European Network of
Transmission System Operators
for Electricity

Explanatory document to all TSOs' proposal for the implementation framework for a European platform for the exchange of balancing energy from frequency restoration reserves with automatic activation in accordance with Article 21 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing

18 December 2018

DISCLAIMER

This document is submitted by all transmission system operators (TSOs) to all NRAs for information purposes only accompanying the all TSOs' proposal for the implementation framework for a European platform for common activation of automatic Frequency Restoration Reserves in accordance with Article 21 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing.

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1 Introduction

This explanatory document describes the scope and content of the all TSOs' proposal for the implementation framework for a European platform for the exchange of balancing energy from frequency restoration reserves with automatic activation (aFRRIF) in accordance with Article 21 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (EBGL).

This explanatory document has been prepared in support of the all TSOs' provision of the aFRRIF. Earlier work on relevant material in the PICASSO project, and previously the EXPLORE project, has been taken into account both in the aFRRIF and in the explanatory document. This includes input received in consultations previously organised in the two mentioned projects. The aim of the explanatory document is to provide insight to stakeholders and other interested parties into the concept of the implementation framework, including the rationale for choices made by the TSOs during its design. It gives some feedback in regards to comments received from stakeholders on topics relevant for the implementation framework during the official consultation on the aFRR Implementation Framework between May and June 2018 especially relevant to specific design choices.

Together with the all TSOs' proposal for pricing of balancing energy and cross-zonal capacity (Article 30 of the EBGL), the aFRRIF will lead to a new international market for aFRR. This is likely to lead to many changes for stakeholders, both from harmonisation efforts and as a result of the integration of the markets. Because of this, the feedback from stakeholders, in particular BSPs and BRPs, is valuable.

The structure of the document is as follows. After this general introduction, the context established by the EBGL is described. This is followed by a description of the relevant timelines related to the aFRRIF and the platform implementation (chapter 3).

In chapter 4 and chapter 0, the harmonisation and integration aspects of the aFRR-Platform are discussed.

Chapter 4 focuses on harmonisation aspects, including the description of standard products and the description of the balancing energy gate closure time. It also describes the framework for further harmonisation.

Chapter 0 focuses on integration aspects, including the high-level design of the platform and its business functions: the activation optimisation function and the TSO-TSO settlement function. This chapter also describes the signals sent between TSOs and the usage of cross-border capacity and other aspects of congestion management. Concepts related to the exchange of aFRR energy between synchronous areas are also included in this chapter.

Chapter 6 explains the proposed governance structure of the platform.

Finally, Annex I: aFRRIF mapping and Annex II: Abbreviations show a cross-reference between the articles of the aFRRIF and this document, and a list of abbreviations, and Annex III: Illustrative example of options for counter activation to **Error! Reference source not found.** provide illustrative examples of counter activations cases.

2 EBGL and the scope of the aFRRIF

The main purpose of the EBGL is the integration of balancing markets to enhance the efficiency of the European balancing processes. The integration should be done in a way that avoids undue market distortion. In other words, it is important to focus on establishing a level playing field. This requires a certain level of harmonisation in both technical requirements and market rules. To provide this level of harmonisation, the EBGL sets out certain requirements for the integration of the aFRR markets. Figure 1 gives an overview of the requirements of the EBGL, their interconnection with each other and their interconnections with topics out of scope of the EBGL.

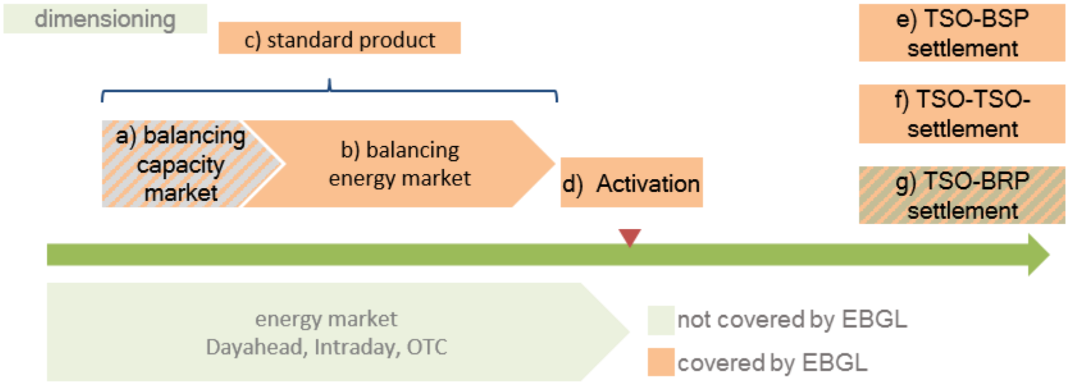

Figure 1: Scope of the EBGL

Dimensioning for aFRR is a local responsibility in accordance with Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (SOGL). Each TSO determines the amount of aFRR to be procured in accordance with their dimensioning and organises its balancing capacity market accordingly. TSOs will be using standard products and, where necessary, specific products to fulfil their dimensioning requirements. The integration of balancing capacity markets is not required by the EBGL and is not in the scope of the aFRRIF or the PICASSO project.

Instead, the focus is on the integration of balancing energy markets for aFRR in accordance with Article 21 of the EBGL through the exchange of standard balancing energy products. The integration of the balancing energy markets is proposed in line with a multilateral TSO-TSO model as shown in Figure 2. To their connecting TSO, BSPs can submit balancing energy bids or update the balancing energy price of their bids until the balancing energy gate closure time for the standard aFRR balancing energy product bids (BEGCT), as defined in the aFRRIF under Article 8. These standard product bids are then forwarded to the platform until the TSO energy bid submission gate closure time for the standard aFRR balancing energy product bids (TSO GCT), as defined in the aFRRIF under Article 9, where they are merged onto a common merit order list (CMOL) for activation by all TSOs through a common activation optimisation function (AOF).

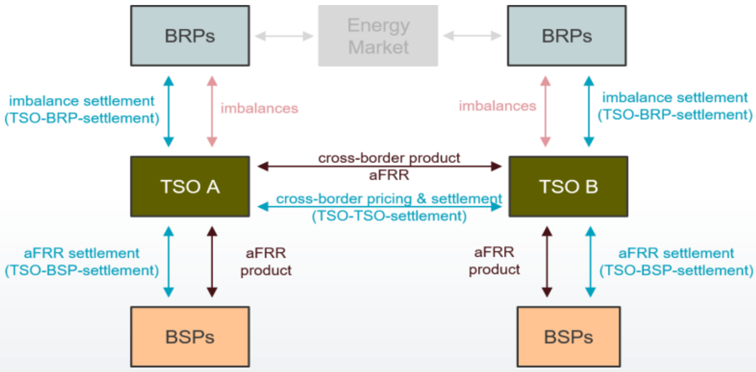

Figure 2: Scheme of TSO-TSO model

Article 21(3) of the EBGL lists a number of points to be included in the aFRRIF for definition of the European market for exchange of standard products for aFRR and the platform. Information on the proposal for these points can be found in the chapters listed hereunder.

- Roadmap and timeline for implementation (chapter 3.2)
- Definition of standard products (chapter 4.1)
- Framework for further harmonisation (chapter 4.3)
- Definition of BEGCT and TSO GCT (chapter 4.2)
- High level design of the platform (chapter 5.1)
- Description of the functions of the platform (chapter 5.1)
- Description of the CMOLs and the AOF algorithm (chapter 5.4)
- Rules for governance, designation of entities, and cost sharing principles (chapter 6)

The platform will ensure information is available for purposes of publication and reporting in accordance with Article 12 of the EBGL. Publication is not further discussed in this document.

Settlement principles are out of scope of the aFRRIF as they are part of the proposals in accordance with Articles 30, 50, and 52 of the EBGL for respectively TSO-BSP, TSO-TSO and TSO-BRP settlement.

Congestion management and determination of cross-zonal capacity, including determination of aFRR cross-border capacity limits relating to the aFRRIF and the platform is described in chapter 5.7.

The designation of activation purposes in accordance with Article 29(3) is out of scope of the aFRRIF, although it can be confirmed that as far as aFRR is concerned there is no intention to use bids for purposes other than balancing.

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3 Roadmap and timeline for implementation

The EBGL sets ambitious goals for the integration of the European balancing energy markets. Article 21(6) requires that all TSOs performing the automatic frequency restoration process (aFRP) are connected to the aFRR-Platform no later than 30 months after the approval of the aFRRIF. This applies for all TSOs of the synchronous areas CE and Nordic, but not currently for the TSOs of the synchronous areas IE/NI, GB and Baltic.

In order to reach the goals of the EBGL and to be able to implement the European aFRR-Platform and for each TSO to connect in time, all TSOs have designated PICASSO to be the implementation project that shall become the aFRR-Platform. This chapter describes the relationship between all TSOs and PICASSO in delivering the aFRRIF and the aFRR-Platform. It also illustrates the timeline for implementation and accession as referred to in the aFRRIF Article 5.

3.1 PICASSO

The establishment of the aFRR-Platform is organised via the implementation project PICASSO, where technical details, common governance principles, and business processes are developed by the TSOs involved.

More information on the background of PICASSO can be found in the PICASSO consultation document of 21 November 2017. At the beginning of December 2018, the PICASSO project consist of twenty two members TSOs, as well as four observers. Figure 3 gives an overview of the current members and observers of the PICASSO project.

Figure 3: Overview of members and observers as of 18.12.2018

All TSOs have developed the proposal for the aFRRIF through ENTSO-E and in close coordination with the PICASSO project. Analysis and discussions within the PICASSO project as well as stakeholders' input gathered by the project have served as input to ENTSO-E. Coordination of various topics with relevance for other implementation projects such as TERRE (RR), MARI (mFRR) and IGCC (IN) are coordinated by ENTSO-E via dedicated working groups.

3.2 Implementation schedule (Article 5)

As explained above, both the compilation of the aFRRIF and other proposals in accordance with the EBGL and the implementation of the aFRR-Platform include strong involvement from the PICASSO project. As such, the timelines of the PICASSO project closely follow the timelines for the delivery of the aFRRIF as well as the timelines for implementation of the platform. The complete timeline, with tentative dates, is briefly presented in Figure 4. It also describes the steps required to achieve the timeline, as well as the interaction between the aFRR-Platform and the imbalance netting platform (IN-Platform).

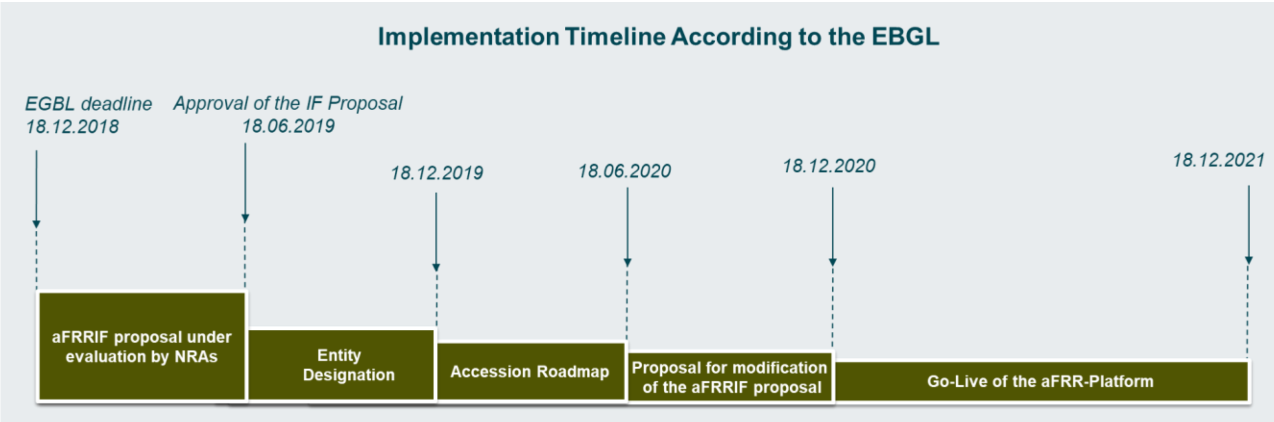

Figure 4: High-level implementation of the aFRR-platform according to the EBGL

High-level implementation timeline

The timeline for implementation is mostly laid out by the requirements in Article 21 (4), (5) and (6) of the EBGL. These indicate that full operation of the platform is expected 30 months after the approval of the aFRRIF. In order to achieve this target six months after the approval of the aFRRIF the entity or entities that will operate the platform shall be designated.

As experiences during implementation of the aFRR-Platform may necessitate change, the EBGL allows for the possibility of a scheduled proposal for modification of the aFRR-Platform.

In case approval of the aFRRIF is given without a request for amendments by NRAs and without escalation to Agency for the Cooperation of Energy Regulators (ACER), this approval is due 6 months after the delivery of the aFRRIF to NRAs. The whole timeline then runs until December 2021, by which time the current project planning aims to have the aFRR-Platform operational and all member TSOs using the platform.

Roadmap

In a first step the entities, which will operate the business functions are designated. The designation considers aspects of the IT implementation and is done in close coordination with the other balancing platforms.

Aside from designating the entities which will operate the business functions of the platform, ensuring that the obligations in regards to the timeline are met requires several steps:

- Establishment of the platform

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- National changes to:
  - market design
  - legislation
  - systems
- Accession to the platform

For these steps to be finalised, the dedication of all TSOs is required. For this reason the aFRRIF requires TSOs to make changes to their national terms and conditions for balancing, and commits TSOs to the necessary adjustments of processes.

Aside from this commitment, an accession roadmap is necessary. It will not be possible to connect all TSOs at the same time, and some time will be required for interoperability and operational testing. Currently, the most feasible way forward is to have an accession process whereby groups of TSOs connect to the platform at the same time, with the last group connection completed ahead of December 2021.

A detailed accession roadmap will be developed within 3 months of the approval of the aFRRIF. This roadmap will be reviewed at least annually and take into account the time required for national changes as well as the required testing and end when the aFRR-Platform must be used by all TSOs using aFRR, at the latest.

All TSOs shall foresee a possibility of early regional operation of the aFRR-Platform in line with national legislation. Early regional co-operations, exchanging balancing energy from aFRR, shall be superseded by the aFRR-Platform in accordance with the deadline of Article 21(6) of the EBGL requiring that all TSOs using aFRR shall use the aFRR-Platform. Early regional co-operations can remain in operation as long as the aFRR-Platform is not in operation.

Interaction between the aFRR-Platform and the IN-Platform

The consistent usage of available cross-border capacity for the IN-Platform and the aFRR-Platform at the same time has to be ensured. A calculation of both processes in one activation optimisation function guarantees this necessary consistency. TSOs foresee including both (IN and aFRR) processes in the AOF of the aFRR-Platform. For more information see chapter 5.4.

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4 Harmonising the European aFRR market

When integrating European balancing energy markets, it is important to pay special attention to the level playing field for participants in those markets. Establishing a level playing field requires a certain level of harmonisation of both technical requirements and market rules. To provide this level of harmonisation, the EBGL sets out certain requirements. Some forms of harmonisation are a direct result of the EBGL requirements, such as the requirement for the platform to utilise merit order activation. Others will follow from the settlement proposals in accordance with Article 30 and 52.

This chapter describes those aspects of the aFRRIF that explicitly lead to additional harmonisation among different countries involved in the exchange of aFRR for balancing energy. Specifically, it describes the following aspects of harmonisation, as required by Articles 21(3) (f), (h), (i) and (j) of the EBGL:

- Definition of standard product (chapter 4.1)
- Definition of BEGCT and TSO GCT (chapter 4.2)
- Framework for further harmonisation (chapter 4.3)

4.1 Standard product (Article 7)

The EBGL sets up certain requirements for standard products in Article 25(4) and Article 25(5). Article 25(4) sets out the technical parameters:

> *The list of standard products for balancing energy and balancing capacity may set out at least the following characteristics of a standard product bid:*
>
> *(a) preparation period;*
>
> *(b) ramping period;*
>
> *(c) full activation time;*
>
> *(d) minimum and maximum quantity;*
>
> *(e) deactivation period;*
>
> *(f) minimum and maximum duration of delivery period;*
>
> *(g) validity period;*
>
> (h) *mode of activation.*

The harmonisation of the above mentioned parameters is optional. Due to the heterogeneous generation structure within Europe and the resulting differences in the existing aFRR market, TSOs foresee a progressive harmonisation, with only the essential concepts being harmonised before the launch of the platform. It is deemed necessary to harmonise the minimum bid size, bid granularity and validity period from the start of the platform and set a fixed date for the harmonisation of the full activation time.

The full activation time can be divided into a preparation period (during which no energy is delivered) and a ramping period. The requirements for the preparation period vary across Europe as it depends on the mode of activation in use (see chapter 4.1.4) and the local generation structure. Nevertheless, for aFRR the preparation time remains very short as aFRR delivery is an automatic process. TSOs consider that specifying a harmonised full activation time will provide enough quality guarantee of the aFRR product, while the detailed requirements for the preparation period can remain at the national level.

Regarding the deactivation period, TSOs consider that the duration of the full activation time is also relevant for deactivation.

The following sub-chapters lay out the foreseen harmonisation of full activation (and deactivation) time, bid sizing and validity period.

4.1.1 Full Activation Time (FAT) and Deactivation

The FAT defines the maximum allowed duration for the full activation or deactivation of a standard aFRR energy bid after the activation request. The compliancy of each BSP with the FAT requirement is checked during the prequalification process and is later translated into local monitoring rules. In case of activation or deactivation of a bid, the BSP has to deliver the requested volume at latest within the FAT to be compliant.

Currently, the aFRR FAT requirements of the European countries cover a wide range from 2 to 15 minutes and reflect the local generation structures and requirements. In the process of creating common European markets for balancing energy, these requirements must be harmonized to create a full level playing field for BSPs and ensure a comparable activation of aFRR in case of imbalances, regardless of the structure of the Common Merit Order List. For the selection of a future harmonized FAT value and a harmonization roadmap, the following main aspects have been considered:

- The activation speed of balancing products has a direct impact on the resulting frequency restoration control error (FRCE) of individual LFC blocks and areas and the quality of the system frequency of a whole synchronous area. Hence, the maximum FAT has to be short enough to fulfil the FRCE and frequency quality target parameters required by SOGL Articles 127 and 128.
- The FAT has to be long enough to ensure the availability of the required capacities on the local capacity markets and facilitate liquid markets for aFRR capacity and energy.

From previous ENTSO-E discussions, the number of feasible candidates for FAT was limited to two: 5 and 7.5 minutes. These two candidates have been qualitatively and quantitatively assessed in detail, considering the abovementioned aspects of frequency quality and impact on capacity procurement.

4.1.1.1 Technical assessment

In order to qualitatively assess the impact of the aFRR FAT on the FRCE quality, TSOs simulated the aFRR activation process for the LFC blocks of Austria, Belgium, France, Germany and the Netherlands with different assumptions for the FAT. The resulting FRCE quality has been compared with the target parameters defined in the SOGL.

Since these LFC blocks constitute a large part of the interconnected network of Continental Europe (CE) and their generation structures reflect the heterogeneous generation in CE, the impact of the FAT on the combined FRCE of these LFC blocks is also a proxy for the impact on the CE system frequency. In this spirit, the impact of the FAT of these five LFC blocks on the CE frequency quality has also been simulated and compared to the frequency quality targets defined in the SOGL.

The simulations have been performed on the basis of historical aFRR demands, available aFRR and energy exchanges due to imbalance netting of one complete year (April 2016 – March 2017). For the simulation, merit order activation has been assumed for all LFC blocks, since this activation scheme is a requirement from the EBGL. Moreover, it was assumed that the BSPs will react according to the FAT requirement. The sensitivity of the major results to the increase of the available aFRR band and to the change of controller settings has also been analysed.

The main results of the assessment are:

- Under the given assumptions, at least one LFC block does not comply with the FRCE target parameter laid out by the level 2 FRCE range according to SOGL Article 128 when choosing a FAT of 7.5 minutes.
- The global FRCE quality of the assessed LFC blocks (Figure 5) and hence frequency quality would be better than the historical quality when choosing a FAT of 5 min and worse when choosing a FAT

of 7.5 min. This result is however strongly sensitive to the degree to which BSPs react faster than required by the FAT and the simulations cover the worst-case scenario in this manner.

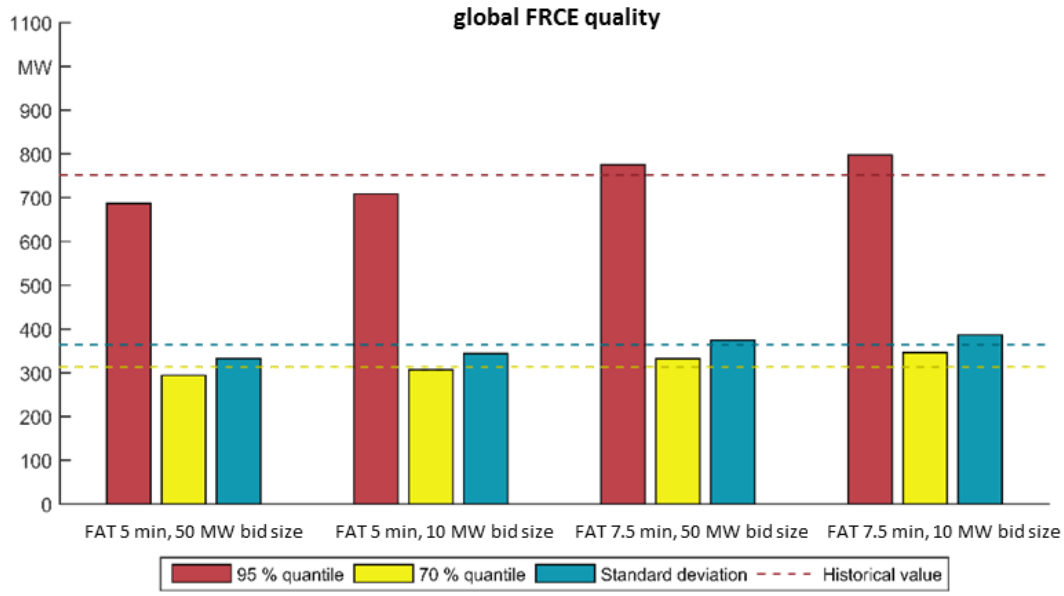

Figure 5: Simulation results for the global FRCE quality

- The frequency quality target according to table 2 in the Annex III of the SOGL of a maximum number of 15 000 minutes outside the standard frequency range of Continental Europe will be fulfilled with a FAT of 5 min but will not be fulfilled with a FAT of 7.5 min (see Figure 6).

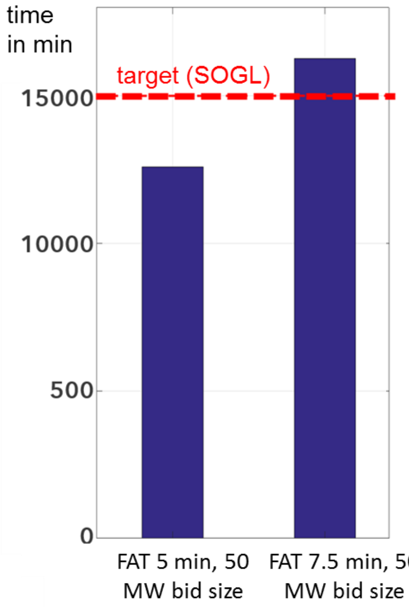

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Figure 6: Simulated yearly minutes outside the standard frequency range of Continental Europe

- The increase of the available aFRR band, which could be achieved by an increased procurement of reserves or the availability of free bids, cannot compensate the impact of a slow FAT on the fulfilment of the frequency and FRCE quality targets. Particularly in LFC blocks with very volatile imbalances and frequent sign changes of the aFRR demand, an increased procured capacity does not increase the FRCE quality in case of a FAT of 7.5 min.

4.1.1.2 Economic assessment

In addition to the technical assessment, some TSOs (Elia and RTE) performed an economic assessment based on the current prequalification requirements to identify the impact of a FAT reduction on the volume of offered aFRR capacity bids and their impact on aFRR capacity procurement cost in their LFC areas. This assessment aims to be generic and relatively easy to be applied by each TSO. Therefore, assumptions with a certain degree of simplifications were identified. All TSOs consider these assumptions as valid for a change of FAT in a range between 5 and 15 minutes.

- In case FAT is decreased compared to a TSO’s current local standard, the aFRR capacity offered by thermal units (Combined Cycle Gas Turbine (CCGT), coal fired, nuclear) connected on this TSO’s grid is reduced linearly with the FAT decrease.
- A FAT change has no impact on offered aFRR capacity for non-thermal units (PV, demand side management, hydro, wind, batteries)
- Relative price effect due to expected setpoint changes of units and corresponding increase of opportunity costs, in particular when units are facing a must-run situation.
- Impact of setpoint changes on efficiency and corresponding impact on costs is neglected
- Any new providers and/or changes in bidding behaviour due to the potentially increased prices are neglected

The table below summarises the main characteristics of the French and Belgian aFRR market:

	Belgium (Elia)	**France (RTE)**
Current FAT	7.5 minutes	6.7 minutes (400 seconds)
Dimensioned aFRR volume	≈ 140 MW	[500 MW – 1200 MW] (dynamic band) (≈ 660 MW on average)
Type of aFRR providers	Gas units (CCGT)	Nuclear, coal, gas, demand side, hydro

Table 1: French and Belgian aFRR markets

In order to estimate the impact of a FAT reduction to 5 minutes on available aFRR volumes and procurement costs, the two TSOs used two different approaches:

- RTE used a cost-based approach: the impact is estimated based on individual characteristics of the different aFRR providing technologies (available volumes, availabilities of production units, etc.) and assumptions on fuel costs.
- Elia used a market-based approach: based on historical records of aFRR bids, the volume and price effects caused by the FAT reduction are estimated. Besides this, a simplified cost-based assessment and a sensitivity analysis of the results on the clean spark spread were also performed.

From its analysis, RTE estimates that a FAT reduction from 6.7 minutes to 5 minutes would cause an aFRR procurement cost increase of approximately 26 Mio. € per year (+54 %). This increase is mainly caused by the fact that the reduction of aFRR capacity offered by coal and gas power plants forces to reserve more aFRR on nuclear units. Since the opportunity cost is much higher on nuclear, aFRR capacity procurement cost increases accordingly.

In the case of Elia, the FAT reduction from 7.5 minutes to 5 minutes would cause an increase of aFRR procurement cost between 8 to 20 Mio. € per year (between +20 % and +50 %). This increase is mainly caused by the fact that the reduction of aFRR capacity offered by gas units forces to reserve aFRR on a broader and/or less optimal set of production units; this leads to big increase of must-run costs for aFRR capacity procurement. As a consequence, this result is highly sensitive to the clean spark spread evolution. In the case of Belgium, liquidity issues were detected for 5 weeks out of the studied year.

It is interesting to note that despite the root cause of the cost increase being the same (FAT reduction), the mechanics behind it are very different: in France, the cost increase is driven by an increase of average opportunity cost for aFRR (more aFRR has to be reserved on units that would like to produce at full power), while in Belgium, it is driven by an increase of must-run costs (more / less optimal units have to be put in service in order to offer the required aFRR). PICASSO TSOs considered that this assessment was sufficiently diverse and representative enough of what could happen to "slower" TSOs if FAT of 5 minutes was chosen. Therefore, a detailed assessment was not performed for each participating country.

4.1.1.3 Considered options

When the results of the technical and economic assessments are brought together, it can be concluded that both FAT options have unacceptable impacts for some TSOs. This statement is globally confirmed by the stakeholders' consultation:

- On the one hand, many BSPs already displaying a FAT of 5 minutes (or even less) strongly emphasise their wish to keep a 5 min FAT, arguing that a longer FAT would be an issue for ensuring a level playing field and / or would reduce the differences in ramping requirements between aFRR and mFRR products by too much.
- On the other hand, some BSPs displaying a longer FAT confirmed that the FAT reduction to 5 minutes would have a significant impact on the volumes that they could bid on the aFRR capacity market.

Facing this scenario, TSOs investigated multiple options, which are not limited to plain values of the FAT but also include combinations with measures to mitigate the technical or economic shortcomings that might result for some TSOs. These measures include the use of specific products according to Article 26 of the EBGL for a limited timeframe after the start of the platform. Additionally, different combinations of the FAT and the maximal cross-border ramping period have been analysed. The maximal cross-border ramping period is used by the FRCE Adjustment Process (FAP) for the division of the responsibility for the FRCE resulting from slow aFRR activation between the exporting and the importing TSO (see chapter 5.6). TSOs only studied mitigation measures which could be taken in the scope of the project, excluding for example the introduction of new balancing products, ramping restrictions for generators and other measures specifically targeting deterministic frequency deviations (DFDs).

