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 manual activation in accordance with Article 20 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 the exchange of balancing energy from frequency restoration reserves with manual activation in accordance with Article 20 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing.

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1. Introduction

This Explanatory Document provides background information and the rationale for choices made in the all TSOs' proposal for the implementation framework for a European platform for the exchange of balancing energy from frequency restoration reserves with manual activation (hereafter referred to as "mFRRIF"), being developed pursuant to Article 20 of Commission Regulation (EU) 2017/2195 establishing a guideline on electricity balancing (hereafter referred to as the "EBGL").

The Explanatory Document has been prepared to support the all TSOs' provision of the mFRRIF taking into account the feedback received from the stakeholders during the MARI stakeholder workshops and consultation, which were held during the last 12 months. Content of this Document

The document describes the overall design of the mFRR Platform which is foreseen to involve a large number of TSOs. MARI would like to stress as a preliminary remark that MARI project participants took as an objective to cope with the necessary requirements of the TSOs foreseen to use the future mFRR Platform while lowering as much as possible its level of complexity.

Chapter 1 gives a general introduction to the EBGL and the mFRR Platform process. Chapter 2 provides a detailed explanation of the mFRR standard product and process timing. Chapter 3 presents details concerning the algorithm optimization function and creation of the common merit order list, covered in Article 10 and 11 of the mFRRIF.

Chapter 4 provides details on the approach to congestion management, part of Article 10 and 11 of the mFRRIF.

Chapter 5 addresses the mFRRIF approach to harmonization of the aspects, which fall under terms and conditions for BSPs responsibility but could have a significant impact on the liquidity of the mFRR Platform.

Finally, in Chapter 7 of the document you can find a list of abbreviations. Annex I: briefly describes the possible approach to settlement. However, the details on settlement will be presented as part of the consultation on pricing and settlement according to Article 30 and 50 of the EBGL.

1.1. EBGL and the mFRR process

The main purpose of the EBGL is to integrate the markets for balancing services, and by doing so enhance the operational security and the efficiency of the European balancing system. The integration should be done so that it avoids undue market distortion. In other words, it is important to focus on establishing a level playing field. This requires a certain level of harmonization in both technical requirements and market rules. To provide this level of harmonization, the EBGL sets out certain requirements for the integration of the mFRR 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.

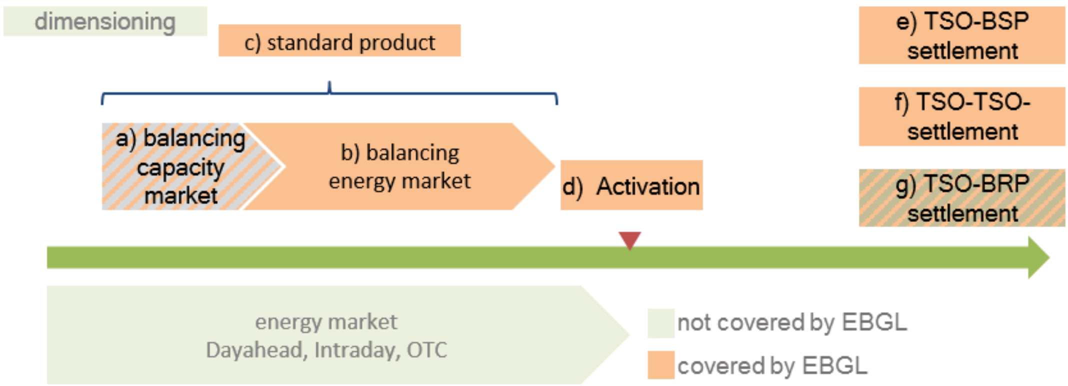

Figure 1: Scope of the EBGL

1.2. Platform Background Introduction

The development of the mFRR Platform is organised via the implementation project MARI (see figure 2 for the overview of the involved countries), where technical details, common governance principles, and business processes are developed by the involved TSOs in the project. Furthermore, MARI shall implement and make operational the European platform, where all standard mFRR balancing energy product bids shall be submitted and the exchange of balancing energy from mFRR shall be performed.

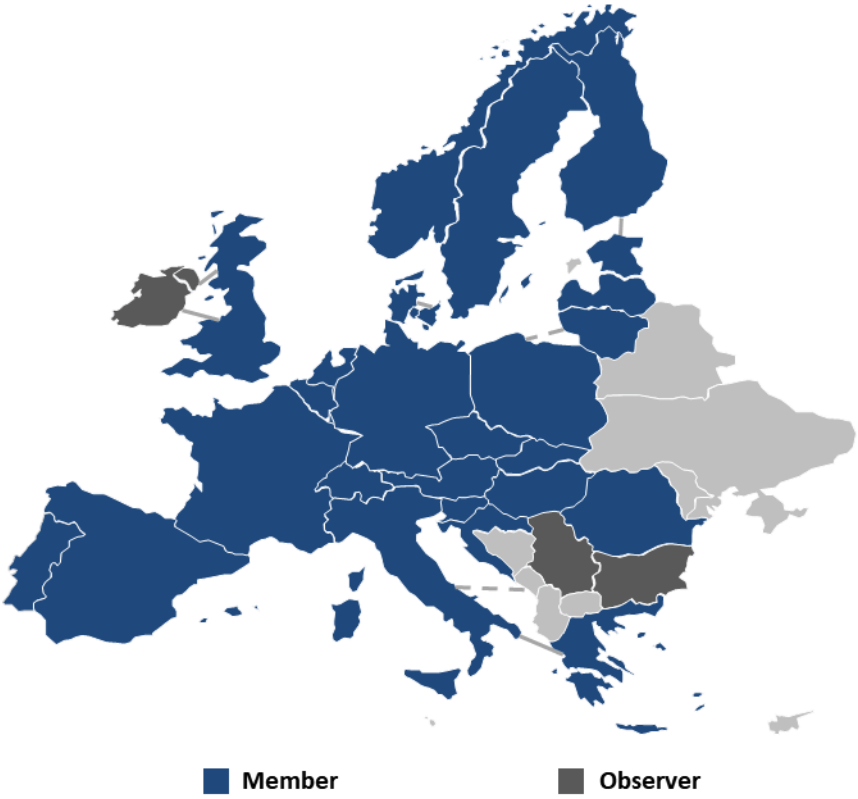

Figure 2: Overview of Members and Observers as of 18.12.2018

All participating and member TSOs developed through ENTSO-E and in close coordination with MARI the proposal for the mFRRIF. Analysis and discussions within the MARI project as well as stakeholders' input gathered by the project served as inputs to ENTSO-E. Topics with relevance for other implementation projects such as TERRE (RR), PICASSO (aFRR) and IGCC (IN) are coordinated by ENTSO-E via dedicated working groups.

The timeline for implementation is mostly described by the requirements in the EBGL Article 20 (4), (5) and (6). These indicate that full operation of the platform is expected 30 months after the approval of the mFRRIF. To achieve this target six months after the approval of the mFRRIF the entity that will operate the platform shall be designated. As experience during implementation of the mFRR Platform may necessitate change, EBGL governs the process for any future amendments of the mFRRIF.

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

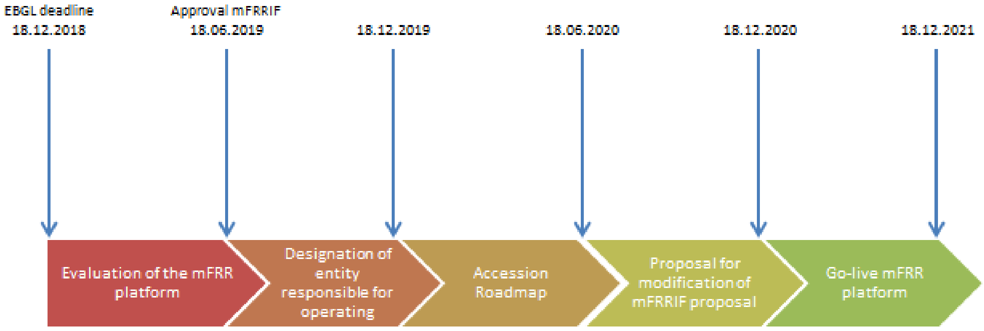

Figure 3: High-level Implementation of the mFRR Platform according to the EBGL

1.3. mFRR Process in the Context of TSOs Balancing Strategy

European TSOs use different processes to restore their frequency:

1. automatic frequency restoration reserves (aFRR);
2. manual frequency restoration reserves (mFRR).

aFRR is activated automatically and in a continuous manner. It is by its nature more deeply integrated with the TSO systems. mFRR is activated manually in both a discrete and “close to” continuous manner by TSOs. For this reason, it is foreseen to allow direct and scheduled activations in the mFRR Platform. Further details and reasons why both direct and scheduled activations are needed are given in Chapter 2.5.

In theory TSOs can be categorized as proactive and reactive based on the extent to which they forecast the imbalance. As a consequence, the TSOs use the different processes to either solve a forecasted imbalance or solve imbalances in real-time. This impacts how mFRR (including the use of direct and scheduled activations) and aFRR reserves are used.

1.4. General mFRR Process

Figure 4 below explains the general process as foreseen for the mFRR Platform:

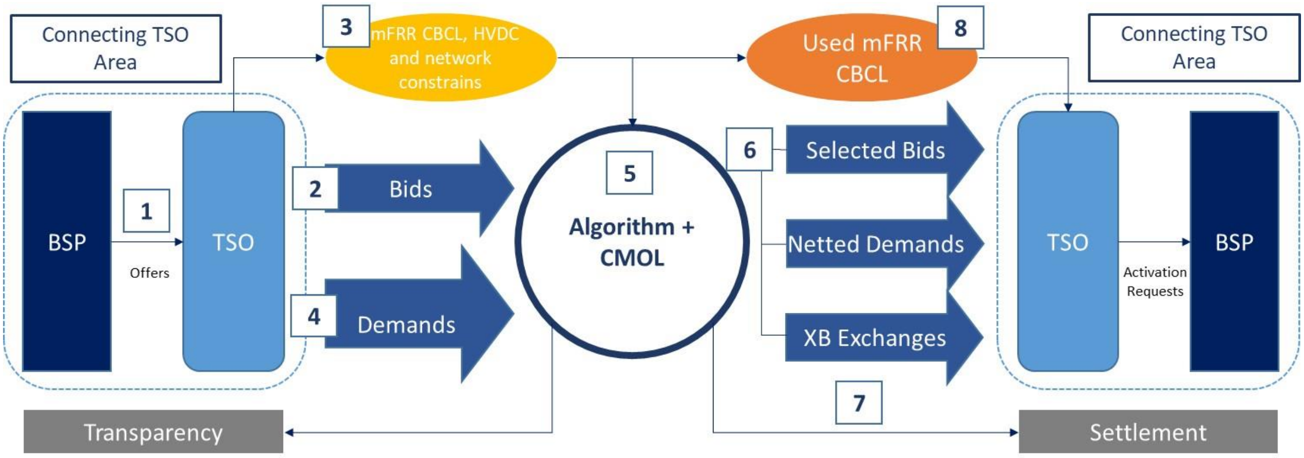

Figure 4: General Process of mFRR Activation

Legend:

1. TSOs receive bids from BSPs in their imbalance area
2. TSOs forward standard mFRR balancing energy product bids to the mFRR Platform
3. TSOs communicate the available mFRR cross border capacity limits (CBCL) and any other relevant network constraints as well HVDC constraints
4. TSOs communicate their mFRR balancing energy demands
5. Optimization of the clearing of mFRR balancing energy demands against BSPs' bids
6. Communication of the accepted bids, satisfied demands and prices to the local TSOs as well as the resulting CB schedules
7. Calculation of the commercial flows between imbalance areas and settlement of the expenditure and revenues between TSOs
8. Remaining mFRR CBCL are sent to the TSOs

2. Product and Process

2.1. Standard Product

The standard product of the mFRR Platform is defined by the standard bid characteristics, the variable bid characteristics and the bid characteristics defined in the terms and conditions for BSPs as defined in Article 7 of the mFRRIF.

The details of those characteristics are described in Chapter 2.2 and in Chapter 2.3. Given the variety of intrinsic differences between local markets, TSOs management of the system, and pre-qualification requirements defined in the terms and conditions for BSPs, bid characteristics defined in the terms and conditions for BSPs cannot easily be harmonized across Europe at this moment and will therefore be left at the discretion of the terms and conditions for BSPs.

