements for system balancing are based not only from fundamental requirements in the Regulation on the Internal Electricity Market[3], but also on the guidelines on the topics of "System Operation"[4] as well as "Electricity Balancing"[5]. Both guidelines entered into force as EU regulations in 2017. The guideline on Electricity Balancing (EB GL) 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. The system operation guideline (SO GL) 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). This defines general principles, such as on the system responsibility of the operators of transmission system, as well as specific requirements for the market-based procurement and provision of balancing services. This 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, other regulations are also relevant for the balancing topic. This particularly concerns the prequalification for the provision of balancing services of approved technical units. The relevant prequalification requirements are originally described in the Transmission Code of the German TSOs (last amended in 2007). These regulations were gradually replaced by revised prequalification conditions between October 2018 and December 2019.[6] Further developments of the prequalification requirements are agreed with the providers on a contractual basis and the current status can be found in the published model contracts. Likewise, the obligations of the balancing responsible parties are regulated in balancing group contracts, the latest version of which is also provided as a template by the TSOs.
- The EB GL 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). EB GL 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, the approval is provided by BNetzA's stipulation. Regional proposals must be approved by all affected national regulatory authorities, all-TSO proposals by all national regulatory authorities. Since the Clean Energy Package (CEP) came into force on 1 January 2020, applications submitted by all European TSOs have been forwarded directly to the Agency for the Cooperation of Energy Regulators (ACER) by the respective regulatory authorities.

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[3] Accessible at: *https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32019R0943*

[4] Accessible at: https://www.entsoe.eu/network_codes/sys-ops/

[5] Accessible at: https://www.entsoe.eu/network_codes/eb/

[6] Also refer to the prequalification portal: https://pq-portal.energy/

Even this short summary confirms 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.

3 Grid access model

3.1 Organization of the balancing process

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. In addition, the feed-in to storages and the feed-out from storages also requires active management.

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 3.1.

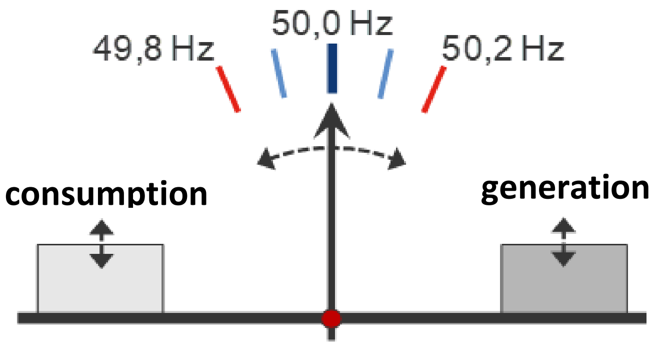

Figure 3.1: Necessity of balancing consumption and generation in the power system to maintain the target frequency of 50.0 Hz

The occurrence of deviations between feed-in and consumption and thus of imbalances 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 (for example wind and photovoltaic) – can be precisely forecasted. The active continuous control of imbalances is therefore essential for the stability of the power system.

In Germany, the EnWG specifies that the four TSOs operating their load-frequency control (LFC) areas are responsible for the balancing of these load frequency control areas (LFC areas). Therefore, each TSO continuously carries out the balancing processes. Chapters 4 and 5 cover the technical implementation of this concept and the procurement of the necessary balancing services in more detail. In addition, the four 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.

3.2 Balancing group system

Electricity balancing is defined within the German energy law framework as a joint task, which each TSO, operating an LFC area performs as part of its system responsibility, as defined in the EnWG, for all grid users within its LFC area and the costs of which it passes on to the grid users.

To implement this task and to enable a cause-based settlement of the balancing costs, electricity suppliers and electricity traders form balancing groups within an LFC area, in which the feed-ins and electricity trading quantities for which they are responsible and the withdrawals of the consumers they supply are bundled. Every feed-in, withdrawal and traded volume in a 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. A balancing group's imbalance corresponds to the balancing energy which the balancing group has used or supplied.

According to the StromNZV and the balancing group contract, the BRPs are obliged to ensure that their balancing groups are balanced every 15 minutes. The TSOs have drafted a new standard electricity balancing group contract which was approved by the BNetzA in April 2019 and entered into force on 1st August 2020.[7] The new standard balancing group contract meets the requirements of Article 18(6) EB GL while the framework contract does not have any effect on the fundamental balancing responsibility of the BRPs.

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

The balancing energy used by an BSP is settled by the respective TSO with the BRP based on an imbalance price, determined every 15 minutes, and multiplied by the respective balancing group imbalance. This price, which can be positive or negative, is applied uniformly nationwide for all balancing energy quantities used (over-supplies and under-supplies). The imbalance price settles the costs that the TSO incur due to the use of balancing energy in the respective 15-minute period (see section 6.2).

The concept of a uniform imbalance price per unit (for a given 15-minute period) implies that there is no differentiation regarding the causes for the imbalance energy demand of the individual balancing groups. In this respect, all balancing deviations (in the same direction) are assigned the same imbalance price independent of their cause. In this respect, the BRPs form a community in which the costs of system control charged via the imbalance prices are divided to use, without differentiating between the causes for the imbalance energy demand of the individual BRPs.

The volumes of the positive and negative imbalances settled for a 15-minute period are generally far greater than the balancing energy used in the same 15-minute period, since both positive and negative balancing group balances occur in practically every 15-minute period. The balancing groups therefore provide each other with imbalance energy.

[7] see BNetzA stipulation BK6-18-061.

4 Implementing the load-frequency control

4.1 Requirements for the load-frequency control

As explained above, the feed-in and withdrawal of energy in the power system must be balanced at all times. In principle, the balancing is achieved by continuously adjusting the energy generated or withdrawn electrical from controllable technical units. It is referred to as balancing or load-frequency control.

The balancing is organized on several levels:

- During system operation, minor disturbances of the system balance occur continuously and unavoidably, for example 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 braked (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 balance of the entire synchronous area and serves as a trigger for further measures of system control.
- A stable system frequency without major deviations from the target value is a key feature of the quality of the supply in power systems and significant deviations from the system frequency cannot be tolerated from a technical point of view. Therefore, 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.

Ensuring a stable system frequency and the balance of the entire synchronous area is one task of the load frequency control process. Moreover, it ensures that the system balance in the LFC area of each TSO (see Figure 4.1) is kept. The balance of each LFC areas is controlled based on a set point representing the sum of all scheduled nominated by the grid users[8]. To achieve this, each TSO operating an LFC area has its own load frequency controller which permanently 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.

[8] For instance, the notification of an energy delivery from LFC area A to LFC area B leads to an increase in the target value for balancing in A and a corresponding reduction in LFC area B. A balance must exist within the entire synchronous area.

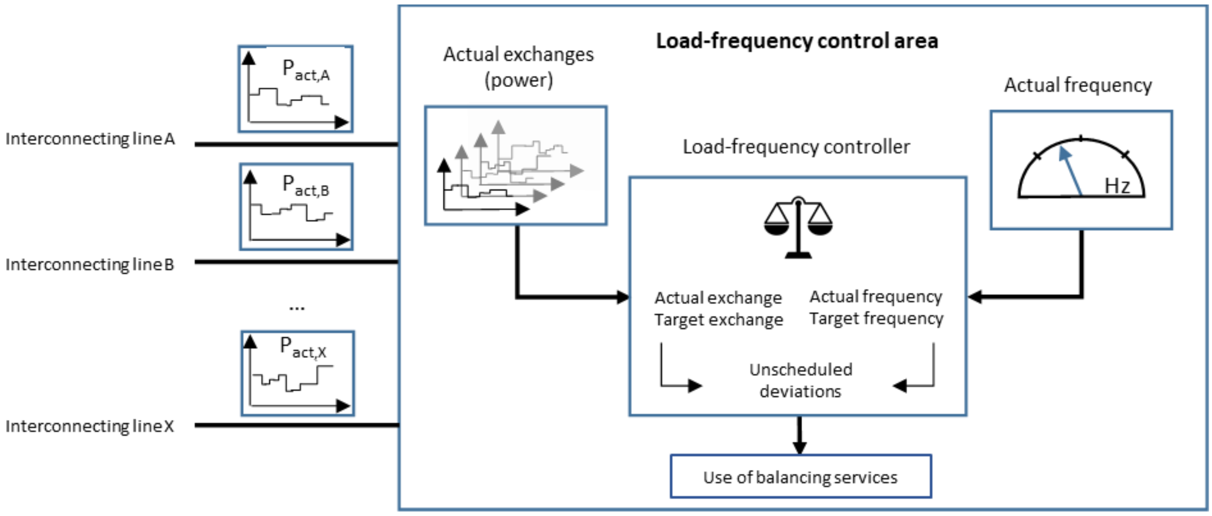

Figure 4.1 Schematic representation of the load-frequency control process

4.2 Balancing services

To fulfil the tasks of balancing the system, the TSOs procure balancing services which can be activated at different speeds (activation of balancing reserves). The properties and tasks of the different types of balancing services and the interactions between them are described below. Figure 4.2 provides an initial overview, while Figure 4.3 shows the interaction of the different types over time.

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. 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 is controlled solely by the locally measured system frequency, which is identical across the interconnected system, no central control system is required. Rather, FCR is activated by local control systems of the participating technical units.

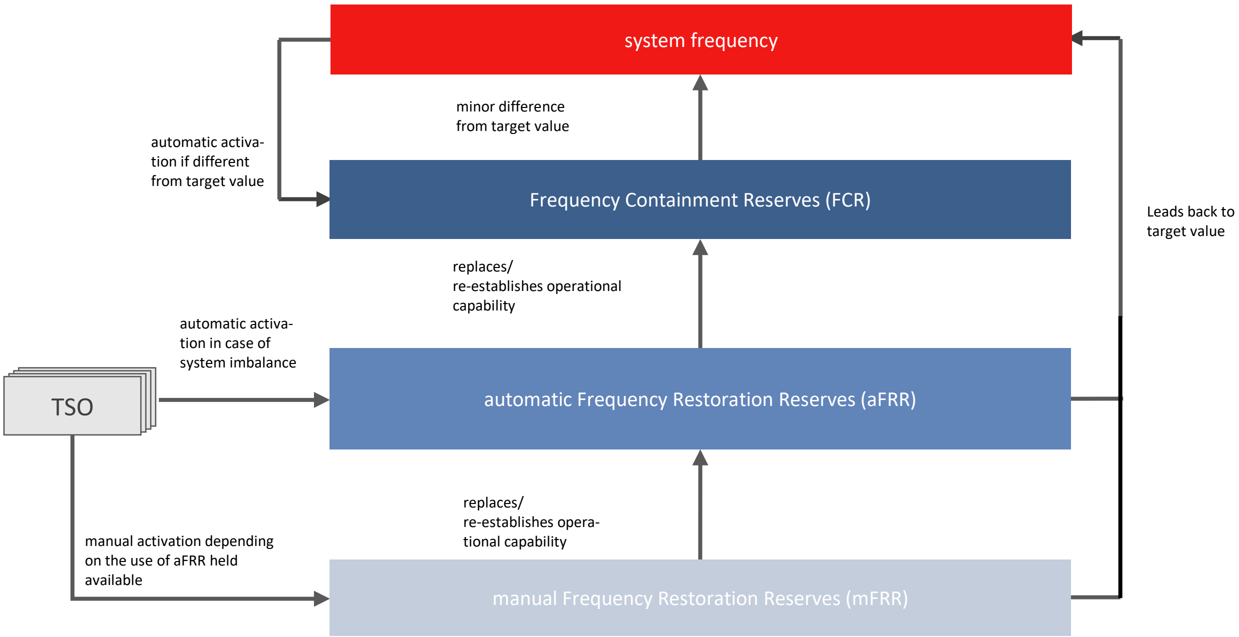

Figure 4.2: Overview of the use and tasks of the different types balancing services

The prequalification requirements in Germany (section 5.1) 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 available to balance renewed 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 only balance an imbalance (for example due to the outage of a power station) and stabilize the system frequency at a new operating point. 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 aFRR.

The aFRR is an automatically activated reserve, just like the FCR. Unlike FCR, it is not activated on unselectively across the entire synchronous area, but only in the LFC areas which cause the system imbalance. (If TSOs cooperate in the field of balancing, there may be deviations from this principle.) The load-frequency controller operated by the respective TSO for its LFC area is responsible for detecting the system imbalance and the automatic activation of frequency restauration reserves. This controller operating with an optimization cycle of few seconds, continuously calculates 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 passes on a corresponding control signal to the balancing service providers which are IT-wise directly connected. 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). This common MOL (CMOL) consists of all locally procured bids and is sorted in ascending order by the individual bid prices. This practice corresponds to the requirements of EB GL.

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. To do so, 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 it is available again for counteracting any further disruptions. Thus, the activation of the aFRR is also a time-critical process for which an upper limit of the full activation time of 5 minutes has been set in Germany. 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 provided by aggregated power stations. This enables balancing service providers to optimize the activation in the best possible and most efficient way.

Due to the high technical requirements described for the technical units used for aFRR provision, it is neither sensible nor necessary to procure the entire reserve capacity required to counteract even extended imbalances, for example due to forecasting errors or after power station outages[9], as aFRR. Instead, part of this reserve capacity is procured as mFRR. Technical requirements on mFRR providing technical units (TU) are lower than for aFRR providing units (full activation time within 15 minutes, no continuous balancing signal, rather it is processed as a scheduled delivery, for example in 15-minute-intervals or as direct activation[10]). Therefore, TUs with limited technical features can prequalify for this balancing service. 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 certain cases, a preventive activation of mFRR can also take place to compensate for expected major imbalances. In Germany, the activation of mFRR is now carried out electronically via the MOL server (MOLS), the activation tool for the mFRR MOL of the bids obtained on the balancing market.