The following options have been considered:

Option 1: aFRR standard product FAT of 5 minutes, local specific products with longer FAT

With this option, the FAT of aFRR standard products and the maximum cross-border ramping period are equally set to 5 minutes. If the liquidity on a local market for aFRR capacity is not sufficient, TSOs have the choice to procure additional capacity using specific products with a longer FAT. However, these specific products are only used locally: they are not forwarded to the common merit order list (CMOL). As shown on Figure 7 and Figure 8, this can be done in two different ways, depending on whether the conversion of specific aFRR bids with longer FAT into standard aFRR bids is performed or not. This conversion can be done by asking BSPs to communicate which part of the volume of each specific bid can be delivered within the harmonized FAT. The rest of the volume of the bid can be activated only if the standard part is already fully activated.

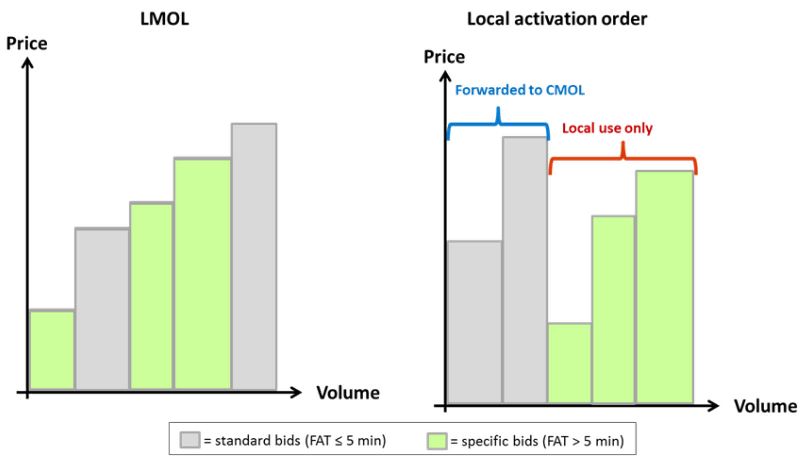

Figure 7: Local implementation of option 1, without conversion of specific products

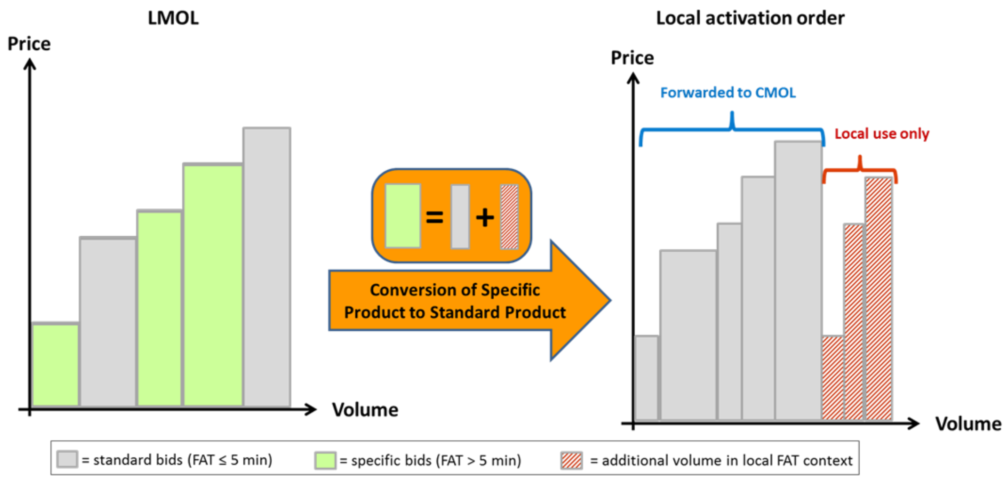

Figure 8: Local implementation of option 1, with conversion of specific products

Each LFC area needs to keep a single controller to activate all aFRR bids, regardless of whether they are standard or specific. Since the activation of slower specific bids for cross-border exchange is not foreseen in this option, specific bids or additional volumes of specific bids therefore need to be placed at the end of the local merit order in order to avoid undue activation by the AOF. Hence, the local activation order has to differ from the local price ranking of bids, which leads to local economic inefficiencies during activation. A possible consequence of these inefficiencies could be an increase of capacity price of specific products: because they are placed at the end of the LMOL, specific products will be activated less often; therefore, BSPs might want to increase their aFRR capacity prices in order to compensate a lack of revenue on the aFRR energy market.

The conversion of specific products allows to increase the total volume that is forwarded to the CMOL, increasing the liquidity on the common aFRR energy market and reducing the local economic inefficiencies described above. However, this comes at the expense of a major complexity increase for local implementation, especially for TSOs currently sending an aggregated activation signal per BSP. Indeed, in this sub option, separate targets for standard and specific volumes need to be communicated to each BSP.

In any case, all specific products should be defined in local terms and conditions and should only be used for an intermediate timeframe until local capacity markets have evolved and provide more liquidity.

To summarise, this first option for all TSOs guarantees a good FRCE quality and mitigate the impact on the procurement costs, but show some serious drawbacks for slower TSOs: use of specific products, local economic inefficiencies, major implementation changes, and uncertain benefits in terms of capacity procurement costs.

Option 2: aFRR standard product FAT of 5 minutes, specific products allowed in CMOL

As in option 1, the FAT of aFRR standard products and the maximal cross-border ramping period are equally set to 5 minutes. If specific products with longer FAT are locally required, the specific bids are also forwarded to the CMOL and are thus also activated in a cross-border context. However, the total volume of non-standard bids that each TSO can forward to the CMOL is limited to the dimensioned volume. In this case, this option does not affect the level playing field on the energy market, since energy pricing depends on marginal costs and is therefore independent of the FAT.

With this approach, the adjusted FRCE quality of exporting TSOs with specific bids at the beginning of the CMOL will be impacted. This effect incentives TSOs to minimize their amount of procured specific bids and foster the development of local markets for fast reserves. The resulting frequency quality depends on the share of specific bids in the CMOL but is generally worse than with option 1. The implementation effort is lower than with option 1, as no local separation between standard and specific products in the real-time processes is necessary.

The option presents the drawback of an inconsistency of the cross-border ramping period and local FAT requirements in markets that use specific products.

Option 3: aFRR standard product FAT of 7.5 min, shorter cross-border ramping period

With this option, the FAT of aFRR standard products is set to 7.5 minutes. However, the maximum cross-border ramping period is set to a shorter value (e.g. 5 minutes). This means that connecting TSOs of BSPs with a FAT longer than the cross-border ramping period are considered as responsible for this slow reaction and the resulting FRCE. Therefore, they are incentivized to influence the BSPs in their LFC area(s) to react faster (e.g. by implementing incentives for a faster reaction in the local TSO-BSP settlement scheme).

Regarding the short-term effects, option 3 is comparable to option 2. In the long-term however, option 3 strives to achieve fast reaction through sustainable incentives while option 2 is based on more stringent FAT requirements. However, this incentive is strongly depending on the structure of the CMOL. With option 3, connecting TSOs of slow BSPs with low generation costs would have to bear a high risk of an increasing FRCE.

Option 4: aFRR standard product of 7.5 min, equal cross-border ramping period

As in option 3, the FAT of aFRR standard product is set to 7.5 minutes. However, the cross-border ramping period is equally set to 7.5 minutes. Since a faster effective reaction of the BSPs than 7.5 minutes is most probably needed in the long term to fulfil all frequency and FRCE quality requirements, local incentives for a faster reaction will have to be implemented with this option. The fulfilment of the frequency and FRCE targets depends on the effectiveness of these incentives. However, the incentives cannot be harmonized without harmonization of the TSO-BSP settlement including the determination of the settled volume. Thus, it cannot be guaranteed that these incentives are equally strong in all participating LFC blocks.

Option 5: Intermediate value of FAT between 5 minutes and 7.5 minutes

From previous ENTSO-E discussions, the number of feasible candidates for FAT was limited to 5 and 7.5 minutes, as such TSOs focused their assessments on these two options. An intermediate value would be possible, but the result of the assessments provided no indication that an intermediate value would provide a more optimal solution considering the technical and economic aspects and would thus just be an arbitrary choice. An intermediate value would not solve the technical or economic shortcomings of the two values that have been assessed in detail. Therefore, none of the TSOs favoured to select an intermediate value.

Option 6: CMOL filtering based on ramp rate

Respecting ramping speeds in the process of bid selection (filtering the CMOL in real-time according to the current ramp rates of BSPs) could lead to a faster effective activation of aFRR without stringent FAT requirements. This approach could in theory allow to fulfil the FRCE and frequency quality targets with a FAT of 7.5 minutes. A similar approach is currently applied in Hungary. However, due to incompatibilities with the concept for the interaction between controller and optimizer (control concept) and with the optimisation algorithm, this model cannot be implemented in a cross-border context with distributed activation of BSP.

Following the control demand model (see chapter 5.1.3.1), the aFRR optimisation according to the CMOL is performed on the central platform while the LFC and activation logic including any ramping of output signals remains on the local TSO side. The central platform does not technically interfere with the individual control loops of each TSO but translates the imbalances into real-time energy exchange schedules between the LFC areas.

This separation has multiple advantages:

- The stability of the process is independent of the BSP behaviour and imperfections or possible errors in the IT-process and can be proven mathematically
- The concept does not affect the performance of the individual control loops
- The concept allows to tune the settings of each LFC to the dynamic behaviour of the local BSPs and thus allows to efficiently combine BSPs with different dynamic behaviour (e.g. pumped storage plants and gas fired plants) in a common market

The detailed rationale for selecting the control demand model is provided in chapter 5.1.3.5.

With the control demand model it is however not possible to synchronize the processes of aFRR optimisation (based on the CMOL) and the local BSP activation (based on the local MOL) when using dynamic constraints.

This is illustrated with an example shown in Figure 9. In this example, bid 1 covers 80 MW but only 50 MW can be activated within 5 min. In a case of a stepwise demand of 100 MW, the AOF determines that 50 MW of both bids must be activated simultaneously in order to fully compensate the imbalance within 5 minutes. The local activation of bids is however not based on the aFRR demand but on the control target (P_{Target}), which is the output of the local LFC (with proportional-integral dynamic behaviour). The integral term of the controller leads to a delay of the control target. Due to this delay, parts of bid 1 are already activated when control target reaches the 50 MW threshold and a larger share of the total volume of bid 1 is “unlocked”. Therefore, a larger share of bid 1 and a smaller share of bid 2 is activated than foreseen by the AOF

MOL

	Volume	Volume avail. within 5 min	Price
Bid 1	80 MW	50 MW	10 €/MWh
Bid 2	50 MW	50 MW	20 €/MWh

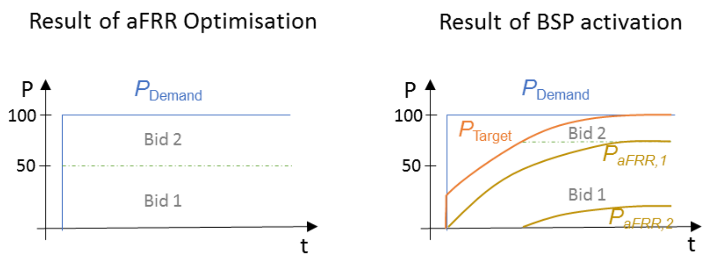

Figure 9: Example of MOL deviations due to dynamic constraints

This type of CMOL deviations can only be prevented by some kind of real-time synchronization between the AOF and the local activation logic. However, any real-time synchronization of both processes would undermine the separation between the AOF and the feedback LFCs, which is the key to the stability of the process. Hence, the implementation is not only an IT problem but is generally incompatible with the planned control concept.

This issue could only be solved by a complete change of the control concept e.g. towards the "control request" concept which is not practically proven and is much more complex with regards to the stability of the process. Changing the control concept would also massively increase the implementation effort and costs because it requires the harmonization of all controllers. See also Chapter 5.1.1 for more elaboration on the reason of the choice of the control demand model.

At the same time, the consideration of ramp rates in the AOF adds additional constraints to the optimisation. Respecting these constraints while at the same time satisfying all demands leads to an optimisation problem that can only be solved by deviating from the CMOL (additional bids are selected to respect the ramp rate constraints).

As an example, let us assume that bid 1 of the MOL in Figure 9 is completely activated in LFC area A for an imbalance in LFC area B. Now, the imbalance completely disappears. Normally, the optimizer would correct the demands so that the bid is fully deactivated, however, only 50 MW of the bid can be deactivated within 5 minutes and the optimizer has no access to the remaining 30 MW of the bid. In order to maintain the system balance, the optimizer will activate downward aFRR of 30 MW, leading to counteracting aFRR bids. This negative aFRR is activated regardless of its price, as the AOF is trying to avoid to increase the FRCE.

The physical impact depends on the location of these downward bids. If they are located in the same LFC area than the upward bids, they will not be activated and the intended ramp rate will not be achieved, leading to an increasing FRCE. If they are located in another LFC area, there will be counteracting aFRR bids in violation of the principles stated in chapter 5.4.

Option 7: Two aFRR standard products in CMOL, selective activation

Two standard products with different FAT (e.g. 5 minutes and 7.5 minutes) are procured; the bids of both products are forwarded to the CMOL. However, TSOs can chose to cover their demand only with fast bids if they require a fast reaction to fulfil the FRCE quality targets. The AOF selects the bids that are activated for each TSO accordingly.

This option implies a vast complexity increase it would cause at AOF level (algorithm), for the communication between AOF and local LFC (AOF should specify how to split the control target between fast and slow products), and for local activation and calculation of the setpoint towards BSPs (each BSP would need to know how much volume of "slow" bids and "fast" bids he needs to activate). Additionally, this option leads to a market split and thus has detrimental effects on the liquidity on the aFRR energy markets.

Selected option

After careful consideration of all abovementioned options in the light of the technical and economic assessments, the TSOs came to the conclusion that a compromise solution is necessary. They acknowledged that due to the FRCE and frequency quality requirements, a FAT of 5 minutes is the superior long term option, because of its advantages in terms of system response. By this, they take into account that:

- The frequency quality targets for Continental Europe are currently already hard to fulfil with an average FAT of 6.5 minutes and a majority of LFC blocks using pro-rata activation. The changes on the aFRR market will render these requirements even more challenging. Additionally, the frequency quality in Continental Europe has been decreasing during the recent years and the future development is subject to major uncertainties (more volatile generation due to development of markets and generation structure, reducing system inertia). Stringent FAT requirement are needed to fulfil these requirements in the future.
- European balancing markets are currently evolving and many new BSPs are entering the market (renewables, batteries, power to heat, demand response). For most of these technologies, the FAT is not the factor that limits the capacity they can offer on the aFRR market. Shorter FAT requirements

help to utilize the flexibility of these units for the improvement of the system response and thus for the fulfilment of the FRCE and frequency quality targets.

- The European aFRR-Platform will also include the smaller Nordic synchronous area, which currently has effective FAT values of 2 to 3 minutes. A FAT of 7.5 minutes would significantly impact the Nordic system frequency. The Nordic TSOs indicated that extensive mitigation measures (e.g. local specific products) would be necessary in such a case, which would undermine the concept of a common European aFRR market.

However, it was also clear that the move to a FAT of 5 minutes could not be overtaken too quickly, because time is needed in countries with longer FAT to develop a faster, broader local aFRR market in order to avoid (or at least largely mitigate) cost increase of aFRR capacity. The aFRR capacity lost on the thermal units by the reduction of the FAT is indeed expected to be compensated by new non-thermal units. Once the aFRR-Platform becomes operational, the market integration and the merit order activation will be incentives to install non-thermal for the aFRR market, process for which a duration of 4 years is considered to be reasonable.

Therefore, the best option that all TSOs could agree on was a stepwise approach:

- No harmonization of FAT at go-live of the platform until 17 December 2025: in this first step, each BSP has to comply with the FAT requirements of its connecting TSO, and all standard aFRR bids will be merged in the same CMOL regardless of their FAT. The FRCE adjustment process will have a maximum cross-border ramping period of 7.5 minutes. This creates an incentive for TSOs that currently have a longer FAT to foster a fast reaction of their local BSPs.

- As of 18 December 2025 the FAT is to be set at 5 minutes and as a result the FRCE adjustment process will have a maximum ramping period of 5 minutes also starting from 18 December 2025.

With this solution, the FAT will remain a local choice until 17 of December 2025. It is expected, that TSOs with a FAT of 5 minutes or less will not increase their local FAT beyond 5 minutes in this phase, therefore a significant deterioration of the FRCE and system frequency quality is not expected. Even though a full harmonization of the markets is not given in this transitory phase, a major distortion of the level playing field is not expected as TSOs will already have to start the transformation of the local aFRR markets and BSPs will have to develop their portfolios in the light of the full harmonization of the FAT.

Besides, following additional advantages for harmonizing the FAT in 2025 have also been identified:

- The TSO's joining the platform in 2023 will still have 2 years ahead to comply with the harmonized FAT.

- The need for developments of specific products will be reduced, however the use of specific products locally can be defined in local terms and conditions.

In the consultation, stakeholders have expressed different views on the proposal. Many stakeholders were requesting immediate harmonisation, but the values towards which they were willing to harmonise were different (and mostly in line with the current value they have to comply with). No better compromise than the one described here above has been identified, hence TSOs favour keeping this stepwise approach.

4.1.2 Bid size and granularity

The current bid sizing of TSOs is relatively similar. The minimum bid size, which defines the minimum size of the energy bid volume offered, ranges between 1 and 5 MW. The minimum bid size affects the number of bids in the CMOL and therefore has an IT and administrative impact. On the other hand, the minimum bid size impacts the barriers for new market entries. The lower the minimum bid size, the lower the barrier for new market players.

It can be seen from the results of stakeholder consultation that the majority of respondents are in favour of a minimum bid size of between 1 and 5 MW, with a slight preference for 1 MW.

Moreover, no TSO showed any major concerns about a 1 MW minimum bid size, and 1 MW was considered to be a good way to facilitate lower entry barriers and manageable complexity at the AOF level. This point, concerning the manageable complexity at the AOF level, has to be confirmed during or after the IT implementation of the AOF. If TSOs realise that the minimum bid size of 1 MW and the possible significant increase of the total number of bids could significantly slow down the AOF or cause problems in data management, then the minimum bid size might be re-evaluated, for example increased to 5 MW, in line with the amendment process outlined in Article 6 of the EBGL. As the aFRR activation is a real-time process, the runtime of the AOF algorithm should be kept sufficiently short. However, TSOs acknowledge that an increase of the minimum bid size poses an entry barrier to the market and will only consider the increase of the minimum bid size after careful evaluation of technical solutions (e.g. increasing the computing power of the AOF).

As aFRR energy bids are divisible (see chapter 4.1.5), TSOs consider the maximum bid size mostly an IT limitation, which will be set to 9999 MW.

The bid granularity defines the possible increment of offers above the minimum bid size. TSOs apply a bid granularity of 1 MW, in line with the input of most stakeholders and the capability of LFCs of all TSOs.

4.1.3 Validity Period

The validity period defines the amount of time for which a bid is valid and firm. This means that activation requests from the TSO to the BSP can only happen within the validity period. A shorter validity period gives a BSP the opportunity to adapt the price and volume of their bids closer to the boundary conditions given by the market and the fluctuating generation by renewable energy sources.

A validity period of 15 minutes agrees with the current discussion on harmonisation on the following topics: harmonized imbalance settlement period, scheduling periods and the market time unit on intraday market.

On the other hand, a short validity period generally leads to more frequent changes of the CMOL. This sets higher requirements on the technical processes on the sides of TSO and BSP, which will be tackled by highly automated processes for bid processing.

Furthermore, changes to the CMOL between two consecutive bid validity periods lead to up- and down-ramping of aFRR bids and might cause deteriorations in the FRCE and frequency quality in cases where the ramping speeds of activated and deactivated bids do not match. TSOs have assessed this effect on the basis of a sensitivity analysis, taking into account the hypothesis that more frequent CMOL changes also lead to a lower share of replaced bids at the end of each validity period, since changes in the bid placement of BSPs can be distributed over a longer timeframe. The correlation with deterministic imbalances has also been considered in the analysis.

The analysis shows, that a short validity period of 15 minutes does not significantly reduce the FRCE and frequency quality in comparison to a longer validity period of 30 or 60 minutes.

Therefore, TSOs propose a validity period of 15 minutes, in line with expected validity period for mFRR.

4.1.4 Mode of Activation

The mode of activation for aFRR is automatic due to the nature of the aFRR process. This means, that the LFCs automatically send setpoint for activated bids. During the validity period of their offered bids, the setpoint signals sent to BSP can constantly change their values, depending on the aFRR demand.

In Europe two different approaches and their variants are used for the calculation of the setpoint signal which is sent to the BSPs. These two approaches are described below.

Ramping approach

The first approach is based on the limitation of the rate of change of the setpoint sent to the BSPs and it requires the BSP to follow the setpoint in a narrow tolerance band (defined according to national terms and conditions). This is displayed in Figure 10. Ramped setpoint (orange line) is sent to the BSP. The BSP has to follow the sent setpoint in the given tolerance band (yellow area). BSP settlement can take into account the requested energy volume defined by the controller output. TSOs can incentivize the BSP to stay within the tolerance band by applying penalties and additionally by a consistent TSO-BRP settlement.

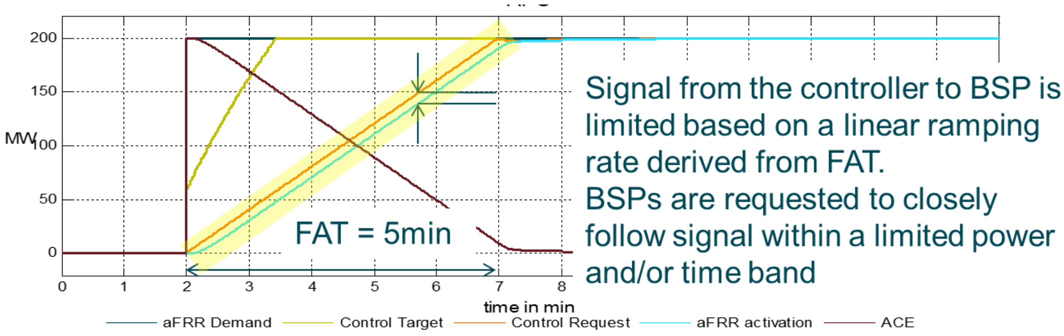

Figure 10: Ramping approach

TSOs applying this approach would give BSPs the opportunity to nominate ramp rates which would exceed the minimum dynamic requirements. Through this BSPs with fast activation would have the opportunity to gain even more in the TSO-BSP settlement thanks to the higher delivered volume.

This approach is mainly applicable for countries with BSPs which can follow ramp rates closely and where the ramp rate is known in advance (e.g. for CCGT).

FAT approach

The second approach does not foresee a limited rate of change for the setpoint sent to the BSP. BSP settlement takes into account the energy volume based on the delivered aFRR. This approach is depicted in Figure 11.

Due to the unramped setpoint BSPs cannot precisely follow the given request and as such the tolerance band may be larger than in the previous approach, depending on the local prequalification requirements. The given TSO-BSP settlement implicitly incentivises BSPs to activate as fast as possible and increase the volume to be settled. Additionally TSOs can incentivise BSPs to deliver the minimum dynamic requirements by applying penalties in the event of „underfulfilment".

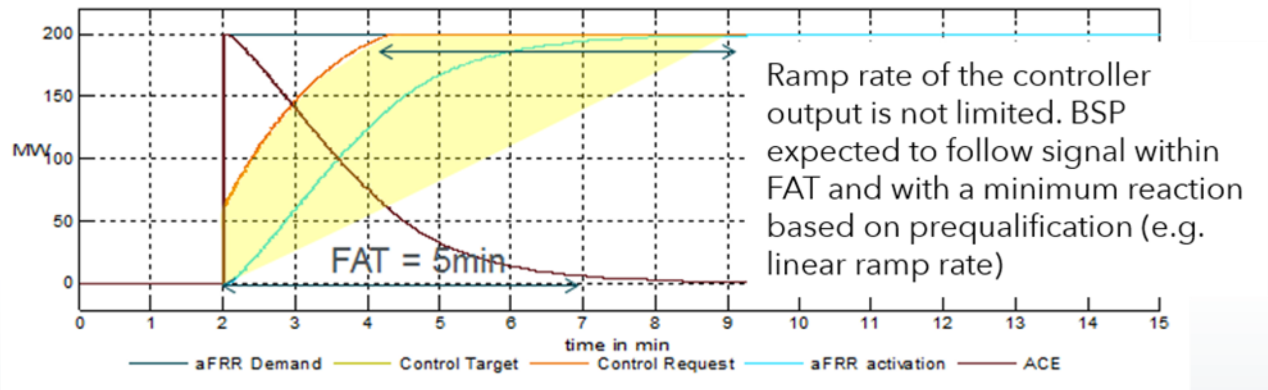

Figure 11: FAT Approach

This approach is mainly used by countries with a high share of BSPs where the ramp rate is not known in advance (e.g. coal mill delay) or where additional costs would apply (e.g. discrete pumps).

However, in practice both approaches should lead to similar results and both allow for the facilitation of the TSO-TSO exchange proposed by TSOs. Both approaches also allow valorising fast flexibility. Moreover, giving the flexibility for each country to keep its historical approach mean that the adaptation of all existing interfaces between TSOs and BSPs, and possibly adaptations of controllers at BSP side, can be avoided. Hence, TSOs have agreed not to harmonise this part of the product characteristic and through this give every TSO the opportunity to apply the appropriate method corresponding to the existing generation structure of its LFC area.

4.1.5 Other characteristics of aFRR energy bids

Article 25(5) of the EBGL, lays down the obligatory parameters for standard products:

> *The list of standard products for balancing energy and balancing capacity shall set out at least the following variable characteristics of a standard product to be determined by the balancing service providers during the prequalification or when submitting the standard product bid:*
>
> *(a) price of the bid;*
>
> *(b) divisibility;*
>
> *(c) location;*
>
> *(d) minimum duration between deactivation period and the following activation*

This sub-chapter will specify the bid related characteristics that are required by the EBGL and how TSOs envision their setup.

According to Article 31 (4) of the EBGL, bid prices should be expressed in the currency of EURO and is linked to the validity period.

Another parameter for the bid definition is 'divisibility', i.e. whether a minimum bid volume constraint during activation applies or not. Due to the nature of the aFRP, energy bids have to be divisible in order to be activated continuously. The activation request can be lower than the minimum quantity and minimum granularity.

The EBGL requires the standard product to specify the location of a bid. TSOs require at least the LFC area to be indicated for each bid; however, a more detailed geographical location might be required locally, e.g. to facilitate the filtering of bids for congestion management. This more detailed location request is also linked with the local choice to allow portfolio bidding or not.

The EBGL requires the standard product definition to specify the minimum duration between the end of a deactivation period and the following activation. TSOs consider a value of zero for this minimum duration feature, as the aFRR product is considered to be continuously available for activation. BSPs with resting constraints should adapt a bidding strategy that takes these constraints into account.

To start by investigating cross-platform communications before the platforms are implemented would be complicated, as this could in turn increase the complexity of the initial implementation. However, as explained in chapter 4.2, there is a collaboration between the PICASSO, MARI and TERRE projects towards finding the best possible sequence of balancing energy gate closure times for the different balancing processes, in order:

1. To consider different bidding approaches (e.g. unit-based or portfolio bidding) and the fact that basically a flexibility can provide either one or different balancing services at the same time;
2. To offer as much as possible the possibility of BSPs submitting their flexibilities on the different balancing platforms, by permitting the TSO to allow BSPs to submit conditional bids locally for a flexibility where its availability to the subsequent balancing process (e.g. aFRR bid) is linked to the

state of activation of a bid for another balancing process (e.g. mFRR process): for example, a BSP could participate in the aFRP if not activated by the mFRR process.

3. To offer, as much as possible, the possibility of the TSO to releasing the bids for the local intraday market according to Article 29 (10) of the EBGL.

This submission of bids (including conditional bids) will be done by BSP themselves in the local TSO-BSP bidding interface before BEGCT. For a conditional bid, the conditions of usage of such a bid shall be declared by the BSP before the BEGCT, according to the national terms and conditions, and shall become firm after the BEGCT, Furthermore, a TSO can have the possibility of updating a bid or flagging the availability status of a bid submitted to the aFRR-Platform, once the local bid conditions become valid; since making the initial submitted bid invalid pursuant to Article 29(9) of the EBGL. No other modifications of bids other than updating or flagging as available or unavailable according to local bid conditions (when applicable) or more generally pursuant to Article 29(9) of the EBGL after the TSO GCT are foreseen by the TSOs.