However, regardless of the BSP bid characteristics accepted locally, the product exchanged between the TSOs through the mFRR Platform will always have the same characteristics and is referred to as the '*TSO-TSO exchanged shape*'.

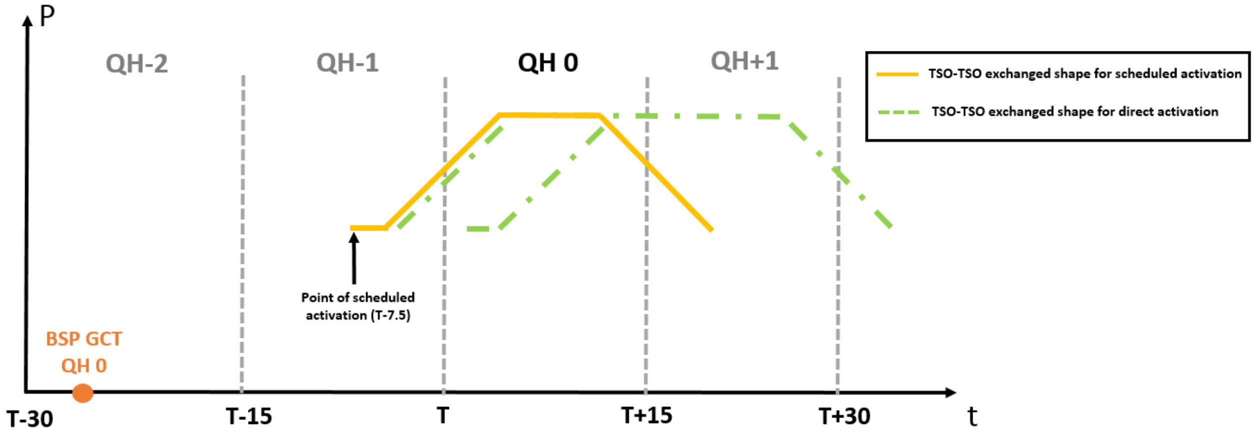

Figure 5: Illustration of the Shape of the Cross-border Exchange for a Schedule Activation and Various Direct Activations

The TSO-TSO exchanged shape refers to how the changes in physical flows resulting from activations of the Platform are realized. The TSO-TSO exchanged shape is defined according to the standard product characteristics.

Currently, the TSOs foresee using a linear ramp of 10 minutes for the cross-border exchange. A 10 minute ramp equals the ramp which is already in use for scheduled programs of exchange across Continental Europe. An infinite ramp would not be possible, as there are limits to how quickly the flow can be changed between synchronous areas without risking reduced operational security and voltage problems. It is assumed that following a 10 minute ramp is more realistic for most BSPs.

The '*BSP-TSO delivered shape*' refers to the actual delivery/withdrawal of certain units. Deviations between the TSO-TSO exchanged shape and BSP-TSO delivered shape will lead to imbalances in the connecting TSOs imbalance area. Each TSO has the opportunity to define certain product characteristics in the terms and conditions for BSPs, as listed in Chapter 2.3, in order to incentivize BSPs to follow the TSO-TSO exchanged shape or to incentivize BSPs to react faster.

2.2. Standard mFRR Product Bid Characteristics and Variable Characteristics of the Standard mFRR Product

The standard mFRR product bid characteristics and the variable characteristics of the standard mFRR product, as described in Article 7(1) and Article 7(2)(a) of the mFRRIF, list the bid characteristics which have to be provided in each mFRR bid[1] by the BSP.

- Mode of activation

  'Mode of activation' means the implementation of activation of balancing energy bids, manual or automatic, depending on whether balancing energy is triggered manually by an operator or automatically in a closed-loop manner.

This Explanatory Document and the related IF refer only to the manually activated product.

- Activation type

  Bids have two activations types:

  - '*Scheduled only*' means bids which can only be activated at the point of scheduled activation;
  - '*Direct*' means bids that can be activated at the point of scheduled activation and anytime during the 15 minutes after the point of scheduled activation.

- Full activation time – (element 3 in Figure 6 and Figure 7)

  'Full activation time' means the period between the activation request by the connecting TSO in case of TSO-TSO model or by the contracting TSO in case of TSO-BSP model and the corresponding full delivery of requested MW power of the concerned balancing energy bid.

  Full activation time is set at maximum 12.5 minutes.

- Minimum and maximum quantity

  The term '*quantity*' refers to the change of power output (in MW) which is offered in a bid by the BSP and which will be reached by the end of the full activation time.

  For the standard mFRR balancing energy product, TSOs propose a minimum quantity for balancing energy bids of 1 MW. This is a result of consensus between TSOs, who want the minimum quantity to be large enough to carry out their work in good conditions, and BSPs, who want the minimum quantity to be small enough to facilitate their participation.

  TSOs propose a maximum quantity for standard mFRR balancing energy product bids of 9999 MW. This ceiling is mainly justified by IT factors.

[1] TSO applying a central dispatching model will convert the integrated scheduling process bids received from BSPs, pursuant to Article 27 of the EBGL, into standard mFRR balancing energy product bids and then submit the standard mFRR balancing energy product bids to the mFRR Platform, taking into account operational security of the power system.

- Activation granularity

  'Activation granularity' means the smallest activation increment in volume of a standard mFRR balancing energy product divisible bid.

- Bid granularity

  '*Bid granularity*' means the rounding off that is to be applied to bids' volume. Bid granularity for bids is set at 1 MW.

- Minimum duration of delivery period – (element 4 in Figure 6 and Figure 7)

  'Delivery period' means the period of time during which the BSP delivers the full requested change of power in-feed to/withdrawal from the system.

  The mFRRIF defines the minimum duration of delivery period at 5 minutes.

- Validity period

  'Validity period' means the period when the balancing energy bid offered by the BSP can be activated, where all the characteristics of the product are respected. The validity period is defined by a start time and an end time;

  More precisely, it means the time period for which a balancing energy bid submitted by a balancing service provider can be activated:

  - for a schedule activation this is a single fixed point in time for each quarter hour, known as the '*point of schedule activation*';
  - for a direct activation this is a period of time between two points of schedule activation.

  Stakeholders should be aware that it is possible for a direct activatable bid submitted for a specific quarter hour to deliver outside of that quarter hour (i.e. the subsequent quarter hour). A probable consequence is that BSPs will have to carefully consider in which quarter hours they can safely bid (see also technical linking in Subchapter 2.7.2). It has to be noted that for this reason, it is not possible that the validity period for the mFRR is strictly equal to the intraday market time unit (MTU).

  For a directly activatable bid submitted for QH 0, where T is the start of QH 0:

  - the earliest point of direct activation is T-7.5;
  - the latest point of direct activation is T+7.5.

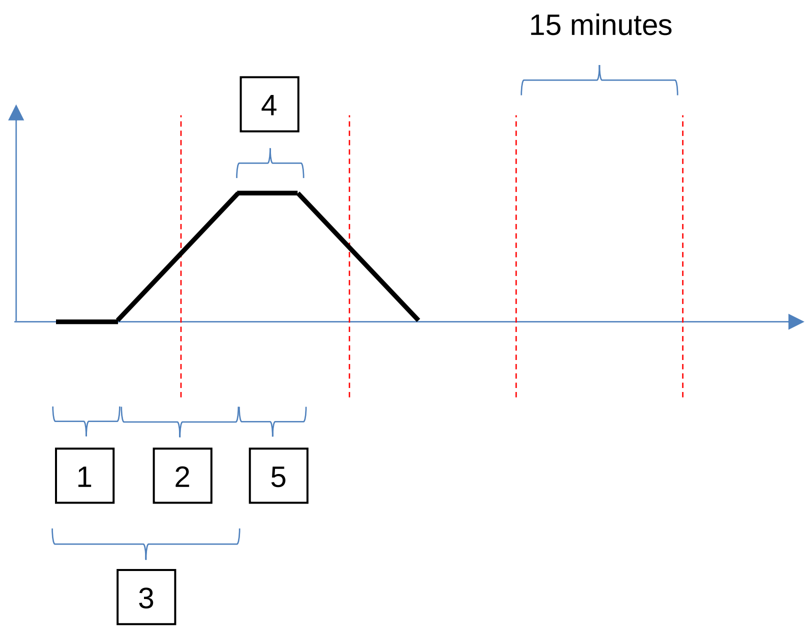

Figure 6: Example of a Possible Shape of the mFRR Scheduled Product

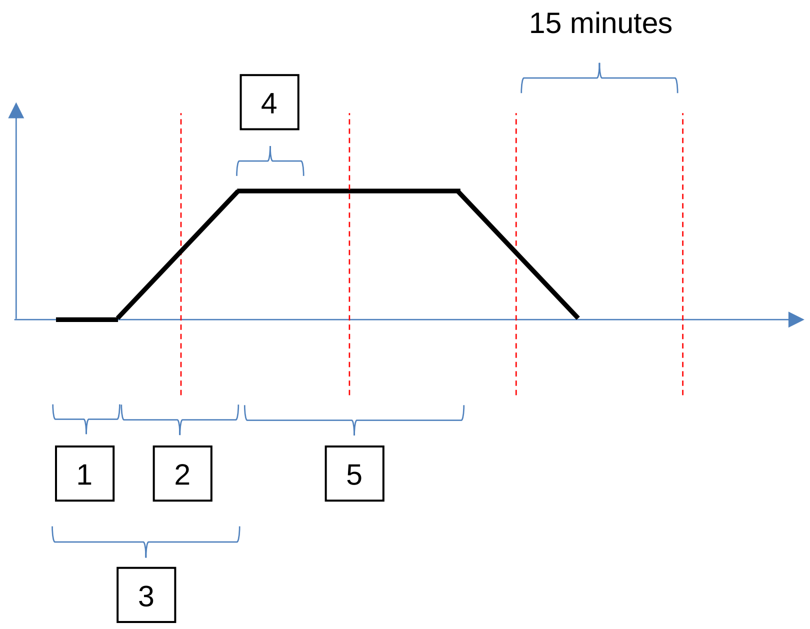

Figure 7: Example of a Possible Shape of the Longest Direct Activation of mFRR

- Price and price resolution

  All bids submitted by BSPs shall be priced in €/MWh with a minimum price resolution of 0.01 €/MWh.

- Location

  When submitting a bid BSPs shall indicate the location of this bid. If a LFC area consists of several bidding zones, then the location of the bid shall be provided per bidding zone. If a bidding zone consists of several LFC area, then the location of the bid shall be provided per LFC area.

- Bid Divisibility

  BSPs are allowed submit divisible bids as well as indivisible bids.
  Divisible bids will have an activation granularity of 1 MW. This means that the activation of a divisible bid will always lead to a non-decimal number in terms of activated volume.
  Indivisible bids with no limitation in terms of volume will be allowed as far as this is compliant with terms and conditions for BSPs as further detailed in Chapter 2.3.
  In order to promote flexibility and to incentivize the submission of divisible bids as well as indivisible bids with a small amount in terms of maximum size in MW, TSOs foresee not allowing unforeseeably rejected divisible bids. Indeed, bidding indivisible bids with a small volume will decrease the probability to be rejected by the AOF in the clearing process.

- Technical links and Economic links are exhaustively explained in Chapter 2.7.

2.3. Bid Characteristics defined in the terms and conditions for BSPs

mFRR Product Bid characteristics defined in the terms and conditions for BSPs are bids characteristics that shall remain under terms and conditions for BSPs. In order to take into account the intrinsic differences between the local markets, the TSOs' management of electric network (for e.g. central dispatching and self-dispatching TSOs, electric systems with low inertia and other with robust inertia, proactive and reactive TSOs, unit based bidding and portfolio bidding etc.) and the different BSPs' pre-qualification requirements in each country, all TSOs have unanimously decided to define some product bid characteristics in the terms and conditions for BSPs, at least at this stage. This is foreseen so as to ensure TSOs to securely manage the system while guaranteeing at the same time liquidity for the mFRR Platform. However, it should be clear that when specifying the bid characteristics defined in the terms and conditions for BSPs for the mFRR bid product, TSOs strived to ensure an adequate level-playing field for BSPs, limiting where applicable these defined bid characteristics defined in the terms and conditions for BSPs and pushing harmonization as much as possible. In other words, when drafting this proposal, TSOs tried to ensure a sufficient and efficient standardisation so as to promote the cross-border competition among BSPs and to facilitate demand facility owners, renewable energy sources and storage units.