FCR and FRR (the sum of aFRR and mFRR) are procured by the TSOs as positive reserve (to balance deficits) as well as negative reserves (to balance surpluses). It should be noted that the names of comparable products can vary. For instance, mFRR is often referred to internationally as tertiary reserve.

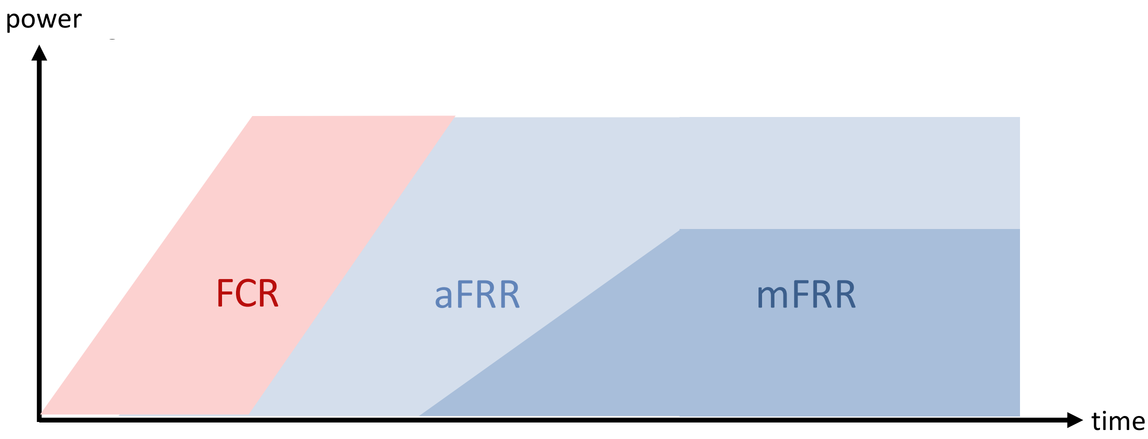

Figure 4.3: Three-stage balancing concept in Germany (schematic representation)

In addition to FCR, aFRR and mFRR, in some countries in the Continental Europe the Replacement Reserve (RR) is procured, not being used in Germany, however. The balancing services shown in Figure

[9] In Germany, according to the StromNZV, after a power station outage, the transmission system operators are responsible for replacing the lost power with reserve for up to four 15-minute periods, including the 15-minute period in which the power station outage occurred. After this period, the power station operator is responsible for activating its own reserve at short notice (for example by trading scheduled energy at the intraday market of power exchanges.).

[10] Direct activation of mFRR differs from scheduled activation in that the time of activation is more flexible. Since direct activation only accounts for a very small proportion of the activated volume of mFRR, the description of mFRR in the remainder of this document will be based on scheduled activation.

4.3 are mandatory for balancing in Germany according the StromNZV. In exceptional situations (for example in the case of high imbalances) German TSOs can make use of further remedial actions. These include the exchange of emergency reserve with other TSOs, the use of interruptible loads or trading scheduled energy at the intraday market of power exchanges to balance the system. These remedial actions are taken based on availability at the time the extraordinary situation.

4.3 Grid Control Cooperation

In line with the polluter principle and LFC-area-based activation of aFRR and mFRR, counter-activations of balancing services may occur in neighboring LFC areas. For example, positive reserves could be activated to balance a power station outage in one LFC area, while negative reserves could be simultaneously activated in a neighboring LFC area to correct an overestimated load forecast. Alternatively, both LFC dispense with the activation of reserves and instead of this agree on an additional power exchange from the LFC area with excess capacity to the LFC area with a deficit.[11] If this additional flow does not affect system security, depending on the costs of balancing energy activation, this approach of imbalance netting (IN) can reduce the balancing costs in the overall system.

In the period from 2008 to 2010, the German TSOs formed the Grid Control Cooperation (GCC) and since have gradually expanded this cooperation. In the initial phase, only the imbalances were netted. Presently, the GCC includes a cost-optimal aFRR and mFRR activation, a joint dimensioning of reserve capacity and the joint tendering of balancing capacity. Moreover, a common balancing market was established, in which all balancing service providers can offer their available generation capacities to all TSOs on a common market based on the connecting TSO principle. The member TSOs are responsible for the operational processing of the power exchange. The intensive collaboration has significantly reduced the required reserve capacity in Germany.

The cooperation in the GCC is structured in such a way that load-frequency controllers of the LFC areas are not replaced. Correction signals control the imbalances in the participating LFC areas in a manner that enables the coordinated activation of the necessary balancing services. Thus, from each load-frequency controller, only the directly connected TUs can be activated. The correction signals are determined by a central optimization module installed in the TransnetBW control system. The load-frequency control in the four German LFC areas connected via the GCC is therefore identical to the behavior of a single German LFC area.

In addition to the GCC, German TSOs also cooperate with various European TSOs in various fields and intensities. These international cooperations regarding balancing are described in chapter 7.

5 Procurement and use of balancing services

The StromNZV requires balancing capacity and balancing energy to be procured within the framework of a joint, cross-LFR-zone and anonymized tender via an internet platform and used in accordance with the tender results based on bid curves.

This chapter provides a detailed overview of the specific regulations for the procurement and activation process, starting with the technical prequalification process of the balancing service providers down to transparency requirements and the resulting publications.

[11] Explicit agreement on the power exchange and coherent adjustment of the target values of the transferred power between the involved load-frequency controllers are necessary because the power exchange would otherwise effectively be counteracted by the controller using aFRR.

5.1 Prequalification of balancing service providers

The StromNZV expressly stipulates that balancing service providers must proof that they meet the technical requirements for providing the different types of balancing services. As a result, potential balancing service providers are required to pass a technical prequalification process to prove their capability of providing the respective reserves (for each type of balancing service). This is also required in the SO GL, combined with the obligation to repeat the prequalification on a regular basis.

In addition to technical competence, proper provision of the balancing services must be guaranteed under operational conditions with the economic performance of the potential provider being ensured. For all control reserves, prequalification are to be carried out exclusively with the TSO in whose LFR zone the relevant unit to be prequalified is connected, irrespective of the voltage level (connection TSO). The units to be prequalified are also referred to as technical units (TUs[12]). Prequalification can be applied for by the BSP for a reserve unit (one or more TUs at a grid connection point) or a reserve group (aggregated TUs at different grid connection points).

A prequalification process generally requires up to three months. The connecting TSO is to be notified immediately by the BSP in the case any significant change occurs in the BSP's general conditions related to the prequalification. The documents that the BSP submits to the connecting TSO to prequalify its TU must be submitted via the prequalification portal (www.pq-portal.energy). The restructuring of the prequalification via the PQ portal ensures compliance with the requirements of the SO GL.

Until 2018, prequalification was based on the minimum requirements, which differed by type of balancing service, documented in Annex D of the Transmission Code. The prequalification requirements were revised in October 2018 in line with the SO GL and gradually entered into force until the end of 2019.

An essential part of the prequalification for new BSPs or after significant changes is a trial activation ("Doppelhub"). The activation template for each type of balancing service is published on the tendering platform www.regelleistung.net. Figure 5.1 shows an exemplary trial activation of positive mFRR.

[12] Technical unit is the general term for plants providing balancing services and refers to generating units as well as controllable consumption units.

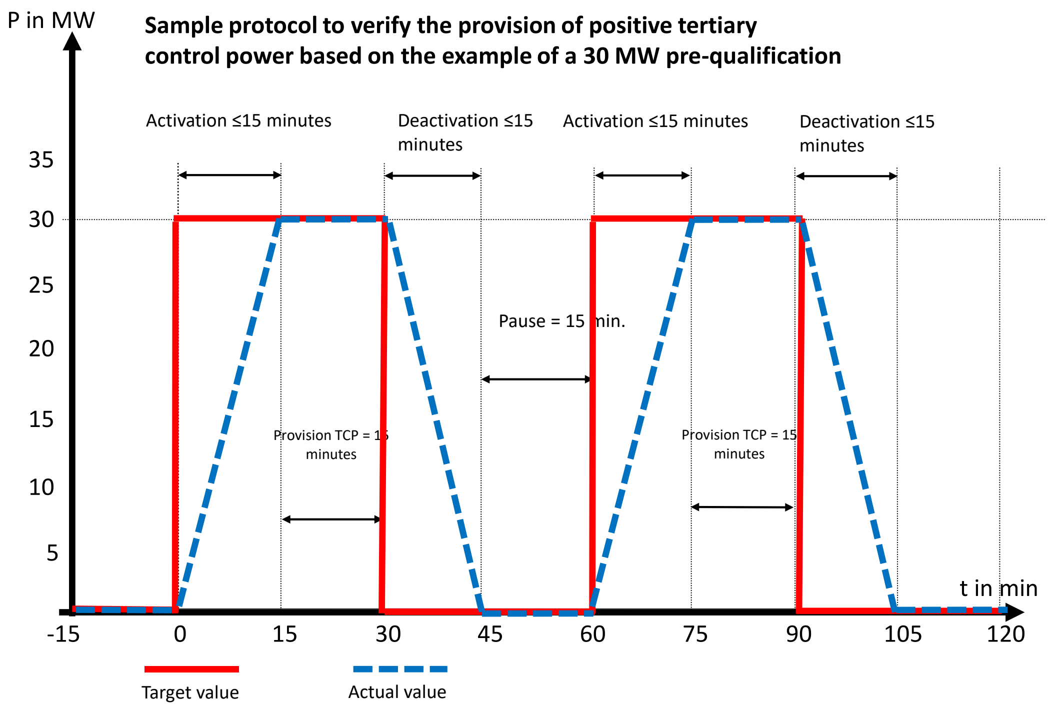

Figure 5.1: Sample trial activation of positive mFRR

In addition to quantifying the prequalified capacity via the capacity changes that can be activated during the activation period (FCR: 30 seconds; aFRR: 5 minutes; mFRR: 15 minutes), the prequalification also serves to check control and communication IT connections (for example to the load-frequency controller of the connecting TSO for aFRR or the MOLS for mFRR) as well as the organizational requirements (approval of the owner of the TU and the relevant BRP).

Aggregation is now also possible for all types of balancing services to ensure the economically optimized activation and provision of the offered balancing capacity. An aggregation consists of individual TUs, potentially of various operators at various locations within an LFC area.

As soon as the prequalified capacity meets the respective minimum bid volume, the connecting TSO concludes a framework contract with the BSP for each type of reserve, which is in turn a prerequisite for participating in the tendering procedure for the respective balancing products (model contracts are published at www.regelleistung.net).

According to the BSP list published by the German TSOs, 30 BSPs are currently (28th January 2022)[13] prequalified for FCR, 34 providers for aFRR and 34 providers for mFRR. Figure 5.2 shows the prequalified balancing capacity in Germany differentiated by primary energy source.

[13] https://www.regelleistung.net/ext/download/anbieterliste.

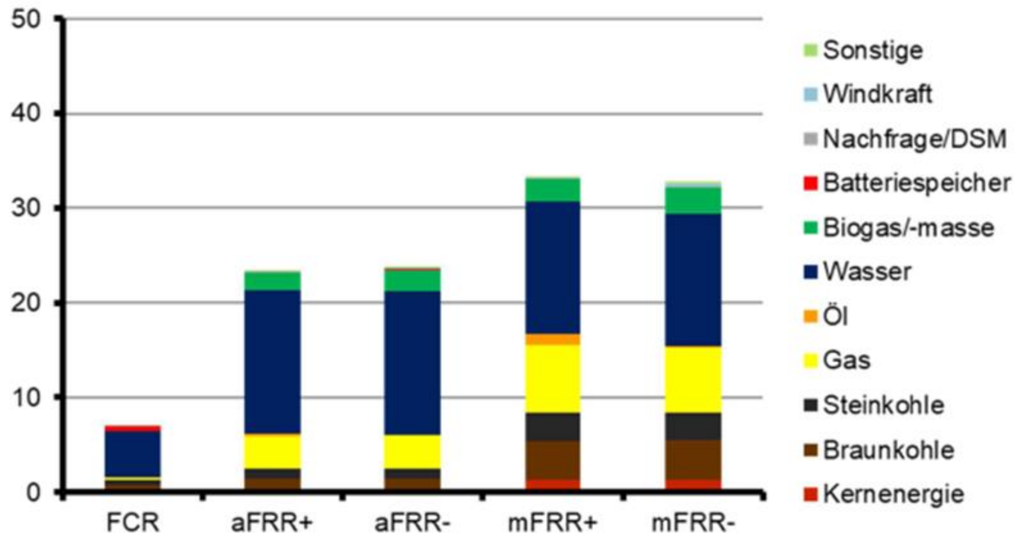

Figure 5.2: Prequalified balancing capacity (in GW) in Germany differentiated by primary energy source/balancing quality (source: Regelleistung.net as of: 01.01.2022)

5.2 Dimensioning of balancing capacity

A key part of the market-based procurement of the required balancing capacity is the comprehensible determination of demand. Here, a distinction must be made between FCR dimensioned and activated across all Europe and aFRR[14] and mFRR dimensioned and activated within the GCC.

According to SO GL, the provision of 3,000 MW FCR is currently necessary to operate the Continental European synchronous area securely. This requirement arises from the objective of being able to manage two overlapping dimensioning incidents with the available FCR. A dimensioning incident is the largest expected imbalance from a single cause. In the current system, this dimensioning incident corresponds to the instantaneous outage of the largest generation units operated in the Continental European synchronous area. These are currently large nuclear power plants with a capacity of approximately 1,500 MW, which explains the FCR requirement of 3,000 MW. Furthermore, it is regulated that each LFR zone must maintain a share of this total FCR requirement that corresponds to its share of the total electricity generation and withdrawal in the synchronous area. In accordance with this rule, the FCR to be held by each LFR area is updated once a year. Currently (in 2022), FCR of 555 MW is procured in Germany.[15]

For the dimensioning of aFRR and mFRR, the ENTSO-E provisions are less relevant. As a result, the aFRR and mFRR dimensioning practice of the European TSOs differs significantly in some cases. However, the EU regulations, in particular the SO GL, specify minimum requirements to be met by the TSOs. German TSOs recently revised the procedure for calculating the FRR demand to be able to adapt the demands to the relevant situation on shorter notice. In December 2019, the former static dimensioning methodology, which was used to calculate a constant demand of FRR capacity for an extended period (quarterly), was replaced by a dynamic dimensioning procedure for aFRR and mFRR[16]. The situation-

[14] For the cooperation of German and Austrian TSOs in the aFRR procurement see section 7.2.5.