As an illustration, one BSP who would schedule to provide 10 MW of aFRR, considering one turbine of the hydro power plant would be scheduled in operation. With the same unit the BSP could offer upward mFRR activation starting up a second turbine, leading to additional aFRR volume of 10 MW valid for aFRR-Platform. If activated in mFRR process after the aFRR TSO GCT, then the previously submitted aFRR bid of 10 MW for this unit could be updated with new valid volume of 20 MW, since 10 MW is not valid anymore. The other way around could also apply, by stopping one turbine, leading to unfeasible initial volume in such a case.

Finally, TSOs do not foresee the possibility of handling complex bids directly by the aFRR-Platform, such as linked or exclusive bids; considering such bids in the aFRR optimisation would make solving the optimisation problem within the time needed for the aFRP unfeasible.

4.2 Bidding process and balancing energy gate closure time (Article 8 and 9)

This paragraph explains and justifies the choices that were made for the BEGCT and the TSO GCT. Before the justification itself, an overview of the aFRR bidding process and a definition of the key concepts will be provided. Special care will be taken to show the interactions with the design of the other balancing processes (MARI for mFRR and TERRE for RR) and cross-zonal and local intraday markets.

4.2.1 General overview of bidding process and key definitions

This sub-chapter illustrates the future bidding process flow for aFRR energy between BSPs and TSOs. The timeline is given in Figure 12. The figure shows the main steps of the bidding process for balancing energy and other key moments before the start of a validity period at time t.

For each validity period, there will be:

(a) The balancing energy gate opening time for BSPs (BEGOT): this is the first moment at which BSP can submit energy bids for a specific validity period.

(b) The balancing energy gate closure time for BSPs: this is the point in time after which submission or update of a balancing energy bid is no longer permitted for a specific validity period. This implies that the submitted balancing energy bids become firm from the BSP towards the local connecting TSO for this validity period at the moment of BEGCT. The submission of energy bids is performed via a local TSO-BSP interface. Hence, each TSO will still operate its own platform for collection of bids. For TSOs applying central dispatching model, the BEGCT for aFRR integrated scheduling process bids shall be defined pursuant to Articles 24(5) and 24(6) of the EBGL.

(c) The TSO energy bid submission gate closure time (TSO GCT): this is the point in time when each TSO will have to submit its local merit order list (LMOL, one per direction of activation) containing at the minimum the standard product bids to the aFRR-Platform, which will then collect and merge all the LMOLs to form the two common merit order lists (CMOLs), one per direction of activation.

The resulting CMOLs will contain all bids which are valid for use by the common activation optimisation function (AOF) during the respective validity period. However, each TSO shall have the possibility at all time after the TSO GCT (including within the validity period) of changing the availability status of this bid. A bid can be set as unavailable in accordance with Article 29 (9) of the EBGL. A bid can also be set as unavailable or available accordingly to the national Terms and Conditions that allow, for instance, conditional bidding of one underlying asset to different balancing processes. The communication of the availability status to BSPs will follow the national Terms and Conditions. This sequence is repeated for each validity period.

The time period between BEGCT and TSO GCT will be used by TSO to perform all the required local processes on the bids received at BEGCT (e.g. consistency checks, IT fall-back rules and congestion management needs). Besides the above mentioned bidding related processes, Figure 12 shows two more relevant gate closer times from the ID process. The cross-zonal intra-day gate closure time (cross-zonal ID GCT), marking the point in time when the bid submission for cross-zonal ID closes, is currently determined to be one hour in advance of real time and the BEGCTs for balancing processes need to be shorter than or equal to the cross-zonal ID GCT according to the requirements from Article 24 of the EBGL. Additionally the local intra-day gate closure time (local ID GCT) is shown marking the point in time when the bid submission for local ID closes. Note that the exact value may be different in each country and this local ID GCT is given for illustrative purpose, in order to emphasise the fact that local trades are still possible in some markets after the cross-zonal ID GCT.

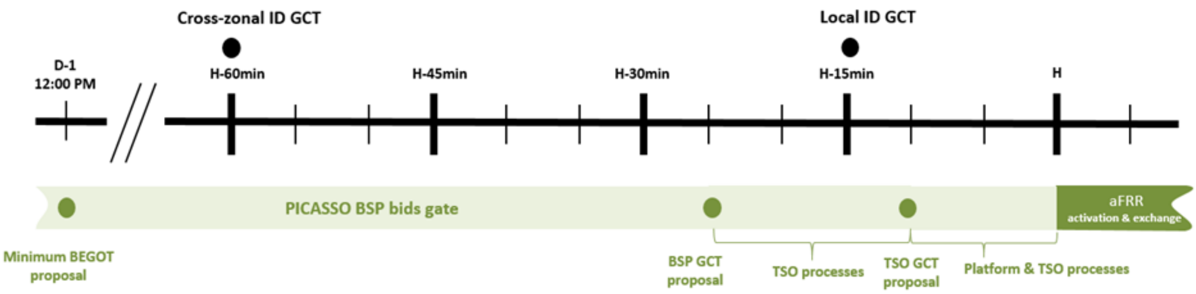

Figure 12: General overview of bidding process

TSO applying a central dispatching model (CDM) uses the integrated scheduling process (ISPr) to manage the system, e.g. balance the system, solve network constraints and procure the ancillary services. The ISPr is a centralized process performed by TSO that allows to determine the unit commitment and dispatch of majority of generating units in the economically efficient way based on the bids submitted by the BSPs (ISPr bids) and taking into account the requirements regarding secure operation of the power system. The ISPr bids are complex bids containing all commercial data and technical parameters related to the individual power generating facilities or demand facilities that are taken into account by ISPr, to ensure full feasibility of the ISPr commitment and dispatch decisions. The ISPr is an iterative process that usually begins a day before the energy delivery time, just after day-ahead market results, and ends in the real time when the final setpoints of the generating and demand facilities are calculated. In order to exchange the balancing energy from RR, mFRR and aFRR with other TSOs on the European balancing platforms, the TSO applying the CDM shall convert as far as possible the ISPr bids into standard products taking into account the operational security, according to Article 27 of the EBGL.

Although the EBGL does not require its definition in the implementation framework, the BEGOT is a parameter that TSOs have to set for each of the balancing energy processes (aFRR, mFRR and RR). The BEGOT means the point in time at which BSPs can start to offer their balancing energy bids to their connecting TSOs.

The offered bids only become firm as of BEGCT. A long duration between the BEGOT and BEGCT could reduce the criticality in the event of business or IT-problems by reducing the need for fall-back solutions during real-time operation. It could also increase bidding flexibility for BSPs by reducing the workload or the frequency of interaction if some BSPs are not able or willing to offer their bids often enough. A long enough BEGOT also provides more time to place aFRR bids.

All TSOs have agreed on BEGOT to be no later than 12:00 PM D-1 CET for all the validity periods of D

For central dispatch countries this BEGOT applies for the integrated scheduling process bids GOT.

4.2.2 BEGCT

The BEGCT marks the last point in time when BSPs can submit their balancing energy bids to the local platform. The EBGL requires a harmonised unique BEGCT for each of the balancing processes (aFRR, mFRR and RR) – which could overlap or differ between those processes. Each local BEGCT for the same balancing process must therefore be at the same point in time across different LFC-areas in order to ensure a level-playing field for BSPs.

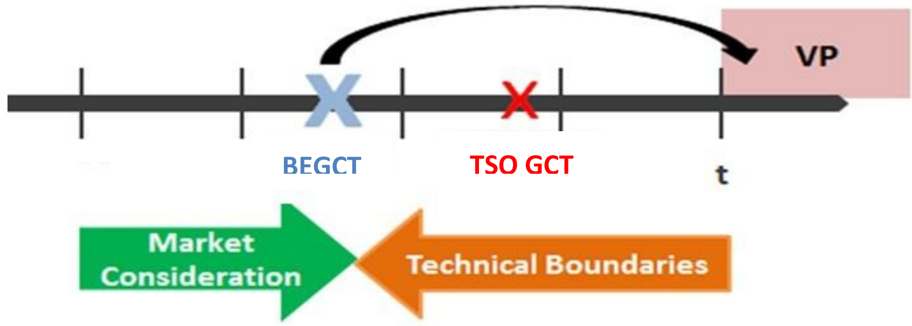

Figure 13: Market considerations vs. technical boundaries

The EBGL states three main requirements for the BEGCT, namely: not to be before the cross-zonal ID GCT as stated in the previous chapter, to be as close as possible to real time and to ensure sufficient time for the necessary balancing processes (at local and platform level). The constraints for the choice of BEGCT can be categorised in two groups: the market considerations and the technical boundaries as illustrated in Figure 13.

First the market considerations translate the wish to offer flexibility among the different balancing processes and between the balancing processes and local ID markets. The timing sequence should allow BSPs to reoffer the bids that have not been activated in previous markets into the next ones as much as possible. Where applicable, this could be feasible between RR and aFRPs and between aFRR and local ID processes in the case of the application of Article 29(10) of the EBGL, if BSPs are able to resubmit bids quickly enough. However, as the point in time of activation for mFRR is close to the start of the validity period (VP), it is not possible to set an aFRR BEGCT that would allow BSPs to reoffer bids which have been released from the mFRR platform. Moreover, bids that are capable of direct activation cannot be reused as they could be activated after the start of the validity period.

The technical boundaries are set by the amount of time used by the platform and the TSOs to perform consistency checks, congestion management analysis, fall back rules or IT communications. These technical boundaries move away the BEGCT from the start of the validity period and further underlines the challenges of setting a sequence that would allow the BSPs to re-offer the flexibility which was offered in mFRR and was not activated.

Given these market and technical considerations, the proposal of setting the BEGCT at 25 minutes before the validity period, except for central dispatch markets, is a trade-off between providing options to re-use flexibility for the RR, FRR and local ID markets and ensuring sufficient time for the necessary technical processes.

According to Article 24(5) of the EBGL, by two years after entry into force of the EBGL TSO applying the CDM shall define at least one ISPr gate closure time which shall: enable balancing service providers to update their integrated scheduling bids as close as possible to real time and be no longer than eight hours before real-time.

According to Article 24(6) of the EBGL, after ISPr gate closure time, the ISPr bids may only be changed in accordance with the rules defined by the TSO in the terms and conditions for balancing service providers set up pursuant to Article 18 of the EBGL. These ISPr bids update rules shall be implemented before the TSO joins any process for the exchange of balancing energy and shall allow BSPs to update their ISPr bids to the extent possible until the cross-zonal ID GCT.

4.2.3 TSO GCT

The TSO GCT marks the point in time when each TSO will have to submit its LMOL per direction of activation to the aFRR-Platform. The EBGL requires a TSO GCT for each of the balancing processes (aFRR, mFRR and RR). Sufficient lead time for TSO and platform process is required, especially in the initial phase of operation of the aFRR-Platform to allow sufficient time for fall-back procedures for merging local MOLs to the CMOL.

Taking these technical considerations into account, TSOs propose setting the TSO GCT at 10 minutes before the beginning of the validity period.

Having TSO GCT of 10 minutes provides the best balance between the TSO and Platform processes for aFRR-Platform. However different requirements resulted in a different best balance for the mFRR process.

According to Article 24(5) of the EBGL, TSO applying the CDM shall define ISPr gate closure time (ISPr GCT) which shall be set before the TSO energy bid submission gate closure time.

The time between ISPr GCT and TSO GCT is needed to do conversion of ISPr bids into the standard products and to ensure that standard products as a result of conversion are technically feasible and can be activated by the European platform. In case of the PICASSO project, the closer to the real time the TSO GCT is, the better standard products as a result of ISPr bids conversion reflect availability of resources to provide aFRR.

4.2.4 Further evolutions of BEGCT and TSO GCT

Proposals for BEGCT and TSO GCT have been based on the current analysis of the different constraints by the TSOs. When developing the detailed specifications, when implementing the platform and the local systems or when gaining experience during the first months and years of the aFRR-Platform, it could become apparent that these GCTs should be changed. Changes in both directions are possible. If it is concluded that the limited window does not give sufficient time to develop robust operational processes, GCTs further away from the real time may be proposed. On the other hand, if it appears that the operational processes can be executed faster and that this would allow for more opportunities to reoffer flexibility, GCTs could be moved closer to validity period. In both cases, the change of GCTs would be performed according to the amendment process described in Article 6 of the EBGL.

Figure 14 summarises the TSOs proposals for BEGCT and TSO GCT whilst taking into account the interactions with other balancing processes and the local ID processes.

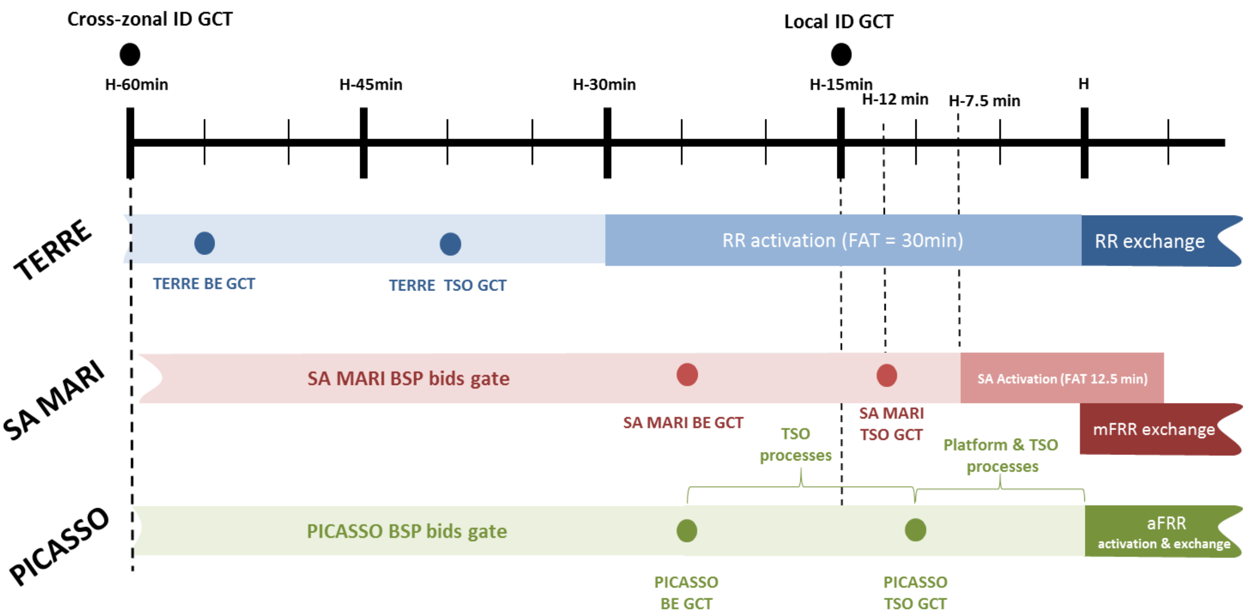

Figure 14: GCT for different products and stakeholders

**RR BEGCT will be H-55 minutes. For an interim period of no more than 12 months after the entry into operation of the RR-Platform, the RR BEGCT will be H-60 minutes*

4.3 Framework for further harmonisation

Going forward, and concurrent with the development of the balancing platforms, it is essential that all TSOs involved harmonise the market design elements that are key to creating a level playing field for balancing market participants. For aFRR, this includes the balancing energy gate closure time, minimum bid size, bidding granularity and pricing rules of balancing energy, which will be harmonised by the implementation date of the aFRR Platform.

Further harmonisation of terms and conditions for balancing service providers, balancing the responsible parties and the methodologies of TSOs can contribute to further improving the level-playing field. Therefore, the TSOs involved in the aFRR Platform will continuously consider harmonisation of such terms and conditions in coordination with the development of other European balancing platforms. On this basis, and at defined terms during the implementation phase and the operational phase of the aFRR Platform, all TSOs will review their national terms and conditions related to balancing with the aim of harmonisation.

Topics for harmonisation are identified through direct dialogue with stakeholders. Holding a stakeholder survey every year to identify harmonisation needs is therefore proposed. TSOs will report on the survey results. The first survey will be organised no later than one year after the aFRR-Platform becomes operational.

Based on the result of these surveys, All TSOs will establish a priority list, specify options for the priority topics identified, and consult upon these options over a two month period. Taking the consultation results into consideration, a common harmonisation proposal will be created. Every 36 months, all TSOs will make a proposal for amending the aFRRIF including the common harmonisation proposal.

For information, following topcis have been proposed by the stakeholders during the consultation hold in November 2017:

- Requirement for Prequalification
    - Energy Availability Requirements
    - Symmetry of bids

    - Unit based vs. portfolio based bid
    - Back-Up requirements
    - Communication & IT-Requirements
- Mode of Activation (see chapter 4.1.4)
- Volume determination for TSO-BSP settlement
- Penalities

This list will be used as a starting point when launching the survey according to the proposed process.

This process should lead to a stepwise harmonisation of aFRR markets that is both feasible and effective. It is assumed that those topics that would receive the highest benefits in harmonising will be tackled first as stakeholder input will help identifying those topics.

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5 Integrating aFRR markets

This chapter describes the high level scheme of the aFRR-Platform, including the main business functions necessary for the operation of the platform for the exchange of aFRR with their general input/output information. It describes how the platform interacts with the local control loops that are necessary to operate the aFRP. This chapter also presents the business rules in terms of CMOL usage and congestion management approaches, including aFRR exchanges between synchronous areas.

5.1 High level scheme of the aFRR-Platform: input/output

The high level scheme of the aFRR-Platform with the main functions the aFRR-Platform shall provide is explained in this section. These main functions listed as follows:

- aFRR AOF: the function containing the activation optimisation algorithm which determines the bids that are activated.
    - TSO-TSO aFRR exchange module: the module included in AOF function which determines the TSO-TSO exchange based on clearing results. The FRCE induced on the connecting TSO follows from this exchange.
- TSO-TSO settlement function: the function which calculates the TSO-TSO settlement of aFRR exchanges based on the optimisation results and TSO-TSO exchanges.

A high-level scheme showing the interaction of the different functions of the aFRR-Platform with each other and with other processes is shown in Figure 15. The inputs to the activation optimisation function of the aFRR-Platform are listed in Article 3(4) of the aFRRIF.

From this list, as further described in chapter 5.4, inputs are directly used by the algorithm on each optimisation cycle aiming at determining the selected bids for activation and the XBMP per uncongested area:

- the aFRR demand of every LFC area of each participating TSO being continuously reported to the aFRR-Platform by each participating TSO;
- the aFRR cross-border capacity limits for the concerned aFRR balancing borders or set of aFRR balancing borders being continuously reported to the aFRR-Platform;
- the list of standard aFRR balancing energy product bids for the LFC area of each participating TSO, which shall include all available standard aFRR balancing energy product bids from each scheduling area which belongs to the LFC area of the submitting TSO;
- the availability status of aFRR balancing energy product bids that become available or unavailable after the TSO energy bid submission gate closure time according to Article 9(2) of the aFRRIF;
- the operational security constraints provided by the participating TSOs or affected TSOs in accordance with Article 150 of the SOGL, where applicable;

Note: according to Control Demand concept described in chapter 5.1.3.1 some inputs are continuously updated at every TSO internal control cycle of its LFC (between 1 to 10 seconds). The algorithm uses the last updated input at every optimisation cycle.

The outputs of the activation optimisation function are listed in Article 3(8) of the aFRRIF.

Some of those outputs from the algorithm as well as direct inputs are used in a second step for the same optimisation cycle as input of the TSO-TSO aFRR exchange module aiming at determining the adjusted FRCE per LFC area and the automatic frequency restoration power interchange on the aFRR balancing borders:

- the automatic frequency restoration power interchange on the aFRR balancing borders as defined in the Article 147 of the SOGL;
- the volume of activations of balancing energy from standard aFRR balancing energy products;
- the volume of satisfied aFRR balancing energy demands;
- the net position of each LFC area resulting from the aFRR-Platform;
- the aFRR demand of every LFC area of each participating TSO being continuously reported to the aFRR-Platform by each participating TSO;
- the estimated aFRR balancing energy activation of every LFC area of each participating TSO being continuously reported to the aFRR-Platform by each participating TSO;

The outcome of the TSO-TSO aFRR exchange module is then for the same optimisation cycle the automatic frequency restoration power interchange on the aFRR balancing borders. In the determination of the aFRR interchange the application of the FRCE adjustment with a maximum ramping period of 7.5 minutes is applied. By 18 December 2025, the maximum ramping period will be 5 minutes.

For operation purposes, the activation optimisation function provides also on the optimisation cycle as an outcome the setpoint for each HVDC cable fulfilling the HVDC interchange resulting from the algorithm, in accordance with Article 147(5) of SOGL.

As further described in chapter 5.6, the outcome of the TSO-TSO aFRR exchange module can be used by the participating TSOs for real time monitoring of the FRCE the participating TSO is responsible for. This outcome is also more generally used for evaluation of the FRCE and the frequency quality criteria required by SOGL.

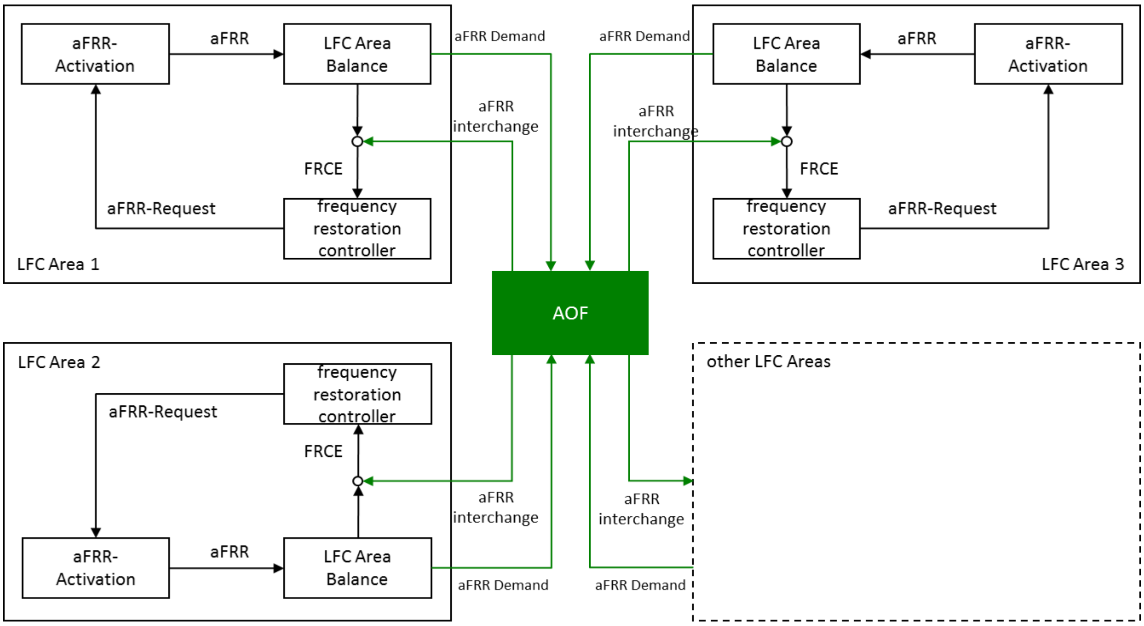

Figure 15: High level scheme of aFRR-Platform

5.1.1 Control exchange model

The control exchange model defines the interaction between the AOF and the control loops of the aFRP in each LFC area. TSOs agreed to use the control demand model for this interaction. Figure 16 shows the basic interactions within the control demand model at a high-level. To facilitate further understanding, this chapter will give background on the aFRP, the technical principles underlying the exchange models, describes the main options – the control demand model and the control request model – compares them, and explains the conclusion of choosing the control demand model. This decision is interrelated with the FAT decision.

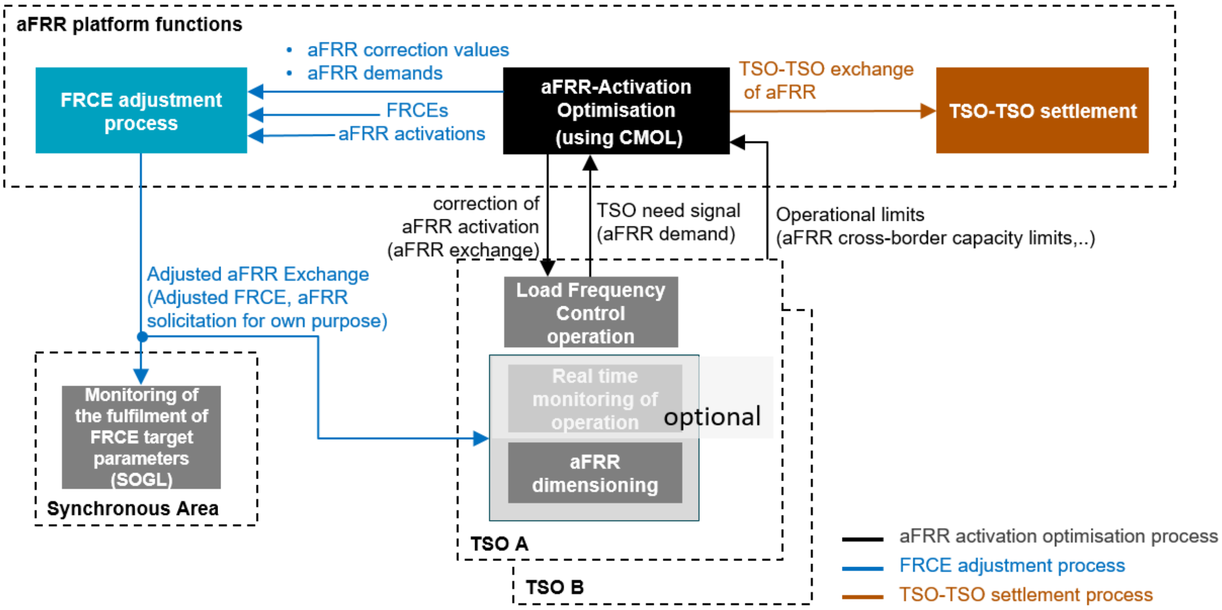

Figure 16: Activation optimisation function with control demand model

5.1.2 Basics of the aFRP in an LFC area

The automatic frequency restoration process is based on local control loops in each LFC area and aims to regulate the frequency restoration control error (FRCE) to zero. The FRCE is the difference between scheduled and realized exchanges plus an adjustment for the activation of frequency containment reserve. By regulating the FRCE of each LFC area to zero, the aFRP also restores the system frequency of a synchronous area and progressively replaces the activated FCR. This process must be finished within the time to restore frequency, defined by SOGL.

According to SOGL Article 145 (4), the aFRP must be operated in a closed loop manner and regulate the FRCE with a proportional-integral behaviour. By this, it is ensured that the FRCE is reliably regulated to zero, even in case of delayed or imperfect activation of aFRR by the BSPs.

As shown in Figure **17**, a closed control loop consists of a controller and an actuator. In the aFRP, the BSP serves as actuator controlled by the frequency restoration controller. In each control cycle (1 to 5 seconds), the controller takes information on the current FRCE of its LFC area and calculates a new aFRR setpoint. Since the FRCE is impacted by activated aFRR, the FRCE depends on the dynamic behaviour of the actuator of the control loop. Therefore, also the calculated setpoint itself depends on the dynamics of the actuator. To ensure a stable behaviour of the control loop and achieve a good FRCE and frequency quality, the parameterisation of the frequency restoration controller has to be adapted to the dynamics of the corresponding BSPs in the LFC area.