Below a list of the mFRR product bid characteristics defined in the terms and conditions for BSPs that shall remain under terms and conditions for BSPs responsibility:

- Location

  As stated in Chapter 2.2 when submitting a bid BSPs shall indicate the location of this bid (the smallest between the LFC area or the bidding zone). However, some TSOs may require more detailed locational information pursuant to terms and conditions for BSPs in order to safely manage the system (for e.g. this information might be needed for solving congestions by filtering bids located in a congested location).

- Preparation period – (element 1 in Figure 6 and Figure 7)

  'preparation period' means the period between the activation request by the connecting TSO in case of TSO-TSO model or by the contracting TSO in case of TSO-BSP model and the start of the ramping period;

- Ramping period – (element 2 in Figure 6 and Figure 7)

  'ramping period' means a period of time defined by a fixed starting point and a length of time during which the input and/or output of active power will be increased or decreased;

- Deactivation period

  'deactivation period' means the period for ramping from full delivery to a set point, or from full withdrawal back to a set point;

  The deactivation period will start after notification of the scheduled auction results for the next quarter hour (QH+1) to the activated BSP taking place at T+7.5. This will allow the BSPs not to deactivate if they are selected again for delivery in the next quarter.

  For the direct activation, the deactivation will occur around the end of QH+1 regardless of when the activation was initiated. Where T is the start of QH 0; the QH for which the bid was placed.

- Maximum duration of delivery period – (element 5 in Figure 6 and Figure 7)

  'delivery period' means the period of time during which the BSP delivers the full requested change of power in-feed to/withdrawal from the system.

  As stated in the previous chapter, the proposal for the mFRRIF defines a standardised minimum duration of delivery period. However, there are no harmonized conditions set for the maximum duration of the delivery period in the proposal for mFRRIF due to the non-harmonisation of the preparation period, ramping period and the deactivation period.

The preparation period, ramping period, deactivation period and the maximum duration of the delivery period depend on the tolerated deviation between the TSO-TSO exchanged shape (yellow trapezoidal shape in Figure 8) and the BSP-TSO delivered shape, which is defined individually by each TSO in accordance with their terms and conditions for BSPs. Indeed, some TSOs might have wider tolerances on the deviation between the TSO-TSO exchanged shape and the BSP-TSO delivered shape so as to allow and incentivize a prompt reaction of the BSPs. Other TSOs might have stricter tolerances on the deviation between the TSO-TSO exchanged shape and the BSP-TSO delivered shape in order to limit and contain as much as possible the imbalances that occur when the two shapes diverge too much.

Those differences between TSOs are inherent to the current local markets situations and balancing strategies including but not limited to the difference in energy mixes (an hydro power plant has different ramp rate as a gas or coal power plant or demand response) and especially the level of penetration of each type of balancing unit in the mix; the possibility to bid portfolio or only unit based (unit based bidding closely links the delivery profile from a BSP to the technical limits of the balancing unit which cannot necessarily cope with a strict/harmonised preparation, ramping, maximum delivery period or deactivation period).

On the other hand, in order to ensure a level-playing field in Article 7(1) and Article 7(2) of this proposal, TSOs have set the boundaries where these differences should be contained.

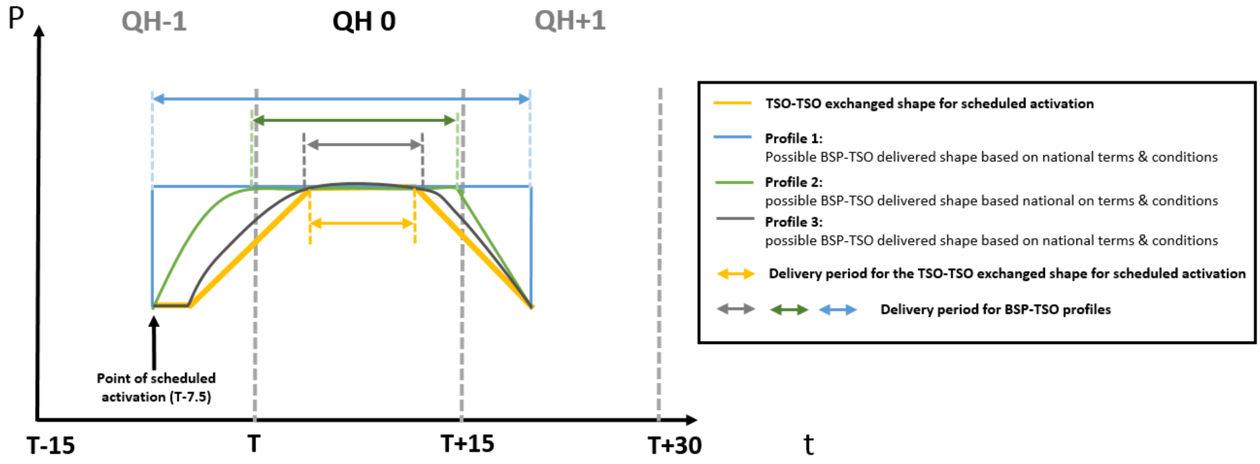

Figure 8: Illustration of different BSP-TSO delivered shapes and their influence on the duration of the delivery period in the case of a schedule activation. Since the BSP-TSO delivered shape can be defined by each TSO individually, it is not possible to define a global maximum delivery period

- Indivisible Bids

  Indivisible bids will be allowed with no limitation in terms of volume as far as this is compliant with national terms and conditions. In other words, rules defined in the terms and conditions for BSPs will be applied to the maximum volume for indivisible bids. Allowing indivisible bids is considered to have a positive impact on the volume of bids offered to the mFRR Platform and will ensure that the maximum range of providers and technology types can participate.

- Minimum duration between the end of deactivation and the following activation

  Minimum duration between the end of deactivation and the following activation is strongly dependent on the BSP asset's technical characteristics and on the pre-qualification, requirement defined by each TSO in the terms and conditions for BSPs.

2.4. TSO Balancing Energy Demand Characteristics

The balancing energy demands that the TSOs submit to the platform will include at least the following characteristics:

1. quantity [MW];
2. direction: Positive (system short) or Negative (system long);
3. TSO demand price [€/MWh] with a price resolution of 0.01€/MWh (optional demand characteristic for the scheduled activations only);

   This characteristic will enable the TSOs to deal with uncertainties about costs when they have alternative measures to solve their imbalances. It may increase the demand to the platform as it removes the incentive for the TSO not to send a demand to the platform when it has alternative measures with more certain costs. A demand can then be submitted with a price reflecting the cost of the alternative measures. A TSO can also declare a price inelastic demand;
4. location of demand: bidding zone or LFC area; where a common mFRR demand is estimated for an LFC block, the demand can be provided for the LFC block.

   TSOs will provide demand depending on the applied frequency restoration process and topology of the LFC areas and bidding zones. If the LFC area consists of several bidding zones – demand may be provided per bidding zone or total demand for the LFC area. If a bidding zone consists of several LFC areas – demand shall be provided for each LFC area. Where an LFC block consists of several LFC areas and the demand is determined for the LFC block, the demand can be provided for the LFC block. In this case, the power balance equation is applied for the LFC block demand and all bids provided by the LFC areas in this block.

Additionally, to explain the difference between LFC area border and bidding zone border the following should be noticed: in general, a LFC area border represents a technical border between LFC areas while bidding zone border represents a market border between bidding zones. In the context of MARI IF both are used. More precisely, according to Commission Regulation (EU) 2017/1485, LFC area means a part of a synchronous area or an entire synchronous area, physically demarcated by points of measurement at interconnectors to other LFC areas, operated by one or more TSOs fulfilling the obligations of load-frequency control. The LFC border therefore represents a border between the LFC areas. A bidding zone is defined in Commission Regulation (EU) 1222/2015 and represents the border between the bidding zones;

5. purpose: balancing purposes or other purposes.

   TSOs foresee that the platform can be used for other purposes than balancing with other rules for activation and settlement.

All balancing energy demands are assumed to be divisible. An example of a balancing energy demand is presented in Table 1.

TSO	Direction	Quantity (MW)	TSO Demand Price (€/MWh)	Elastic/Inelastic	Location
TSO 1	Positive	100	10	Elastic	LFC area A
TSO 2	Positive	100	--	Inelastic	Bidding zone B
TSO 2	Negative	-50	-20	Elastic	Bidding zone C

Table 1: Demand Example

In Table 1: *Demand Example*, the TSO 1 has an elastic positive demand of 100 MW with a price of 10 €/MWh. This implies that this TSO is willing to pay a maximum of 10 €/MWh to satisfy its demand. TSO 2 has an inelastic positive demand of 100 MW which is located in the bidding zone area B and an elastic negative demand of 50 MW located in the bidding zone C with a price of -20 €/MWh. That is, TSO 2 accepts that its demand of 100 MW in the bidding zone B will be met irrespective of (high or low) marginal prices, while also satisfying negative demand in the bidding zone C by selling 50 MW for a minimum of 20 €/MWh.

2.5. Direct and Scheduled Activation

For a direct activatable bid, the activation request from the TSO can be issued to the BSP at any point in time after the scheduled auction for each quarter hour. Such a bid can be activated and exchanged between TSOs shortly after an incident happens as it does not involve the potential waiting time associated with the process for scheduled activation.

Direct activation (DA) is needed for the TSOs using mFRR to resolve large imbalances within the Time To Restore Frequency (see System Operation Guideline) to have the ability to activate mFRR bids at any point in time when a large imbalance occurs. Typically, this could be N-1 incidents.

For a scheduled activatable bid, the activation request from the TSO is issued to the BSP at a specific point in time (point of scheduled activation). To be more specific, the BSP according to Figure 9 receives the activation request from the TSO 12.5 minutes before expected full activation.

Scheduled activation (SA) is typically used to replace previously activated aFRR bids or alternatively to handle forecasted imbalances proactively depending on the TSO's balancing strategy. For the TSOs, this allows the gathering of several demands and realizing benefits from the netting demands in opposite directions. For the BSPs, it gives certainty on the timing of any activation which would be useful when the capacity is subsequently offered in different markets (for instance: used in ID and then offered as mFRR).

2.6. Timing of the mFRR Process

In this section we focus on the various aspects of the timing during the process, starting with the TSO submitting their demands to the platform and continuing until full activation of bids is reached.

The duration of this process is dependent on the following elements:

- computation time of algorithm;
- time to change flow on HVDC cables;
- communication times between platform, TSOs and BSPs;
- full activation time of the balancing product;
- potential delay from the moment when a demand is submitted to the platform until the algorithm starts to process it, i.e.:
    - waiting time until a scheduled process starts;
    - waiting time if algorithm is already running due to earlier activation.

The time needed for all listed elements is uncertain. Figure 9 illustrates the different elements of the scheduled process with some assumptions on their respective timings that yield 15 minutes total time from for the last moment in time when TSO's may submit their demand for the scheduled activation until full activation of balancing bids. TSO Gate Closure Time (TSO GCT according to the EBGL terminology) is the last moment in which TSO's may submit the received bids to the platform and is fixed at T-12 minutes at latest, in order to allow for some fallback time until the start of the AOF.

Based on the knowledge we have today, both the assumption of 3 minutes for changing the flow on HVDC cables and 1 minute for the processing time of the algorithm may be challenging to realize.

From the chart, we can see that from the time the results of the platform are communicated to the TSOs the process of (i) changing the flow on HVDC cables and (ii) the communication process TSO-BSP can start in parallel.