[15] It must be noted that TSOs from Belgium, Germany, France, the Netherlands, Austria, and Switzerland jointly procure FCR. FCR capacity awarded in Germany can therefore vary (see chapter 5.3).

[16] A comprehensive description of the new dimensioning procedure is provided under https://www.regelleistung.net/ext/tender/remark?lang=en.

dependent methodology now dimensions the necessary FRR capacity in accordance with the requirements of BNetzA stipulations BK6-15-158 and BK6-15-159. The demand for reserve capacity is calculated on a rolling basis over 4-hour-product. Like the previous procedure, the calculation is performed based on a probabilistic approach.

The dimensioning is designed such a way that the German TSOs can independently balance imbalances caused in Germany. The dynamic dimensioning therefore also considers imbalances that have been netted with neighboring TSOs and thus did not lead to activation of balancing energy in Germany. This makes sense since the historic netting potential of opposite imbalances with neighboring LFC areas cannot be reliably continued in the future due to the uncertain availability of the cross-zonal capacities after intraday trading.

Figure 5.3 shows the tendered FRR volumes in 2020 and 2021.

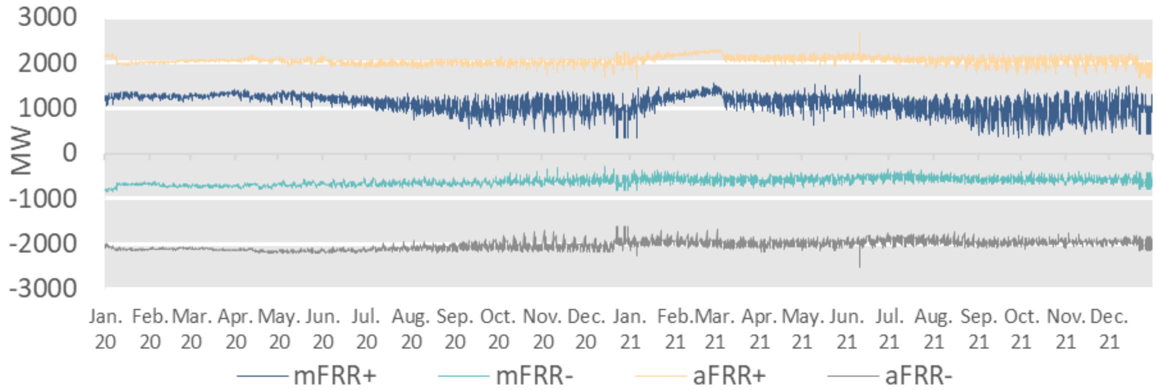

Figure 5.3: Development of the tendered aFRR and mFRR quantities (4-hour time slices)

Since 9th December 2019 dynamic dimensioning has been applied so that in future the dimensioned and thus tendered quantities will be more volatile than in the past when they were determined on a quarterly basis. When this method was introduced, its dynamic was still dampened to limit the transition effects. Figure 5.4 shows this effect shortly after introducing the dynamic control reserve dimensioning; as time goes on, the dynamics of the quantities tendered increase noticeably.

The tendered quantities of positive and negative FRR fluctuate over the period shown. In the course of 2020, the fluctuations in the quantities tendered within one day increase noticeably, fluctuations decrease significantly with the turn of the year and pick up again over the year. The demand for mFRR+ increased slightly at the beginning of 2021 and is more volatile overall than the demand for aFRR. In the last quarter of 2021, the intraday fluctuations in the tendered mFFR+ are above 80% on each day compared to the highest fluctuation between two product periods.

On a monthly average, the dimensioned mFRR- demand decreased from 700 MW to 600 MW in the two years under consideration. After a drop throughout 2020 and an increase at the beginning of 2021, the mFRR+ demand drops to a monthly average of 1,000 MW by the end of the year. The aFRR- demand moves around 2,000 MW on a monthly average, decreasing from the beginning to the end of each of the two years. The monthly average aFRR+ demand has decreased slightly from an initial level of over 2,000 MW over the two years.

Figure 5.4 shows that the imbalances, which form the basis for the dimensioning, remained constant in the two years covered by this report. It should be considered here that the dynamic dimensioning procedure was introduced gradually in 2020 and has only been fully effective since the middle of the fourth quarter of 2020. The GCC balance presented here as a reference only includes part of the historical balance sheet deviations. In practice, the GCC balance changes continuously and sometimes has significantly higher extreme values than the 15-minute averages shown. In addition, involuntary exchange and the frequency correction component are missing from the GCC balance. The dynamic dimensioning is currently based exclusively on daily characteristics. This means that especially the imbalances in the previous weeks and previous year's periods (reference periods) have an influence on the dynamic dimensioning results. Deviations from the tender quantities and the actual demand are always possible, since the tender quantities must consider all expected balance deviations, but the imbalances in the reference periods can fluctuate strongly. With the future planned consideration of external influencing factors such as wind and solar feed-in in addition to the daily characteristics, the control reserve tendered should match the demand even more accurately in the future.

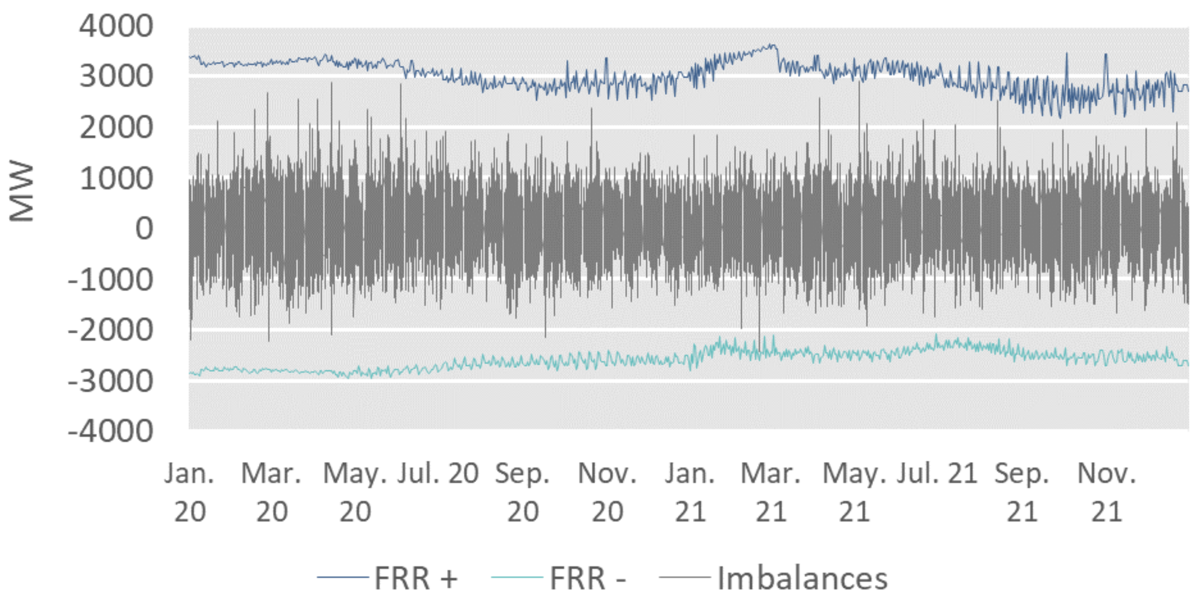

Figure 5.4 GCC imbalance and tendered FRR (15-minute-values)

The evaluation also shows that the FRR was sufficiently dimensioned at all times during the reporting period to balance imbalances that occurred in the GCC. This is in line with the SO GL, which requires that TSOs maintain FRR to the extent that the dimensioned control reserves can compensate for the imbalances at least 99% of the time in a year (so-called deficit probability).

5.3 Balancing markets

The balancing services are tendered via the internet platform www.regelleistung.net, jointly operated by the TSOs for the submission of bids and access to the tender results, each BSP has access to an individual secure BSP section on the internet platform.

The market rules and conditions for the balancing services are defined by the BNetzA or ACER after consulting the TSOs and suppliers. FCR, balancing capacity and balancing energy are procured on a combined market. Until 3rd November 2020, mFRR and aFRR balancing capacity and balancing energy were also procured on a combined market. On 2nd October 2019, the BNetzA approved the introduction of a balancing energy market (RAM) for mFRR and aFRR (decision BK6-18-004-RAM).[17] It was introduced on 3rd November 2020. The balancing capacity is procured on the balancing capacity market (RLM).

Table 5.1 provides an overview on key product features. The main differences between the different balancing services are detailed below.

Table 5.1 Key product features of the types of balancing services procured in Germany

	combined market	balancing capacity market		balancing energy market	
	FCR	**aFRR**	**mFRR**	**aFRR**	**mFRR**
tender period	daily D-1 (8 a.m.)[18]	daily D-1 (9 a.m.)	daily D-1 (10 a.m.)	daily 1 h before delivery period	
product duration	6 x 4-hour blocks[19]				
product differentiation	none (symmetric product)	positive and negative			
minimum bid size	1 MW[20]				
bid increment	1 MW				
tendering	capacity price merit order	capacity price merit order		energy price merit order	
remuneration	pay-as-cleared (capacity price)	pay-as-bid (capacity price)		pay-as-bid (energy price)	

- Tender period: FCR, aFRR and mFRR are procured in daily tenders. In the case of FCR, the procurement of balancing capacity and balancing energy takes place on a combined market whose gate closure time (GCT) is at 8 a.m. of the previous day. The procurement of aFRR and mFRR capacity takes place on the balancing capacity market (RLM). The GCT for aFRR and mFRR capacity bids is the previous day at 9 a.m. and 10 a.m. respectively. Subsequently to the RLM, balancing energy bids of mFRR and aFRR are procured on the RAM (pursuant to Article 16 (5) EB GL). It opens after

[17] see *https://www.bundesnetzagentur.de/SharedDocs/Pressemitteilungen/DE/2019/20191008_Regelenergiemarkt.html*

[18] until 01.07.2020 tenders took place Monday till Friday D-2.

[19] until 01.07.2020 FCR was tendered as a daily product time slice.

[20] The BNetzA has set the minimum bid size at 5 MW. If an mFRR (aFRR) bidder submits only one bid per product time slice of the mFRR+ (aFRR+) or mFRR- (aFRR-) in the respective LFR zone, bid sizes of 1 MW, 2 MW, 3 MW or 4 MW are also permitted.

the results of the RLM auction has been announced. On the RAM, bidders may submit energy bids up to 60 minutes before the start of the product delivery period, which is simultaneous for aFRR and mFRR.

- Product duration: Procurement now takes place uniformly for all control reserve qualities in six separate products each. Each day is divided into time slices of four hours.
- Product differentiation: While FCR is procured as a symmetric product, for aFRR and mFRR positive and negative balancing reserves are tendered separately. For FCR, suppliers must therefore be able to provide both an increase and a reduction in the amount of the offered capacity. However, different TUs can be used for the two control directions.
- Tendering: For suppliers of FCR on the combined market and for suppliers of FRR on the RLM, the tender is awarded based on the balancing capacity price submitted by the supplier. On the RAM, the tender is awarded based on the balancing energy price demanded by the bidder.
- FRR bidders who were unsuccessful on the RLM or did not submit a bid may submit energy bids on the RAM without a capacity price. Combined bids in the form of a capacity and energy price can be submitted on the RLM, but the energy price is not considered when bids are selected and can be adjusted by the bidder after the end of the auction. The submission of an energy bid on the RLM is therefore voluntary. However, successful bidders on the RLM are obliged to submit an energy bid on the RAM. This ensures that sufficient bids are received on the RAM to cover the TSOs' demand.
- Suppliers on the RAM must adhere to a price cap when submitting energy bids. The cap of EUR 9,999/MWh applicable in the combined market, was suspended with the introduction of RLM and RAM. This price cap was introduced because high balancing energy prices had occurred, and the cap was intended to prevent them to protect the BRPs from high imbalance prices. When the RAM was introduced, the price cap was raised to a purely technical limit of EUR 99,999 /MWh but has since been lowered again to EUR 9,999 /MWh due to high balancing energy prices. Following a complaint by a market participant, the cap was suspended again on 11th January 2022. With the accession to the European platforms planned for 2022 (see chapter 7), a price cap of 15,000 EUR/MWh applicable on these platforms will become effective.
- If the supply on the RAM exceeds the capacity required by the TSOs, the most expensive bids on the RAM will not be awarded and will be released. These released or unsuccessful balancing energy bids can be marketed on other markets or used for portfolio optimisation after publication of the tender results.
- Remuneration: For FCR, provision and activation are remunerated via the capacity price; there is no separate remuneration for activation. The capacity price of the highest bid still awarded applies to all successful bidders (pay-as-cleared). Prior to the introduction of the RAM, suppliers of FRR received remuneration for the provision of the capacity as well as remuneration for activation in the form of the balancing energy price. Now, in the case of a successful bid on the RLM, the remuneration equals the offered price for the provision of the balancing capacity. On the RAM the price offered for the balancing energy on demand is remunerated.
- The Regulation on the Internal Electricity Market and the EB GL stipulate that in future the remuneration for balancing energy will be based on marginal pricing (unit price method, pay-as-cleared) and that each FRR supplier will be paid in the amount of the price of the most expensive product activated. The introduction of marginal pricing is intended to coincide with the introduction of the target market design, which enables the accession to the European platforms (see chapter 7). The

implementation of the target market design is announced for mid-2022.[21] FCR is already remunerated based on marginal pricing.