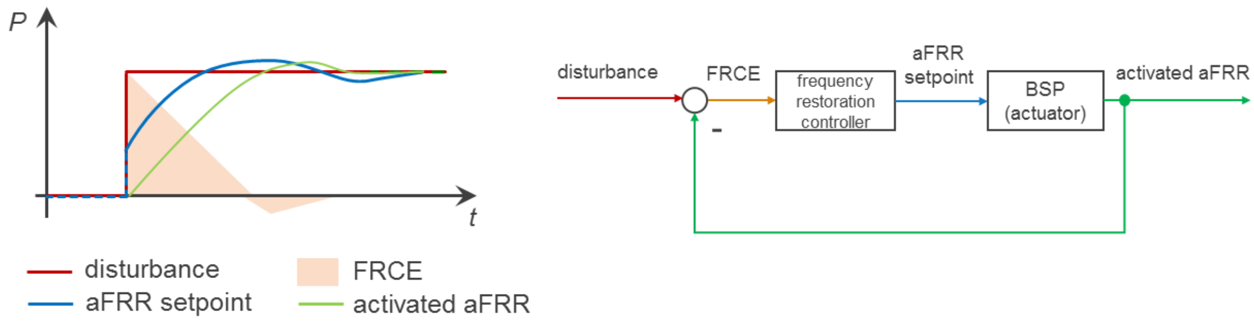

Figure 17: Example for closed control loops

This interaction between controller setting and BSP behaviour is further outlined in Figure 18**Error! Reference source not found.**. In case a slow controller is used for activation of fast BSPs (left), the flexibility of the BSPs is not fully utilized, which results in a higher FRCE and worsens the frequency quality. If a fast controller is used for slow BSPs (right), the activation can significantly overshoot the original disturbance and might even result in oscillations and an unstable system. Only when the controller parameters are adapted towards BSP dynamics (middle) the optimal dynamic behaviour is achieved. Because of this interaction, frequency restoration controllers are "tuned" to the aFRR providing units in the respective LFC area.

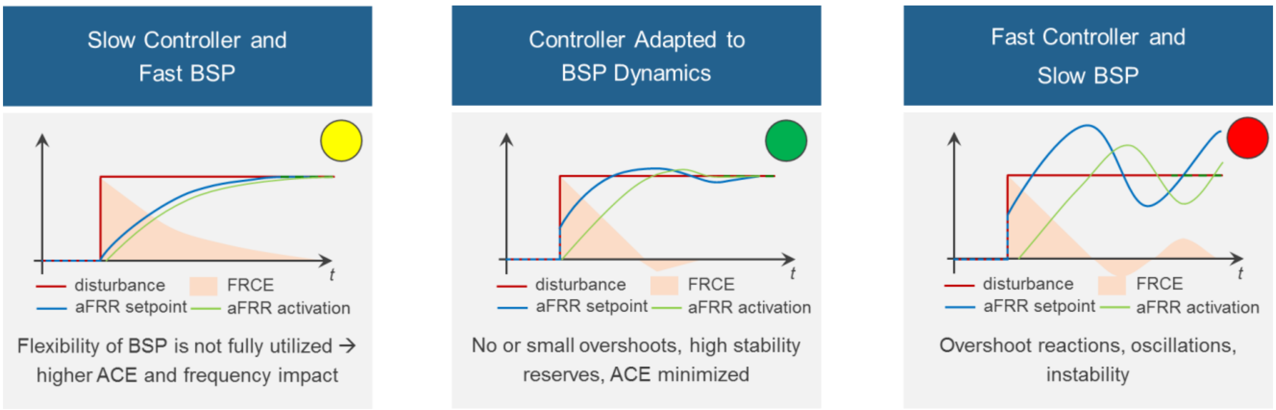

Figure 18: Interaction between BSP behaviour and controller settings

5.1.2.1 Example of signals in aFRP

Figure 19 shows a practical example of signals from a day in 2016, from a TSO applying a FAT approach with a fast aFRR product.

It can be seen that the aFRR setpoint (blue line) quickly reacts to the FRCE (yellow line) and continues ramping in the direction of the disturbance (red line) until the activated aFRR (green line) completely compensates the disturbance and the FRCE reaches zero. The frequency restoration controller can react that fast without risking overshooting activation because it has been adapted to the fast BSPs (mostly hydro units) in the respective LFC area.

In comparison, the output of a frequency restoration controller in an LFC area with slower BSPs would react much slower to the same disturbance, usually with a small or no proportional term and a slower ramp rate.

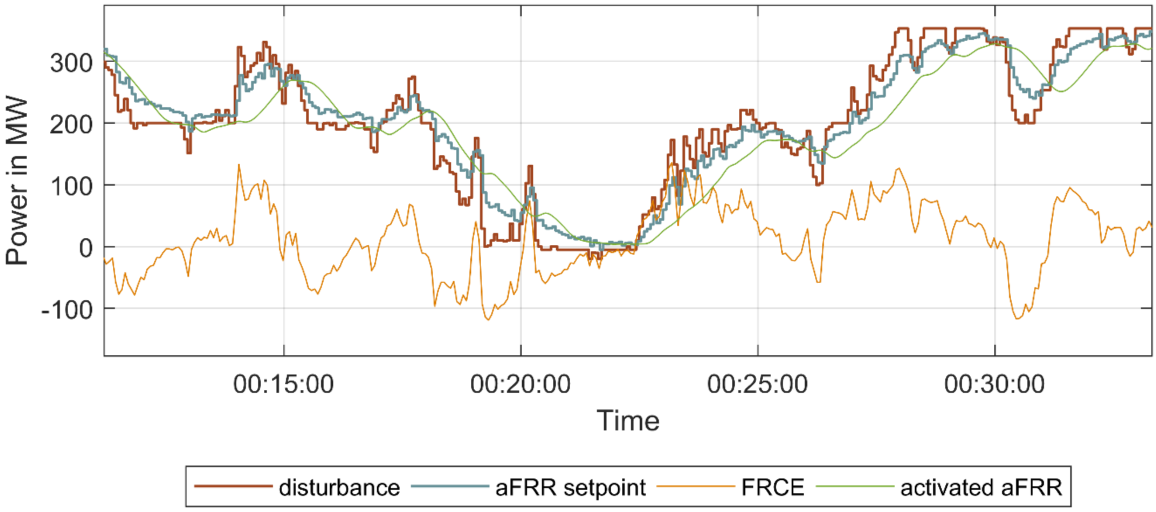

Figure 19: Local TSO signals:

5.1.3 Concepts for TSO-TSO exchange models

There are two main concepts for the TSO-TSO exchange model: the control demand model, and the control request model. These concepts were studied in some more detail in EXPLORE, and more information can be found in the EXPLORE report[1]. The current paragraph describes these main concepts. Other concepts, including the control target model, were discarded in an early stage and not studied in detail.

5.1.3.1 Control demand model

The basic principles of the control demand model are listed below:

- Each TSO calculates in each control cycle the aFRR demand for each of its LFC areas. The aFRR demand resembles the imbalance before any aFRR activation, but taking into account all earlier processes (including activation of mFRR). The aFRR demand cannot be measured directly but must be determined by the addition of the measured, uncorrected FRCE and the already activated aFRR. The amount of already activated aFRR is determined either on the basis of the requested volumes or on measurement. It should be noted that the open loop ACE, the control demand, and the aFRR demand all refer to the same signals

- The aFRR demand is provided as input to the AOF, which then uses it to determine the aFRR correction value for each LFC area based on the CMOL and at least available aFRR cross-border capacity. The aFRR correction equals the automatic frequency restoration power interchange of the LFC area.

- The correction value P_{corr} from the AOF is sent, without taking into account possible ramping constraints related to the locally activated bids. In the event of a step change in the aFRR demand of the requesting LFC area, the full step change would be induced in the FRCE of the connecting TSO of the bids which are activated according to the CMOL. By this, it will increase the FRCE of aFRR exporting LFC areas. An FRCE adjustment method is considered necessary to mitigate negative impacts on the FRCE quality monitoring (see chapter 5.6)

- The aFRR correction value is directly included within the aFRR control loop of each participating LFC area (see Figure 20), in accordance with Article 147(4a) of SOGL. Through this, the individual

[1] https://www.entsoe.eu/Documents/Network%20codes%20documents/Implementation/EXPLORE/20161021_EXPLORE_FRR_TARGET_MODEL.PDF

controller input of each LFC area is adapted according to the outcome of the aFRR AOF. The sum of the aFRR demand and the aFRR correction value is the so-called corrected aFRR demand and reflects the amount of aFRR, which the individual LFC area has to provide.

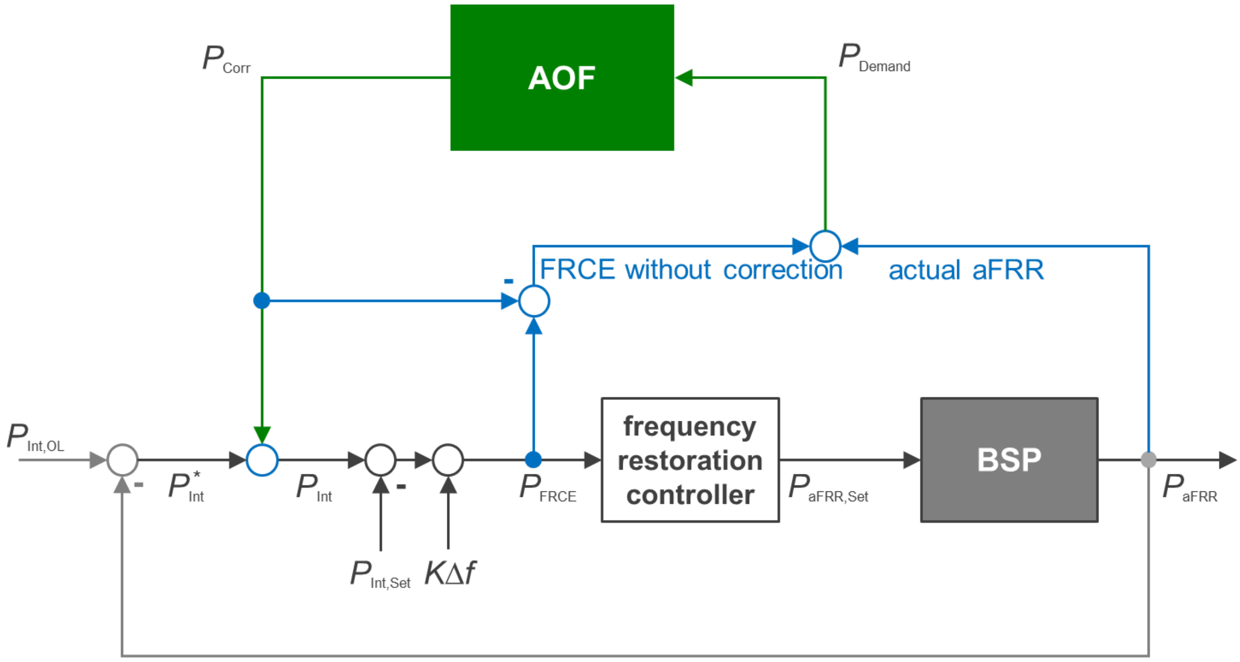

Figure 20: Scheme of the control demand model

The integration of the control demand model in the local control loops and the exchanged signals are illustrated in Figure 20. The control structure of control demand model is mathematically equivalent to the structure shown in Figure **21**. By this rearrangement of the structure it can be seen, that the closed loop of the individual LFC areas is not impacted by the AOF. In fact, the correction value impacts only the setpoint for the exchange of each LFC area and can thus be considered as "real-time schedule"

By this, each frequency restoration controller can be perfectly tuned to the dynamics of the local BSPs, which allows a stable operation as required by Article 147(3b) of SOGL and a good FRCE and frequency quality (see chapter 5.1.2). Furthermore, there is mathematical proof, that if the local closed control loops are stable, they remain stable also in case of a coordination through the AOF.

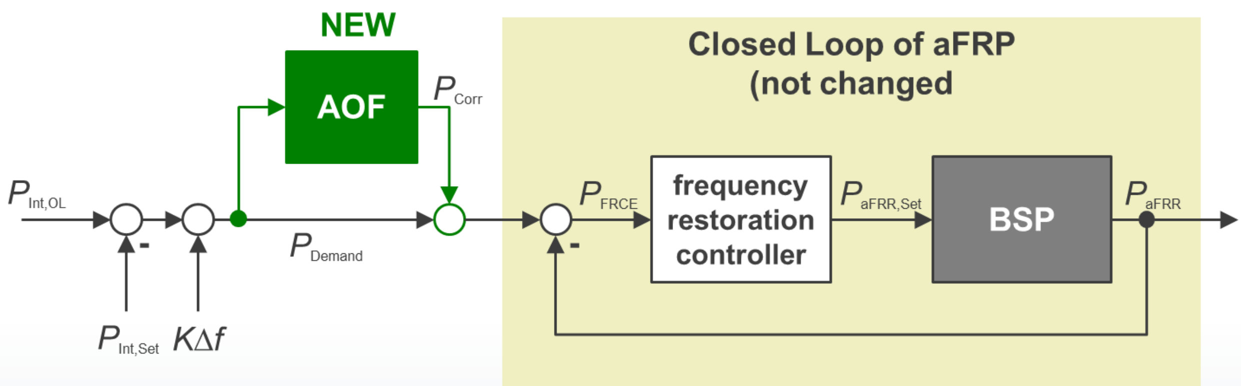

Figure 21: Structural proof of stability for control demand method

5.1.3.2 Control request model

The basic principles of control request are listed below:

- The local controller of each TSO calculates in each control cycle the local control target of each LFC area. The AOF uses the control targets to determine correction values for each TSO.
- On the basis of the correction values, the AOF uses nominated ramp limitations for each selected bid to determine the control request for these bids.
- The AOF sends the control requests to the TSOs, who passes the control request on to the relevant BSPs.
- The AOF sends a correction signal to each LFC area representing the automatic frequency restoration power interchange. This signal locally corrects the FRCE to eliminate the impact that the interchange has on the measured tie-line flows.

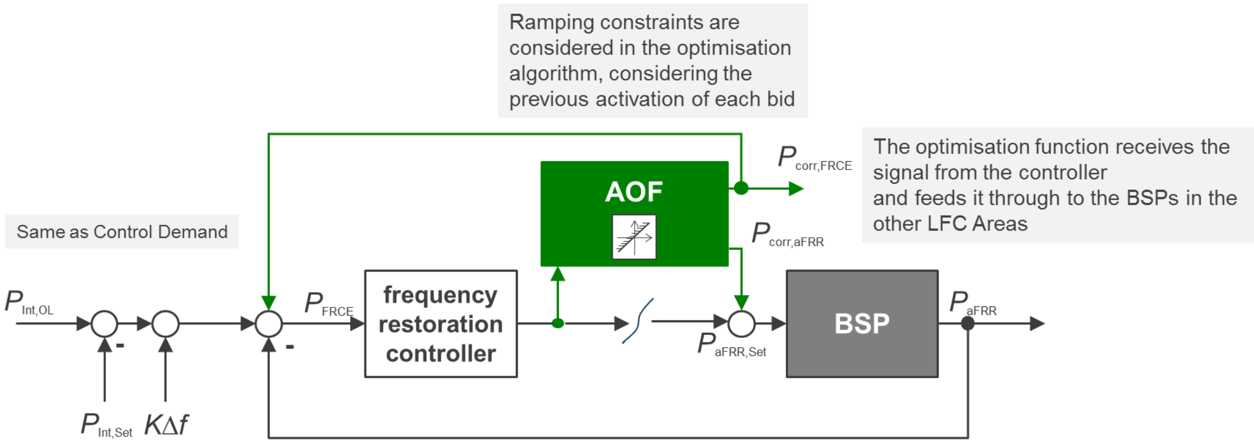

Figure 22: General principles for Control request

In case of control request it becomes obvious from Figure 22 that the optimisation itself is part of each individual control loop and by this connecting the individual control loops. In comparison to the control demand model The dynamic interaction between the control loops are much more complex and the stability of the total system cannot easily be proven. The dynamic behaviour depends on a coordinated parameterization of all involved frequency restoration controllers in coordination with all participating BSPs.

To be at least stable in normal operation and avoid oscillations, the parameterization of all LFCs has to be based on the slowest BSP in the system (see 5.1.2 and Figure 16). Due to this parameterization requirements, the flexibility of fast BSPs cannot be utilized with the control request model. Hence, more stringent FAT requirements are required to fulfil the frequency and FRCE quality targets (see also chapter 4.1).

5.1.3.3 Simulation results

To further assess the concepts for the control exchange model, dynamic simulations of the approached have been performed. In the control demand model, the dynamics (LFC and BSP) within LFC areas are not linked, hence an imperfect activation or badly parameterized LFCs do not impact other LFC areas or the whole system. Figure 23 shows an example of a simple example applying the control demand model. LFC area I has an aFRR demand of 100 MW. LFC area II has the cheaper aFRR balancing energy bids, hence, the AOF shifts the aFRR demand from LFC area I to II resulting in an activation of 100 MW in LFC area II for LFC area I.

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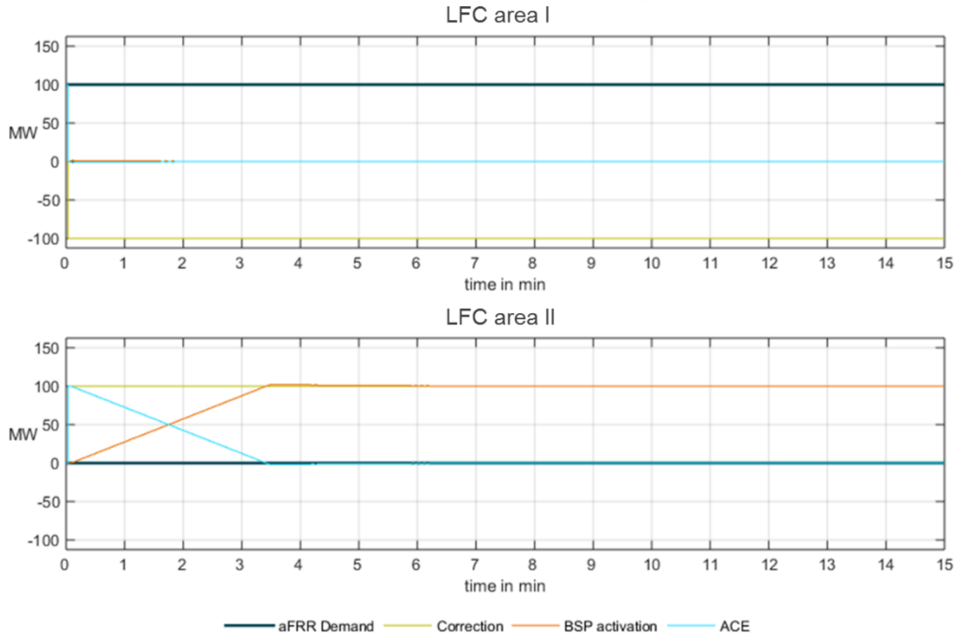

Figure 23: Example for an exchange of aFRR from LFC area II towards LFC area I with the control demand model

Figure 24 shows the application of the same example in the control request model. The disturbance in LFC area I leads to a control target (blue line) in LFC area I. Based on the nominated ramp in LFC area II the exchange (yellow) is calculated. Due to dynamics the actual activation (orange) in LFC area II does not exactly match the exchange. Due to this imperfect activation an ACE is induced in LFC area II. This ACE leads to a control target in LFC area II and by this to an input to the AOF, which does not correspond to any disturbance. Due to BSP dynamics the activation of BSPs would in reality never be able to match the calculated exchange of the AOF and by this induce control targets not matching any disturbance in the system and by this not compensated by any TSO.

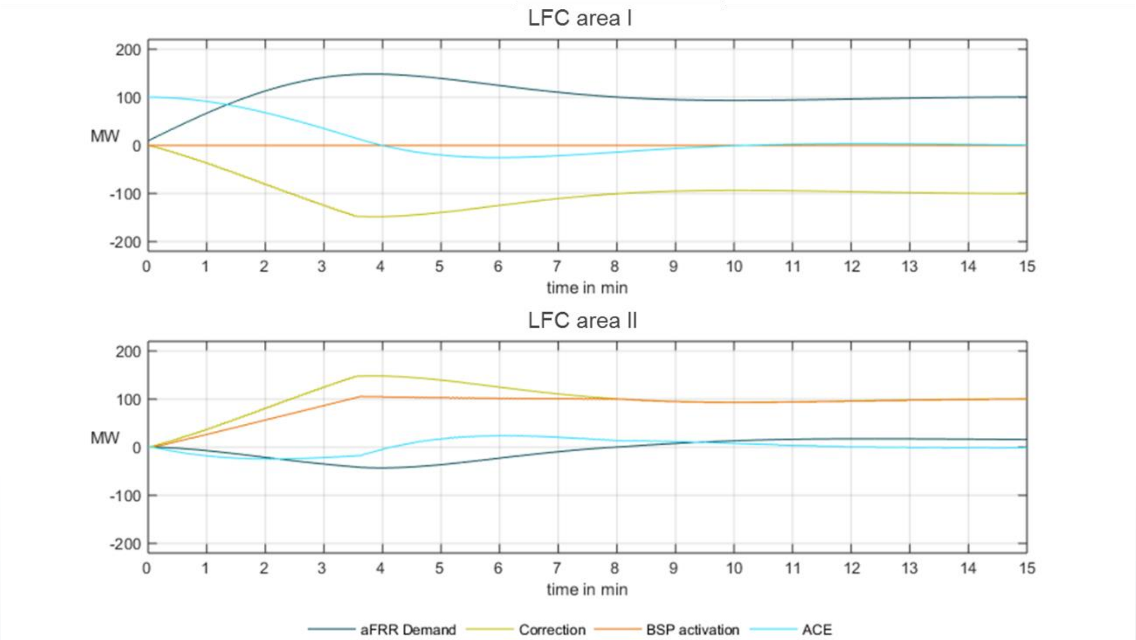

Figure 24: Example for an exchange of aFRR from LFC area II towards LFC area I with the control request model

Figure **25** shows the same example with the control request model in case of an uncoordinated parameterization of the LFCs. The faster controller in LFC area I leads to oscillations when interacting with the slower BSPs in LFC area II.

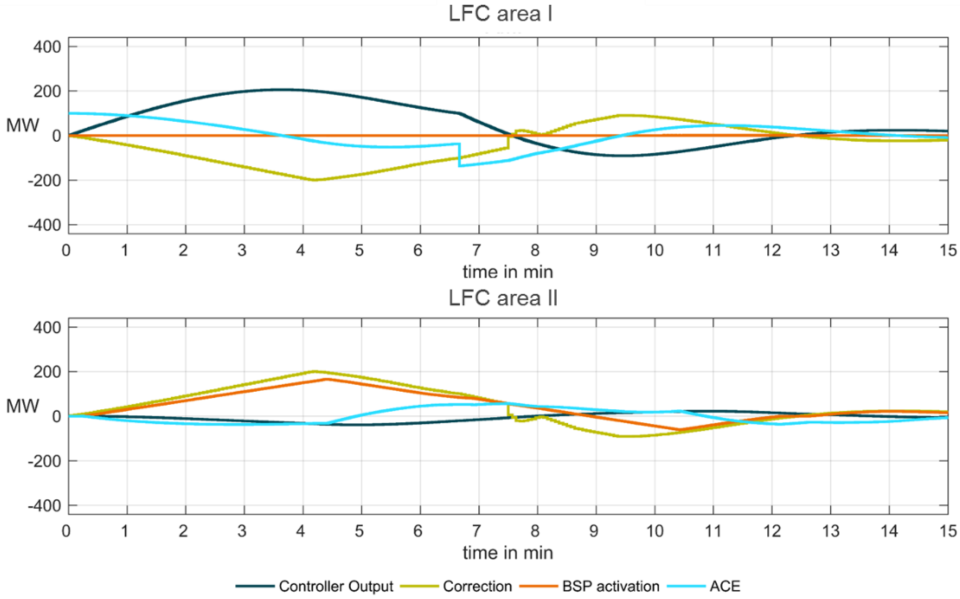

Figure 25: Example of uncoordinated parameterization of LFC with the control request model

In the next example (Figure 26) an IT error in the correction signal is simulated. In case of the control request model this leads to an unstable behaviour of the participating LFCs.

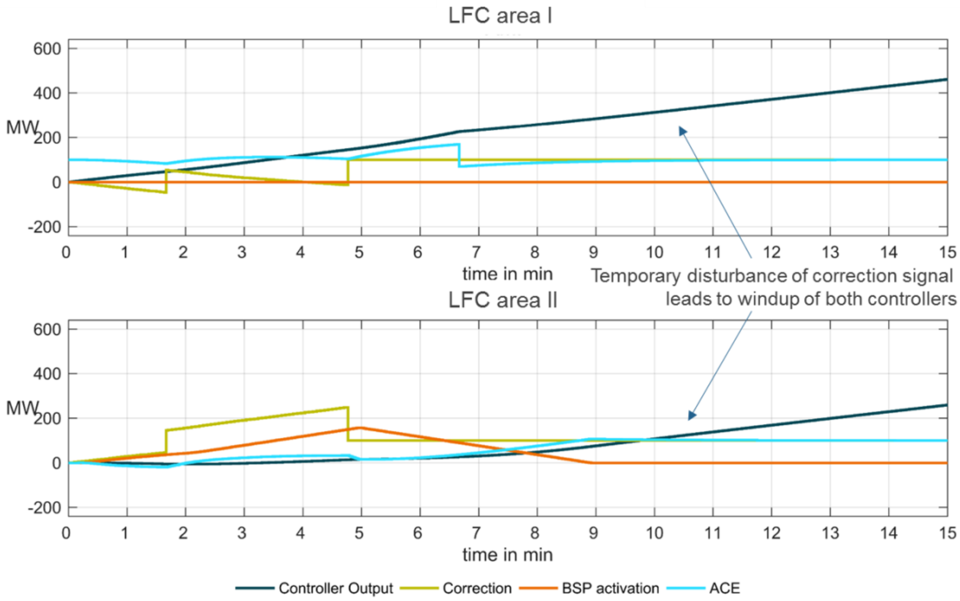

Figure 26: Impact of an IT error in the control request model

5.1.3.4 Comparison between the control demand and control request models

The two exchange models are compared in the table below.

	Control demand	Control request
Impact on products and ramping (see chapter 4.1.4)	FAT approach and ramping approach are both possible with incentives to react faster. TSO-BSP signal is determined locally on the basis of the local approach.	Ramping approach with fixed or variable ramp rate necessary. TSO-BSP signal is determined centrally by the AOF on the basis of the nominated or fixed ramp rates, and passed through to the BSP by the TSO.
Complexity	Knowledge of local ramp limitations is not necessary FRCE adjustment process adds complexity, but does not impact the control loops.	Knowledge of local ramp limitations is necessary Coordination of local controller settings necessary
Interaction with imbalance netting	Interaction with IGCC perfectly possible: - shared congestion management.	Close interaction between IN platform and aFRR platform not possible. .
Stability	Stability is mathematically proven Local control loop is not affected – Parametrisation considering local conditions possible GCC stable in operation since 2008	Stability not proven theoretically neither in practice Coupling of two or more control loops with possible interaction might make the stability proof difficult
Fall-back for disconnection of TSO from the platform	The fullback process is relatively simple	Specific fullback procedures are required for local TSOs to calculate control request themselves
Optimisation cycle and control cycle	There is no link between the optimization cycle and local control cycles. Any combination will function.	The optimisation cycle should always be at least as fast as the fastest local control cycle.
Impact on FRCE	The stepwise exchange can worsen the ACE of the connecting TSO and improve the ACE of the requesting TSO.	The required nominated ramp rate prevents the need for an FRCE adjustment process

	An FRCE adjustment process is considered necessary to compensate effects on FRCE.	
Impact on system frequency	No immanent impact on system frequency	Coordinated tuning of controller settings to slowest BSP decreases frequency quality. Shorter FAT necessary to keep frequency quality

Table 2: Cross Border Comparison

5.1.3.5 Conclusion

As can be concluded from the material above, the choice of a control exchange model is one that has a significant impact, not only on the TSOs participating in the project, but also on other choices. Aside from technical and implementation efforts, choosing a control request model would necessitate:

- Introduction of a ramping approach for each TSO. This would also have consequences for the volume determination applied in each country.
- Some loss in autonomy for the TSOs as the control request would be centrally calculated
- Explicit netting prior to the aFRR optimisation
- Shorter FAT to mitigate impact on system frequency

Although these points are important considerations, as is the necessarily longer implementation time of a control request model, the main reasons TSOs finally selected a control demand model are of a technical nature:

- The control demand model is already under operation in IGCC cooperation and German-Austrian aFRR cooperation. It has proven to work stably for ten years.
- The closed loop of the individual LFC areas is not impacted by the optimization in the control demand model. This prevents problematic consequences of the control request model as follows:
  - The correction signals issued by the AOF do not directly interfere with the local control loops but act like a "real-time schedule" for the cross-border exchange of energy. Thus, the stability of the concept can be mathematically proven and the robustness of the process to local phenomena is guaranteed as required by Article 147(3b) of SOGL.
  - The local responsibility of the TSO towards the TSO-BSP signal is not complicated due to delegation of the task of calculating the control request to the AOF, and compliant with the requirement of Article 145(4) of SOGL of having the setpoint for automatic FRR calculated by a single frequency restauration controller operated by a TSO within its LFC area. The model maintains the local responsibility of TSO towards the aFRP operation in accordance with Article 141(4) of SOGL in its own LFC area(s) and BSP local aFRR delivery, and does not require coordination between controller settings.
  - Control demand exchange enables TSO to parameterise their load-frequency controller(s) in respect to local generation. LFC areas with different LFC settings and different BSP ramping speeds can interact smoothly through the AOF, by the exchange of their aFRR demands and the correction signals. aFRR demands that could not be netted will be transferred by the AOF to the TSO(s) with the cheapest available aFRR bids if the available aFRR cross-border capacity allows it. The aFRR exporting LFC Area(s) will then take care of the aFRR activation according to its / their own LFC settings and to the speed of the selected bid(s).