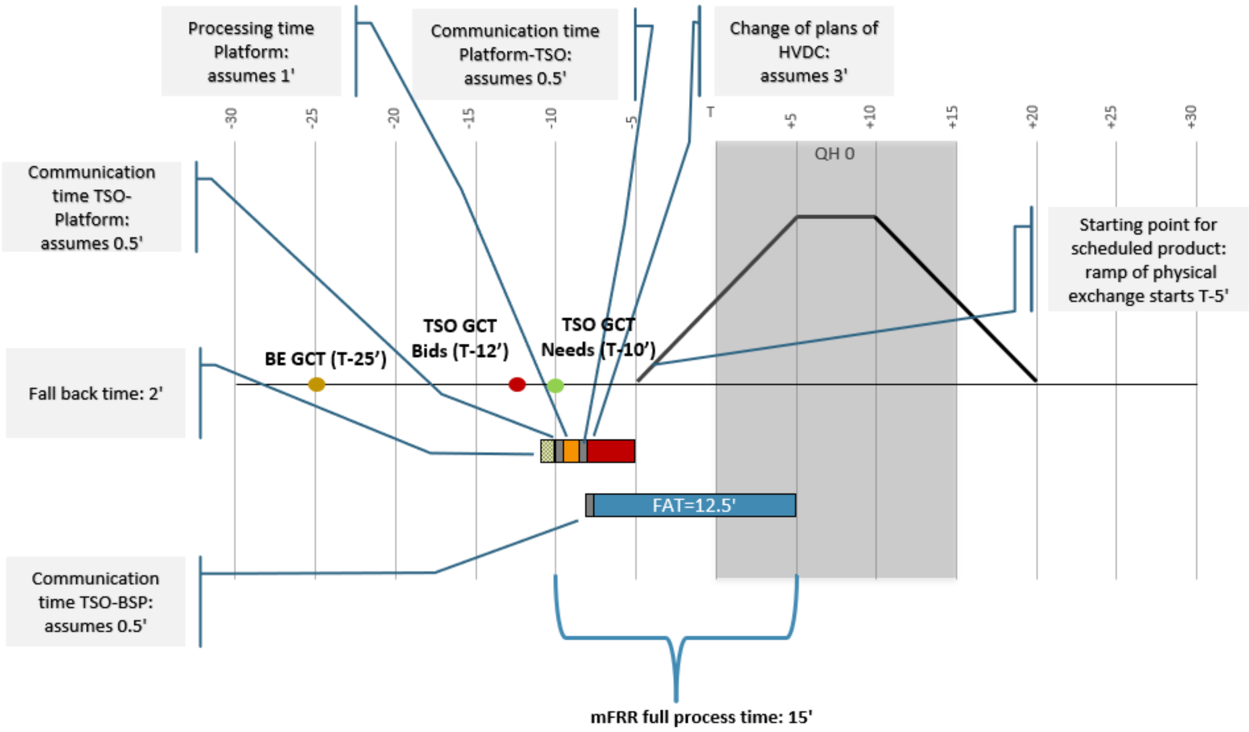

Figure 9: Timing of the Scheduled Process

Today, the total time needed for changing the physical flow of HVDC cables varies between cables and depends on several features:

- electronic interfaces between market management systems, energy management systems/SCADA and controllers;
- physical properties and functionalities of the cable;
- resolutions of HVDC plans (typically 1 or 5 minutes).

It is uncertain how much time can possibly be gained and when this improvement can be realized. However, it is clear that improved IT systems, automation and development of more efficient procedures adapted to the platform will be necessary. Several critical elements are involved in the process of changing the flow on HVDC cables and currently we need to account for minimum 2-3 minutes[2]. Parts of this process will have to be fully completed before the cable is ready for making new HVDC plans, which determines how frequently direct activations can impact the flow across HVDC interconnections.

[2] Taking into account new investments in IT systems and processes, technical experts in Statnett and National Grid have assessed the time needed from the point where a TSO receives a request until the flow of a cable can start to change. The estimated time of 2-3 minutes is uncertain and the functionality of older HVDC cables may not allow this flexibility.

2.6.1. The Process of Direct Activations

It is intended that the DA process minimizes the time between TSO demand being submitted to the Platform and the full activation of bids being reached. This time should not be longer than 15 minutes. In the same way as SA, the total time needed for DA will have to include time for communication between the TSOs, the platform and BSPs and the computation time of the algorithm in addition to the full activation time according to the product definition. The selection of bids and update of mFRR CBCLs between bidding zones must be completed before the algorithm can start to process another TSO demand (i.e. runs of the computation algorithm must run sequentially in series and not in parallel).

2.6.2. The Interaction between the Direct and the Scheduled Process

All bids submitted for a certain quarter hour (QH) can first be used for SA and then the remaining direct activatable bids will be available for DA. The alternative sequence of using the bids for DA first and then allowing the remaining bids to be available for SA afterwards has also been investigated.

The two options have been evaluated according to a number of criteria and there are advantages and disadvantages to both. The main reasons for having SA before DA is that it allows more time for TSO to assess mFRR CBCLs and the availability of bids according to grid constraints, before sending them to the platform. It also allows balancing energy gate closure time (BE GCT) to move closer to real time giving BSPs more time to update the bids. For TSOs it is also possible to ensure that enough direct activatable bids are available for tackling an incident without limiting liquidity.

The detailed timings of the chosen option (SA before DA) are illustrated and explained below. For the direct activation, a continuous process with close to zero computation time of the algorithm is assumed in these illustrations. As explained above, we need to take into account that there will also be a computation time for direct activations and it is uncertain how short we can keep this computation time. Direct activations have to be processed in sequence because the inputs to the algorithm (e.g. mFRR CBCL values, activated bids etc.) are dependent on the outputs of the previous algorithm run.

We have assumed that the communication times between the platform, the TSOs and BSPs are the same as for the scheduled process (1 minute assumed for clearing the scheduled auction).

We assume 1 minute for the algorithm to process the scheduled activation. Thus, if a TSO's demand is received by the platform just after the clearing of the scheduled auction starts, this demand has to wait for 1 minute before it can be processed.

The process of direct activation itself takes 14 minutes assuming close to zero computation time, but as a result of the above mentioned, the total time for a direct activation can take up to 15 minutes maximally if the 1 minute waiting time applies (with zero computation time).

SA Process before DA Process

The TSO can submit demands for direct activation just after the TSO GCT of the same specific quarter hour until just before the TSO GCT of the next quarter hour. This is between T-12 and T+5, referring to the quarter hour starting at T (QH 0). Correspondingly, BSPs can receive the activation signal at T-7.5 for the scheduled activation and between T-7.5 and T+7.5 for the direct activation.

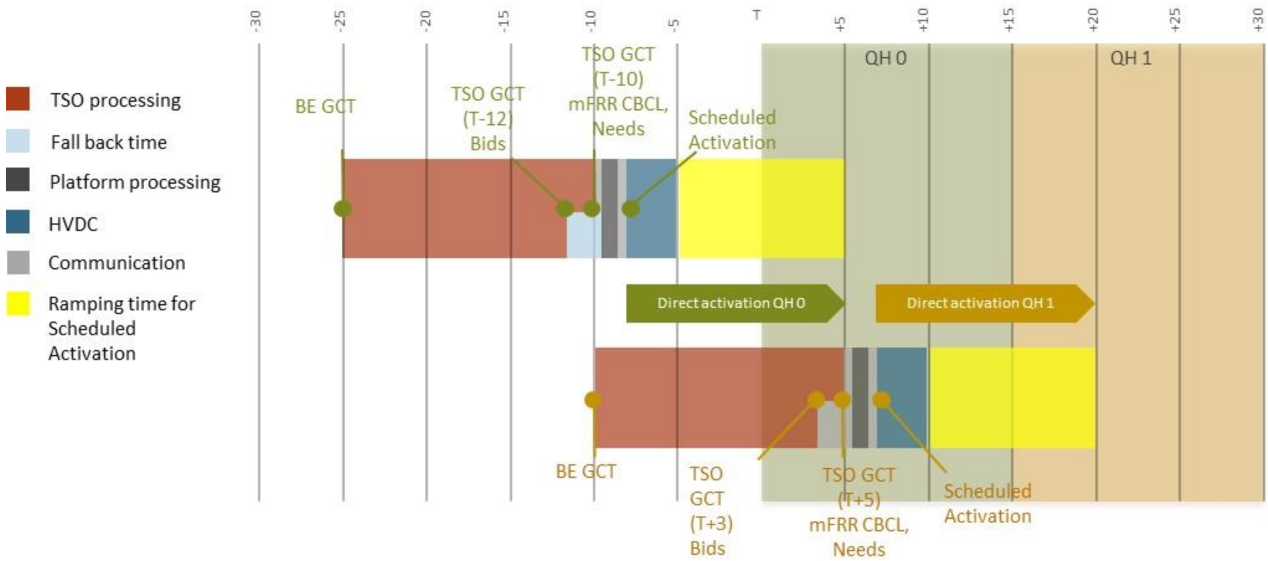

Figure 10: Scheduled before Direct Activation for Two Consecutive Quarter Hours

It is sufficient for TSOs to submit bids and mFRR CBCLs at the same time as the SA demand and thus a GCT of T-25 for BSPs is feasible. However, given that the results of the mFRR Platform for QH 0 are published after the BE GCT for QH 1, the BSPs that have submitted bids will not have the opportunity to update their bids for QH 1 after knowing the results for QH 0.

TSO Processing Time

The TSO processing time is foreseen to be 13 minutes (between T-25 and T-12). This time is required for TSO to perform all the required local processes in the bids received at BSP BE GCT:

- consistency check according to Article 9 (b) of the EBGL;
- conversion of specific products according to Article 26 of the EBGL;
- conversion of bids from integrated scheduling process according to Article 27 of the EBGL which includes evaluation of operational security and internal congestion management according to Article 24(6) and 24(7) of the EBGL.

Interaction of BE GCT between Different Processes

Figure 11 summarizes the proposals for BE GCT and TSO GCT for RR, aFRR and mFRR processes.

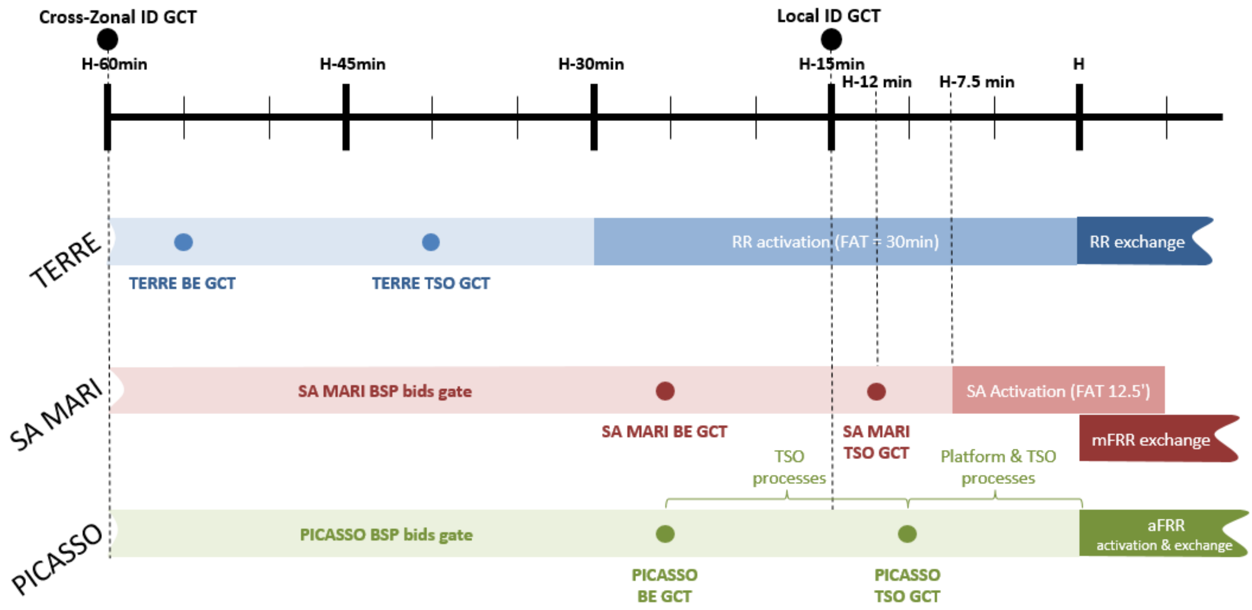

Figure 11: Interaction between BE GCTs for Different Balancing Processes

Proposal on mFRR Gate Opening Time (GOT):

TSOs are proposing the same GOT as t for the aFRR platform as it is the harmonised position from TSOs: no later than 12:00 CET for all validity periods of the next day. The proposal given in the Implementation Framework gives the boundary for the GOT (the latest possible time for the GOT). TSOs can locally allow an earlier GOT.