Regarding the tendering of balancing reserve, various special features must be taken into account:

- With the commissioning of cross-control field collateralisation on 12th July 2019, suppliers were permitted to transfer successful FRR bids to a collateral provider in another LFR zone in the event of non-availability of their own TUs in the LFR zone. Since the introduction of the RAM, cross-control field collateralisation for FRR is only offered for successful bids on the RAM.

5.4 Procurement results on the markets for balancing services

For FCR, only the capacity price is remunerated in the amount of the marginal price of the tender. The development of the capacity price in 2020 and 2021 is shown in Figure 5.5. The monthly averages show an increase in the price level in the period under consideration. Since October 2021, very high electricity market prices have dominated due to increased gas prices, which generally represent opportunities for BSPs to consider when preparing offers. This is reflected in the balancing capacity prices, which increased in this period specifically.

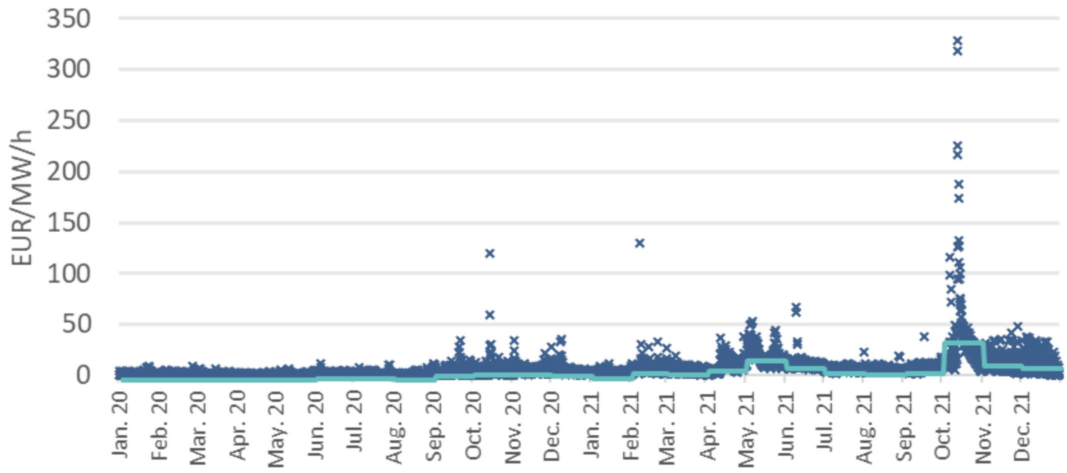

Figure 5.5: Capacity price development of FCR and monthly average

Figure 5.6 and Figure 5.7 show the development of the average capacity prices for aFRR and mFRR in 2020 and 2021. In the combined market, bidders were selected based on their capacity prices. Therefore, there was a high price pressure on them - margins were generated predominantly based on balancing energy prices. On average, low capacity prices – in extreme cases of 0 EUR/MW/h – were the result.

After the end of the combined procurement, only the capacity price determines the revenue of a BSP who bids on the RLM. Accordingly, BSPs will not submit bids below their individual costs for providing balancing capacity. After the introduction of RAM, the capacity prices of aFRR and mFRR increased. As with FCR, the effects of the high electricity market prices, which constitute an opportunity for the suppliers, on the capacity prices also became visible in the last quarter of 2021. The prices and thus also price mark-ups strongly depend on bidder behavior.[22]

[21] According to the TSO's announcement of 22nd March 2002 on www.regelleistungs.net, the introduction of the target market design is planned for 22nd June 2022.

[22] see, for example, mid-April 2021, which the TSOs have reported to the Market Transparency Unit and the BNetzA.

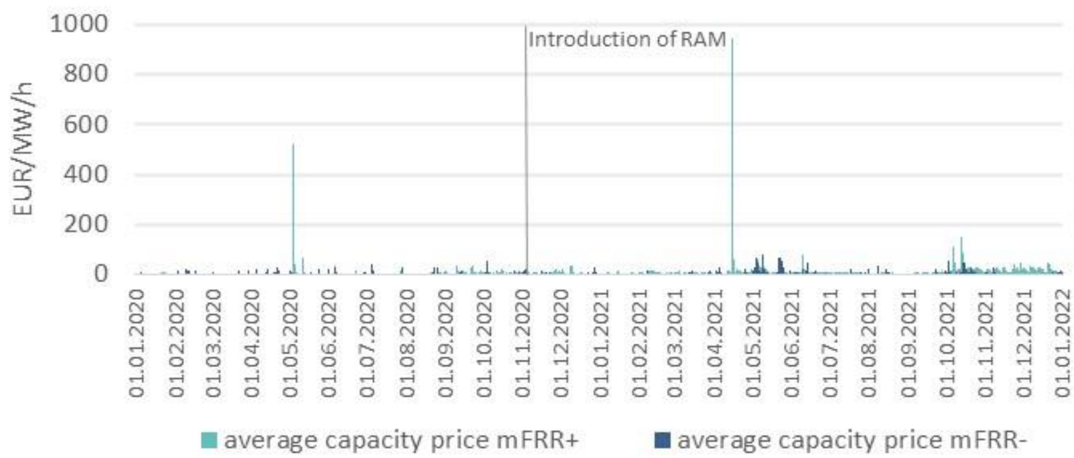

Figure 5.6: Development of the balancing capacity price for mFRR

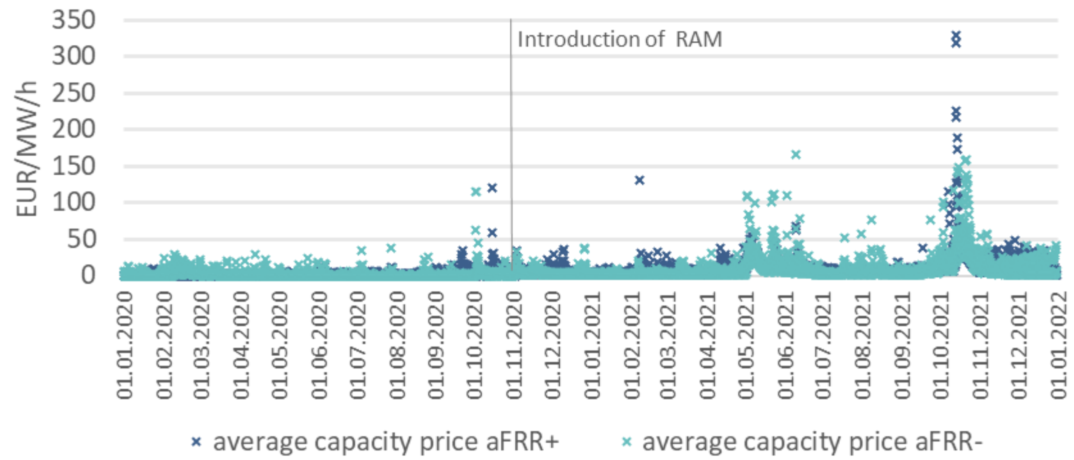

Figure 5.7: Development of the balancing capacity price for aFRR

Figure 5.8 and Figure 5.10 depict the development of the average energy prices for aFRR and mFRR since the introduction of RAM. High balancing energy prices can be identified in the first few months. As of 19th January .2021, the price cap of EUR 99,999 /MWh applies; Figure 5.9 and Figure 5.11 illustrate the developing average energy prices since then.

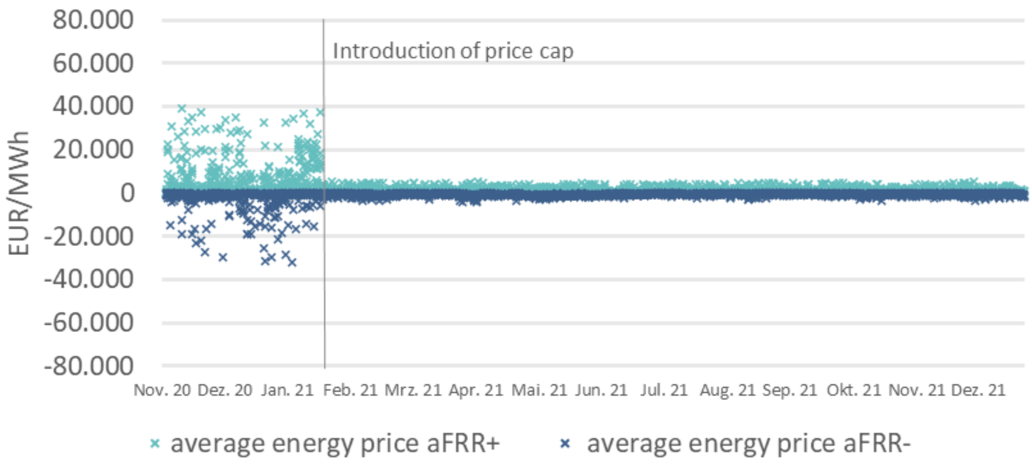

Figure 5.8 *Energy price development of aFRR on the balancing energy market (Nov. 2020 until Dec. 2021)*

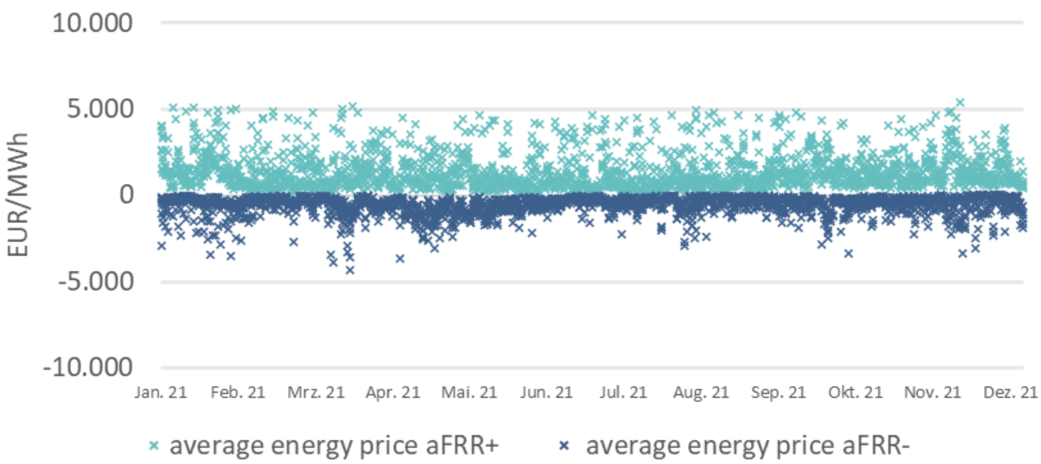

Figure 5.9: *Energy price development of aFRR since the introduction of the price cap on 19th January 2021*

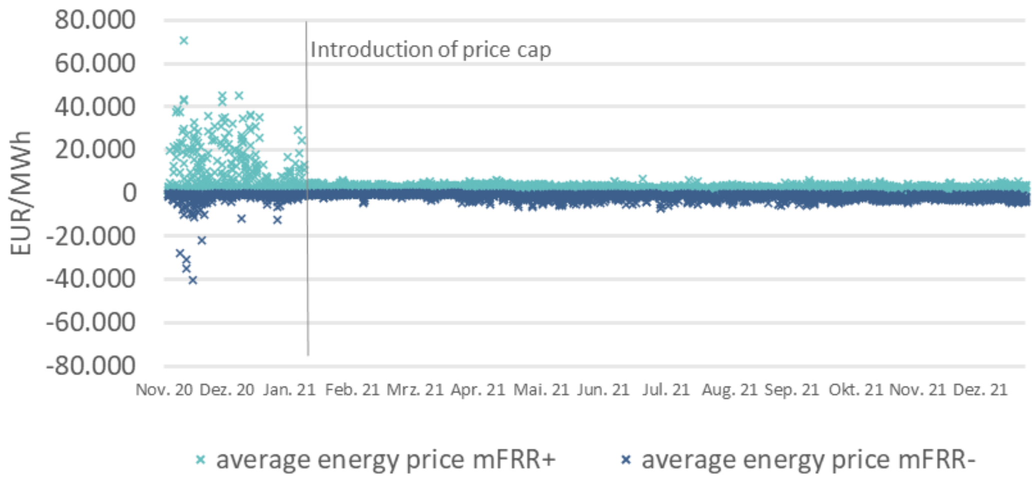

Figure 5.10: *Energy price development of mFRR on the balancing energy market (Nov. 2020 until Dec. 2021)*

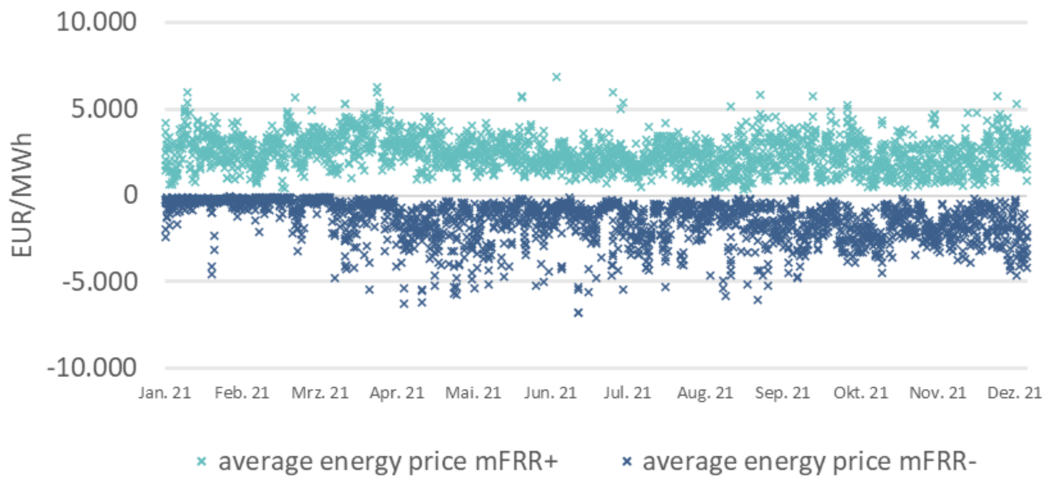

Figure 5.11 *Energy price development of mFRR since the introduction of the price cap on 19th January 2021*

The following evaluations of the demand and bid surpluses for balancing capacity (Figure 5.12 to Figure 5.14) show that for all three balancing reserves, the bids for balancing capacity exceeded the demand at all times and that there was also a clear bid surplus in the event of changes in demand. On average, the capacity offered for both FRR and FCR in 2020 and 2021 was about 2.5 times higher than the corresponding demand thus proving that the market for FCR and the capacity market for FRR in Germany can be regarded as sufficiently liquid and that there are currently no negative repercussions on the security of supply that could arise in less liquid markets.