- This concept allows smooth fall back to local operations in case of technical complication, as further explained in chapter 5.1.4.
- There is no link between the length of the control cycle and the optimisation cycle.

To conclude, the control demand model is a robust model that can be implemented in accordance with the EBGL timelines. Other exchange models require further investigation to assess whether stability can be proven. The control request model in particular is more deeply integrated in TSO systems, requiring coordination or even harmonisation of controller settings. TSOs prefer the control demand model due to its relative simplicity and limited technical impact.

5.1.4 Fall-back process

In case of technical problems with the aFRR optimisation locally for one participating TSO or globally in the aFRR-Platform, the aFRP will still continue to work in order to guarantee that the FRCE is continuously regulated to zero. In such case, the concerned participating TSO will stop its participation to the aFRR-Platform. The corresponding aFRR demand and bids will be removed from the AOF, and the participating TSO will continue the aFRP with the local bids, following its local rules.

5.2 Full access to CMOL (Article 3)

TSOs propose that each participating TSO shall be allowed to request activation of a higher amount of aFRR than that submitted to the common merit order list. For the aFRP, it is considered acceptable if the sum of aFRR demands of all LFC areas in one TSO occasionally exceeds the aFRR bid volume (sum of contracted and free bids) that this TSO has submitted to the platform.

In essence, TSOs foresee no general rules to exclude full access to the CMOL as:

- There is a benefit in allowing TSOs to have access to as much aFRR as possible, as this enables them to regulate their FRCE to zero and so restore the system frequency. In order to maximise the security of supply, the access to aFRR should not be limited.
- Neither the probabilistic nor the deterministic part of FRR reserve dimensioning depend on the activated aFRR but on the observed imbalances. Therefore, the FRR dimensioning should not radically change due to the full access to CMOL.
- The full access to CMOL is subject to available aFRR cross-border capacity and therefore not guaranteed. Hence TSOs cannot rely on this and need to have enough local aFRR volumes available.
- An ex-post monitoring will be implemented for accessing more capacity than submitted to the CMOL. This is to prevent any misbehaviour (such as under dimensioning).

However, such full access to CMOL must not block the local access of each participating TSO to the aFRR volumes submitted to the platform within its LFC areas, or otherwise obtained through sharing or a common procurement process. Thus, the design of the aFRR optimisation function includes priority access to local aFRR volumes in case of unsatisfied demand (see chapter 5.4).

Additionally, TSOs will monitor the satisfaction of the aFRR demands when activated volume exceeds the submitted volume to the platform, since the aFRR exchange process is subject to system operation concerns via, for instance, the TSO notification process as required by SOGL. In other words, the amounts of aFRR activated for each participating TSO will be monitored and satisfaction of aFRR demands could, for operational reasons, be limited to the volume submitted to the platform by TSOs (e.g. progressive increase of full aFRR exchange at the go live, volatility of flow changes in real time, DFDs handling).

Generally full access to CMOL is coherent with one step-optimisation approach for AOF (see chapter 5.4) and the control demand model (see chapter 5.1.1). Limited access to the submitted volume to CMOL would technically be possible with the technical and market consequences described as follows:

- Technical concerns: Control demand model implications
    - If for instance the aFRR demand of one TSO is capped to its submitted volume as an input of the algorithm, then the AOF will provide a result and a corrected demand considering the capped aFRR demand
    - The consequence will be that locally the corrected demand will not be capped and may lead to an activation of additional bids in the local Merit Order List: resulting a deviation towards the objective of limiting the satisfaction of the demand up to the submitted volume to the platform.
    - In order to avoid such effect, additional features will have to be implemented locally leading to additional complexity:
        - For instance, the local controller shall consider the cross border marginal price of the platform in real time to cap the local activation up to a certain amount.
- Market concerns: restriction of netting potential
    - Applying a restriction to the full access to CMOL might lead to a restriction of the netting potential of the participating TSO in a target situation when there will be no separate processes between IN and aFRR, and a complete integration of IN in the aFRP. This is due to the fact that with the orientation taken of having one optimisation step (including netting of demands and activation of offers), it is technically not possible to identify the part of the aFRR demand satisfaction covered by netting or by activation of aFRR bids for one TSO individually.

5.3 Merging of CMOLs (Article 10)

In order to perform a global optimisation of the aFRR activation the aFRR-Platform shall be able:

- to merge all the local merit order lists received from each participating TSO, valid for one validity period, into two common merit order lists, respectively for upward and downward direction; and
- to optimise the aFRR demand received in every control cycle using the common merit order lists in order to satisfy the aFRR demands in the most economically efficient way.

To do so, each BSP shall submit the aFRR balancing energy product bids from the aFRR standard and specific product to the connecting TSO.

Each balancing service provider connected to a TSO applying a central dispatching model shall submit integrated scheduling process bids to the connecting TSO.

The connecting TSO shall submit all aFRR standard balancing energy product bids and where applicable all aFRR specific balancing energy product bids converted to aFRR standard balancing energy product bids to the aFRR-Platform in order to be included in the common merit order lists with the exception of the bids not forwarded in accordance with Article 29 (10) of the EBGL.

Connecting TSOs applying a central dispatching model, shall convert the integrated scheduling bids received from the BSPs into available aFRR standard balancing energy product bids, and then submit these to the aFRR-Platform to be included in the common merit order lists.

Within the validity period where the bids are valid, each participating TSO shall submit the aFRR demand on a control cycle basis for each of its LFC areas to the aFRR-Platform in order to be able to regulate the FRCE to zero.

For each control cycle the aFRR-Platform shall perform an optimisation of activation based on the two common merit order lists containing all the available aFRR standard balancing energy product bids submitted

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by the participating TSOs and all aFRR balancing energy aFRR demands submitted by the participating TSOs.

The activation optimisation function shall contain the continuously updated common merit order lists that shall contain all available aFRR standard balancing energy product bids depending on real time situation: i.e. between the balancing energy gate closure time up to real time, the common merit order lists shall be updated considering for example failure of aFRR providers or unavailability due to local congestions.

5.4 Optimisation algorithm of the AOF (Article 11)

The optimisation algorithm of the AOF aims to provide the optimal solution for the selection of bids to be activated. To do so, it has the following priorities:

- First priority: maximise satisfaction of the aFRR demand of individual LFC areas;
- Second priority: minimise the volume of selected standard aFRR balancing energy product bids;
- Third priority: maximise the economic surplus;
- Fourth priority: minimise the amount of the automatic frequency restoration power interchange on each aFRR balancing border between LFC areas.

The practical effect of applying these priorities on the selection of bids can be understood as follows:

- The next priority shall become relevant for the outcome of the algorithm and for the selection of the bids if there are multiple solutions possible that fulfil the current priority: for instance, if you can satisfy demands in multiple ways, the volume used shall be minimised. If you end up with multiple demands, the economic surplus shall be maximised (choosing the first bids on the CMOL in the relevant direction). If then there are still multiple solutions (for instance due to bids with the same price), the amount of automatic frequency restoration power interchange shall be minimised. Order of priorities is ensured by applying appropriate weights to the individual priorities.
- Combination of the first and second priorities means that if all demand can be netted (without congestions) there shall be no activation. In the aFRR-Platform counter activations shall not be allowed. This is elaborated upon in chapter 5.5.
- The objective of the fourth rule of power exchange minimization is to choose the optimal solution which uses the least cross-border capacity when several solutions fulfil all earlier objectives.
- In case fulfilment of demand is not possible, the rules on priority access to submitted volumes shall apply to determine the remaining TSO responsibility. The priority access rules are described in the chapter 5.4. Applying these rules should not affect the bids selected, but the automatic frequency restoration power interchange.

For the aFRP, because aFRR demands are inelastic and the bids are divisible, the objective function will result in one multilinear optimisation problem. Moreover, pursuant to chapter 4.1.5, no link between bids (including for instance upward and downward bid for a unit providing symmetric aFRR) will be considered directly in the algorithm. In the algorithm the bids will be considered as independent from each other. Having a linear problem is necessary to be able to perform the optimisation in a few seconds. Then, for the same reasons in terms of mathematical description of the model the maximisation of economic surplus will always lead to the minimisation of costs.

In order to calculate the results the optimisation makes use of the following inputs:

- the common merit order lists (for more details see chapter 5.3);
- the aFRR demands (for more details see chapter 5.1.1);

- the aFRR cross-border capacity limits calculated in accordance with Article 4 of the aFRRIF (for more details see chapter 5.7).

Finally, the AOF takes into account the following constraints. These constraints ensure that the stability of the FRP of each LFC area and operational security are not affected by the frequency restoration power interchange:

- The power balance equation is a constraint formulated for each LFC area. The constraint ensures that for each LFC area, the cross border aFRR exchanges including implicit netting, the aFRR balancing energy bids selected for activation within the LFC area and the satisfied aFRR demand, are summed up to zero. In combination with the target to minimize unsatisfied demand, this constraint ensures that the power balance of each LFC area is not affected and additional FRCE is avoided.

- The sum of all automatic frequency restoration power interchanges is equal to zero, in accordance with Article 147 (6) SOGL.

- The frequency restoration power exchange on a border shall not exceed the available aFRR cross-border capacity limits as explained in chapter 5.7.

It is noted that the available cross-border capacity defined in the previous timeframes may be defined in a set of borders (see also chapter 5.7). In such cases, the sum of the frequency restoration power exchanges on each of the borders or that set of borders should not exceed the available cross-border capacity.

5.4.1 Interaction with the Imbalance Netting process

According to Article 11 of the aFRRIF, the AOF will perform the selection of bids and the implicit netting of upward and downward aFRR demands in a single optimisation step. This integrated approach will result in the most economically efficient distribution of the available netting potential, since the AOF will maximize the platform surplus under consideration of the bid prices. The algorithm will net the demands according to the highest priced bids for upward and lowest priced bids for downward activations in priority.

In contrast, with two optimisation steps, the distribution of the netting potential would always be performed according to rules which cannot take into account prices defined a priori and leading to potential sub-optimal use of cross-border capacity and sub-optimal distribution of the netting potential between the participating TSOs. Additionally, having two separate optimisation steps for netting and activation will greatly increase the complexity of the general optimisation problem when the rules of priority access to the submitted volume to the platform would have to be taken into account, since netting and activation must always respect priority access to control areas, LFC blocks, etc. The more complex the LFC structure, the more optimisation steps should be performed, leading to complex architecture, additional arbitrary rules and sub-optimal solutions.

However, due to derogation or regulatory limits it might be that not all TSO, which are participating in the IN-Platform will also participate in the aFRR-Platform. Hence, there is the need to separate the processes into multiple optimisation steps. In this case, the following sequence of steps is proposed:

1. Optimisation of cross-border interchange of aFRR and activation of bids from the common merit order list, including the implicit netting of aFRR demands

2. Netting of all remaining aFRR demands of the IN-Platform in accordance with Article 11 of the INIF, under consideration of the remaining cross-border capacity after the first step

3. Optimisation of the activation of bids from the common merit order list and determination of the XBMP, considering the aFRR interchange and netting determined in the previous steps

This sequence ensures that

- The cross-border capacity between the LFC areas that participate in the cross-border interchange of aFRR are optimally allocated in the first step

- The priority access to aFRR capacity within an LFC block or sharing regions is ensured
- Merit order activation is followed
- XBMP corresponds to the highest price of selected bid for the uncongested area.

The steps in the sequence will be performed each optimisation cycle, which has a fixed interval of less than 10 seconds, using the aFRR demands and constraint inputs received by each participating TSO in real time. The optimisation is performed on each optimisation cycle independently from previous optimisation cycles outputs. By this all TSOs participating in the aFRR-Platform and also participate in the IN-Platform will form an optimisation region in accordance with the imbalance netting implementation framework.

Nevertheless in order to achieve simplification of the necessary optimisation steps, the TSOs recommend that NRAs incentivise and enable the geographical regions of the participating TSOs in the aFRR-Platform to be the same as the geographical regions of the participating TSOs in the IN-Platform, i.e. all the participating TSOs in the IN-Platform to become participating TSOs in the aFRR-Platform.

5.4.2 Priority access to submitted volume to CMOL

The optimisation algorithm shall consider the process responsibility structure of the participating synchronous areas: i.e. the hierarchisation of the participating synchronous area including LFC areas with their borders shall be taken into account. The different configurations of common procurement and/or exchange or sharing of reserve within/or between LFC blocks shall always be respected from a system operation security perspective.

In the algorithm this basically means that when all demands are satisfied, no any specific rules (additionally to economic surplus maximization and cross border flows minimization) shall apply. However, in case of unsatisfied demands:

- The LFC areas which form one control area shall have priority access to the offered standard aFRR balancing energy product bids and transmission capacity inside the control area, e.g.: in case of unsatisfied demand. This is required to ensure that in case there is unsatisfied demand, the principle set out in Article 29 (12) of the EBGL is respected, which gives each TSO access to the volumes submitted to the aFRR-Platform. This is in line with Article 32(1) of the EBGL states that TSOs can procure balancing capacity within their *control area*.
- The LFC areas which form one LFC block and perform common dimensioning shall have priority access to the standard aFRR balancing energy bids and available cross-border capacity inside the LFC block, e.g.: in case of unsatisfied aFRR demand.
- The TSOs procuring a part of their balancing capacity outside of their scheduling areas pursuant to Article 33 of the EBGL shall have priority access to this procured volume. The TSOs sharing aFRR pursuant to Article 168 or Article 177 shall have priority access to the shared volume in case of unsatisfied demand.

All TSOs developed a robust and flexible solution permitting for one optimisation step approach to consider the process responsibility structure of the participating synchronous areas for the distribution of the unsatisfied demand:

- The prioritisation approach for one step optimisation was defined for guaranteeing the prior access concern considering all LFC structure configurations via the definition of a target value for distribution of unsatisfied demand per LFC area in the algorithm itself.

This basically means that in a scenario where all TSO have full access to CMOL:

- In case all aFRR demands are fully satisfied (i.e. there is no unsatisfied demand for any LFC area) in a given optimisation cycle, there is no need for prioritisation access. All target values for unsatisfied

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demand will be zero for each LFC area and distribution of activation will be based on cross border flow minimization.

- In case there is an overall unsatisfied demand in a given optimisation cycle then this unsatisfied demand shall be distributed between LFC areas according to specific prioritisation rules respecting LFC structure.

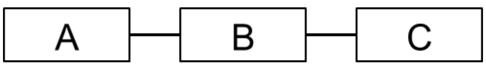
All TSOs approach considers the hierarchisation of the participating synchronous area including LFC areas with their borders shall be taken into account. The approach takes into account the unsatisfied demand determination on different layers:

- Synchronous areas
  - in case of sharing or exchange of reserves
- LFC Block performing exchange or sharing of reserves between blocks
- Control area performing their own dimensioning or sharing or exchange of reserves
  - Control area is needed for handling the Nordic configuration where the LFC block consists of multiple TSOs/control areas, some of which consist of multiple LFC areas. To enable the TSO to have priority access to all bids within its own control area, this hierarchical level is needed.
- LFC area

In terms determination of unsatisfied demand per layer, the following rules were identified by the TSOs. In case LFC areas or blocks are performing:

- Exchange of reserves (between LFC Blocks or SA):
  - Commonly submitted volume is considered for the distribution of unsatisfied demand within the exchange region when full procured volume is commonly procured for the exchange process
  - Only exchanged volume is considered for the distribution of unsatisfied demand between individual concerned areas/blocks when part of procured volume is exchanged between areas/blocks
- Sharing of reserves (between LFC Blocks or SA)
  - Only shared volume is considered for the distribution of unsatisfied demand within the sharing region

Here below some illustration cases of distribution of unsatisfied demand in different configurations, with 3 connected LFC areas:



Case 1: Simple configuration with A, B and C without performing any distribution rules for unsatisfied demands. In this case, cross-border flow minimization would apply by default.

LFC Area	A	B	C	Total
aFRR demand	200	100	150	450
Procured volume	100	200	100	400

Submitted volume to the platform	100	200	100	400
Local Unsatisfied demand	100	0	50	150
Global unsatisfied demand		50		
Global Unsatisfied demand distribution	25	0	25	50

Table 3: Case 1 – Unsatisfied Demand

Case 2: Configuration with A, B and C without performing any exchange nor sharing but performing proportional distribution rule for unsatisfied demands. In this case the distribution of unsatisfied demand has priority to cross-border flow minimization and apply according to local unsatisfied demands.

LFC Area	A	B	C	Total
aFRR demand	200	100	150	450
Procured volume	100	200	100	400
Submitted volume	100	200	100	400
Local Unsatisfied demand	100	0	50	150
Global unsatisfied demand		50		
Global Unsatisfied demand distribution (target value)	33	0	17	50

Table 4: Case 2 – Unsatisfied Demand

Case 3: partial exchange of reserve configuration: B and C performing a partial exchange of reserve of 50 MW from B the connecting area to C the requesting area. In this case, C has access only to the 50 MW additional volume in the way the local unsatisfied demand is calculated.

LFC Area	A	B	C	Total
aFRR demand	200	100	150	450
Bilateral procurement volume	100	200 50 →	100	
Submitted volume	100	200 50 →	100	400
Local Unsatisfied demand	100	0	0	100
Global unsatisfied demand		50		
Global Unsatisfied demand distribution (target value)	50	0	0	50

Table 5: Case 3 – Unsatisfied Demand

Case 4: full exchange configuration: A and B performing full exchange of reserve of 100 MW from B the connecting area to A the requesting area (e.g. via common procurement process of 300 MW). In this case, A has access to the 100 MW additional volume in the way the global unsatisfied demand is distributed, since A and B are forming a full exchange region.

LFC Area	A	B	C	Total
aFRR demand	200	100	150	450
Common procurement volume	150 ↔	150	100	400
Submitted volume	100 ← 50	200	100	400
Local Unsatisfied demand	100	0	50	150
Global unsatisfied demand	50			
Global Unsatisfied demand distribution (target value)	0	0	50	50

Table 6: Case 4 – Unsatisfied Demand

Note: The unsatisfied demand on the region level is considered in this case being equal to 0 MW since the sum of aFRR demands of A and B is equal to 300 MW and the global submitted volume also equal to 300 MW. A receives in this case the 100 MW of activated volume from B.

To summarise, the determination of the unsatisfied demand is calculated then following the top-down distribution approach, as illustrated in the following figure:

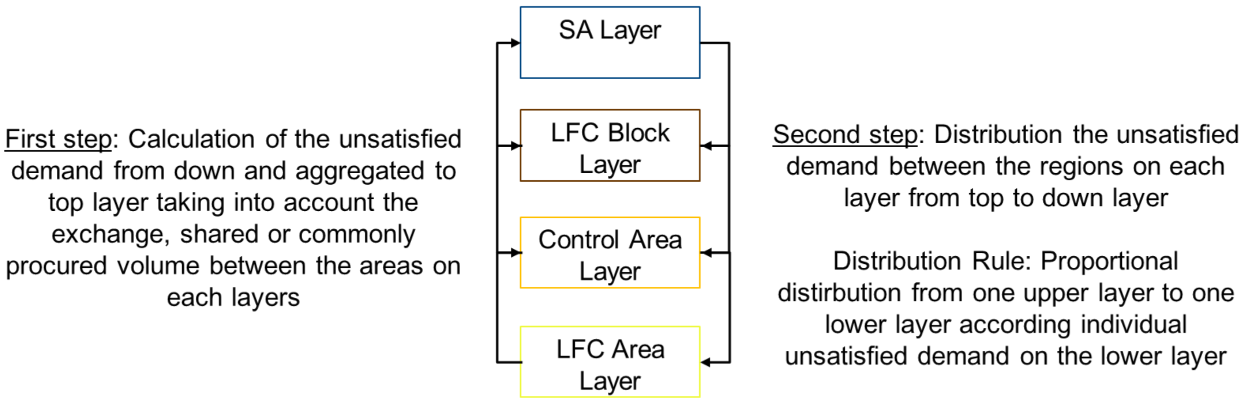


Figure 27: Calculation of unsatisfied demand

In a first step the unsatisfied demand is calculated on each layer from bottom layer (LFC area) up to top area (synchronous area). When volume is exchanged, shared or commonly procured with other areas on one layer, the unsatisfied demand is determined accordingly.

Once the overall unsatisfied demand is calculated on the top layer, then in a second step this overall unsatisfied demand is distributed from one upper layer to one lower layer proportionally to the individual unsatisfied demand calculated in step one.

5.4.3 aFRR cross-border flows minimization

Finally, the algorithm will aim at minimising aFRR exchanges, everything else being equal, meaning that when several solutions provide the same level of economic surplus maximisation, the chosen solution will be the one which distributes the netting and activation of bids ensuring the lowest possible usage of aFRR cross-border capacity for aFRR exchanges. This also applies to a solution where several bids are equal in pricing to the cross border marginal price. If the bids are located in different LFC areas then the activation of bids

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will be performed according to aFRR cross-border exchange minimisation. If the bids are located in the same LFC area then the activation will be performed according to local rules. This approach means not having to harmonise the distribution of activation case when prices are equal, which may depend on different local regimes and leads to a simplified objective function for the aFRR-Platform to guarantee better performance.

5.4.4 Losses in the HVDC Lines

A topic that has an influence on the algorithm is the treatment of HVDC losses. This topic is also under investigation and discussion in the previous timeframes, namely day-ahead and intraday markets. Generally the choice between implicitly and explicitly treating losses is to be made. Considering the complexity of the topic, the maturity of the topic in the intraday timeframe, and the impact on pricing and settlement of taking losses into account implicitly in this stage of the project this is not foreseen. The topic will be revisited in the future, depending on other developments.

5.5 Counter activations

In this chapter the choice not to allow counter activations in the aFRR-Platform is complemented with a discussion on the topic. It is explained why they could occur if allowed, which options for implementation were considered, and what the market and technical considerations were in regards to these options, as well as legal and regulatory considerations. The situations for the aFRR and mFRR Platforms cannot be compared, which is why it was opted to have separate solutions in regards to counter activations.

Occurrence of counter activations

A precondition for counter activations is reverse pricing i.e. the price of a bid for upward activation is lower than the price of a bid for downward activation. Price reversal can occur within both a single LFC area or between LFC areas, for several reasons including inefficiencies in bidding strategies and price differences in previous markets to the balancing market due to congestions.

The realisation of these price reversed counter activations depends on whether they are located within an LFC area or between LFC areas, and whether there is available transmission capacity to accommodate them between the LFC areas. Most TSOs currently can only activate bids in one direction within one LFC area, hence counter activations within a LFC area would be most of the time not realised.

Not allowing counter activation implies that all possible netting will be performed, regardless of the bid prices.

5.5.1 Considered Options

PICASSO EG discusses three options in regards to counter activations. These three options are the following:

- No limitation of counter activations
- Complete avoidance of counter activations within uncongested regions (netting of demands only)
- Limiting counter activation to a certain threshold

A more detailed description of the options is given below with a common example, which is based on the following example:

Platform consists of three TSOs and respective downward offers (DO) and upward offers (UO) as described in the table below:

	aFRR demand	Available bids
TSO 1	-100 MW	BSP 1 DO 300 MW at 50€/MW
TSO 2	-100 MW	BSP 3 UO 300 MW at 40€/MW

TSO 3	+ 150 MW	BSP 2 DO 100 MW at 30€/MW

Table 7: Counter Activation Example

5.5.1.1 *Option 1: No limitation of counter Activation*

In each optimisation cycle the AOF will select a set of bids to be activated based on the principle of cost minimization, where payment to the TSO is seen as a negative cost. In certain cases, when reverse pricing is present on the merit order list, this can lead to counter activations of aFRR even within an uncongested area in a single optimisation cycle under the condition that there is available transmission capacity.

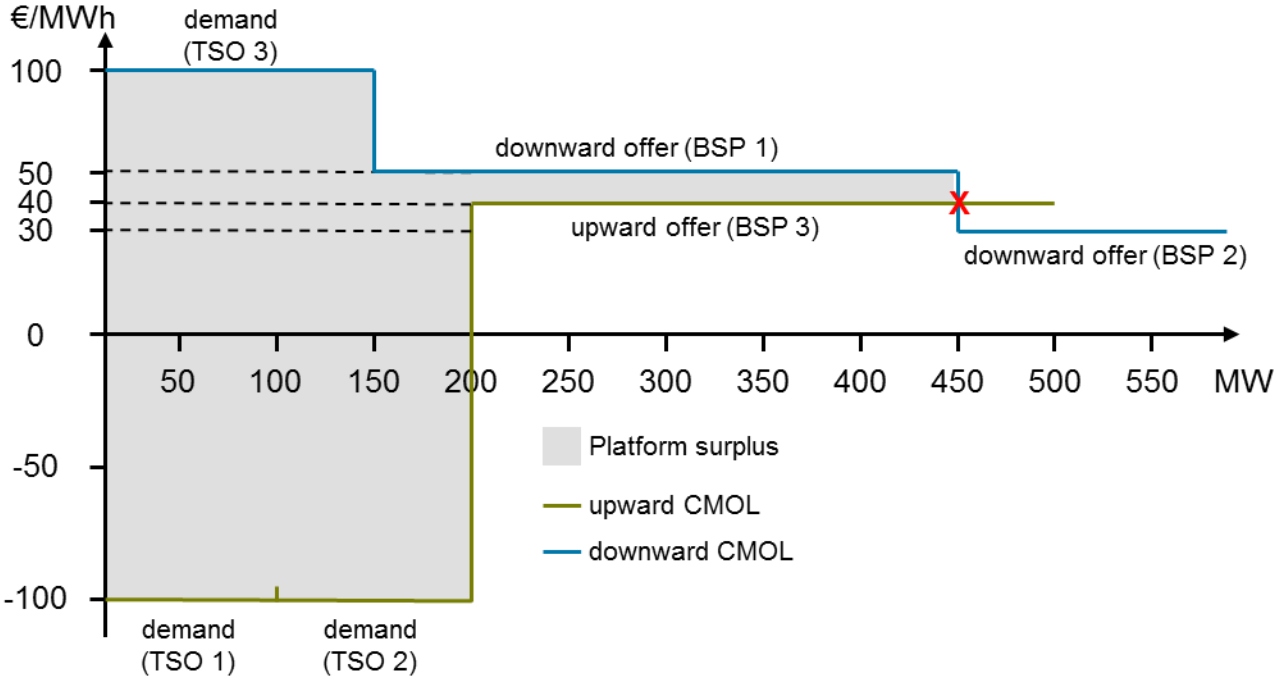

Figure 28: Example of Option 1

Counter activation happens until the intersection of the downward CMOL and the upward CMOL, where the upward CMOL includes the negative aFRR demands and the downward CMOL includes the positive aFRR demands. For illustration the aFRR demands are priced here with a price of ±100 €/MWh.

5.5.1.2 *Option 2: Complete avoidance of counter activations within uncongested areas*

Counter activations within an uncongested area are fully prevented. Within an optimisation cycle in each uncongested area there will only be upward or only downward bids selected for activation. All TSO demands are netted as far as possible by the AOF, without regard for the aFRR bid prices and possibly lower alternative costs.

In comparison to Option 1 that means that there are fewer bids selected for activation by the AOF; all bids that are in Option 1 solely selected due to reverse pricing on the CMOL are not selected in Option 2. The result of the example for this option is shown in Figure 29. The positive aFRR demands of TSO 3 is netted with the negative aFRR demand of TSO 1 and 2. The remaining negative aFRR demand of 50 MW is covered by the partial selection of downward offer of BSP 1.