2.7. Other Bid Properties

2.7.1. Introduction to Linked Bids

It is of the utmost importance to distinguish between the linking of bids for economic reasons and for technical reasons:

- technical linking: links between bids in consecutive quarter hours or in the same quarter hour, needed to avoid the underlying asset of a bid being activated twice or is performing unfeasible activations;
- economic linking: links between bids with the purpose of economic optimization, allowing BSPs to offer more flexibility and to maximize the opportunity of being activated.

2.7.2. Technical Linking

Due to the nature of the MARI process, the gate closure times and the BSPs assets' technical constraints, there is a need to "technically" link bids between quarter hours and within the same quarter hour. For example, when considering bids submitted in consecutive quarter hours, due to the fact that the results of the mFRR Platform for QH 0 are known only after the BE GCT for QH+1, a technical link between bids submitted both for QH 0 and QH+1 will avoid that the underlying asset of a bid is activated twice, i.e. with overlapping delivery periods but activated in different quarter hours. Moreover, for activations where the delivery period is between 5 and the maximum duration of delivery period, this linking between bids will even have to extend over more than one quarter hour. Such technical links between bids will be especially needed for a BSP with small portfolios or for countries with unit bidding.

The Activation Optimization Function (AOF) will need rules for avoiding unfeasible overlapping activations of the same bid submitted for consecutive quarter hours and within the same quarter hour. Hence, BSPs will be required to indicate if bids in consecutive quarter hours and/or in the same quarter hour are technically linked, i.e. to indicate if the underlying assets of a bid are the same as a bid offered in previous/current quarter hour(s) or if there is a technical constraint.

Below are listed the most relevant rules for technical linking between two consecutive quarter hours (Figure 12):

1. A bid direct activated in QH-1 is not available in QH 0 for direct activation;
2. A bid direct activated in QH-1 is not available in QH 0 for scheduled activation;
3. A bid scheduled activated in QH-1 is not available in QH 0 for direct activation, unless the asset can perform ramping up during ramping down of a scheduled bid activated in QH-1 (see red dotted shape in Figure 12).

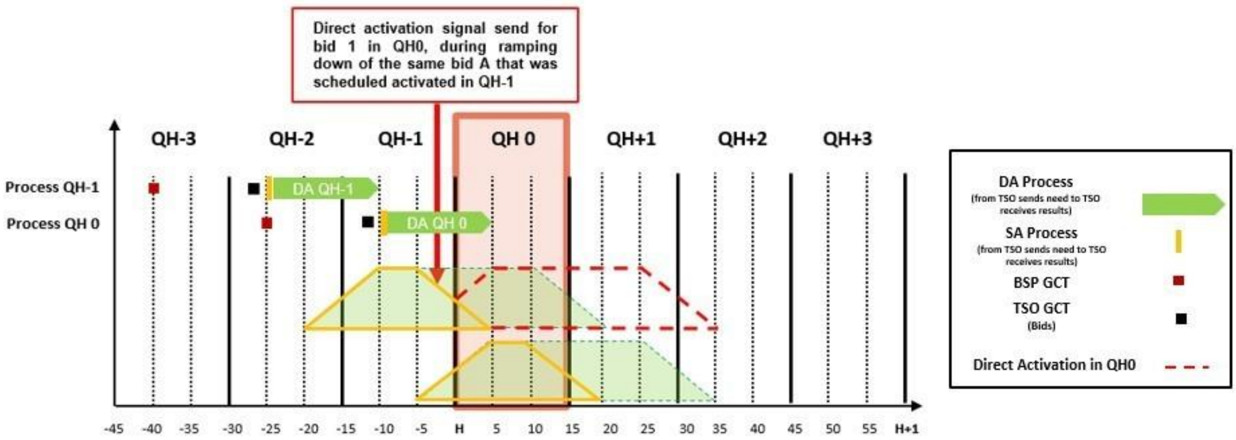

Figure 12: Graphic Representation of Two Consecutive mFRR Processes

Below is listed the rule for technical linking between consecutive quarter hours i.e. more than two quarter hours (Figure 13):

1. A bid direct activated in QH-1 is not available for direct activation in QH+1, unless the asset can perform ramping up during ramping down of a direct activated bid in QH-1 (see red dotted shape in Figure 13).

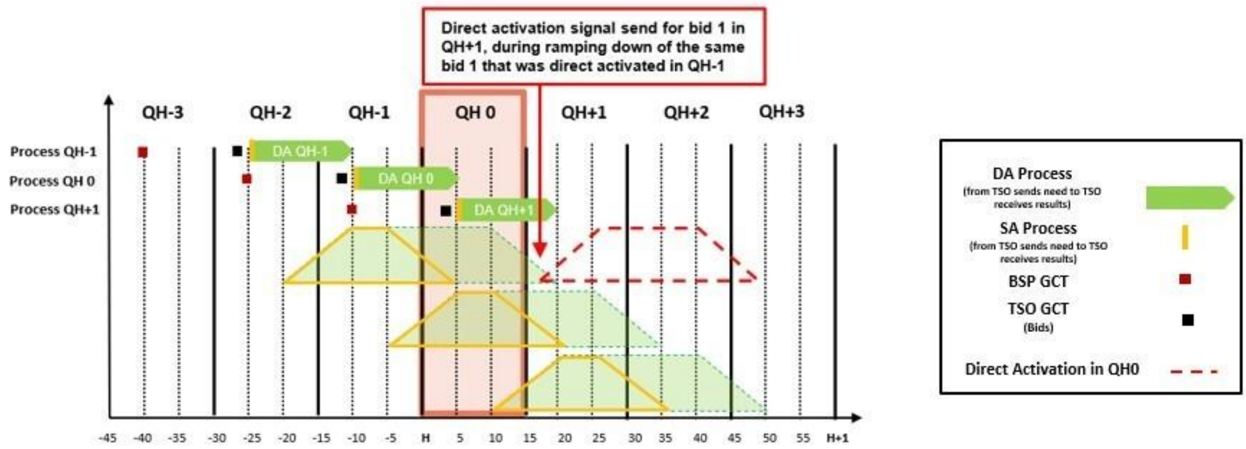

Figure 13: Graphic Representation of Three Consecutive mFRR Processes

Technical links might also be needed for considering the BSPs assets' technical constraints (for e.g. ramping constraints) so as to avoid unfeasible activations.

Example (Figure 14): let's assume that a single asset has a maximum allowable gradient of 5 MW/min both in upward and downward direction. Then an upward scheduled bid of +50 MW and a downward scheduled bid of -50 MW can be submitted to the mFRR Platform for QH 0 and QH+1.
The upward bid is fully activated (+50 MW) in QH 0 and at the end of this quarter hour the bid is deactivated pursuant to the standard product characteristics. For QH+1 the downward bid is fully selected (-50 MW). The deactivation of the upward bid in QH 0 and activation of the downward bid in QH+1 should lead to a down regulation from +50 MW to -50 MW over 10 minutes, equivalent to a gradient of 10 MW/min (which is double the maximum 5 MW/min gradient, thus unfeasible), because both bids are deactivated/activated at the same time (T+7.5). In other words, when a TSO submits a demand of -50 MW in the scheduled auction of QH+1, starting from T+7.5 the TSO would like to down regulate from +50 MW to -50 MW, but owing to the technical ramping constraints of the BSP asset this is not possible, and a technical linking should be foreseen. The same issue would occur if the downward bid instead of schedule activated was direct activated in QH+1.

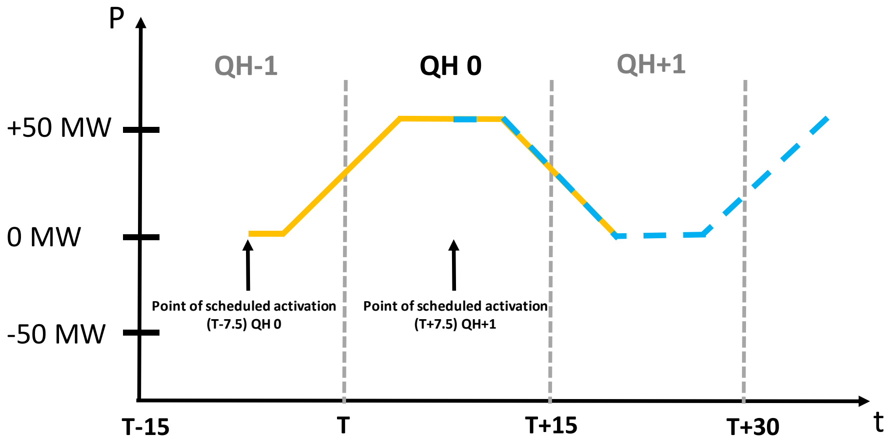

Figure 14: Example of How Incorrect Links Can Lead to Unfeasible Activations

This latter situation could also occur between a schedule activated upward bid and a direct activated downward bid within the same quarter hour. In other terms, this means that this situation is not subject to the positioning in time of the BE GCT. Thus, even if the BE GCT will allow BSPs to update their bids submitted in the next quarter hour, a technical link would still be needed to take into account these situations.

Below is an example (Figure 15) of why it is essential that BSPs provide themselves the correct ID and the correct technical linking between the bids.

Example: assuming that a BSP has only one asset which can deliver only 60 MW in the upward direction until maximum power is reached. This BSP, submits bids A,B,C for QH 0 and bids F and C for QH+1. In QH 0 there is a TSO's upward demand of 40 MW. Hence, bids A and B are activated in the CMOL for QH 0 as they are the cheapest bids. In QH+1 there is a new TSO's upward demand of 40 MW. Bid F in QH+1 is actually formed by bid A and B in volume (i.e. F=A+B) but if the BSP doesn't provide the correct linking to the AOF (i.e. doesn't specify that bid F= bid A+ bid B), there could be a risk of unfeasible activation.

CMOL QH 0			
BID CODE	Power	BSP	Price
A	20 MW	BSP 1	10 €/MWh
B	20 MW	BPS 1	15 €/MWh
C	20 MW	BSP 1	60 €/MWh

CMOL QH+1			
BID CODE	Power	BSP	Price
F	40 MW	BSP 1	12 €/MWh
C	20 MW	BSP 1	60 €/MWh

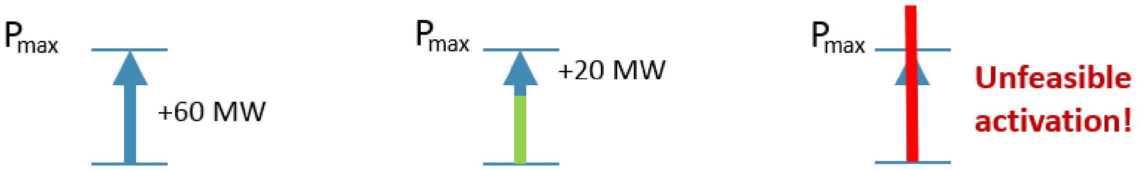

Figure 15: Example of How Incorrect Links Can Lead to Unfeasible Activations

Technical linking will rely on simple and pragmatic rules. These rules, will modify the currently considered CMOL or the inputs given to the next CMOL based on the activations (direct or scheduled) made in the currently considered CMOL.

In conclusion, it is of utmost importance that the BSPs give precise information about which bids are technically linked from one quarter hour to the next and within the same quarter hour. For example, an ID number could be assigned to the bids (an idea could be to efficiently adapt the Energy Identification Coding scheme -EIC- for this purpose). Bids with same ID are linked together and are subject to the technical linking rules implemented in the AOF. The TSOs will investigate further, how this feature will be practically implemented.

2.7.3. Economic linking

Economic linking of bids is an important feature, allowing BSPs to offer more flexibility, maximize the opportunity to be activated by fitting with the TSOs' demands, reduce costs of balancing and contribute to an efficient and competitive balancing market. Moreover, economic linking will help to maximize the liquidity of the mFRR Platform.