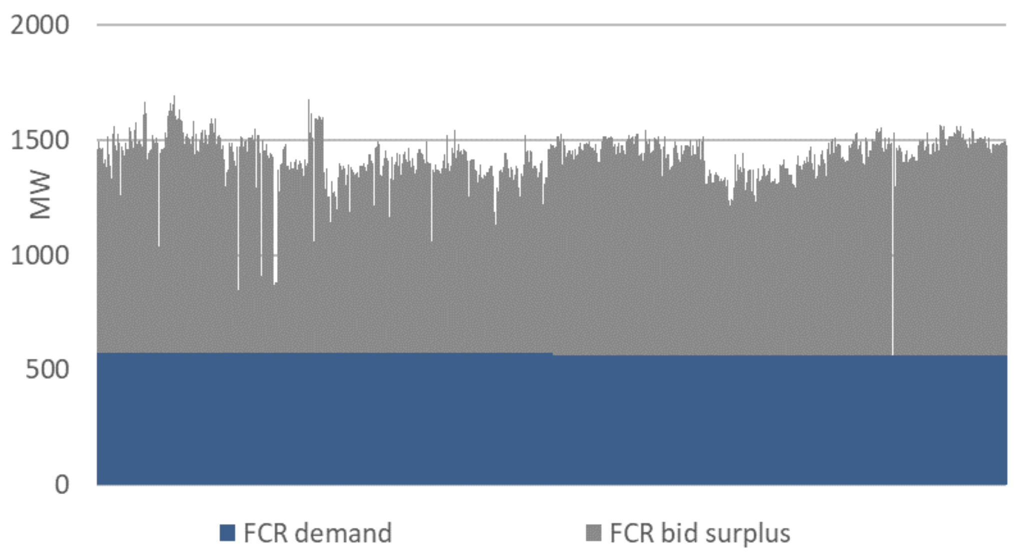

Figure 5.12 FCR demand and bid surplus (symmetric product) (daily resolution)

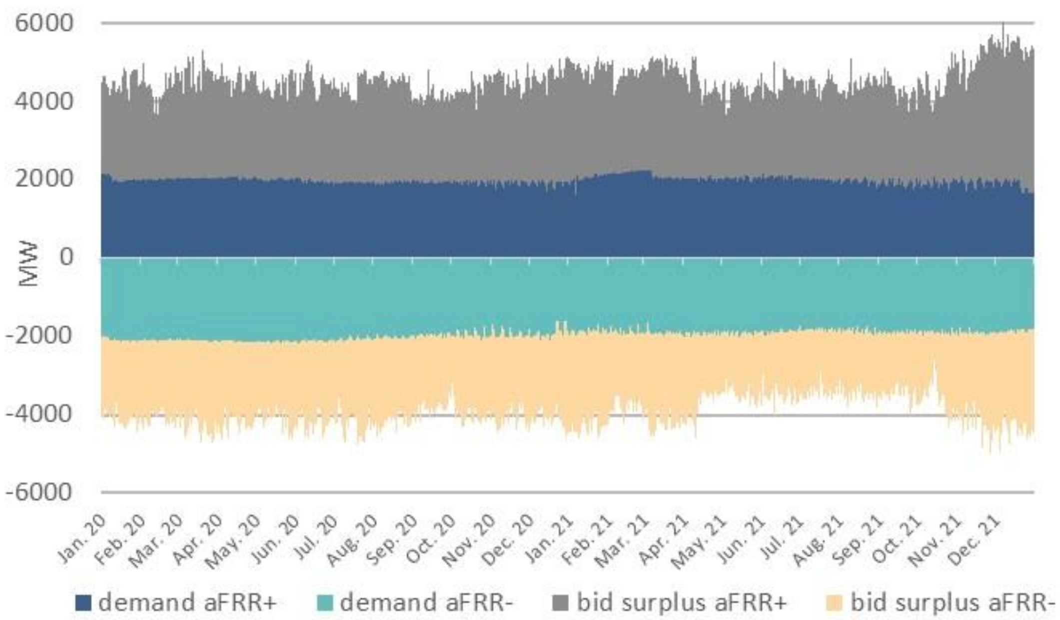

Figure 5.13 aFRR-capacity demand and -bid surplus (hourly resolution)

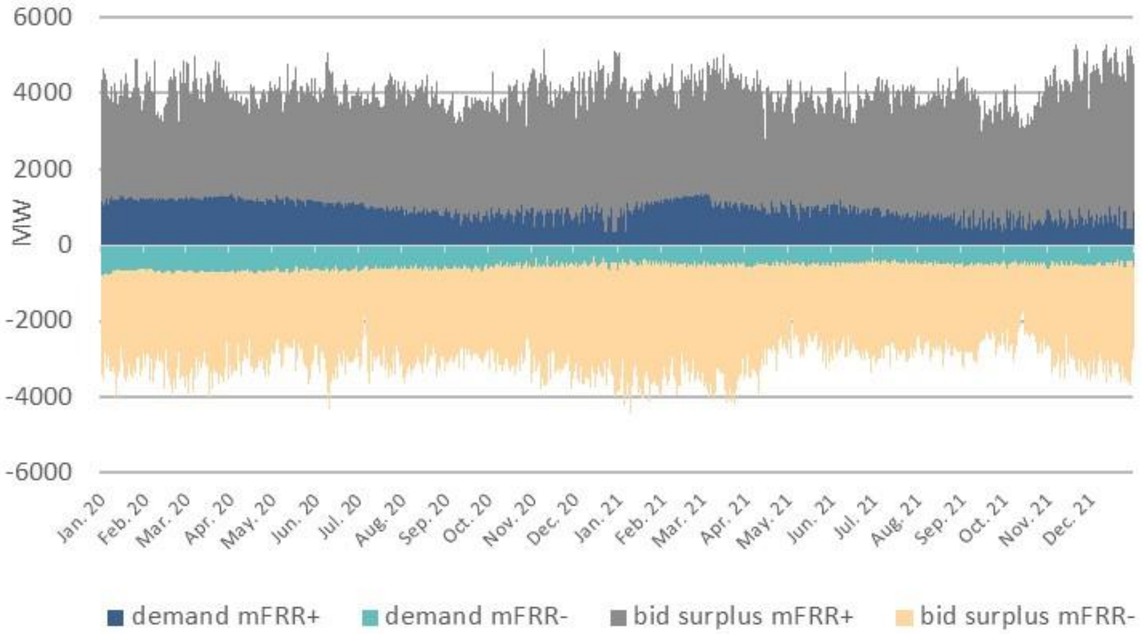

Figure 5.14 mFRR-capacity demand and -bid surplus (hourly resolution)

The following evaluations of the demand and bid surpluses for balancing energy in Figure 5.15 and Figure 5.16 show that there is not a bid surplus at all times and that the bid surplus is considerably lower compared to the balancing capacity bids. It must be noted that since the introduction of the balancing energy market there are only few additional bids that were not successful on the capacity market. The traded volume on the energy market was considerably lower than on the capacity market.

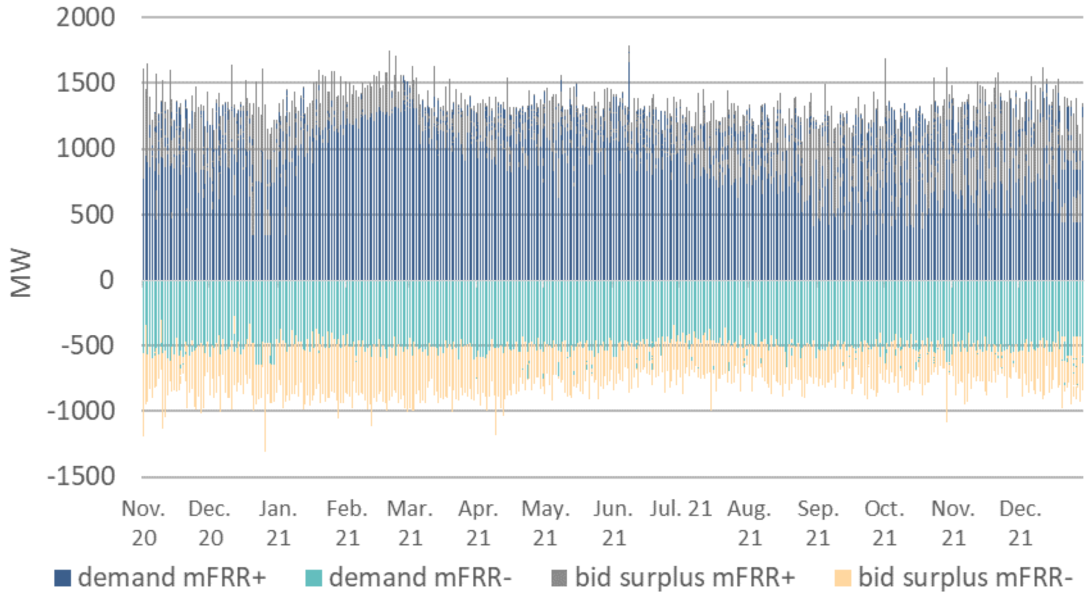

Figure 5.15 mFRR energy demand and -bid surplus (hourly resolution)

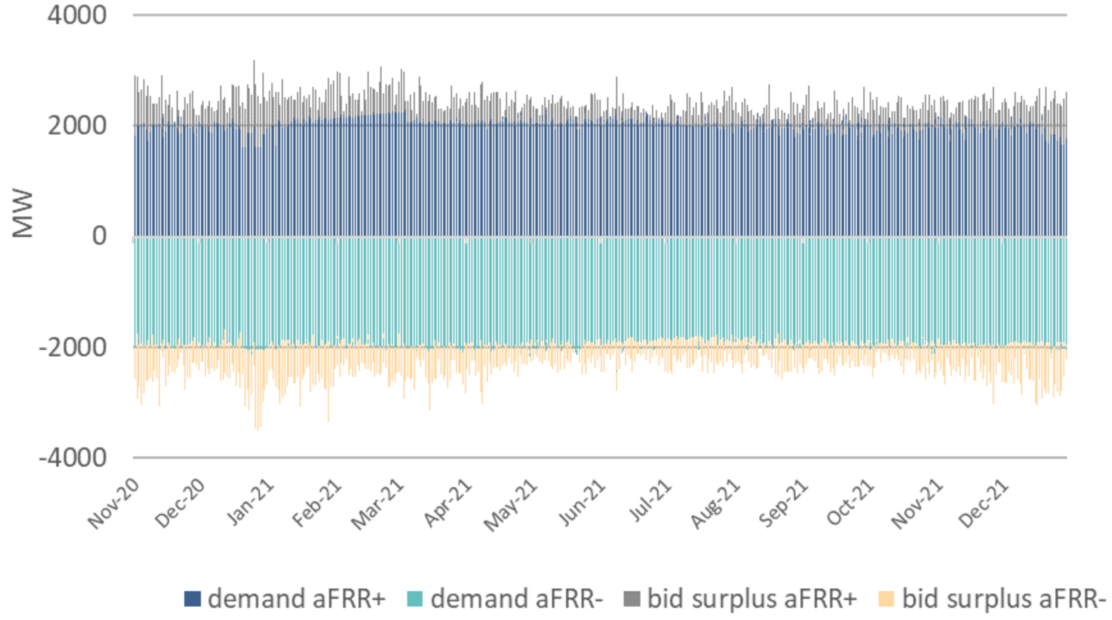

Figure 5.16 aFRR energy demand and -bid surplus (hourly resolution)

5.5 Use of balancing services

Balancing reserves are exclusively activated from BSPs whose bids have been accepted according to the process described in the previous chapter.

There is no central activation for FCR. Instead of this, TUs with accepted bids provide FCR based on the locally measured system frequency.

aFRR is activated automatically by the LFC, which considers the deviations of the system balance as well as the frequency from their respective target values in its decision for activation. Deviations between requested and activated aFRR are assigned to the BSP as imbalances. Activation follows the merit order of the balancing energy price bids. The GCC ensures a national merit order regardless to which LFC the TU is connected.[23] The merit-order-based activation aims at minimizing the costs of activation of each of the balancing services. Activation based on the MOL corresponds to the activation strategy stipulated by EB GL. BSPs are required verify the provision of the requested aFRR to the TSO upon request. Furthermore, the TSO can check the provision via test activations.

If it is deemed appropriate and necessary for operational reasons TSOs activate mFRR. mFRR is activated to replace aFRR in the event of foreseeable extended system imbalances so that the entire range of aFRR is made available again to manage other system imbalances that occur at short notice. No economic trade-off is considered between the use of aFRR and mFRR. However, the activation of mFRR energy bids is based on the national merit order of the balancing energy price bids to minimize the costs of mFRR activation.