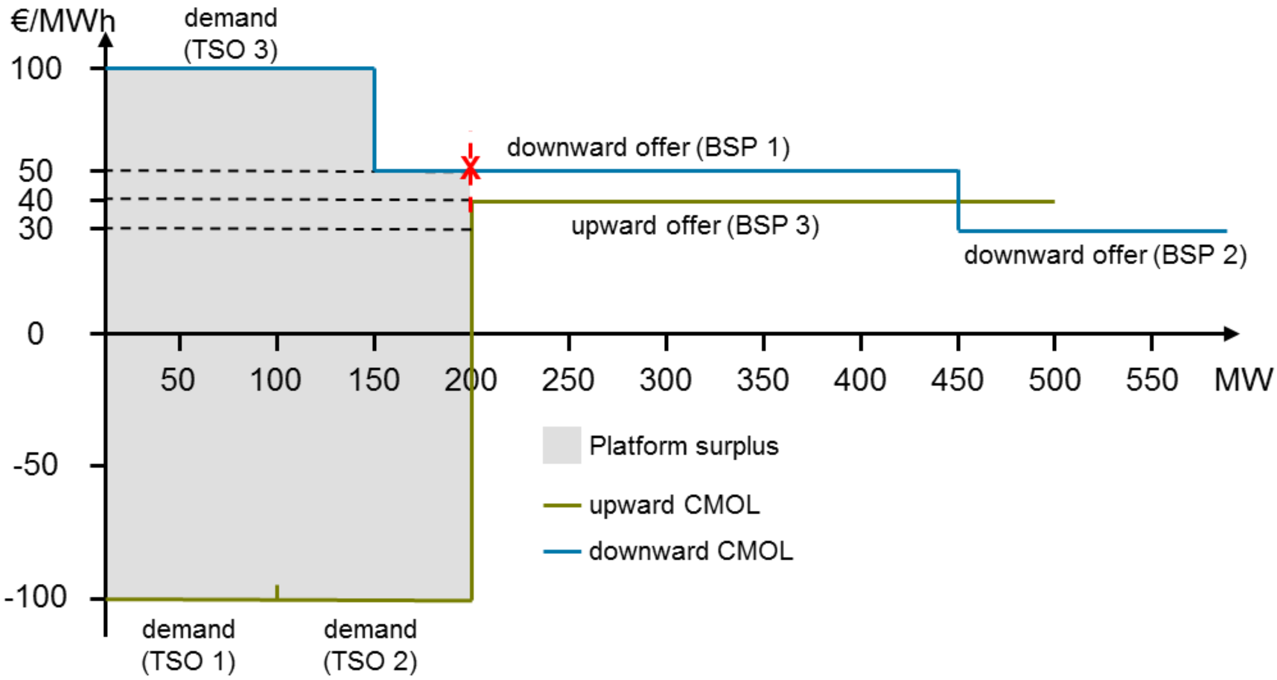

Figure 29: Example of Option 2

5.5.1.3 Option 3: Limiting counter activations to a certain threshold

In this option there is a volume based limitation on the amount of counter activations that can take place. The limit is valid for the entire platform, and is based on the maximum netted demand volume of the whole platform. The result of the example for this option is shown in Figure 30. The netted volume is 150 MW, hence the total counter activation for economic reasons is limited to 150 MW. Volume limit is based on the fact that counter activation would be a part of satisfaction of TSOs' demand. 200 MW of downward offer of BSP 1 are selected for activation. 50 MW of this selection is for covering the remaining aFRR demand and the remaining 150 MW is for counter activation of the 150 MW selection of upward offer of BSP 3.

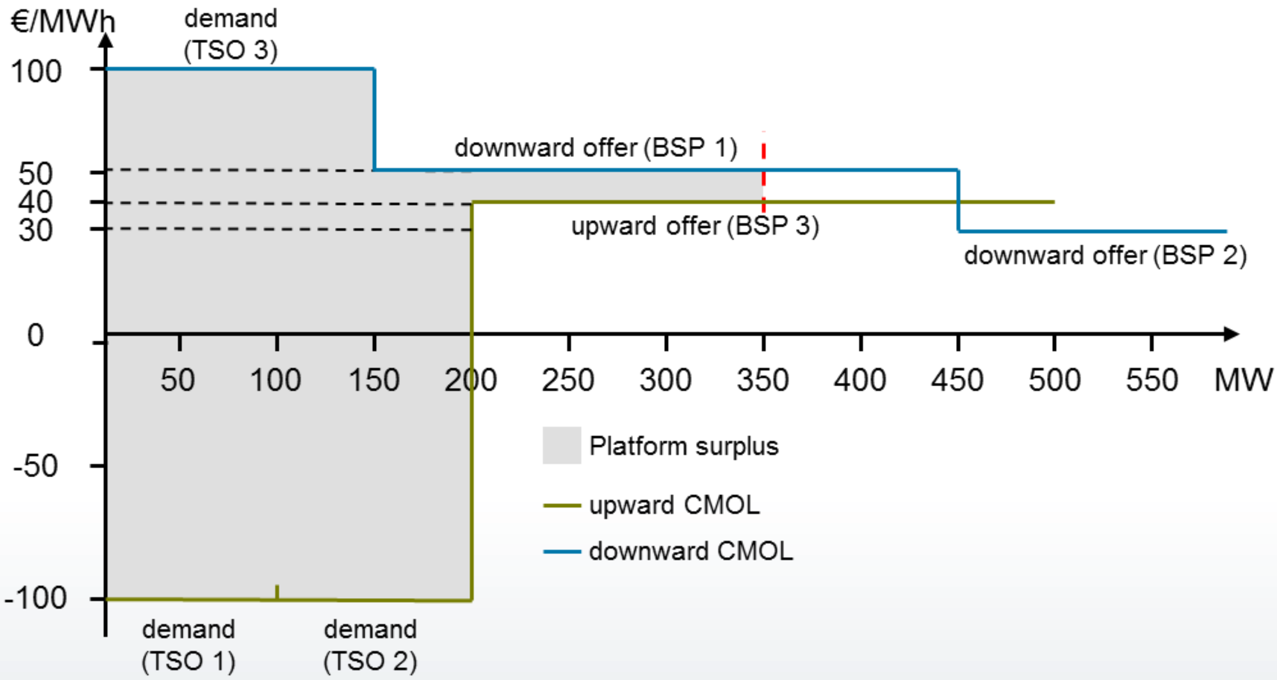

Figure 30: Example of Option 3

The difference between Option 1 and Option 3 depends on the ratio between netted volumes and volumes on the CMOL with reverse pricing. There could be a reduction in the volume of counter activations. However, since in 60 % of the time the netted volumes are expected to be higher than 500 MW, the difference between Option 1 and Option 3 could be quite limited. But, other limitations of counter activations could be defined. Figure 31 shows the ordered amount of netting and their percentage of occurrence for a simulation of one month of Continental Europe.

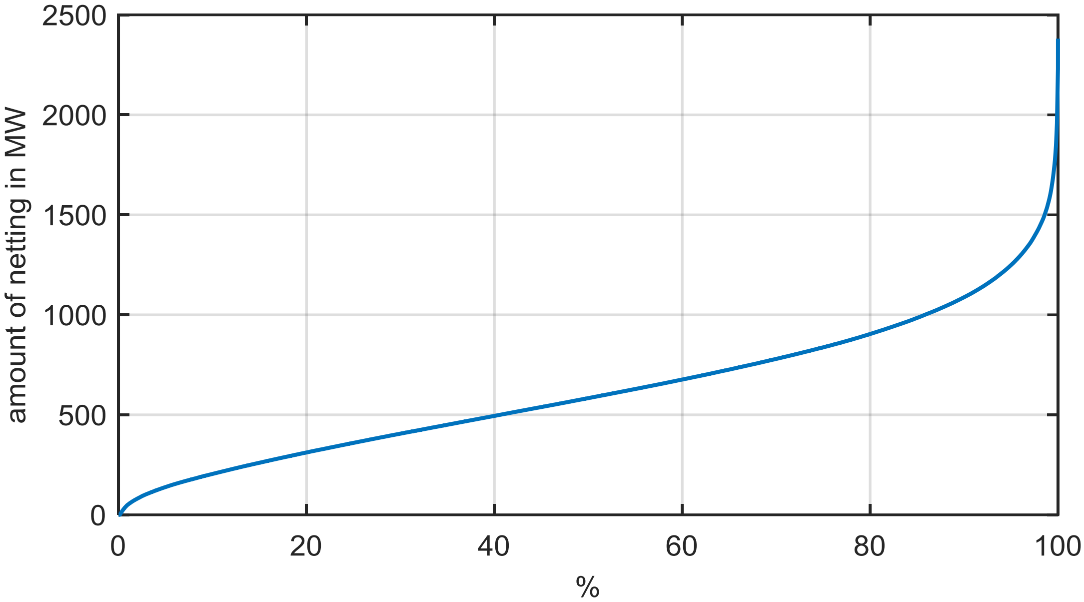

Figure 31: Ordered amount of netting based on simulation of one month for Continental Europe

5.5.2 Market considerations

A single cross border marginal price (XBMP) shall be used for each uncongested area for the activation of bids and implicit netting of demand performed by aFRR-Platform. However, there are two main opposing views regarding balancing and marginal pricing:

- view A: the marginal price is defined for selected activations in both directions for each run of the algorithm or optimisation cycle.
- view B: the netted demand defines the only direction for which a price is determined for each optimisation cycle.

In case of view A the allowance of counter activations (Option 1 and 3) leads to a marginal price as the intersection of the upward and downward MOLs, where the MOLs include the respective demand. In this view, every bid selected for activation in the respective uncongested area has a bid price lower or equal to the corresponding XBMP. In this view, restricting counter activations could lead to situations where the XBMP is higher than a bid price of a bid, which is not selected for activation as it is on the side of MOL where the demand is netted. This is seen as not intuitive and not transparent. The analysis done by N-Side for MARI had the same understanding of view A (one price per algorithm run); this marked option 2 as not transparent and not traceable.

For TSOs with the view B it is clear, that the BSP with the bid of the side of the MOL with the lower demand is not selected for activation as it does not correspond to the side of the netted demand. For this view there is for each optimisation cycle one corresponding XBMP per uncongested area. This XBMP is either valid for positive aFRR or negative aFRR depending if the netted demand is either positive or negative. By this, also solutions of option 2 are seen as intuitive and transparent to market parties.

View B is logically coupled with the option of not allowing counter activations (option 2). Combining view B with any other option naturally leads to view A since the price is defined by bids for both directions.

These main opposing views explain also the further arguments:

5.5.2.1 Pricing

Distribution of TSO surplus

Allowing counter activations could bring the XBMP closer to the middle between upward and downward aFRR demand leading to a better distribution of TSO surplus (note: the TSO surplus reflects the surplus of the TSOs' LFC area). This effect on prices is independent of the final volumes to be activated. Even in cases where counter activations take place within the same LFC area and some bids will finally not be activated, there is still a positive effect on prices that converge close to the middle point between the two directions.

Important note: In the Figure 32 below, the new XBMP is still acceptable by all BSPs as it does not lead to any losses.

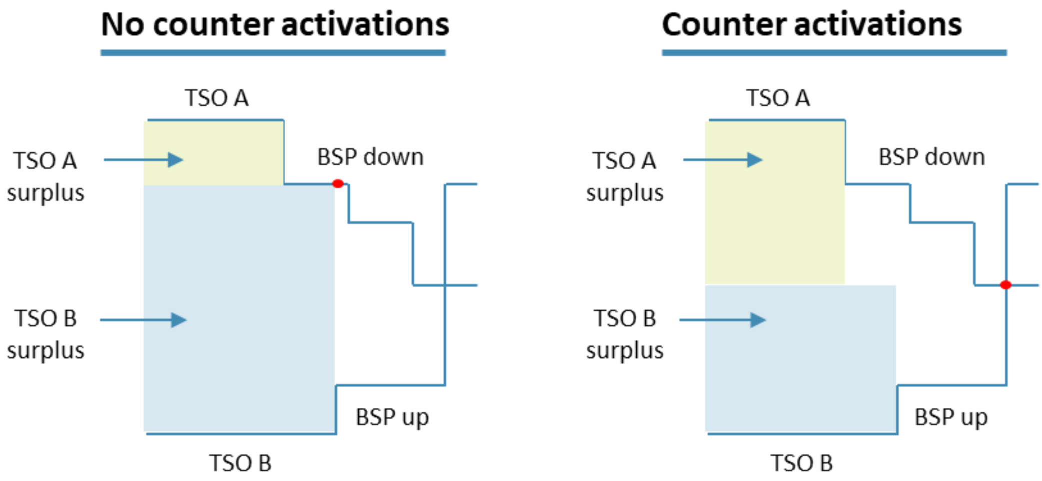

Figure 32: Effect of counter activations on distribution of TSO surplus

Mark-ups

TSOs in favour of options 1 and 3 fear that the non-intuitive rejection of bids with lower price than the marginal price might either lead to mark-ups or reduction of the available volume (a BSP often being rejected although his bids are below the marginal price may decide to offer its volume to other markets instead).

Other TSOs do not share this fear as it is not clear how a BSP could gain anything by putting mark-ups for such cases and by this do not think that not allowing counter activations have an impact on the bidding behaviour of BSPs.

Non-monotonic behaviour of price

TSOs with the view A (described above) are of the opinion that restricting counter activations lead to discontinuity in the correlation between the TSO demands of an uncongested region and the corresponding price. In particular in the moment when the netted demand of the uncongested area changes its sign and by this the marginal price of the uncongested area will result into a "jump" in the price.

These TSOs believe that according to the economic theory increasing the upward TSO demands in one side within the uncongested area (keeping all other constant), the price should be equal or greater. Respectively increasing the downward TSO demands the price should be equal or lower, and by that it reflects the relevant size of needs. When there is no price reversals, i.e. potential for CA, this occurs naturally since the upward CMOL starts at a price higher than the downward CMOL, thus when downward demand is bigger than upward demand the price is equal or lower from the case when the upward demand is bigger that the downward one, i.e. the price changes monotonically.

This is not the case when there is potential for counter activations and this is restricted, since the price has the behaviour described in first paragraph. There could be one small and one large aFRR demand (|upward| < |downward|) and this may lead to a higher marginal price, than the case when the size of demands is opposite (|upward| > |downward|), i.e. non-monotonic behaviour. TSOs with view A consider that by allowing counter activations the price will naturally have a monotonic behaviour as a function of aFRR demand and by that always the resulting price will be reflective of the size of the netted aFRR demand within an uncongested area in a monotonic manner. Please see examples in Annex IV.

TSOs with the view B (described above) are of the opinion that these are two different products and hence, two different prices which could not be compared. Thus, a continuity in the relation of price and imbalance is not deemed necessary.

Additionally, they think that the price reflects always the size of the netted demand and by this gives the right signal.

BSP-to-BSP exchanges

Allowing counter activation may result in BSP bids being selected for activation without (option 1) or with only a weak link to (option 3) TSO demands. This may be seen as a BSP-to-BSP market.

Some TSOs consider allowing counter activation and thus creating a BSP-to-BSP market to be outside of the scope of TSOs. They claim that it is against the original purpose of balancing energy market, which is providing an ancillary service through activating the minimum amount of balancing energy necessary for the efficient elimination of power imbalances.

These TSOs think a BSP-to-BSP market may hinder (development of) parallel markets on a national level such as the imbalance market with freedom of dispatch and intraday markets that are open to all market participants, not just BSPs.

Some TSOs consider these BSP-to-BSP exchanges to be a side-effect of the offered prices of the bids (i.e. the reverse pricing), the realisation of which is seen as necessary to have efficient pricing, see chapter 5.5.2, and additionally such BSP-to-BSP exchanges may allow market participants to correct any (forecasting) errors in previous markets. Some TSOs consider that increased attractiveness of the balancing market (by allowing CA) to BSPs may result into more voluntary volume in real time, which increases operational security. On the long run increased voluntary volume available in real time, might reduce the need for pre-contracted volume of aFRR.

5.5.2.2 Economic efficiency

In case counter activations are allowed, the platform surplus is increased. This surplus is generated by the price difference between the bids for upward and downward activation when the BSP with the upward bid request a lower price for his energy than the BSP with a downward bid is willing to buy back.

In the opposite case, if counter activations are not allowed on the platform, surplus is decreased. The missing surplus will affect the BSPs with bids that are "in the money", but not selected for activation. This will also reduce the socio-economic surplus of the countries that have such bids. It may also affect other parties, depending on cost recovery arrangements in the different countries. One possibility is the imbalance price could be affected, for example in case of a weighted average imbalance price.

TSOs have differing opinions on whether allowing counter activations increases economic efficiency. This is related to a different approach towards what constitutes economic efficiency and how it is measured.

Some TSOs think that by increasing the platform surplus, the economic efficiency is increased. They see the non-matching of bids in the aFRR timeframe as an opportunity loss that could be mitigated by the TSO. They consider that, by enabling the BSPs to shift energy production from expensive to cheaper units by activating bids through the platform according to the BSP pricing choice improves the dispatch of those units. The platform achieves this by having all the information on all the available bids including the available cross-border capacities which is better than each BSP optimizing dispatch within its own portfolio. Their measure for economic efficiency is the platform surplus.

Other TSOs consider that market participants are responsible for ensuring an efficient dispatch and have or should have freedom of dispatch to do so within each bidding zone. These TSOs conclude that when providing proper price signals through the imbalance price, the dispatch cannot be improved through TSO intervention. On each side of the border the dispatch would be optimal on the basis of the current situation. If it were more economically efficient to upward or downward regulate a unit, the market participant would already do so in practice. TSO action can only decrease the economic efficiency. These TSOs consider a smaller activated volume of balancing energy to be a measure of economic efficiency. In the view of these TSOs, the market and TSO are active side by side in real time. It is to be noted that this market for market parties is restricted by grid constraints and adheres to borders of scheduling areas.

Potential negative benefit from the cooperation

In case of no counter activation some countries can have a negative economic benefit from being part of the cooperation.

If two areas have both reverse prices and opposite demands, one of the areas would net the demand with the other area, even if the alternative cost of activation local reserves are lower than the cost of importing netting energy. This can typically happen between areas with congestion and (large) price differences in the energy markets. The flow resulting from the aFRR-Platform would in this case go in the opposite direction of the flow in the energy market.

The project have not quantified this effect, or analysed whether some TSO are systematically exposed to this. We have not analysed whether some TSOs could have an *overall* net loss of taking part in the cooperation.

The project has not planned any compensation for TSOs that have a negative benefit from taking part in the cooperation, but it will be monitored along with other effects of not allowing counter-activations.

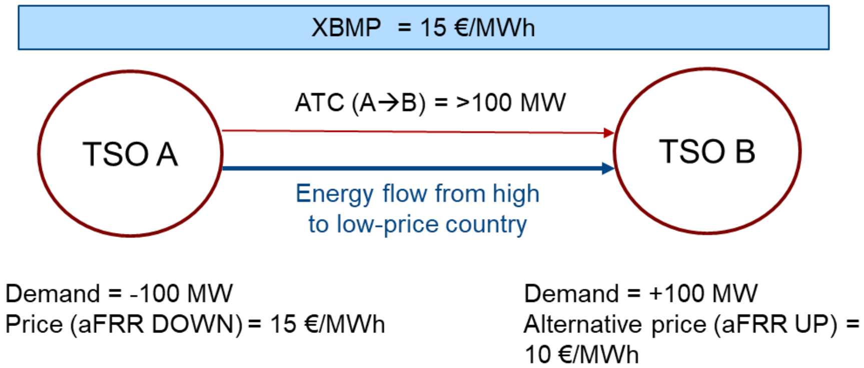

Figure 33: Negative Congestion Example 1

Potential negative congestion rent

In case of no counter activation situations may arise with negative congestion rent. If reverse prices and opposite demands exists, and the resulting netting flow uses all available aFRR cross-border capacity, we will have a situation where energy flows from an area with a higher XBMP to an area with a lower XBMP, and this will generate a negative congestion rent.

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Congestion rent is most often distributed to the TSOs on each side of the congestion[2], and if no additional measures are taken this will be the case also for negative congestion rent.

The project has not quantified this effect, but we do not expect large amounts of negative congestion rent. If you assume a correlation between balancing energy bid prices and DA and ID prices, it is likely that the available ATC in the netting direction will be larger, and this would lead to the situation described in the previous subsection.

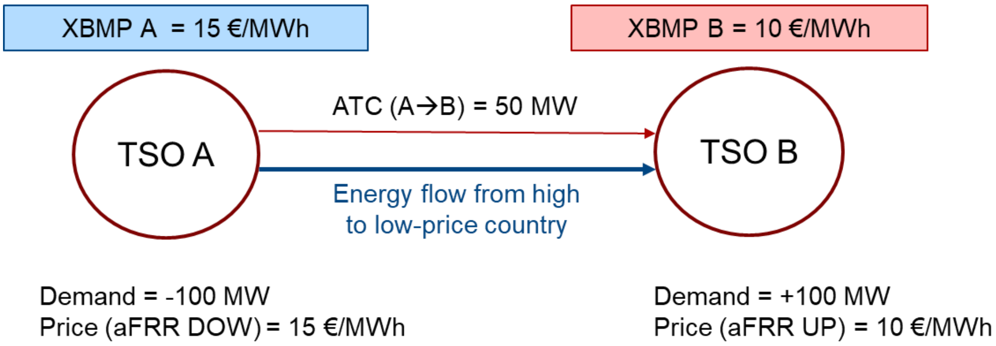

Figure 34: Negative Congestion Example 2

Effect on the imbalance price

The project has not assessed the impact on imbalance price, and it is therefore not discussed in this document.

Efficient use of cross-zonal capacity

Let us consider the following example:

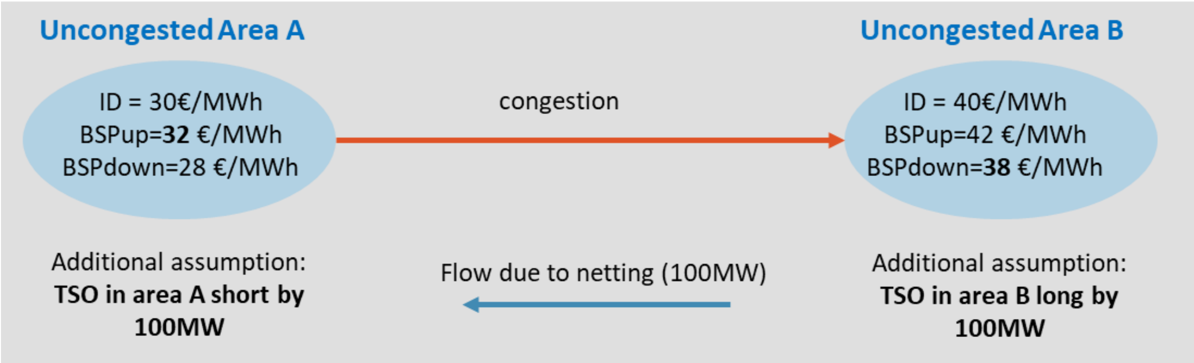

Figure 35: Use of CZC Example.

There was a congestion in the energy market (e.g. ID) that led to different energy prices in the two areas. However, in the balancing timeframe, due to netting of opposite TSO demands, a flow of 100 MW is observed that released the initial congestion. As a result, there is available CZC now even in the direction of the initial congestion.

Additional examples can be found in Annexes III to VI.

Congestions and price differences in previous markets means that the transmission capacity on that connection has a value. This can also be a reason for having reverse pricing in the balancing market since

[2] Congestion rent could also be distributed to other interconnector owners than TSOs.

balancing energy bid prices typically lies around the energy market price (At least for free bids. Pre-contracted bids could have a different pricing behaviour).

If the areas on each side of this connection have opposite demands in the right direction these will be netted if counter activations is not allowed. This will reduce the flow on the previously congested connection, and this scarce transmission capacity will not be used to move as much energy as possible. This is seen by some TSOs as inefficient use of cross-zonal capacity. Allowing counter activations will mean that these areas can regulate themselves in each direction and the flow can be maintained. Other TSOs see this effect as neglectable.

5.5.2.3 Impact on HVDC

Impact on HVDC due to allowing or restricting counter activations was not discussed in PICASSO EG.

5.5.3 Technical considerations

This chapter provides an analysis on the feasibility of the three options as well as an analysis of the impact on complexity and further technical requirements.

5.5.3.1 Feasibility and Complexity

N-side has performed analyses within MARI on the algorithmic complexity of allowing counter activations. The results are not fully applicable to the PICASSO project due to the absence of price elastic demand, indivisible and linked bids. It is therefore difficult to draw any conclusions from the N-side analysis in regards to PICASSO. PICASSO EG considers all three options to be technically feasible as the problem will still remain linear even after adding constrains on counter activations. It is only the performance of the algorithm that may differ.

Due to different possible ways of interaction between the IGCC and aFRR-Platform it cannot clearly stated which option would lead to the most performant solution.

5.5.3.2 Counter activations within LFC area

When reverse pricing takes place on a single LFC areas merit order list, the AOF will still select these bids for counter activations, but this result will not be sent to the LFC area as only one correction value per LFC area is sent. Reverse pricing does occur on some TSOs merit order lists, which can have multiple causes. In such cases the price calculated by the AOF does not reflect the actual activation.

However, since the bids will not be finally activated, it does not have an influence on activated volumes but only on the price determination. The new price will be closer to the middle of the two price curves and is considered by some TSOs to still be acceptable to BSPs.

Some TSOs think this situation is not acceptable, some TSOs see this effect as neglectable as it will only occur rarely and it does not lead to any settlement of non-activated bids.

5.5.3.3 Activation dynamic

There is a mismatch between the outcome of the activation optimisation function (AOF) and the volume that is really activated due the dynamics of the process in the aFRR-Platform. As a result, there is a discrepancy between the settled volume and the activated volumes. In case of allowing counter activations, there will be more volumes activated and as a result, this discrepancy will increase. Increase of the discrepancy could reduce any benefit considered to arise from higher economic surplus.

5.5.3.4 Interactions between IGCC and PICASSO

Interactions between the IN platform and the aFRR-Platform were considered when determining whether or not to allow counter activations. When there is an imbalance netting step before or after a run of the aFRR AOF, there could be an impact on the selected counter activations. When performing netting in the IN platform after the selection of counteractivities, the counter activations could be negated. If counter activation were to be allowed than a mechanism would be required to preserve the economic surplus.

5.5.3.5 PICASSO as imbalance netting function

Article 58.2 of the EBGL describes the imbalance netting algorithm. Here it is stated that "This algorithm shall minimise the counter activation of balancing resources by performing the imbalance netting process (…)". Should the aFRR-Platform perform the imbalance netting function, this article would also apply for the aFRR-Platform.

Interpretations within PICASSO EG differ in regards to the requirements this places on the aFRR-Platform. Some TSOs consider that Art. 58.2 says that counter activations would only be allowed in case of congestions to satisfy local aFRR demand, as the imbalance netting function would be required to "minimise counter activations".

Other TSOs consider the description of imbalance netting in Art. 58.2 differently. The idea of imbalance netting is to reduce the inefficient counter activation of balancing reserves as was the case in Continental Europe before IGCC. These TSOs does not consider Art. 58.2 to be a requirement to mathematically minimize counter activation without regard for economic efficiency. We all agree that counter activation is desirable in case of congestions in the grid to cover the local aFRR demand, and we differ in opinion whether there could be other conditions that would also mean that counter activations are acceptable or desirable.

Some TSOs argue that an interpretation of Art. 58.2 as a strict legal requirement to only do counter activation in case of congestion to cover local aFRR demand is in conflict with other articles. For example Article 29.1 states that "(…) each TSO shall use cost-effective balancing energy bids available for delivery (…)".

The TSOs that interpret the guidelines as a legal requirement that netting should not be prevented disagree with the argument presented in the chapter where counter activations as the prevention of unwanted netting is described as a possible benefit in the chapter 5.5.1.

5.5.4 Conclusion

Considering the differing views of TSOs mainly on the market considerations, the decision not to allow counter activations in the aFRR-Platform is focused on the dynamic effects that could cause counter activations to create additional imbalance. The increased complexity induced in the algorithm if counter activations should be allowed has also played a role in the decision. The effect of not allowing counter activations shall be monitored by TSOs.

5.6 FRCE adjustment process

In the control demand model (see chapter 5.1.1) the TSO-TSO exchange (the aFRR correction signal) is immediate with no ramping time. In practice, there is a delay between the TSO-TSO exchange and the actual delivery by the BSPs, mostly due to its physical ramping but also to the settings of the LFC requesting the activation. The main objective of the FRCE adjustment process is to mitigate the impact of FRCE exchange on local TSO responsibilities.