Nevertheless, economic linking over quarter hours (linking forward in time) will not be allowed since the mFRR Activation Optimization Function does not perform optimized activations over more than one quarter hour (Figure 16). This means that if a bid is selected in a quarter hour, no link will guarantee that another bid in a subsequent quarter hour will be activated as well. In fact, bids submitted for a quarter hour, will be activated by the AOF only if economically efficient.

The following economic linking will be allowed in the mFRR Platform within the quarter hour (Figure 16):

- **Parent-child linking**: a given bid (the child) can only be activated if another specific bid (the parent) is activated as well, not vice-versa. In other words, the acceptance of a subsequent bid can be made dependent on the acceptance of the preceding bid. Parent-child linking could reflect the start-up costs and power limits of their BSP's units more correctly.

  Example: bid 2 (child) can only be accepted if upward bid 1 (parent) is also accepted; i.e. the bid 2 (child) is linked to bid 1 (parent) and not vice-versa. Referring for example to start-up costs, this can be explained as follows: the price of bid 1 is 70 €/MWh and includes a starting cost of 1000 € while the price of bid 2 is only 50 €/MWh. There is no starting cost in bid 2 but only energy related costs. However, the use of this bid 2 is conditional to the preceding activation of bid 1.

- **Exclusive group orders**: only one bid can be accepted from a list of mutually exclusive bids. Example: only one of the following bids can be accepted (they can differ in size and price) A1, A2, A3…An.

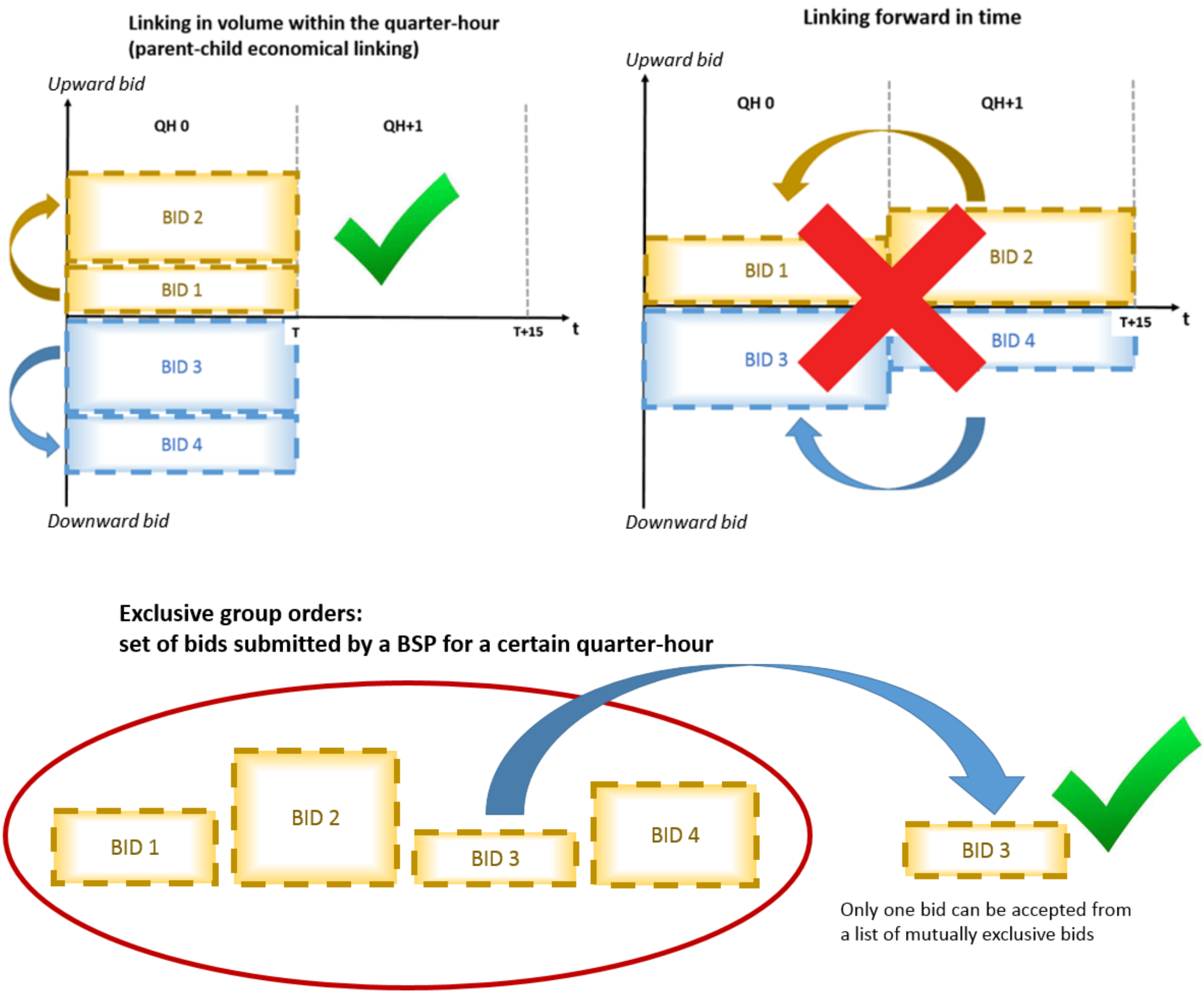

Figure 16: Graphic Representation of the Type of Economic Linking That Are Allowed and Not Allowed

It is interesting to note that the BE GCTs do not allow BSPs to update their bids submitted in the subsequent quarter hour themselves (in terms of price and volume) if a bid was activated in the previous quarter hour (Figure 17). This could penalize some BSPs offering a bid with start-up cost in a quarter hour, because they cannot update the price and volume of that bid in the subsequent quarter hours if the first bid was activated.

Example:

- bid 1 contains start-up cost (e.g. 70 €/MWh and includes a starting cost of 1000 €) and is placed by a BSP for QH-1, QH 0 and QH+1;
- this bid is activated (scheduled or direct), in the CMOL of QH-1 (between T-25 and T-10);
- since the BE GCT for QH 0 is at T-25, the BSP cannot update the price and volume of bid 1 for QH 0 (i.e. reduce the price of bid 1 for QH 0, since start-up costs have been already covered by the activation in QH-1, and possibly change volume);
- the same situation could occur even for QH+1. In fact, if bid 1 is direct activated for QH-1 just before T-10, the BSP will receive the activation signal just after the BE GCT for QH+1 at T-10 (due to communication and computational time).

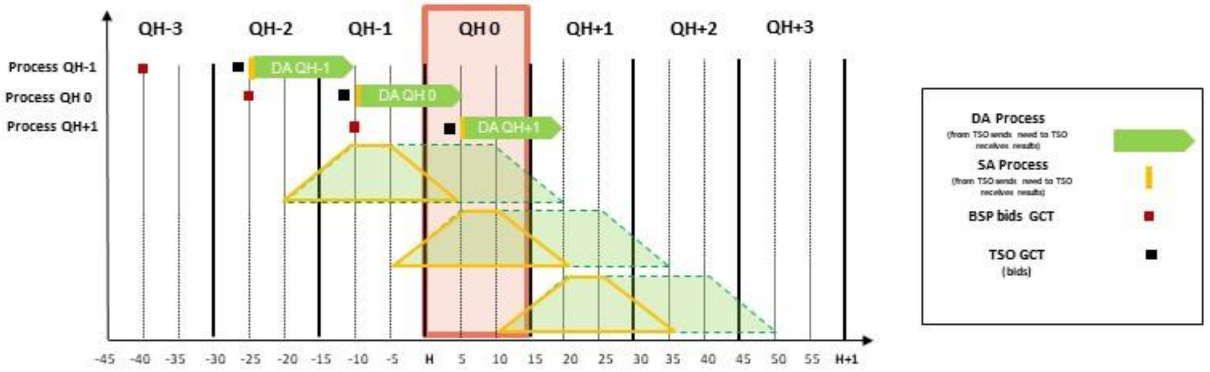

Figure 17: BE GCT and Activation Process

The TSOs are investigating whether the introduction of an economic linking in time for start-up purposes (Conditional Bids - economic linking backward in time) is feasible and easily implementable in the algorithm. This feature will allow an automatic update of the bids submitted by a BSP in a subsequent quarter hour if a bid with start-up costs submitted in a preceding quarter hour has already been activated.

If this feature is implemented, BSPs will need to provide conditional links between the bid with start-up costs submitted in a quarter hour and the bids submitted in following quarter hours (e.g. if bid 1 is activated in QH 0, then consider bid 2 in the next quarter hour (Figure 18)).

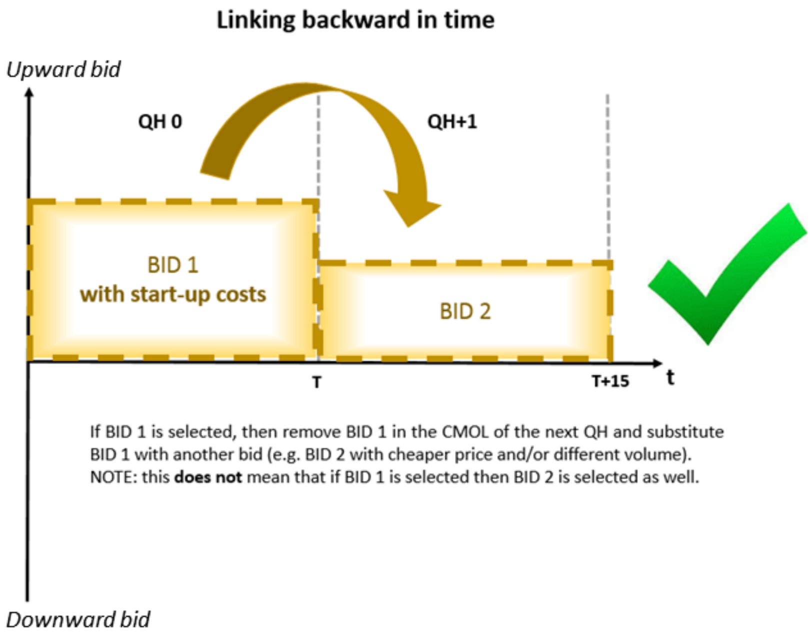

Figure 18: Linking Backward in Time - Bids with Start-up Costs

Below are listed some rules for economic linking backward in time (only for start-up costs reasons):

- if bid 1 (e.g. 70 €/MWh and includes a starting cost of 1000 €) is activated in the scheduled auction of QH-1 (at T-25), the linked bid is available in the scheduled auction of QH 0 but at a lower price (e.g. 50€/MWh);
- if bid 1 (e.g. 70 €/MWh and includes a starting cost of 1000 €) is activated in a direct auction of QH-1 (between T-24 and T-10) the linked bid is available in the scheduled auction of QH+1 but at a lower price (e.g. 50€/MWh).

This feature will reduce balancing costs and increase liquidity as BSPs will be more able to accurately reflect their actual costs in their bid prices. Moreover, the issue of start-up costs and not paying them more than once in several consecutive quarter hours, can be tackled. A logic could be implemented to automatically adapt the bid price and/or volume of the same bid for the next consecutive quarter hour based on information given by the BSP when the bids were submitted. This means for example that the price of a bid for consecutive activations after the first activation could be lower by the amount of the start-up cost. Consequently, it would increase the probability of the bid being selected again in the following activation period.

2.7.1. Cross process linking

Linking of bids between different European Platforms (e.g. PICASSO and TERRE projects) is a particular challenge that is investigated and will not be facilitated at a first stage at the Platforms. Nevertheless, there might be specific local arrangements that may facilitate this (see aFRR IF explanatory document).

2.7.2. How to ensure that TSOs have access at all times to the submitted mFRR volume

Rationale

In order to allow TSOs to manage in a secure way the network and to keep the system's balance, it is of utmost importance that TSOs can have access when required to a sufficient reserve capacity on FRR at any time in accordance with the FRR dimensioning rules. In particular, when unforeseen incidents or unexpected demands in real time occur, TSOs might need to have access to a certain volume of "direct activatable bids" to perform the Frequency Restoration Process within the Time To Restore Frequency (TTRF).
In their dimensioning TSOs rely on having a certain volume of mFRR bids available for direct activation in order to be able to tackle incidents in their system and can only take responsibility for this through securing enough bids from their own control area or in cooperation with other TSOs. Majority of TSOs use the procurement of balancing capacity to secure the necessary volume, however some of them rely also on energy only bids.