Since mid-2012, mFRR energy bids are no longer been activated by phone, as it was previously the case, but rather electronically via the Merit Order Lists Server (MOLS). mFRR energy bids are activated as scheduled delivery or direct activation. This means that, in the event of mFRR activation, a schedule

[23] Deviations from the nationwide merit order are only permitted in exceptional cases. For instance, in case of grid congestion within Germany, individual TSOs may limit participation in GCC so that aFRR bids within the own LFC area are activated with priority independent of the nationwide merit order. Technical line faults in GCC or incidents, such as trial activations, can also lead to deviations from the merit order. These deviations are documented by the TSOs.

is agreed between the BSP and the connecting TSO. In this case, activation must take place no more than 7.5 minutes before the schedule. Deviations between requested and activated mFRR are attributed to the BSP as imbalances. In addition, BSPs are obliged to appropriately verify the provision of the requested mFRR to the TSO upon request. Moreover, the TSO can check the provision via test activations.

To understand the use of balancing services it is important to note that the balancing energy bids activated during a 15-minute period do not necessarily have to have the same direction for various reasons:

- The timeline of aFRR demand is extremely volatile with frequent changes of the imbalance direction within one 15-minute period and even within individual minutes so that positive and negative activations of aFRR energy can take place within one 15-minute period. In addition, the target direction of activation and the actual provision of aFRR may differ due to the inherent inertia of the TUs supplying aFRR (subject to a minimal ramp-up). In particular, in the event of changes to the direction of imbalance in the aFRR demand, it may be the case that the activation signal is requesting positive aFRR, while negative aFRR is being provided at the same time or that positive and negative aFRR are being provided.
- The activation of the mFRR is not available as quickly as aFRR activation and by definition follows the aFRR demand with a delay and slower activation speed. Thus, it cannot follow all movements (and imbalance direction changes) of the aFRR demand. The activation of both types of balancing reserves within a 15-minute period may therefore happen in opposing directions.

5.6 Balancing cost

In the past, the cooperation in the GCC reduced the cost of provision and activation through cost-optimal aFRR and mFRR activation. Figure 5.17 shows this development. However, especially in 2021 the cost increased significantly again. This can partly be explained by increased electricity wholesale prices, which influence the balancing cost. Furthermore, an unusually high number of unavailabilities of hydro plants which make up a large share of balancing reserves, increased the cost. The introduction of the balancing energy market was expected to increase the competition between balancing energy providers and in turn lower balancing energy prices. Especially due to the limited quantities traded on the balancing energy market these expectations did not manifest. In contrast, a significant increase of both balancing energy and capacity prices can be observed especially for FCR and aFRR.

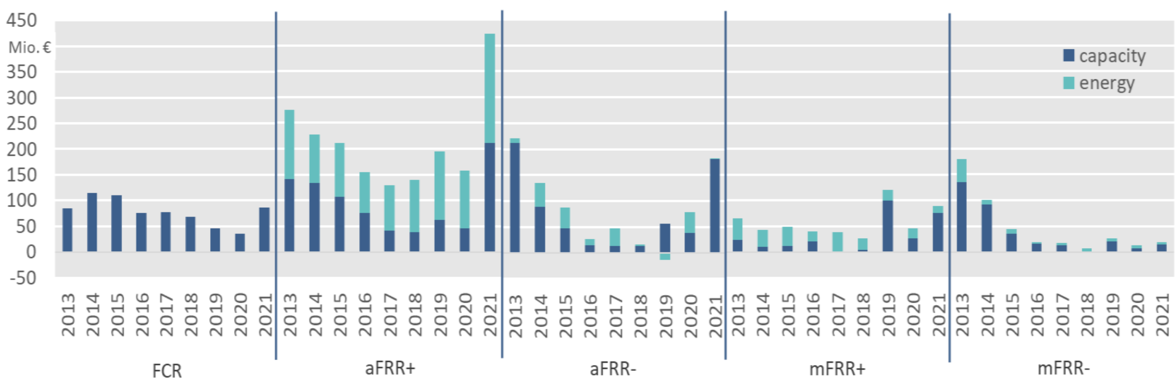

Figure 5.17 Development of balancing capacity and energy cost in Germany

5.7 Settlement and payment flows between providers and TSOs

As explained in section 5.3, a capacity price-based remuneration is paid for the procured balancing capacity for all types of balancing services (FCR, aFRR and mFRR) and an energy price-based remuneration is paid for the activation of mFRR and aFRR energy bids for the balancing energy actually used. The remuneration for balancing capacity provision always represents a payment from the TSO to the BSP. Depending on the direction of the imbalance and the price for an accepted bid, the remuneration for activated balancing energy may be a payment from the TSOs to the BSPs or the other way around.

The remuneration for the balancing capacity provision and for the balancing energy activation is based on the following principles:

- The remuneration of BSPs is based on the quantities to be settled (for example, capacity provided, and energy activated) and the capacity and energy prices offered by the BSPs for the relevant bid.
- The remuneration of BSPs is always settled for a whole month in the first week of the following month.
- BSP settlement is always organized by the TSOs, irrespective of whether this results in a payment from the TSO to the BSP (for example a credit note from the perspective of the TSO) or a payment from the BSP to the TSO (for example an invoice from the perspective of the TSO).
- Every TSO settles the balancing capacity provided and the activated balancing energy with the BSPs whose TUs used for the activation of the balancing energy are connected to its LFC area, irrespective of where the demand for a certain balancing volume arose. TSOs refer to this setup as the "connecting TSO principle". This means that every TU is assigned to one TSO responsible for settlement. In the internal relationship between the TSOs, this results in the necessity of compensation payments for the provision of balancing services.

For remunerating the provision of balancing capacity, the volumes to be settled are calculated directly in the procurement process. However, these volumes need to be corrected in exceptional cases, for example if BSPs cancel their offer after procurement due to technical non-availability.

The energy volumes relevant for remunerating the activated balancing energy of aFRR and mFRR are determined separately for each bid used of each BSP and for every 15-minute period in the delivery month and, after multiplication with the relevant energy prices, added together to generate the monthly settlement amounts. The individual amounts and therefore also the monthly sums can be positive or negative, depending on the direction of activated balancing energy and the direction of energy prices, and represent payments in different directions between TSOs and BSPs.

The settlement-related balancing energy volumes are determined from Monday to Friday, after the end of a delivery day, and coordinated between the TSOs and the BSPs during the delivery month. Different approaches are taken for aFRR and mFRR:

- aFRR activation is based on a time cycle of one or a few seconds. The control signals for the controllers of the connected TUs are updated and sent in each cycle. These aFRR activation signals are archived in the TSOs' control systems. In addition, the control systems receive feedback from the BSPs about the actual aFRR provision. This is calculated from the measured values of the TUs active in aFRR provision and the power plant schedules. The actual values are also archived in the TSOs' control system.
  The archived values are used to retrospectively determine the 15-minute-target and actual values for every delivery day, which are transferred to the BSPs for review. As a result, precisely one target and one actual value are determined for each BSP per 15-minute period for the activation of positive and negative aFRR balancing energy, even if several bids from the same BSP were used in the

15-minute period. In this case, the energy values are allocated to the different bids used according to the merit order of the energy prices for settlement.

After clarifying and implementing any adjustments, the volumes to be settled are determined based on the target and actual values. For every 15-minute period, the TSOs select the target and actual values that lead to the lowest overall costs for the TSOs (and therefore ultimately the system users and BRPs, to whom the costs are passed on). For example, in the event of the activation of positive aFRR with positive bid prices, the minimum of both values (target and actual) is used. If the BSP supplies more balancing energy than requested (for example the actual value exceeds the target value), the excess balancing energy supply is not remunerated. If the BSP supplies less balancing energy than requested (for example the actual value is below the target value), only the delivered balancing energy is remunerated. The terms and conditions for BSPs specify penalties for cases in which the provision of balancing energy was incomplete. The same considerations apply for negative balancing energy and the (particularly relevant in this case) differentiation by the direction of the bid prices.

- On 18.06.2018, the German TSOs proposed a new settlement method for aFRR[24], in which an accepted range was defined, which describes the area in which aFRR must be provided. Lower and upper limits are established for the accepted range depending on a dynamic gradient that depends on the course of the target value. A tolerance range is placed around this accepted range, which reflects the accepted fluctuations in the provision. The target value, actual value, acceptance value, tolerance value and the under-fulfilment are used to calculate the settlement volume. It is also ensured that aFRR energy, which is provided by an aggregation, can be assigned to the associated individual contracts, and settled at the relevant balancing energy prices. In October 2020, the BNetzA reached a decision[25] on introducing the new aFRR settlement, which entered into force on 1st October 2021.[26]
- In contrast to aFRR, mFRR has no distinct measurement, so the separate acquisition of the actual provision is not possible in this case. Instead of this, the mFRR is considered in the imbalance system in that, for every activation, a 15-minute-exchange-schedule is generated between the balancing group of the mFRR providing BSP and the mFRR balancing group of the relevant TSO. If the provider provides the mFRR precisely as requested and therefore in line with the generated schedule, the schedule settles the changes to the provider's generation and consumption associated with the provision. However, if deviations occur, they are automatically identified as part of the balancing group settlement and treated as imbalance which the BSP has caused. For determining the settlement volumes, the 15-minute-values of the schedule provided by the TSOs' MOL server to the BSPs are considered.

5.8 Transparency requirements

For various reasons (including the removal of barriers to market entry and increasing competition in the balancing markets, assessing the bid situation on the electricity wholesale markets, transparency of the balancing energy pricing), the TSOs aim at the greatest possible transparency in tendering, procurement, and usage of balancing services.

[24] Further information on this adjustment is available at *https://www.regelleistung.net/ext/static/srl*.

[25] see BNetzA stipulation BK6-18-004

[26] For further information see *https://www.regelleistung.net/ext/static/market-information*

The StromNZV (§ 9) and the BNetzA decisions of 2011 on the tendering of the different balancing services[27] as well as the European Regulation 2013/543/EU on the submission and publication of data in electricity markets (the so-called Transparency Regulation) contain corresponding requirements. Specifically, the publication of various information on www.regelleistung.net as well as in some cases on the ENTSO-E transparency platform is required. These are

- for FCR,
  - the overall German and international demand,
  - an anonymized list of accepted FCR bids (incl. bid volume and price),
  - volume-weighted average capacity price (for pay-as-bid) and marginal price,
- for FRR (separate for aFRR and mFRR)
  - the demand per product and LFC area, including any approved core demands,
  - an anonymized list of accepted FRR bids (incl. bid volume, capacity and (if applicable) energy price bid) and, where applicable, identification of bids accepted based on core shares,
  - volume-weighted average capacity price and marginal price per product,
  - activated balancing energy (separate for positive and negative FRR) in 15-minute-resolution across the entire GCC, differentiated by the providing LFC area
  - the period of deviation from the merit order including a justification.

As part of the go-live of the balancing energy market in 2020, an anonymized list of all accepted aFRR and mFRR balancing energy bids, separately for each positive and negative FRR, which contains the bid volume and the balancing energy price for every bid (merit order of balancing energy), will be published. The publications will continue to include the FRR energy activated in a 15-minute-resolution, separately for positive and negative balancing energy, in a joint representation for the GCC and all four LFC areas. The period of any deviation has also to be published, from the merit order with a justification. Bid prices and volumes of rejected energy bids will not be published.[28]

In addition, the imbalances of all four LFC areas and the overall GCC[29] must be published in 15-minute-resolution as well as the names of prequalified BSPs for all types of balancing services at www.regelleistung.net.

Since September 2021, the TSOs have also published a GCC balance traffic light for market participants. [30] The GCC balance traffic light's signals gradually indicate either a deficit or a surplus in the system and give market participants the opportunity to recognize indicators of imbalances in their balancing groups and to take appropriate countermeasures.

The data required to meet these transparency requirements can be accessed in full on www.regelleistung.net. This includes

- lists of prequalified BSPs

[27] see BNetzA-stipulations BK6-10-097, BK6-10-098, BK6-10-099

[28] see partial approval of the terms and conditions for balancing service providers regarding the introduction of a national balancing energy market as well as the exemptions from publication obligations (BNetzA stipulation BK6-18-004-RAM).

[29] According to BNetzA stipulation BK6-12-024 on the further development of the imbalance price system, since 01/12/2012, the TSOs have published the imbalance of the GCC at www.regelleistung.net no later than 15 minutes after the end of an imbalance settlement period.

[30] The GCC balance traffic light is published on *https://www.netztransparenz.de/Weitere-Veroeffentlichungen/NRV-Saldo-Ampel*

- information on demand for each type of balancing service and the tendering results under the "Tender details" menu item and
- information on the activation of balancing energy, on LFC area imbalances, on GCC imbalances and deviations from the merit order under the "Data center" menu item. In addition, information on the exchange of balancing services as part of cooperations as well as on the exceeding of the 80% threshold relevant for the imbalance pricing (cf. section 6.2) are published. It should be noted that due to the short publication times, individual data represent operational and thus not yet quality-assured values, which may be corrected in the further settlement and processing process.

Beyond the publications on www.regelleistung.ne prequalified and potential BSPs must be provided with information on aFRR energy activated in second-by-second resolution for a period of at least 12 months. This data is provided via a website of the German TSOs upon request.