The aFRR-Platform will include the FRCE adjustment module in order to provide the different processes, aFRR exchanges between countries that are more representative of the physical reality of the BSP delivery. The FRCE adjustment process will however play no role in TSO-BSP settlement nor in bid selection for activation. As explained in chapter 5.4, the selection of bids will be based only on their price, subjected to the availability of cross-border capacity.

5.6.1 FRCE adjustment process objectives

The main objectives this FRCE adjustment process shall fulfil are:

- Maintaining the local responsibility of the TSOs in regards to their own LFC area imbalance volumes and for the dynamic behaviour of their imbalance.
- Aiming at achieving the physical neutrality of the connecting TSO in regards to the dimensioning requirements of each TSO.
- Ensuring that the connecting TSO is responsible in the event of underdelivery compared to the minimum requirements.
- Making FAP data available for monitoring aFRR activations in real time

During the transition period between the go live of the aFRR-Platform and the target for harmonisation of the FAT 5 min of the aFRR standard product in December 2025 the FAP will also be used to guarantee a minimum cross-border delivery corresponding to a FAT of 7.5 min (Chapter 4.1). Until that time, the minimum requirement is set to a fixed value of 7.5 minutes. The minimum requirement of the FRCE adjustment process becomes equal to the FAT once the FAT is harmonised. The difference between the local FAT and the minimum requirement, whether positive or negative, can lead to an increase of FRCE when taking part in the aFRR-Platform in comparison to not taking part. A connecting TSO with a FAT larger than 7.5 minutes will import FRCE from the requesting TSO. A requesting TSO will export FRCE (import aFRR) with a speed corresponding to maximum 7.5 minutes, which might mean a decrease in FRCE quality if local responses would have been quicker.

5.6.2 FRCE adjustment process constraints

The main constraints to be fulfilled by the FRCE adjustment process are:

- To respect the aFRR cross-border capacity constraints
- To respect the sum of all exchanges is always equal to zero

The FRCE adjustment process can be based on an adjustment of the induced FRCE methodology. The concept is further illustrated in Figure 36 and Figure 37. As mentioned in sub-chapter 5.1.1 on the control demand model, the exchange of aFRR demand will be a step function, e.g., in the event of an outage. As effective aFRR delivery follows a certain dynamic, there will be FRCE induced by the aFRR demand exchanges, as illustrated by the orange areas in Figure 36 and Figure 37. The FRCE Adjustment process (FAP) will aim at determining the induced FRCE for each TSO and subtract the impact of the aFRR activation for cross-border purpose. The FAP will integrate the possibility of BSP providing a faster reaction compared to the aFRR FAT. In case of faster reaction than the minimum requirement (see Figure 36), the requesting TSO will benefit from it and obtain a faster correction of its FRCE. In the event of non-compliant delivery due to a slow BSP (slower than the minimal requirement, see Figure 37), the connecting TSO will remain responsible of the under-delivery with respect to the minimum requirement and the requesting TSO will receive a reaction corresponding to the minimum requirement.

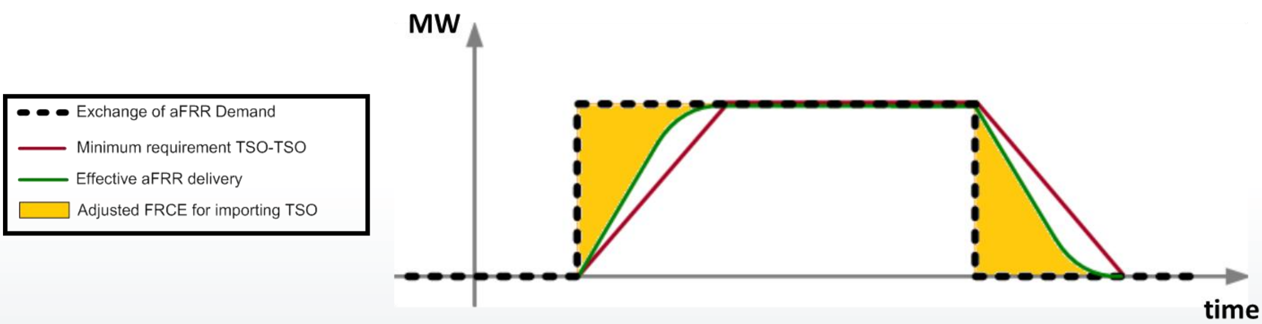

Figure 36: Example for FRCE adjustment volume and TSO-TSO exchange

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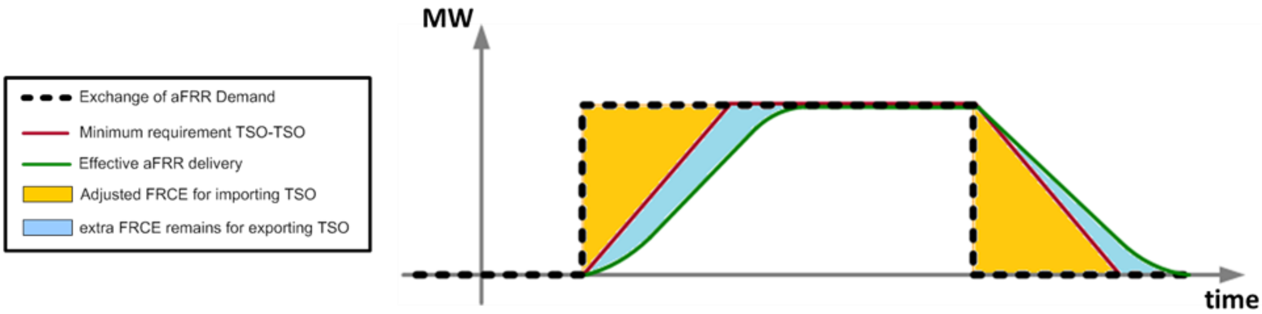

Figure 37: Example of FRCE adjustment volume and TSO-TSO exchange with non-compliant aFRR activation

The FAP will be included in a separate module of the aFRR-Platform that works sequentially after the AOF. Based on the aFRR correction signals for each TSO from the AOF, and the level of aFRR activation provided by each TSO, the module will provide FRCE values for each TSO induced by the aFRR activation for cross-border purposes. The adjusted FRCE reflects the FRCE caused by imbalances in the LFC area, i.e., the increase of FRCE due to the system´s inherent difference between the cross-border aFRR delivery and local activation of BSPs is compliant with the respective FAT and is compensated by the adjustment. The adjusted FRCE will be used for subsequent processes such as evaluation of the fulfilment of FRCE target values in accordance with SOGL, settlement of unintended deviations, dimensioning etc.

5.7 Congestion management and calculation of the aFRR cross-border capacity limits (Article 4 & 11)

This chapter shall explain the relation between the cross-zonal capacities between bidding zones used in earlier timeframes and the aFRR cross-border capacity limits on aFRR balancing borders used in the aFRR AOF. Article 4 of the aFRRIF describes how to find the limits for automatic frequency restoration power interchange between the LFC areas.

Because the aFRR-platform optimizes aFRR cross-border activation between LFC areas, the limits have to be defined for these borders, as explained in more detail in chapter 5.7.1. The borders between LFC areas are defined as *aFRR balancing borders*, and the maximum limit for automatic frequency restoration power interchange is defined as *aFRR cross-border capacity limits*.

Chapter 5.7.2 describes how to find the aFRR cross-border capacity limit following the step-wise procedure in Article 4(2). The chapter 5.7.2 also describes how the aFRR cross-border capacity limits will be adjusted due to exchange of balancing energy from other processes, and the relationship with the usage of aFRR cross-border capacity limits and the imbalance netting platform.

Chapter 5.7.3 describes how the aFRR cross-border capacity limits are used by the AOF.

The congestion management process will consist of the aFRR cross-border capacity limits as well as the marking of bids unavailable as described in Article 9 of the aFRRIF. Sometimes the aFRR cross-border capacity limits will be restricted by other factors such as operational security. This will be explained in Chapters 5.7.4 and 5.7.5.

It should be noted that some countries make use of additional limitations such as for instance technical profiles to determine their available cross-zonal capacities. This means that capacities on several borders might be linked together. It will be addressed briefly in Chapter 5.7.2.1. In the remainder it should be clear that anywhere it reads *border* it could be read as *set of borders*, so as to incorporate these technical profiles.

5.7.1 Cross-zonal capacity and LFC areas

In principle, the balancing platforms, both for exchange of balancing energy and for imbalance netting, make use of all cross-zonal capacity available after the cross-border intraday markets, in accordance with Article 37(2) of the EBGL.

However, the aFRR demand is defined and located per LFC area. For this reason the aFRRIF introduces aFRR balancing borders, which correspond to the borders between participating LFC areas. Often these aFRR balancing borders correspond to the bidding zone borders as well, in which case the aFRR cross-border capacity limits are equal to the cross-zonal capacity on the bidding zone border remaining after intraday, corrected for other processes as described in 5.7.2.

There are two situations in which there can be a difference between the aFRR balancing borders and the bidding zone borders:

- When there are bidding zone borders inside an LFC area, these bidding zone borders do not correspond to an aFRR balancing border.
- When there are LFC area borders within a bidding zone, these are aFRR balancing borders that do not correspond to a bidding zone border.

In case of bidding zone borders inside an LFC area it is not possible to determine how capacity on this bidding zone borders is used due to exchange of balancing energy. The aFRR demand as well as delivery cannot be further specified than the LFC area level. See also the example in 5.7.7.

In the opposite case in which there are aFRR capacity borders inside a bidding zone, the algorithm still takes into account the aFRR cross-border capacity limits on these aFRR balancing borders. For these borders an IT technical limit is defined.

In practice both these situations occur Figure 38**Error! Reference source not found.** summarises the potential configuration cases, illustrating the difference between the different types of borders when it comes to the aFRR cross-border capacity limits.

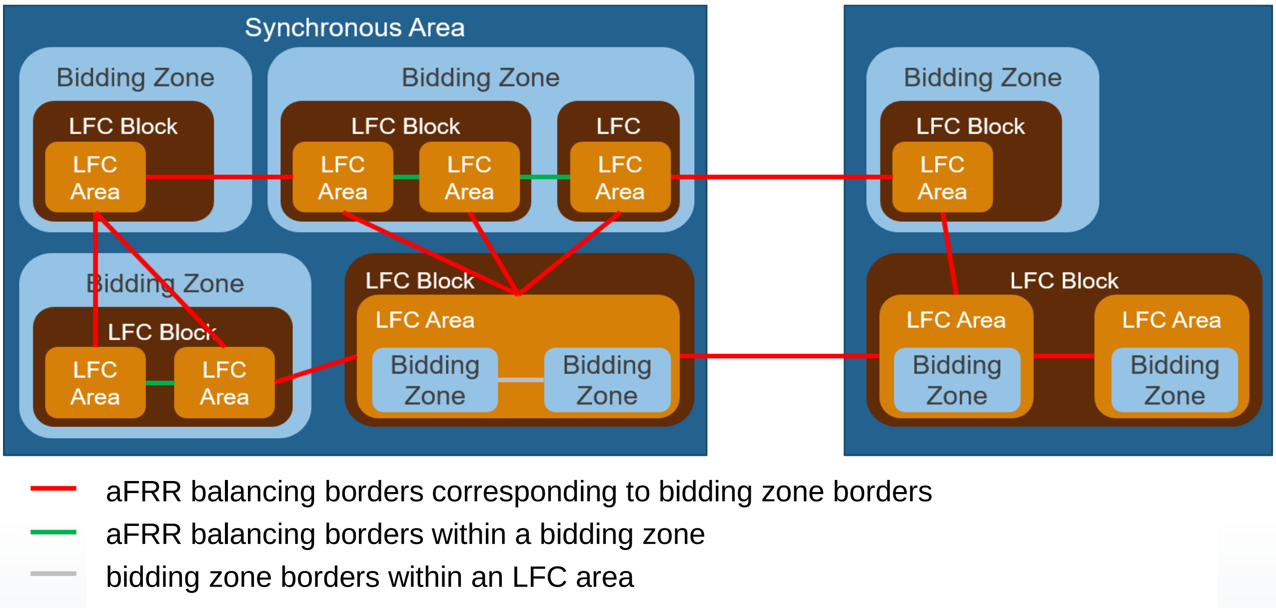

Figure 38: Example LFC structure configuration for participating synchronous areas

These possible configurations include the following:

1. A bidding zone can consist of one LFC block which consists of one LFC area (e.g. France)

2. A bidding zone can consist of one LFC block with more than one LFC areas (Germany after the bidding zone split with AT and neglecting DK1)
3. A bidding zone can consist of more than one LFC block and each of the LFC block can have more than one LFC area (bidding zone of Germany and Austria before the bidding zone split)
4. A LFC block can consist of one LFC area which includes more than one bidding zone (Italy, current Nordic configuration)
5. A LFC block consists of more than one LFC area where each LFC area equals one bidding zone (future Nordic system)

5.7.2 Determination of aFRR cross-border capacity limits

In accordance with Article 4(2) of the aFRRIF, each TSO shall be responsible for determining the aFRR cross-border capacity limits applicable to each of his aFRR balancing borders and providing these limits to the optimisation algorithm. Updated values for aFRR cross-border capacity limits will be provided to the aFRR-Platform in real time on a local control cycle basis. The TSO will do this by following the step-by-step process from Article 4(2) in the IF; First determining the capacity remaining after intraday (Step 1). The TSO then updates the limits for interchange in previous balancing timeframes in line with the first-come-first-serve approach (Step 2), and for any remedial actions that lead to cross-border exchange on the aFRR balancing border (Step 3). Finally, additional limitations may be necessary to be taken into account for operational security reasons (Step 4). The specific situation of capacity on HVDC borders is accounted for in Step 5.

All steps have to be taken but not all of them will lead to a change of the aFRR cross-border capacity limits. The order in which these steps are taken can differ.

5.7.2.1 Step 1: Remaining capacity after intra-day

In the first step the remaining capacity on the borders after the energy markets is determined. How this is done varies for the different types of borders presented in chapter 5.7.1.

If the aFRR balancing border correspond to a bidding zone border, the aFRR cross-border capacity limits are set to be equal to the cross-zonal capacity remaining after the intraday cross-zonal gate closure time in accordance with Article 37(2) of the EBGL. The NTC value, minus the allocation from the day ahead and intraday markets.

For bidding zones which consists of more than one LFC area there are aFRR balancing borders between these LFC areas that do not correspond to a bidding zone border. On these borders there is no cross-zonal capacity defined. The main example of this are the aFRR balancing borders within Germany. In accordance with the zonal model defined by CACM, the available capacity on these internal aFRR balancing borders is assumed to not be limiting the balancing energy exchanges determined by the AOF. For this reason, the aFRR cross-border capacity limits on these borders are set to a value that should not be reached as a result of realistic cross-border exchanges. All member TSOs shall agree on the value of this technical IT limitation.

The last type of border is the result of an LFC area covering several bidding zones. Because the granularity of the aFRR market is the LFC area it is not possible to take the cross-zonal capacities in these borders into account. For the aFRR AOF these borders are not considered, and thus, in practice, considered as infinite.

If a technical profile on the sum of several borders is defined in the intraday market, such limits will also be taken into account in the AOF. These profiles are used in on some borders to limit the sum of cross-border capacity into or out of an area without restricting the individual cross-zonal capacities. Such technical profiles are defined for instance (at least) on the borders out of Poland; from NO2 and NO5 into NO1; and from NO2 and SE3 into DK1.

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5.7.2.2 Step 2: First-come, first-serve

In the second step, the aFRR cross-border capacity limits are updated on the basis of earlier balancing processes in accordance with chapter 2 of the EBGL. This is based on a sequential first-come-first serve approach. That is to say:

- The initial aFRR cross-border capacity limits are corrected for the replacement power interchanges on the aFRR balancing borders. These corrected limits should correspond to the mFRR cross-border capacity limits before any mFRR activation, notwithstanding:
    - any corrections done for purposes of additional limitations in accordance with the next step (reducing limits of both mFRR and aFRR)
    - any corrections done for activated remedial actions (reducing limits of both mFRR and aFRR) in accordance with Article 4(2)(c) of the aFRRIF
    - any allocation of cross-zonal capacity to the aFRR process (reducing limits of mFRR to keep limits for aFRR high enough), as explained below
- The aFRR cross-border capacity limits are also adjusted for mFRR activation, by correcting for the manual frequency restoration power interchanges. This, with the corrections on remedial actions and additional limitation, then defines the aFRR cross-border capacity that are the input to the AOF.
- These aFRR cross-border capacity limits are as input to the AOF used for both aFRR balancing energy exchange and imbalance netting, as described below.

As indicated some cross-zonal capacity may have been allocated to a specific balancing process in accordance with chapter 2 of the EBGL. This allocation is done for the exchange of balancing capacity or sharing of reserves. In case this allocation is done for aFRR, the allocation needs to be taken into account in the distribution of cross-zonal capacity between the platforms, and will be taken into account when applying the first-come-first-serve approach to determine the aFRR cross-border capacity limits. The aFRR cross-border capacity limits should always at least be equal to the allocated cross-zonal capacity for those aFRR balancing borders that correspond to the bidding zone borders on which the allocation for aFRR has been done. This affects the RR and mFRR cross-border capacity limits.

Error! Reference source not found. shows a timeline of the different processes which shows the points of a ttention for the first-come-first serve approach and the distribution of cross-zonal capacity between the platforms in general. Special points of attention for aFRR are the challenging possible overlap between the time in which mFRR can be directly activated, and the time in which aFRR can be activated on the one hand (example – for QH2 the overlap happens from T+15 min to T+17,5 min), and the simultaneous nature of aFRR and IN on the other.

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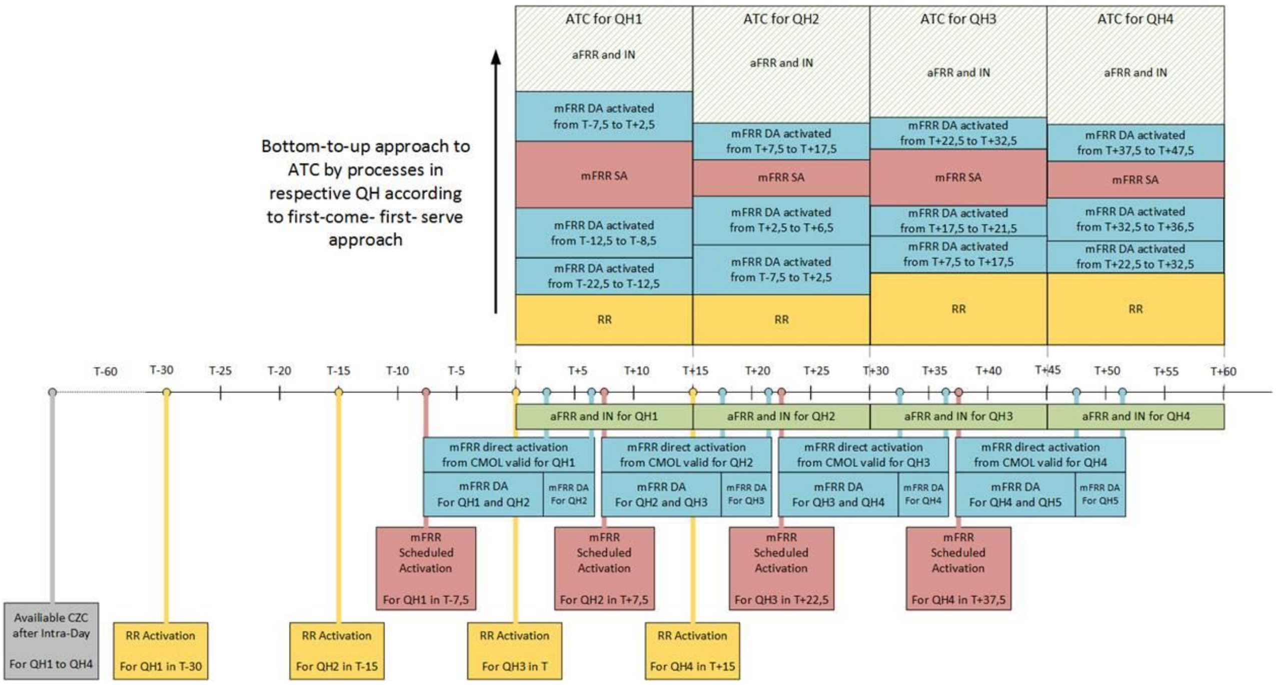

Figure 39: Timeline of activation in platforms with first-come-first-serve approach to capacities

The simultaneous use of aFRR cross-border capacity limits by aFRR and IN is handled by performing both processes on the same IT-platform. As described in chapter 5.45.4, both processes are performed in the same optimization cycle but in separate optimisation steps. The cross-border capacity which is used in the aFRR optimisation step is considered in the subsequent IN optimisation step.

5.7.2.3 Step 3: Updates due to remedial actions

Step 3 of the process presented in aFRRIF Article 4(2) handles the case where the cross-zonal capacities are updated after the intra-day gate closure time. The TSO shall according to the EBGL 37(1) update the available CZC "…every time a portion of cross-zonal capacity has been used or when cross-zonal capacity has been recalculated". Since cross-zonal capacity also can be used for remedial actions, the process for determining the aFRR cross-border capacity limit must take into account that the cross-zonal capacities can be updated after the intra-day gate closure time whenever remedial actions leads to cross-border exchange.

For example, if a desired flow range for system constraint purposes has been requested in either the RR or mFRR balancing platforms, these limitations must be respected by the cross-border capacity limits for the subsequent processes.

5.7.2.4 Step 4: Operational security constraints

The aFRR cross-border capacities can be further restricted by operational security considerations. The aFRR cross-border capacities can be restricted upon request by TSOs participating in the aFRR exchange as well as TSOs that are defined as affected TSOs in accordance with Article 146(3)(c), 147(3)(c), 148 (3)(c), 149(3) and 150(3)(b) of the SOGL. These restrictions can also be applied to aFRR balancing borders that are not bidding zone borders and are therefore usually only limited by IT limitations. Additionally, constraints can be applied through technical profiles that can be defined specifically for the balancing timeframe.

These additional limitations shall be published. If requested by the participating TSOs, the TSO applying these additional limitations will provide a justification. The algorithm is then required to take these adjusted aFRR cross-border capacity limits into account in the optimisation result.

Several situations can make such additional restrictions necessary. Some examples can be:

- An affected TSO can experience flows within its area due to aFRR interchange over another area
- The total exchange in or out of an area can lead to congestions within an LFC area
- Exchange of aFRR between two synchronous systems can lead to frequency deviations. See Chapter 5.8 for more on HVDC.
- An outage or another sudden event in the power system can reduce the available capacity out of an area.

5.7.2.5 Step 5: Technical constraints

Step 5 takes into account that not all aFRR balancing borders consisting of HVDC interconnectors have the technical ability to exchange aFRR, or that the technical ability may be more or less limited. HVDC interconnectors vary in technology and specification, and will have different properties affecting their ability to transfer aFRR interchange.

Some connections might not be available for aFRR at all, while some might have restrictions related to zero-crossings, minimum volumes, maximum ramping rates or other technical restrictions. More information on HVDC can be found in chapter 5.8.

5.7.3 Treatment of aFRR cross-border capacity limits in the AOF

aFRR cross-border capacity limits on all aFRR balancing border will be used as constraints of the objective function of AOF. The AOF will make sure that the cross-border exchange of aFRR resulting from the optimisation does not exceed the aFRR cross-border capacity limits.

If the aFRR cross-border capacity limits does not constrain the optimization the entire PICASSO area will form one uncongested area. On the other hand, if the optimization problem is constrained, several uncongested areas will be defined and separated at the aFRR balancing borders where the congestion occurred. When forming two uncongested areas the power interchange between the areas will always equal the aFRR cross-border capacity limits.

When the AOF form several uncongested areas this will impact the cross-border marginal prices. The regulation will be more expensive in the exporting uncongested area; Generally, for up-regulation the XBMP will be *lower* in the exporting uncongested area, while for down-regulation the XBMP will be *higher* in the exporting area[3].

5.7.4 Internal congestion and unavailable bids

In some areas all bids are not always available for activation depending on the current grid situation. Activation of these bids can cause congestions, voltage problems or other operational security issues within an LFC area. In order to deal with such issues, a participating TSO has the possibility of marking bids unavailable in the common merit order lists in accordance with Article 29(14) of the EBGL. The TSO will assess the bids before the TSO GCT and mark the bids unavailable if necessary. Because it is not possible to predict all situations that can arise before the TSO GCT the TSO can also update the unavailability status of the bids between the BEGCT and the real time.

This is a measure for which no additional mechanism in the algorithm and harmonisation is considered necessary by the TSOs.

The process of marking bids as unavailable is also described in Chapter 4.1

[3] This can be different when reverse pricing occurs (see chapter 5.5)

5.7.5 Other measures for operational security

In addition to restricting the aFRR cross-border capacity limit, it can be beneficial to provide other kinds of limitations. Article 3(4)(e) of the IF describes as an input to the aFRR AOF operational security constraints provided by the participating TSOs or affected TSOs in accordance with Article 146, 147, 148, 149 and 150 of the SOGL.

This can for example be a maximum limit of the net aFRR activation from one LFC area, or other measures that the TSO finds necessary.

5.7.6 Future development

The TSOs shall within five years after entry into force of the EBGL develop a methodology for cross-zonal capacity calculation within the balancing timeframe. Once the methodology pursuant Article 37(3) of the EBGL is approved and implemented, the aFRR cross-border capacity limits shall respect this capacity calculation methodology.

If parts of the whole European intraday market are performed in a flow-based domain, an extraction of available cross-zonal capacity per bidding zone border will be used, comparable to the process between the market coupling in the CWE region and the succeeding intraday market. The part of this available cross-zonal capacity used for the aFRR cross-border activation process will take into account previous balancing processes as described in 5.7.2. In any case, only available cross-zonal capacities will be used for cross-border activation, the transmission reliability margin of TSOs will not be used by the aFRR-Platform.

5.7.7 Example

Consider the configuration as in Figure **40Error! Reference source not found.**, and assume:

- The aFRR demand of LFC Area A is 0 MW and the aFRR demand of LFC area B is 200 MW (upward demand)
- The cheapest bids are located in LFC area A
- There is sufficient CZC between BZ 1 and BZ 2 but only 100 MW of available CZC between BZ 2 and BZ 3

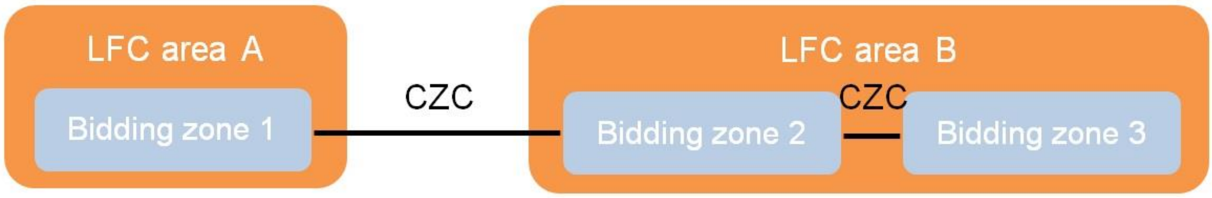

Figure 40: Example configuration of multiple bidding zones in one LFC area

The aFRR demand reflects the real time imbalance of the system in the LFC area. In this case, since the aFRR demand is defined for the complete LFC area B, it is not possible for the AOF to identify which part of the imbalance of LFC area B is located in BZ 2 and in BZ 3. Whatever the actual situation, the AOF will request activation of 200 MW from LFC area A to LFC area B. Then if at least 100 MW of the 200 MW aFRR demand of LFC area B is located in bidding zone 2, the CZC between BZ 2 and BZ 3 will be respected. But if more than 100 MW of aFRR demand of LFC area B is located in BZ 3, the CZC between BZ 2 and 3 will not be respected.