Based on the previous, TSOs should be able to <u>secure enough balancing energy bids for the direct activation process from their own control area</u> <u>or in cooperation with other TSOs (if case of exchange or sharing of reserves agreements)</u>.

Concerns Linked to the Current Design Choices and Nature of mFRR Process to Fulfil the Rationale

TSOs understand that the current design of the Platform as well as due to the nature of the mFRR process may create situations where a TSO cannot ensure completely the rationale presented above. The three main reasons identified are:

1. <u>Process of activation and the existence of scheduled-only bids</u>: Since there is one CMOL for both, scheduled-only bids and direct activatable bids, and since the scheduled activation of bids of this CMOL precedes the direct activations of bids of this CMOL, it might happen that most of direct activatable volume of a TSO is used by other TSOs in the scheduled auction (because these direct activatable bids might be cheaper), leaving the first TSO with insufficient volume of bids for direct activation.

2. <u>Possibility of lack of CZ capacity between bidding zones in real time</u>: even with enough liquidity of direct activatable bids in the CMOL, it might happen that owing changing of CZ capacity in real time, it might be difficult or impossible to have access to other TSO's cheaper direct activatable bids in real time. Even though this situation is foreseen to occur rarely, in order to deal with real time imbalances, it is important to always have a local volume of direct activatable bids.

3. <u>Full access to CMOL</u>: full access to CMOL can create the situation where TSOs demanding for more volume than submitted will decrease the overall available volume of direct activatable bids in the CMOL. This could critically reduce the local available volume of direct activatable bids for some TSOs. This risk is considered to be very low due to the pooling effect of having access to many available bids in the mFRR-Platform from many bidding zones, which mitigates the risks connected with local scarcity of direct activatable bids, but still this situation could occur.

Outcome of Technical Investigations

In order to fulfil the rationale, TSOs have investigated different ways of implementation in the mFRR Platform.

<u>Fulfilment of the rationale by the algorithm</u>: one possible way to ensure the rationale would be to add constraints in the algorithm and to fully rely on the optimisation to ensure that a TSO has always a

guaranteed access to an amount of direct activatable bids locally or from another LFC area (thus in this last case transmission capacity shall be guaranteed at any point in time).

Fulfilment of the rationale outside the algorithm: another way to ensure the rationale would be to prevent that a certain volume of direct activatable bids is activated in the scheduled activation on one side and on the other side during the direct activation process -if needed by some TSOs- to secure a local volume of direct activatable bids- by making the bids available only for this TSO in the CMOL.

Even though TSOs see that the first technical implementation could have some advantage in terms of liquidity and activation process, the current performance time constraints put on the algorithm, the complexity of the process, as well as the complexity of the algorithm does not allow to take such new constraints in design while securing the implementation. Thus, TSOs agreed to secure the implementation and the go-live of the mFRR Platform with the second technical implementation choice (fulfilment of the rationale outside the algorithm).

Nevertheless, TSOs are striving to achieve the goal to a smooth functioning Platform and thus after go-live of the mFRR Platform will monitor the effect of the above implementation choice and if the methodology currently proposed does not sufficient tackle this issue, the TSOs may consider more advanced features to be investigated . This approach will allow all TSOs to gain experience and to assess the magnitude of the problem based on real data.

Proposed Functioning

In order to fulfil the rationale, TSOs are considering to mark as unavailable for other TSOs (but not for themselves – see step 1 below), the necessary direct activatable volume of bids and, if required, activate them through the Platform. This proposed functioning is the outcome of the current discussions and is considered with the today knowledge as a trade-off between the transparency given on this topic (activation through the platform – see step 2 below) and the level of complexity in terms of implementation (fulfilment of the rationale outside of the algorithm). Details on the high level principle for the functioning are presented below.

If there is the need for a TSO to secure a volume of direct bids, this volume may be different depending on the direction of the demand. More precisely, TSOs may have a separate amount of upward and downward direct bids to be secured. For the sake of simplicity, the following elements are only considering one direction.

Step 1 - Marking bids unavailable for other TSOs: based on the elements above and for the sake of simplicity, in order to reduce the risks of direct activatable bids scarcity in a LFC control area during a quarter-hour, TSOs shall be able to mark a volume of direct activatable bids as unavailable for the reasons pursuant to Article 29.14 of the EBGL.

Step 2 - Activation of "unavailable bids" through the Platform: bids that are marked as unavailable for other TSOs with the purpose to guarantee the access to a sufficient amount of direct activatable bids, will be always forwarded to the CMOLs of the mFRR Platform but can only be activated by the connecting TSO through the Platform during the direct activation process only. In other words, activation of the bids marked as unavailable for other TSOs will be performed through the mFRR Platform and no local process is needed for direct activation of these mFRR bids.

Transparency and Working Principles

In order to ensure the well-functioning of the Platform, TSOs are committing to full transparency on the bids that are marked unavailable for the purpose of the direct volume guaranteeing. This principle is described under point 1 below and will allow TSOs to monitor potential excessive usage of the volume that has been guaranteed.

In addition, two additional working principles are currently under consideration in the MARI project and are described under point 2 and 3 below: marking only the most expensive direct bids unavailable and setting a "shrinking" principle of the amount declared unavailable based on the activations performed. Those principles are subject to technical feasibility and will therefore be assessed more in details during the implementation phase. In particular, the way to implement the "shrinking" principle will have to be checked/secured against the fact that MARI is foreseen indivisible bids, links between bids as well as the time constraint of the overall duration of the direct activation process within 15 minutes.

1-Transparency on the guaranteed direct volume (included in the Implementation Framework): in order to facilitate the monitoring of the bids marked as unavailable by the TSOs for guaranteeing a sufficient amount of direct activatable bids in during the direct activation process, it is proposed to "tag" those bids marked unavailable for this specific purpose (e.g. "ensure direct activatable bids volume") when marking bids unavailable pursuant to Article 29.14 of the EBGL.

2-Only the most expensive direct bids marked as unavailable for the purpose of ensuring enough direct activatable bids: each TSO can mark as unavailable for other TSOs only the volume correspondent with the most expensive direct activatable bids of its local merit order list (LMOL), as these bids have the least probability of being activated if they were available in the scheduled or direct activation process.

3-Shrinking volume of direct bids marked as unavailable for the purpose of ensuring enough direct activatable bids: the total volume of these bids marked as unavailable is dynamically changing each time the connecting TSO requires a direct demand during the direct activation process and this demand is satisfied. With this dynamic boundary, BSP's blocked bids have more chance to get activated since more bids will be shared in the Platform.

This principle is foreseen to constitute a mitigation measure towards excessive usage (as previously described in the example 1) of guaranteeing a volume of bids. TSOs are currently considering different possible ways to implement it as described in the 3 examples below (non exhaustive list):

Example 3.1 (direct process only shrinkage):

- D-1: TSO A needs for N-1 dimensioning 700 MW of direct activatable bids, and procures this as mFRR capacity;
- TSO GCT: TSO A submit these 700 MW to the Platform together with 300 MW of voluntary direct activatable bids. Total volume of mFFR direct activatable bids submitted is 1000 MW;
- TSO GCT: TSO A will mark as unavailable 700 MW to ensure enough direct activatable bids;
- T-7.5: 300 MW of direct activatable bids submitted by TSO A is activated in the scheduled clearing;
- T+5: TSO A sends a direct demand of 500 MW to the Platform during the direct activation process;
- T+5.5: the Platform will receive this request and will activate 500 MW from the CMOL. Moreover, the Algorithm will reduce the amount of bids marked as unavailable for TSO A:
    - V'_{TSO} = 700 MW – 500 MW = 200 MW of filtered volume left for TSO A.

Example 3.2 (cross process shrinkage)

- D-1: TSO A needs for N-1 dimensioning 700 MW of direct activatable bids, and procures this as mFRR capacity;

- TSO GCT: TSO A submit these 700 MW to the Platform together with 300 MW of voluntary scheduling activatable bids. Total volume of mFFR bids submitted is 1000 MW;
- TSO GCT: TSO A will mark as unavailable 700 MW to ensure enough direct activatable bids;
- TSO GCT: TSO A sends a scheduled demand of 400 MW to the platform
- T-7.5: 400 MW of bids (direct and/or scheduled subject to a price) were activated for TSO A in the scheduled clearing;
- GV'TSO = 700 MW – 100 MV = 600 MW of GV left for TSO A for direct process
- T+5: TSO A sends a direct demand of 500 MW to the Platform;
- T+5.5: the Platform will receive this request and will activate 500 MW from the CMOL. Moreover, the Algorithm will reduce the amount of bids marked as unavailable for TSO A:
  - V'_{TSO} = 600 MW – 500 MW = 100 MW of GV left for TSO A

Example 3.3 (limit the full access to CMOL for SA process to the remaining bids submitted in SA after GV marking)
For a TSO A:

- DA bids submitted = 1000 MW;
- SA only bids submitted = 0 MW;
- bids marked as unavailable to ensure enough DA bids = 800 MW;
- bids remaining available for SA process for others = 200 MW;

  → The "full access to CMOL" of TSO A for the SA process is limited to 200 MW. TSO A cannot request /activate more in the SA process, but he will always have access to his 800 MW in the DA process.

3. Activation Optimization Function

The Activation Optimization Function (AOF) that will be used in the mFRR Platform is based on the maximization of the mFRR economic surplus (Articles 2, 3 and 11 of the proposal for mFRRIF), and the minimization of manual frequency restoration power exchange on borders (Article 11 of the mFRRIF) which is effective in case the maximization of the mFRR economic surplus provides multiple optimal solutions. Usage of the term mFRR economic surplus throughout this Explanatory Document should be considered in the context of the definition given to this term in article 2.2(h) of the mFRRIF.

A scheme of the optimization model is presented in Figure 19. As illustrated in this figure, the optimization model uses as input the common merit order lists (CMOL) with the balancing energy bids submitted by the BSPs, the balancing energy demands submitted by the TSOs, where applicable system constraint activation purpose requests, as well as network information, i.e. mFRR cross border capacity limits (CBCL) or HVDC constraints and where applicable operational security constraints provided by the participating TSOs or affected TSOs with Article 150 of the SOGL[3]. The AOF creates two curves (one per direction)consisting of the TSO balancing energy demands and the CMOLs of all bids and based on this curve as well as on all defined constraints, it provides the optimal mFRR economic surplus, the satisfied demands, the accepted bids, the CB marginal prices and the CB commercial schedules.

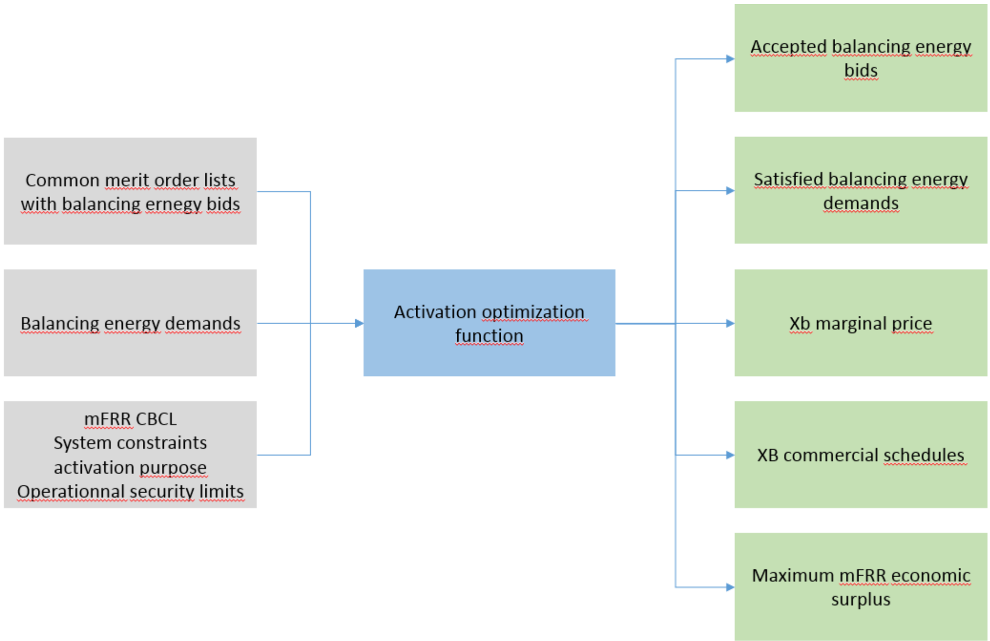

Figure 19: Scheme of the Activation Optimization Function

[3] The mFRR process being subject to TSO notification process according to article 150 of SOGL, limitations on frequency restoration power interchange, additionally to the mFRR cross-border capacity limits, might be required for operational security reasons (e.g. progressive increase of full mFRR exchange at the go live, loop flows or deterministic frequency deviations handling).