6 Calculating and settling balancing energy

6.1 Calculating and settling of imbalance volumes

As explained in section 3.2, the TSOs are responsible for calculating and settling the imbalance volumes used by the balancing groups in their LFC area. The required exchange of information, the obligations of cooperation and the deadlines to be complied with for this process, referred to as balancing group settlement, are set in the market rules for balancing group settlement in the field of electricity ("MaBiS") defined by the stipulation of BNetzA. The process consists of the following steps before and after the delivery date:

- BRPs active in an LFC area inform the TSO of all planned transactions between the balancing groups within the LFC area as well as across the LFC area before the delivery date. The TSO's role in this context is also referred to as balancing coordinator (BC). The information is submitted in electronic, automated processes and are referred to as schedules. After the delivery date, the BRPs can communicate coordinated changes to these exchanges within a LFC area until 4:00 PM the next day.
- All system operators (transmission and distribution system operators) in a LFC area record the 15-minute meter-values of the suppliers and consumers connected to their grid as well as the standardized load profiles, which are used to balance small customers without recording a load measurement, and sum them up for each balancing group, differentiated by the different types of feed-in and consumption. BCs receive these time series for the individual balancing groups and share them with the BRPs. This process and the entire balancing group settlement take place for every delivery month. The settlement of the 15-minute balances for the balancing groups between the relevant system operator and the BRP must be completed no later than by the 20th working day after the delivery month. The status of this data available to the TSO at this time, which is relevant for settlement in accordance with the market rules, forms the basis for the balancing group settlement, which the BCs must prepare by the 42nd working day after the delivery month
- To be able to take account for subsequent adjustments to the balancing group data, which are deemed necessary by the system operators and/or BRPs and are communicated to the BC after this time, an adjustment balancing group settlement takes place eight months after the delivery month, for which the deadlines for data exchange and clearing are also defined with the MaBiS.
- The imbalance prices, according to which the imbalances of the balancing groups are subsequently settled, must be calculated, published, and electronically transferred from the TSOs to each BRP by the 20th working day after the delivery month – for example before the determination of the balancing group imbalances relevant for the first balancing group settlement.

Like the settlement with BSPs, the invoices for balancing group settlement are always prepared by the TSOs and transmitted to the BRPs, irrespective of whether this results in a payment from the BRP to the TSO or vice versa.

6.2 Calculating the imbalance price reBAP

Imbalance settlement takes place in line with the provisions of StromNZV, applying symmetrical 15-minute-imbalance-prices. The imbalance price is calculated for a 15-minute imbalance-settlement-period and applied to withdrawals by an under-supplied balancing group from the system (for example positive imbalance) and to feed-ins by an over-supplied balancing group into the system (for example negative imbalance). This symmetrical imbalance price, which is expressed in Euros per MWh, has also been calculated as the standard national price since introducing the GCC and is referred to as the "uniform cross-LFC-area imbalance price" (reBAP).

The reBAP is generally calculated by dividing the balancing energy costs incurred in a 15-minute period by the activated balancing energy volumes. As balancing energy costs as well as activated balancing energy volumes can have a positive or negative direction, the reBAP may also be positive or negative. A positive reBAP leads to payment from BRPs to the TSO for the balancing energy drawn from the system (for example, if their balancing group is under-supplied) and BSPs receiving payments from the TSO for balancing energy fed-in the system (for example, if their balancing group is over-supplied). The opposite payment flows arise for a negative reBAP. Table 6.1 summarizes the effects of the four possible combinations of the directions of the balancing group balance and the reBAP.

Table 6.1 Financial effects of an imbalance depending on the direction of the balancing group balance and the reBAP

balancing group	withdrawal/feed-in of imbalance	ReBAP direction	financial impact for BRP
under-supplied	withdrawal	positive	invoice
under-supplied	withdrawal	negative	credit
over-supplied	feed-in	positive	credit
over-supplied	feed-in	negative	invoice

The EB GL requires an adjustment of the main component of the balancing energy price calculation, which the TSOs refer to as "Module 1". The prices for balancing energy formed on the market will continue to form the basis, but in accordance with the EB GL requirements, a change from a cost-based to a price-based calculation will have to be made. In the future, the balancing energy price will no longer be determined based on the costs and volumes of the activated balancing energy bids and other measures for balancing the GCC. Instead, the prices and volumes of the balancing energy calculated by the European platforms MARI for mFFR and PICASSO for aFRR are to be used as a basis. To implement these requirements, the TSOs submitted a proposal to the BNetzA in March 2021.[31] In the course of this process, the TSOs have also revised the determination of the GCC balance in line with the European requirements. With the introduction of the target market design, the TSOs plan to consider the quantities of unintended exchanges with neighboring control areas and the FCR in the GCC balance.

[31] see BNetzA procedure BK6-21-192

In departure of the previously explained basic method of calculating the reBAP, different mechanisms are used to adjust the imbalance prices depending on the situation, which have been introduced by BNetzA stipulations during the past years:

- The reBAP is generally limited to the maximum balancing energy price of the activated balancing bids within a 15-minute period to prevent price peaks, which would otherwise occur, especially in the case of very small imbalances (due to the division of the costs by a very small imbalance).
- Another limitation of the imbalance price takes effect in the case of small GCC imbalances to prevent high imbalance prices due to high prices for balancing energy in the case of minor imbalances. If GCC imbalances range between -500 MW and 500 MW, a limitation based on a linear function depending on the GCC imbalance, which includes the volume-weighted average price of the relevant hourly product from intraday trading of scheduled energy. This results in a surcharge or reduction (as applicable) between 100 and 250 EUR/MWh.
- Since December 2012, a coupling of the reBAP to prices from the intraday power exchange has been used as the lower or upper limit for the reBAP (depending on the direction of the imbalance) to eliminate any incentives for the deliberate use of balancing energy by BKV speculating on price differences. At the end of 2019, TSOs submitted a request to BNetzA revising the coupling of imbalance prices and intraday prices, which was approved in May 2020. Since summer 2021, the reBAP calculation has considered quarter-hourly trading instead of hourly trading of intraday trade to better reflect the real-time value of energy in the balancing energy price and to create a stronger incentive to maintain the system balance.
- Also in December 2012, a regulation was introduced, which states that if (in total) more than 80% of procured aFRR and mFRR is activated in the positive or negative direction, a surcharge or reduction (as applicable) is applied to the reBAP to introduce a stronger incentive for maintaining the system balance to preventively avoid such situations. This criterion has been refined so that, from the delivery month of February 2020, the 80%-criterion will refer to the ratio between the GCC imbalance and the procured balancing capacity and not as before, to the amount of the balancing energy activated.
- To reinforce the imbalance price in the event of very high imbalances, if there is no sufficient incentive through the other components of the reBAP for balancing groups to balance through market transactions or to limit the GCC balance, a shortage component was proposed to the BNetzA in December 2020, approved in May 2021 and has been applied since August 2021. The TSOs further intend to adjust the current determination of the GCC balance in the target market design. In particular, the TSOs also plan to consider the quantities of unintended exchange (Article 8 (1a) ISHM) and the primary balancing reserve (Article 8 (1c) ISHM) in the future. The TSOs consider the inclusion of these quantities in the GCC balance to be appropriate, if they were necessary to compensate for imbalances in the GCC.

The market price coupling takes effect in 25% of the settlement quarter hours. The reBAP is therefore primarily determined by the balancing energy costs and quantities. As the price adjustment mechanisms only effect a small amount of the 15-minute-settlement-periods, the reBAP is primarily determined by the balancing energy costs and volumes. However, there is no simple correlation between these two quantities, for example in the sense that the specific (i.e., quantity-related) balancing energy costs rise monotonically with the balancing energy volume (or fall monotonically with it in the negative range). Rather, the prices are influenced by the fact that the two control reserve qualities aFRR and mFRR are procured based on independent tenders and can therefore have very different price structures. As explained in section 5.4, the two types of balancing services can temporarily also be simultaneously used with opposite directions. As a result, the balancing energy costs can be high even for a small imbalance or can be subject to significant fluctuations even in periods with a constant imbalance, as the activated types of balancing services can change. The reBAP and its development over time can therefore only be explained by considering the development of the costs as well as the volumes of both types of balancing services and any additional measures used for balancing.

Figure 6.1 shows exemplarily the imbalance prices and respective GCC imbalances for the 15-minute periods in 2020 and 2021. At one point in time when the GCC balance was controllable, a high imbalance price can be seen, which was triggered by the activation of high balancing energy bids. As a result, the price cap on balancing energy market described in Section 5.3 was discussed and has since been introduced.

The described price adjustment mechanisms imply that the costs attributed to BRPs in the balancing group settlement do not completely match the balancing energy costs in every 15-minute period. Since December 2012, these differences have been covered by the TSOs, who pass them on to the network usage fees. These differences were previously only caused by the first of the three described mechanisms (price limitation). They were referred to as “non-assignable costs” and were considered by a standard surcharge/reduction on the reBAP values in the relevant settlement month.

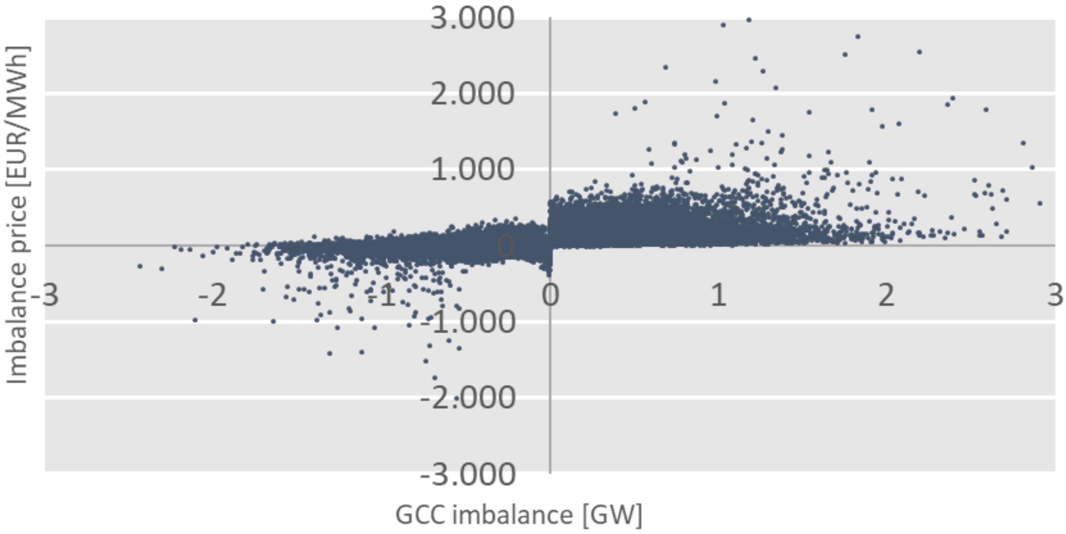

Figure 6.1: Correlation between the imbalance price (reBAP) and the imbalance of the GCC in 2020 and 2021; every data point represents the values for one 15-minute period, the correlation coefficient is 0.40

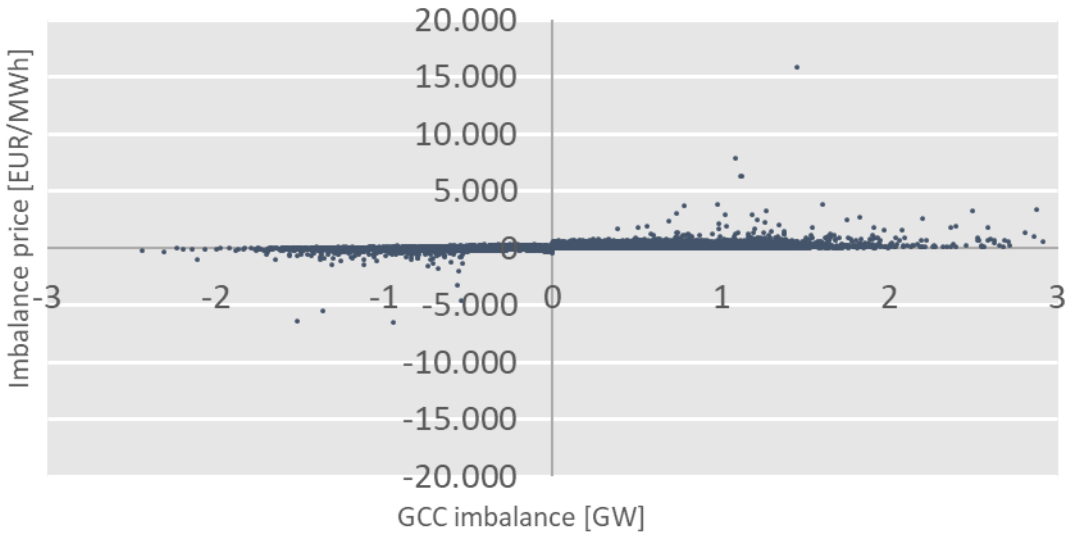

Figure 6.2 Correlation between the imbalance price (reBAP) and the imbalance of the GCC in 2020 and 2021; every data point represents the values for one 15-minute period, detail on prices between ±3,000 EUR/MWh, the correlation coefficient is 0.49

From a procedural perspective, the reBAP is calculated in a way that the four TSOs mutually provide complete information on the costs/proceeds for any additional measures taken, maximum energy prices and the energy volumes used after settlement with the BSPs and the contracting parties. After determining any need for adjustment that arises in case of changes to the calculation method or data exchange modalities, the TSOs publish the reBAP values for the delivery month on the internet.

The details on the steps explained to calculate the reBAP are defined in the model description for reBAP calculation agreed on by the TSOs and the BNetzA and are published on www.regelleistung.net.

6.3 Cost allocation effects and solidarity principle

As explained in section 3.1, in contrast to the theoretically conceivable entirely decentralized balancing responsibility by the individual electricity suppliers, the concept of system balancing by the TSOs leads to significant savings for all of the system users, as it eliminates the requirement for the time-consuming real-time recording of feed-in and consumption and minimizes the need for balancing services through the maximum use of diversification. With this concept, the individual BRP incurs only a small fraction of the costs that he would otherwise incur from the provision and activation of his own balancing services for his own group of customers.

However, the costs and income of the individual BRPs offset each other over time due to the constantly changing direction of imbalances. On a long-term average, every BRP bears only a fraction of the TSOs' balancing energy costs. Their share depends significantly on the extent of the statistical correlation between the imbalance of the individual balancing group and the imbalances of all balancing groups. Random fluctuations, which are not systematically associated with the demand fluctuations in the overall system, do not lead to significant balancing energy costs on average.