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5.8 Exchange of aFRR energy over HVDC and between synchronous areas

The exchange of aFRR energy between synchronous areas is also covered by the PICASSO project. Exchange between synchronous areas will require flow changes on the HVDC cables connecting the synchronous areas. DC and AC connections behave differently, and some special considerations should be made:

- The exchange profile on HVDC cables- the ramping speed- must be explicitly defined and controlled. This is unlike the exchange on AC lines where the flow is a result of the electrical grid configuration. If the power delivered by the BSPs do not match the power change on the HVDC interconnectors this results in an imbalance in the synchronous area of the connecting TSO and a frequency impact. In order to minimize this frequency impact the aFRR exchange over the HVDC shall be as close as possible to the aFRR delivery of the BSPs within each synchronous areas.
- Even with an appropriately selected ramping speed large changes can lead to impacts on for example frequency, flows or similar that affects the operational security in one or both of the interconnected systems. In order to maintain the operational security (according to Article 31.1. (b) of the EBGL) this could make it necessary to restrict the exchange over a single HVDC interconnector, or on the total exchange on a sum of multiple interconnectors. TSOs are already considering a particular monitoring of aFRR exchange with possible additional overall limits if deemed necessary after further investigations. See also Chapter 5.7.2.5.
- aFRR exchange over an HVDC interconnector requires fast flow changes, and a specialised control interface to the HVDC control systems. The ability of each interconnector to exchange aFRR will vary depending on age, type of HVDC technology and other technical parameters. All interconnectors will not necessarily be able to participate in the aFRR-Platform, and some interconnectors will require technical changes before they can participate. See also Chapter 5.7.2.5.
- Unlike in the energy markets, each optimisation of the AOF is independent of the last and all available aFRR cross-border capacity could be used from one step to the next. To limit too fast changes in the exchange caused by activation of bids a dynamic aFRR cross-border capacity limits could be implemented, however there is no way to limit fast deactivation. This means that if fast, large changes on HVDC interconnectors must be avoided to respect the operational security, the total exchange on an interconnector or the total exchange between two synchronous areas could be limited. An alternative to dynamic aFRR cross-border capacity limits could be to apply an ex-post process that filters the AOF result for these interconnectors. Chapter 5.7.2.4.
- HVDC cables have losses. Depending on the starting flow on the interconnector the aFRR-Platform activation could both increase and decrease the flow; both increase and decrease the losses. PICASSO does not take losses into account. Power changes from the aFRR-Platform will follow the reference point of the interconnector. Power deviations on either side due to losses is not handled by the aFRR-Platform.
- TSOs are investigating whether HVDC within synchronous areas could be considered as normal AC borders within a synchronous area from an FRCE adjustment perspective.

6 Governance of the aFRR-Platform

The EBGL states that the rules shall ensure that no participating TSO benefits from unjustified economic advantages through the participation in the aFRR-Platform (Article 21(3) d). This important point is reiterated in the Implementation Framework. A fair distribution of costs between TSO is in the ultimate issue also a question of level playing field for all participating BSP.

The current chapter describes the governance of the aFRR-Platform as proposed in the aFRRIF in Articles 12-14. This includes the following topics:

- Entities operating the business functions;
- Decision processes;
- Cost-sharing arrangements.

6.1 Entities

Article 21(4) of the EBGL requires the designation of entities to operate the business functions of the platform by all TSOs by six months after the approval of the aFRRIF. This will be done through ENTSO-E.

As the balancing processes are real-time processes that are key to a stable system operation, it is important to keep the responsibility for these processes with the TSO. The aFRR-Platform directly interfaces with the TSO systems operating the load-frequency control and will as such form an integral part of the balancing processes. For this reason the platform functions are required to be operated by TSOs, either directly or indirectly.

The IF is proposing to have one entity, which will be a consortium of TSOs or a company owned by TSOs.

TSOs want to state that even though the different functions have to be carried out by the same entity in the platform, the entity can allocate the provision of services and tasks in connection with the functions to different suppliers or contractors.

Therefore TSOs understand that assigning the functions of the platform to one entity gives the opportunity to investigate and, if proven efficient, to take advantage of synergies between the platforms. This setup apart from being efficient from the scope of each platform allows the mutualisation of tasks or services across the platforms in a flexible way.

This will be the case for a given task (e.g. one or some of the TSO-TSO settlement function tasks) when the entity of every platform is able to allocate this particular task to the same TSO or service provider. This way this task could be mutualised across the platforms.

6.2 Decision processes

The aFRR-Platform distinguishes between member TSOs and participating TSOs. Member TSOs are TSOs, which have joined the platform by signing the cooperation agreement. Participating TSOs are member TSOs, which also use the aFRR-Platform by exchanging aFRR through the aFRR-Platform with other participating TSOs.

The target is that all member TSOs will become participating TSOs by 30 months after approval of aFRRIF at the latest, subject to national derogation. The only exception would be when an LFC area consists of more than one monitoring area. In such case, only the TSO appointed in the LFC area operational agreement as responsible for the implementation and operation of the automatic frequency restoration process according to Article 143(4) of the SOGL shall use the aFRR-Platform, i.e.: become a participating TSO. One example for this specific case is the LFC area of Amprion, which consists of the monitoring area of Amprion and the monitoring area of CREOS (Luxembourg). For this LFC area Amprion is appointed as responsible for the implementation and operation of the automatic frequency restoration process according to Article 143(4) of

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the SOGL. Hence, Amprion and CREOS would become both member TSOs, but only Amprion has to become a participating TSO.

The reason to differentiate between member TSOs and participating TSOs is the following:

(a) The PICASSO project may fulfil the requirements according to the aFRRIF earlier than the deadline of 30 months after the approval of the aFRRIF, which means that the aFRR-Platform will be operational before that deadline. Therefore, some member TSOs may become participating TSOs before the deadline to use the aFRR-Platform, i.e.: 30 months after approval of the aFRRIF.

(b) If necessary, a member TSO may apply for a derogation from using the aFRR-Platform by 30 months after the approval of aFRRIF. Therefore, a member TSO can become a participating TSOs later than the deadline of 30 months after approval of aFRRIF, according to granted derogation.

Member TSOs are bearing the common costs of establishing and amending the platform according to Article 15(4) and 15(8) of the aFRRIF. However, any common operational costs according to Article 15(5) and 15(9) of the aFRRIF are being borne only by the participating TSOs since these are using the aFRR-Platform operationally.

In order to implement and operate the aFRR-Platform, the member TSOs of the PICASSO project are required to make decisions on a wide variety of topics. In doing so, TSOs will aim for unanimity and will focus on good communication and the processes that facilitate that aim. It is important for all concerns to be taken seriously, as local arrangements may differ and the effects of different choices may not be apparent at first.

However, if unanimity is not possible, for example due to conflicting local needs, qualified majority voting will be used. The qualified majority voting principles are modelled after those given in the EBGL, although voting is in principle done by member TSOs. This includes member TSOs who are not participating TSOs. This would also include non-EU TSOs that are member TSOs.

In case of a vote, a quorum of at least two thirds of the TSOs involved in the vote is required. Requiring a quorum ensures that each party is aware of the voting process, and that the argumentation of all parties can be taken into account in a proper way in the decision process.

The decision process described above for member TSOs is without prejudice to the provisions of the EBGL. This means that the decisions on the formal deliverables of the EBGL (such as the decision on the aFRRIF) is taken according to the All TSOs' decision process described in the EBGL. All TSOs of the European Union will then take part, whether or not they are members of the PICASSO project.

6.3 Cost sharing

When sharing the costs of establishing, amending and operating the aFRR-Platform, a distinction is made between:

- common costs;
- regional costs;
- national costs,

Article 15 of the aFRRIF gives a detailed overview of which costs fall under which header. Common costs include the costs for implementation and operation of the aFRR-Platform, while national costs include development of national infrastructure to be able to connect to the platform. Regional costs can also include costs for implementation of the aFRR-Platform, when specific implementation aspects are only relevant for a specific region. It can also cover the costs of regional studies.

Common costs shall always result from a decision of the member TSOs of the aFRR-Platform. Costs made prior to January 2018 shall not be shared or considered as historical costs.

It is important to note that only participating TSOs will take part in sharing the common costs for operating and hosting the aFRR-Platform. Member TSOs that do not use the platform do not contribute to operational costs. Common costs are shared between members TSOs or participating TSOs as relevant in a manner that is consistent with the principles set out in Article 23(3) of the EBGL:

- one eighth of common costs shall be divided equally between each Member State and the third country;
- five eighths of common costs shall be divided proportionally to the consumption of each Member State and the third country; and
- two eighths of common costs shall be divided equally between member TSOs or where applicable participating TSOs.

Sharing of regional costs is decided upon in accordance with the regional decision process described above.

6.4 Stakeholders involvement and publication of information

As it is stated and required by the Article 21(2) of the EBGL, the aFRR-Platform represents a close cooperation between TSOs on the basis of the multilateral TSO-TSO model. However according to Article 12(5) of the EBGL each TSO is responsible and obliged to publish all relevant information listed in Article 12(3) of the EBGL as soon as it becomes available. All TSOs are obliged to publish required information no later than two years after entry into force of the EBGL (18th December 2019) in a commonly agreed harmonised format at least through the information transparency platform established pursuant to Article 3 of Regulation (EU) No 543/2013.

According to Article 12(4) each TSO may, after NRA approval, withhold the publication of information on offered prices and volumes of balancing energy bids if justified for reasons of market abuse concerns and if not detrimental to the effective functioning of the electricity markets.

In this context participating TSOs stated that publication of information is a responsibility of each participating TSO. However, some obligations to publish information required by the Article 12(3) can be delegated to the aFRR-Platform in case that such delegation will be approved by all participating TSOs during the implementation phase. Participating TSO agreed that stakeholders will be informed about all relevant design and implementation phases by organising public workshops, reporting to Balancing Stakeholder Group or conducting public consultations.

In accordance with Article 16 of the aFRRIF a stakeholder survey shall be organised every year, with the first survey occurring during the first operational year of the common aFRR-Platform. TSOs will report on the survey results. The first survey will be organised no later than one year after the aFRR-Platform becomes operational.

Based on the result of these surveys, All TSOs will establish a priority list, specify options for the priority topics identified, and consult upon these options over a two month period. Taking the consultation results into consideration, a common harmonisation proposal including an implementation timeline will be drawn up which is then decided upon by all NRAs (see chapter 4.3).

7 Annex I: aFRRIF mapping

This Annex gives a cross-reference between the articles of the aFRRIF and this document, indicating the chapters where more information can be found.

Article 1 Subject matter and scope	Chapter 1, 2, 3.2
Article 2 Definitions and interpretation	N/A
Article 3 High-level design of the aFRR-Platform	Chapter 5.1, 5.2
Article 4 Calculation of the cross-border capacity limits as input to the optimisation algorithm	Chapter 5.4, 5.7
Article 5 The roadmap and timeline for the implementation of the aFRR-Platform	Chapter 3
Article 6 Functions of the aFRR-Platform	Chapter 5.1, 5.7
Article 7 Definitions of standard aFRR balancing energy product	Chapter 4.1, 5.5
Article 8 Balancing energy gate closure time for the standard aFRR balancing energy product bids	Chapter 4.2
Article 9 TSO energy bid submission gate closure time for the standard aFRR balancing energy product bids	Chapter 4.2
Article 10 Common merit order lists to be organised by the activation optimisation function	Chapter 5.3
Article 11 Description of the optimisation algorithm	Chapter 5.4, 5.5, 5.6
Article 12 Proposal of entities	Chapter 6
Article 13 Governance	Chapter 6
Article 14 Decision-making	Chapter 6
Article 15 Categorisation of costs and detailed principles for sharing the common costs	Chapter 6
Article 16 Framework for harmonisation of terms and conditions related to aFRR-Platform	Chapter 4.3
Article 17 Publication and implementation of the aFRR-Platform	N/A
Article 18 Language	N/A

8 Annex II: Abbreviations

The following abbreviations have been employed in this document.

ACER	Agency for the Cooperation of Energy Regulators
AOF	Activation Optimisation Function
BEGCT	Balancing Energy Gate Closure Time
BRP	Balancing Responsible Party
BSP	Balancing Service Provider
CACM	Capacity Allocation and Congestion Management
CCGT	Combined Cycle Gas Turbine
CDM	Central Dispatching Model
CMOL	Common Merit-Order List
CZC	Cross-Zonal Capacity
DFD	Deterministic Frequency Deviation
EBGL	Guideline on Electricity Balancing
FAT	Full Activation Time
FRCE	Frequency Restoration Control Error
FRP	Frequency Restoration Process
FRR	Frequency Restoration Reserves
SOGL	Guideline on System Operation
HVDC	High Voltage, Direct Current
IGCC	International Grid Control Cooperation
ISP	Imbalance Settlement Period
ISPr	Integrated Scheduling Process
mFRR	Manual Frequency Restoration Reserves
MOL	Merit-Order List
RR	Replacement Reserves
TSO	Transmission System Operator
XBMP	Cross-border Marginal Pricing

9 Annex III: Illustrative example of options for counter activation

Example to illustrate the implication of Option 3 (limitation of counter activation):

- Spain is short (100 MW), Portugal is long (-100 MW)
- Hence, the limit for counter activation volume is 100 MW.
- At the same time in a different part of Europe, e.g. Greece and Bulgaria:
- Price for positive activation in Greece: 100 MW for 30 €/MWh
- Price the TSO receives for negative activation in Bulgaria: -100 MW for 40 €/MWh

The result would be for Option 3 (and Option 1)

- Spain receives 100 MW from Portugal (netting)
- Greece activates 100 MW for 30 €/MWh and exports them to Bulgaria
- Which activates -100 MW for 40 €/MWh.
- Additionally, there could even be an ATC limit of 0 from France to Spain and this would happen anyway.

  From technical perspective this outcome is fine
  From market perspective, different interpretation are possible

- More complex situation might be possible: with Portugal & Spain, France & Germany, etc.

  For Option 2, the result would be:

- Spain receives 100 MW from Portugal (netting) only

Another example to illustrate the implication of Option 2 (no counter activation at all):

- Spain is short (150 MW), Portugal is long (-100 MW)
- Bid price for positive activation in Spain: 150 MW for 30 €/MWh
- Bid price the TSO receives for negative activation in Portugal: -100 MW for 40 €/MWh

The result would be for Option 2

- Spain receives 100 MW from Portugal (netting)
- Spain activates 50MW for 30 €/MWh to cover the remaining demand
- No activation in Portugal.

From technical perspective this outcome is fine, but from a market perspective, the results would not be socio-economically optimal and the pricing results would be:

- Portugal and Spain are netted. 100MW flows from Portugal to Spain.
- Activation in Spain sets the XB marginal price at 30€
- Portugal receives 30€ from Spain – 10€ less than if they had activated their own bids at 40€

In this particular example Portugal alone carries the socio-economic loss. A more complicated pricing scheme or cost sharing could be needed to implement and distribute this loss to all TSOs.

For Option 1 (and Option 3 in this case), the result would be:

- Spain activates 150 MW with bid price 30€/MW
- Portugal activates -100MW with bid price 40€/MW
- Socio-economically optimal solution
- XB marginal price would be dependent on MOL structure and available AFRR cross-border capacity.

10 Annex IV: Example for non-monotonic behaviour of price

In the example below there is potential for counter activations based on the prices of aFRR bids. One can observe that in the scenario that the counter activations are allowed to be materialised, by increasing the upward demand, the marginal price increases monotonically and it actually decreases and then increases, in the scenario that the counter activations are restricted (non-monotonic behaviour of price). This is counterintuitive for TSOs with view A. TSOs with view B argue, that in the first case the price is valid for downward aFRR and in the second case the price is valid for upward aFRR, which are based on different CMOLs and hence do not have to be monotonic.

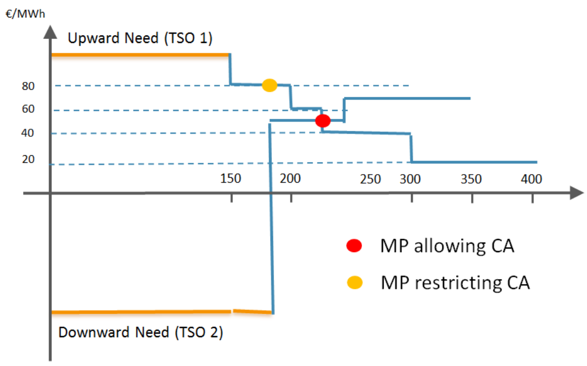

Figure 42: Counter activation example 1a

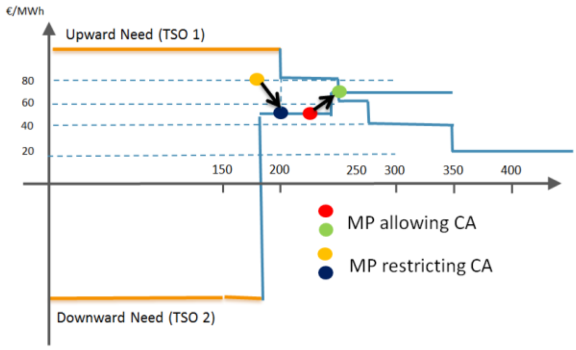

Figure 41: Counter activation example 1b

In case of no price reversals (no potential for CA), the price always increase (or remains the same) with increase of upward demand, i.e. it follows a monotonic behaviour, as it can be seen in the example below.

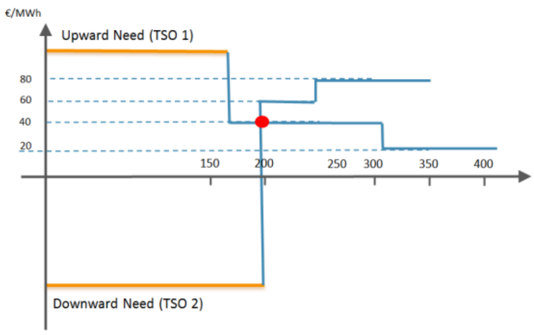

Figure 44: Counter activation example 2a

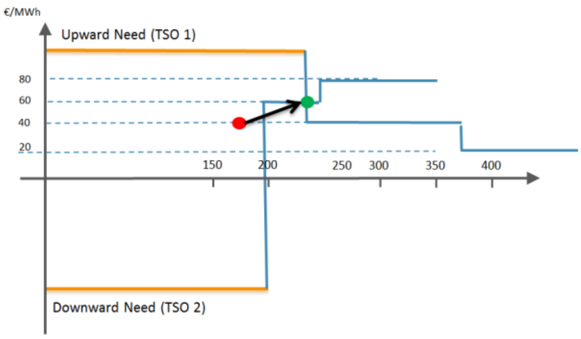

Figure 43: Counter activation example 2b

In the following Figures the price as a function of the netted demand is presented, in the case without CA potential (upper), with CA potential allowed (centre) and restricted (lower):

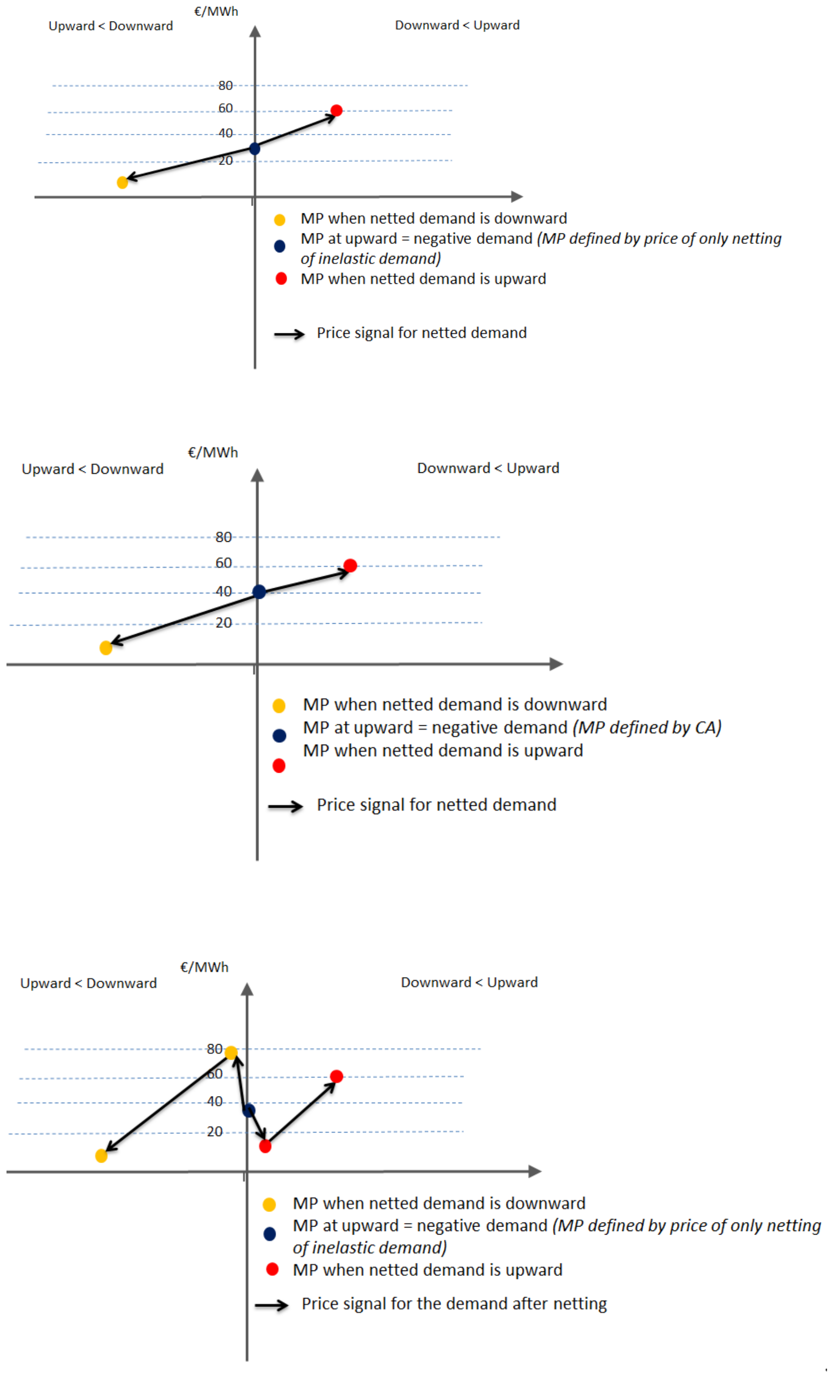

Figure 45: Counter activation example 3

11 Annex V: Reverse pricing between two areas

This example shows the price and flow with and without CA, and with and without congestion.

Area A is a low price area and area B is a high price area. Reverse pricing exist, and this could be because of a congestion on the line between A and B. Prices of CMOLs could also be lower than the ID market, when considering pre-contracted bids.

The example shows that if we allow CA the price will either converge or we will get a congestion also in PICASSO and the two areas will split into two separate uncongested areas with different prices.

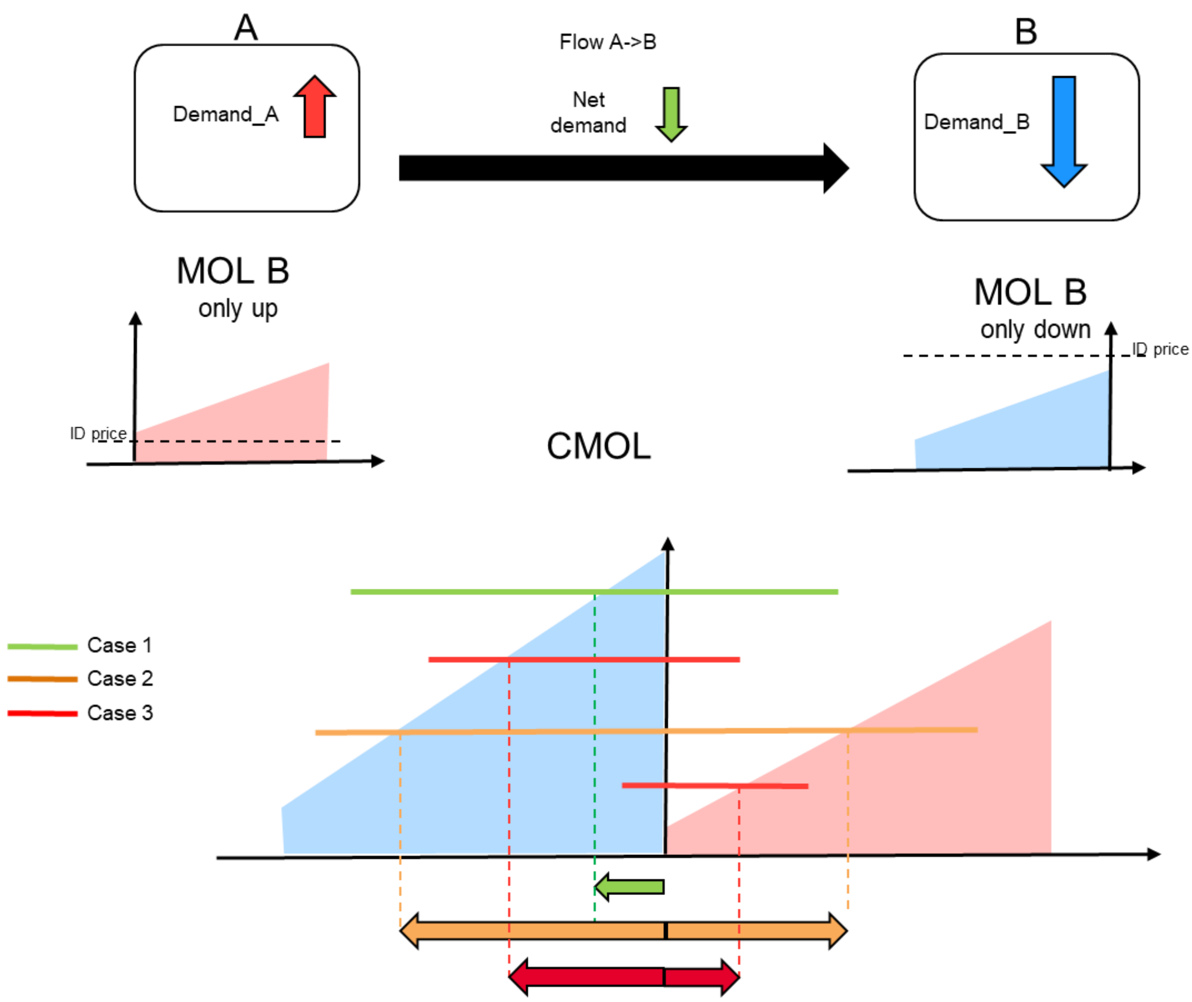

Figure 46: 3 Scenarios of reverse pricing

Case 1 – no CA

- Flow A->B is reduced
- Net volume is activated down in B
- Price for both areas is set by B

Case 2 – CA allowed, available ATC

- Flow increased on A->B
- Activation down in B > *demand_B*
- Activation up in A > *demand A*

- Price convergence of up and down bids

Case 3 – CA allowed, no available ATC

- Flow unchanged on A->B
- Congestion – two separate uncongested areas
- Activation down in B
  = *demand_B*
- Activation up in A
  = *demand_A*

12 Annex 4: Inefficient netting

Example of netting considered by some TSOs to be inefficient.

In this case there is a congestion in earlier time frames that leads to reverse pricing in the balancing markets. This examples assumes there are no pre-contracted bids with prices independent from the ID market.

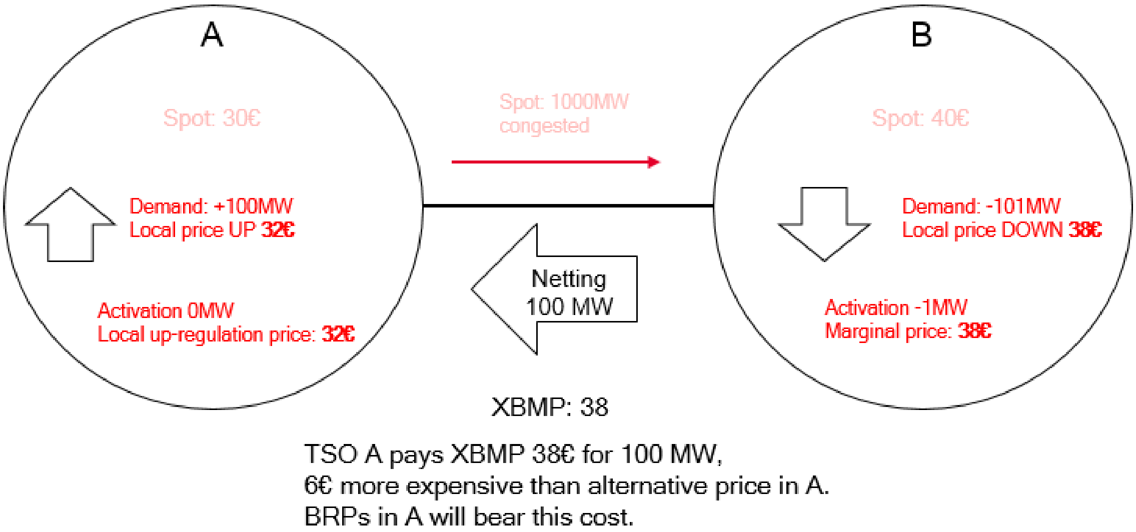

Figure 47: Inefficient netting example