This concept of solidary sharing of the balancing costs between the BRPs requires all participants to accept that the share of the costs of a balancing group does not depend solely on its demand for balancing energy, but also on the imbalance of the other balancing groups. For example, an imbalance price above or below the electricity market prices may arise for a balancing group that is under-supplied in a 15-minute period, depending on whether there is under- or over-supply for the sum of all balancing groups. In addition, the imbalance price is at least partly related to the overall imbalance of for all balancing groups due to the merit order activation of balancing energy.

Another key feature of this concept is that the causes for an individual balancing group's imbalance are essentially irrelevant for the balancing group settlement. Irrespective of the fundamental obligation of BRPs to ensure the balanced management of the balancing groups in each 15-minute period, it is accepted that imbalances occur within plausible limits and that solely the volume of the imbalances is relevant for settlement. In this respect, the causes for individual imbalances or the drivers for their volume – such as, the quality of forecasts, the intensity of the information exchange between BRPs and their customers as well as the type of measures taken for short-term balancing – are not considered.

Only in the event of unacceptably extensive use of balancing energy can BRPs be sanctioned in accordance with the balancing group contract. A fundamental obligation for BRPs to justify imbalance volumes does not exist and would also be difficult to reconcile with the basic concept of imbalances. Only if the TSOs identify significant deviations, they clarify with the affected BRP to what extent these deviations could have been avoided (see for example the situation in June 2019).

6.4 Transparency requirements

In addition to the TSOs' publication obligations for the procurement and use of balancing capacity and balancing energy explained in section 5.8, the transparency requirements regarding the balancing group settlement are predominantly limited to the publication of the imbalance prices and their calculation methodology. The imbalances of all four LFC areas and the GCC imbalance by 15-minute periods also need to be published. Information on the use of balancing energy by the individual balancing groups is treated as confidential and is therefore not published.

7 Further development of the markets for balancing services

7.1 Levels of cooperation

In the past few years, the TSOs intensified and advanced their cooperation activities in the field of electricity balancing. In part, EB GL already calls for enhanced European collaboration in the exchange of balancing energy from all balancing services[32]. In addition, there are voluntary cooperations for the exchange as well as for the joint procurement of balancing capacity. The Collaboration takes place in initiatives with all ENTSO-E member states and as a part of bilateral cooperations. In general, a balancing cooperation can take place in different fields and with different intensities:

- **Netting of imbalances:** This type of optimization aims to prevent or reduce the counter-activation of balancing energy. For the netting of imbalances, counteracting needs for balancing energy in the individual LFC areas (or blocks) are identified and used to determine the necessary exchange volumes of the LFC areas. This prevents a counter-activation and facilitates savings on balancing energy.
- **Harmonization:** Many forms of cooperation require the harmonization of the balancing products as well as the terms and conditions of the different markets. The necessary degree of harmonization of products and the provision and use of balancing services depends on the intensity of the cooperation. Enhanced cooperation is only feasible if the cooperation partners implement uniform balancing market conditions.

[32] This text describes all cooperations in which the German TSOs participate. In addition to this, the **T**rans **E**uropean **R**eplacement **R**eserves **E**xchange (TERRE) also exists for replacement reserves not being used in Germany.

- **Cost-optimized activation**: The aim of this optimization level is to satisfy balancing demand based on the activation via a common (cross-LFC-area) MOL being available in the optimization system and including all accepted balancing bids of the involved LFC areas. In this case, the demands of all participating LFC areas are considered as an overall demand, for example in the case counter-activation is prevented. In addition, all involved LFC areas have access to all balancing services of all participating LFC areas available.
- **Joint tendering:** This involves a form of cooperation with the balancing services being jointly tendered, either in part or in full. Provided that any restrictions are complied with, a provider can hold its balancing capacity available for any LFC area. Activation can just take place directly by the connecting TSO (TSO-BSP model) or indirectly by the connecting TSO (TSO-TSO model). The EB GL prefers the use of the TSO-TSO model.
- **Joint dimensioning:** The controlled capacity exchange in the form of assistance or cost-optimized activation enables the joint dimensioning of the balancing capacity of the involved LFC areas. Joint dimensioning allows to determine the joint reserve capacity requirements all LFC areas. This allows to consider the simultaneous effects that reduce the required reserve capacity, for example in the case of load and renewable forecast errors.
- **Reserve sharing:** In addition to joint dimensioning, "reserve sharing", for example., joint access to the same TUs by different LFC areas, is also possible. A general requirement for reserve sharing are adequate and reliably available cross-zonal capacities, their appropriate consideration in the dimensioning process, the consideration of a reference accident which corresponds at least to the probabilistic dimensioning as well as harmonized products. Considering all levels of cooperation, the joint dimensioning one is the most complex. Accordingly, any cooperation between the TSOs can only be expected once sufficient experience has been gained in the other areas.
  Overall, joint dimensioning could lead to reduced dimensioned reserve capacity as well as reduced associated costs. The possible saving potentials achieved by reserve sharing as well as joint dimensioning conflict with the interdependencies with respect to transmission capacities arising from the external commercial trade schedule. This means that there is a trade-off between the use of cross-zonal transmission capacity for reserve sharing and the use by the markets for scheduled energy with the effects on social welfare needed to be considered. In addition to the resulting power flows, which always need to be considered, the regulatory requirements also particularly need to be considered in this level of cooperation. In practice, reserve sharing is therefore currently primarily used among small LFC blocks, whose reserve capacity requirements are determined by the outage of a single component (for example power station or HVDC terminal).

7.2 Existing cooperations with German involvement

7.2.1 IGCC

One of Germany's cooperations on netting of system imbalances takes place at a European level with various TSOs being involved in the International Grid Control Cooperation (IGCC).[33] In addition to the TSOs from Austria, the Czech Republic, Switzerland, Belgium, the Netherlands, Denmark, France, Croatia and Slovenia, which have participated so far, TSOs from Italy (Terna), Poland (PSE), Hungary (Mavir), Slovakia (SEPS), Spain (REE) and Portugal (REN) joined the IGCC during 2020. In June 2021, the European Imbalance Netting Platform (IN Platform) has been fully implemented as required by Article 22 EB GL. The Greek (ADMIE) and Romanian (Transelectrica) TSOs also joined the platform in 2021.

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

The IGCC is technically integrated into the GCC's aFRR optimization system where the international optimization is subordinate to the German domestic optimization. The IGCC – like the effect of the GCC within Germany – aims to prevent counter-activations of aFRR energy to the extent that sufficient cross-zonal transmission capacities for a cross-zonal netting are available. The resulting cost savings are divided between the participating TSOs. According to current estimates by the TSOs, IGCC reduces the costs for the activated aFRR energy across the entire cooperation by around 50 million Euros per year.

Due to the substantially different price systems for balancing services, this cost saving is not automatically divided between the cooperation partners in a manner that is generally considered to be fair, and which provides adequate incentives for participating in the cooperation. When introducing IGCC, a price system was therefore established based on which IGCC deliveries are settled between the participating TSOs. This calculates the volume-weighted standard settlement price for all IGCC deliveries within a 15-minute period based on the avoided costs (in the event of no positive aFRR energy being activated) as well as the avoided income (in the event of no negative aFRR energy being activated) of the cooperation partners. As a result, all partners benefit from cooperating in IGCC. The calculation of the IGCC settlement prices and the settlement of the IGCC deliveries based on these prices and the correction signals determined by the IGCC module take place monthly ex-post.

This cooperation is relatively easy to implement as it requires neither the harmonization of products and markets, nor the separate treatment of the cross-zonal transmission capacity. The remaining available cross-zonal capacity after the closure of all other markets for electricity is used on best effort basis in real time.

7.2.2 PICASSO

To create a European aFRR cooperation, European TSOs establish the **P**latform for the **I**nternational **C**oordination of **A**utomated Frequency Restoration and **S**table **S**ystem **O**peration (PICASSO).[34] The project implements the requirements from Article 21(1) EB GL, which calls for the implementation of a European platform for the exchange of aFRR balancing energy. It is intended to create the most-efficient model possible from a technical and economic perspective. The aim is to establish a European platform, which provides for a multi-lateral TSO-TSO model with a common MOL for the exchange of all aFRR balancing energy bids. In December 2018, the European TSOs submitted a proposal for the implementation framework of the aFRR platform. This proposal contains the basic structure of the platform, schedules for implementation, proposed provisions for governance, operation, and responsibilities as well as the specifications of the standard products for aFRR balancing energy and the gate closure time of the balancing energy market for all aFRR standard products. The proposal was processed by ACER and adopted in early 2020[35]. According to EB GL, the platform must be implemented by July 2022. The Go-Live of the PICASSO platform took place in June 2022 going operational with the accession of the German and the Austrian TSO on 22nd June 2022.

7.2.3 MARI

The Manually Activated Reserves Initiative (MARI)[36] is responsible for the cooperation at the mFRR level implementing the requirement of Article 20(1) EB GL to establish a European platform for exchanging mFRR balancing energy. MARI is therefore the counterpart to PICASSO for the mFRR. European TSOs submitted a proposal for the implementation framework of an mFRR platform in December

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

[35] see BNetzA procedure BK6-18-110.

[36] see: *https://www.entsoe.eu/network_codes/eb/mari/*

2018. This proposal contains the basic structure of the platform, schedules for implementation, proposed provisions for governance, operation, and responsibilities as well as the specification of the standard products for mFRR balancing energy and the gate closure time of the balancing energy market for all mFRR standard products. The proposal was also processed by ACER and adopted in early 2020.[37] According to EB GL, the platform must be implemented by July 2022 with the German TSOs being scheduled to join with the go-live of the platform in September 2022.

7.2.4 FCR cooperation

Since March 2012, the Swiss (Swissgrid), Austrian (APG), Dutch (TenneT NL), Belgian (Elia) and French (RTE) TSOs have gradually joined the FCR tendering process of the German TSOs as part of the FCR cooperation. Since January 2021, the Danish TSO (Energinet) and the TSO (ELES) have been participating in the joint FCR tender. Overall, a total of around 1,420 MW FCR are procured (as at: April 2022). The tenders consider any permissible FCR exports of a maximum of 30% of the FCR requirement of the respective country, but at least 100 MW. Likewise, core demands are also considered for every participating country. Belgium meets this requirement from SO GL using a separate national tendering. For the other cooperation partners, the following core demands are considered in 2020: Germany 168 MW, France 147 MW, Austria 22 MW, Switzerland 20 MW, the Netherlands 35 MW and Denmark 7 MW. Slovenia, on the other hand, does not designate a core demand.

This cooperation in the field of the FCR represents a voluntary European collaboration for the procurement and exchange of FCR as defined in Article 33(1) EB GL. Currently, the total benefit of the FCR cooperation is estimated at 184 million euros per year.

Since 1 July 2020, daily tendering, and the procurement in 4-hour product slices have been implemented (see section 5.3).

7.2.5 Cooperation between Germany and Austria

Since 2016 there has been a voluntary cooperation within the terms of Article 33 (1) EB GL for the economic optimization of aFRR activation between the German TSOs and the Austrian TSO APG. The cooperation is based on a common MOL within the scope of a TSO-TSO model. Provided that there are no operational restrictions in the grid between the two countries it does allow national balancing energy costs to be reduced by activating the lowest-cost bids across borders.

In addition to the common aFRR activation, a cooperation in the procurement of aFRR capacity was introduced in February 2020. A harmonization of the Austrian and German balancing service products took place in 2017 for this purpose. The cost-benefit analysis developed by APG and the German TSOs calculates the cross-zonal transmission capacities that are assigned to the exchange of aFRR in advance. The monthly cost benefit analysis (CBA), which is adjusted by weekly updates, compares the welfare gains of the cross-zonal transmission capacity attributed to the day-ahead market for scheduled energy with the value of this cross-zonal transmission capacity attributed to the aFRR markets. This comparison is carried out before the monthly auction of the cross-zonal transmission capacity for scheduled energy. Cross-zonal transmission capacities not needed for aFRR exchange are returned to the intraday market.[38] This cooperation addresses the afore-mentioned trade-off between the use of the limited cross-zonal transmission capacities for balancing reserves and for the external commercial trade schedule via the CBA. This cooperation therefore front runs in Continental Europe with regards to the allocation of cross-zonal transmission capacity.

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[37] see BNetzA procedure BK6-18-139.

[38] Further information is available at *https://www.apg.at/de/markt/netzregelung/sekundaerregelung/Kooperation*

In this context, the TSOs adapted the internal TSO-TSO settlement when exchanging aFRR. The joint activation is settled by a specific price that applies for all cooperation partners. In the future, the value of the avoided activation will be considered in the amount of the first uncalled bid of the national aFRR-MOL of the TSO importing the balancing energy. In contrast to the current settlement approaches, this evaluation of the avoided activation does not dependent on the actual volume of the exchanged balancing energy.

The total benefit of the cooperation was 6 million euros in 2020 and 17 million euros in 2021.

A joint activation of mFRR energy has been implemented under the German-Austrian GAMMA cooperation (German-Austrian Manual Merit Order Activation) since December 2019. Similar to the aFRR activation, the cooperation is based on a common MOL in line with the TSO-TSO model. The experience gained with the integration of balancing energy markets are to be used at the European level in MARI.

The implementation of the balancing energy market in both Austria and Germany was synchronized.

EB GL implementation also requires the introduction of marginal pricing for balancing energy. If activated, every BSP is remunerated based on the price of the product setting the market clearing price. The German and the Austrian TSOs are also planning a joint introduction of the new pricing scheme.

Although the German and Austrian modalities of the mFRR product stipulate that it must be provided in full within 7.5 minutes in the event of an activation, in other LFR zones the requirements for mFRR are lower. To harmonize the product modalities in Continental Europe, it is therefore planned to adapt the German-Austrian modalities in the future.