3.1. Inputs for the AOF, Merit Order Lists and Optimal Outputs

The following subchapter presents the structure of the CMOLs and the TSO demands which are received as inputs by the AOF. **Regarding the sign convention used, we note that:**

- for positive demand (short TSOs), a positive price indicates that a TSO is willing to pay (maximum) this price in order for its demand to be satisfied. On the other hand, a negative price indicates that the TSO is willing to be paid (at least) the submitted price in order for its demand to be satisfied;
- for negative demand (long TSOs), a positive price indicates that the TSO is willing to be paid (at least) the submitted price in order for its demand to be satisfied. On the other hand, a negative price indicates that the TSO is willing to pay (maximum) the submitted price in order for its demand to be satisfied;
- for upward bids, a positive price indicates that the BSP wants to be paid (at least) the submitted price in order to be activated. On the other hand, a negative price indicates that the BSP is willing to pay (maximum) the submitted price in order to be activated;
- for downward bids, a positive price indicates that the BSP is willing to pay (maximum) the submitted price in order to be activated. On the other hand, a negative price indicates that the BSP wants to be paid (at least) the submitted price in order to be activated.

3.1.1. Details on Elastic and Inelastic TSO Demand

The submission of TSO mFRR demands to the mFRR Platform happens 10 minutes before the beginning of the QH at the latest. Therefore, some TSOs and particularly those with a proactive balancing philosophy base their balancing process on forecasts that provide better vision on the upcoming minutes or even hours, i.e. on their expectation of the system situation and their ability to be able to balance their system at minimum costs. Using these forecasts, TSOs can elaborate different action plans depending on the expectation of the imbalance on their LFC area, and also the different solutions available. Other TSOs, particularly those with a reactive balancing philosophy, do not make imbalance forecasts.

If no other solution is available within their decision perimeter, or if the realisation of imbalance is certain (such as in the case of outages), then this is the typical case for an inelastic demand: a TSO has to pay that service, i.e. the activation of mFRR balancing energy at any price.

But if other solutions are available, or if there is uncertainty of the forecasted imbalance, a TSO may face a trade-off decision: a TSO that anticipates a forecasted imbalance will not be ready to pay any price for mFRR activation if BSPs are ready to provide the service at a lower price (for instance in case of specific products available locally). In a similar manner if the TSO is uncertain about the expected imbalance and there are other solutions in subsequent processes closer to real time, it will not be ready to pay any price, as they will then not balance the system at lowest cost. From an economic point of view, this simply means that some TSOs can have a limit on the price they are willing to pay to satisfy the proactively activated mFRR demand.

These situations have been taken into account through the concept of elastic demand for the scheduled activations. Any TSO can submit an elastic demand that reflects the price they are ready to pay on the platform, regarding the cost of the available alternative solutions and its expectation of the demand and therefore its risk exposure on the demand uncertainty. The elastic demand concept is expected to increase the mFRR demands volume submitted by TSOs to be satisfied through the mFRR Platform, since it will allow TSOs to better consider the uncertainty of the imbalance and the alternative solutions within their decision perimeter. We note that for direct activation, only inelastic demands are allowed, since direct activation is expected to be used in the case of outages, i.e. when the imbalances are certain and balancing energy is needed as soon as possible. There is no uncertainty of a direct demand.

Tolerance band

The tolerance band is a parameter of the mFRR demand submitted by a TSO that reflects the willingness of the TSO to satisfy a higher\lower volume of mFRR demand than requested with the submitted upward\downward demand, if this would increase the mFRR economic surplus. Use of tolerance band increases the mFRR economic surplus and lead to more intuitive prices. The concept of tolerance band is illustrated on figure 20.

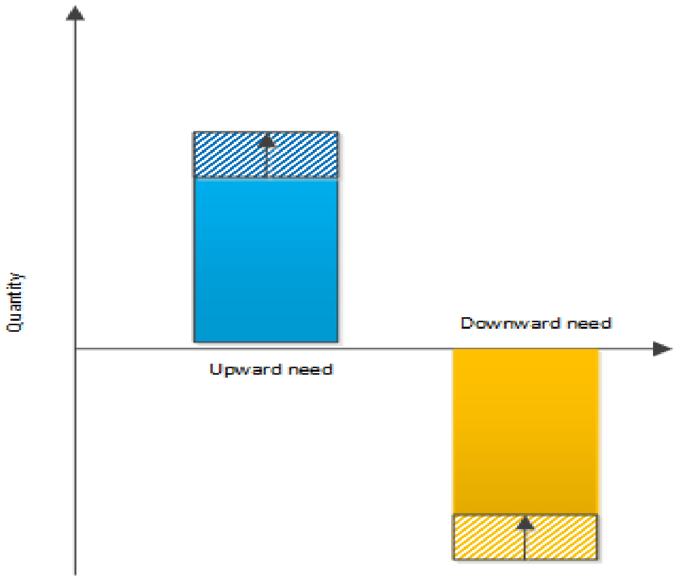

Figure 20: The Tolerance Band for Upward and Downward Demand.

Example:

The tolerance band concept can be illustrated with the following example. In table 2 are given some exemplary values for demand and offers (bids). For each demand or offer the direction, volume (in MW), price (€/MWh), divisibility and tolerance band.

Table 2 – The example of inelastic demand with a tolerance band.

Type	**Direction**	**Volume (MWh)**	**Price (€/MWh)**	**Divisibility**	**Tolerance band**
Demand	Upward	100	100	Divisible	50
Offer 1	Upward	110	20	Indivisible	-
Offer 2	Upward	100	80	Divisible	-

Additionally, the case can be illustrated as shown on figure 21 below. Upward demand is indicated with blue curve, while upward offers 1 and 2 are marked as a green curve.

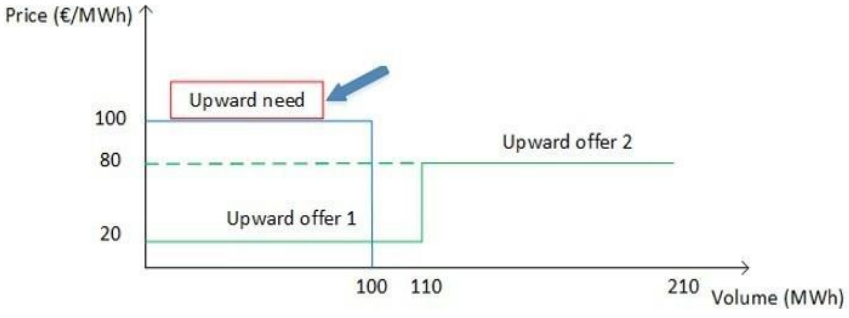

Figure 21: Graphical Representation of the Example.

From *Figure 21* two cases with and without tolerance band can be presented.

Without the tolerance band activated: 100 MWh of the upward offer 2 are activated to satisfy the imbalance demand. Therefore, the mFRR economic surplus is equal to

(100 €/MWh * 100 MWh) - (80 €/MWh * 100 MWh) = 2000 €.

The indivisible upward offers 1 is rejected.

With 10MWh of tolerance band activated: 110 MWh of the upward offer 1 are activated to satisfy the imbalance demand of 110 MWh. The tolerance band is not considered in the mFRR economic surplus and therefore the mFRR economic surplus is equal to

100€/MWh*100MWh + 0€/MWH*10MWh-20€/MWh*110MWh = 7800€.

In case the TSO express a demand, the tolerance band can either increase or decrease the counteractivation with subsequent process in the case of upward tolerance band. In the case of downward tolerance band is application and either increases or decreases the demand volume submitted in the subsequent process.

3.1.2. CMOL

In the EBGL Article 37, paragraph 2 sets the requirements for the common merit order list:

> *Common merit order lists shall consist of balancing energy bids from standard products. All TSOs shall establish the necessary common merit order lists for the standard products. Upward and downward balancing energy bids shall be separated in different common merit order lists.*

This provision is reflected in the mFRRIF Article 10 [CMOL], which explains how the CMOL will be formed. In the mFRR Platform there will be two CMOLs created (one for each direct activation) for the scheduled activation and the direct activation. In the schedule activation all the available bids are used, while in the direct activation only the direct available bids remain:

- The two CMOLs:
  - all the available upward bids create the first CMOL (a)
  - all the available downward bids create the second CMOL (b)
- After the schedule activation, for the direct activation:
  - all the available direct upward bids remain in the first CMOL (c)
  - all the available downward bids remain in the second CMOL (d)

As a result, each CMOL- curve consists of the mFRR balancing energy bids. The input to the optimization algorithm for the schedule activation is the respective CMOL merged with the TSO balancing energy demands. The upward CMOL is merged with the downward demands, and the downward CMOL with the upward demands. An example of such an input is illustrated in Figure 22 and is based on the bids and demands for schedule activation provided in Table 3.

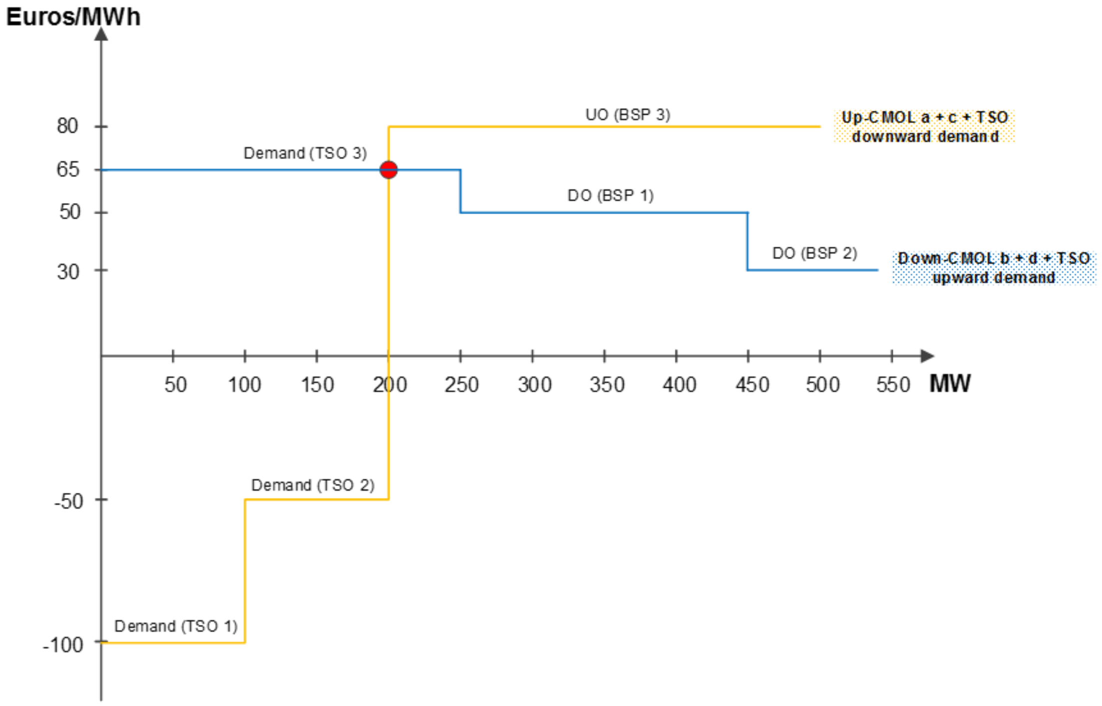

Figure 22: CMOLs Merged with Balancing Energy Demands

Type	Volume (MWh)	TSO demand price/Bid price (€/MWh)	Elasticity of Demand
Demand (TSO 1)	-100	-100	Elastic
Demand (TSO 2)	-100	-50	Elastic
Demand (TSO 3)	250	65	Elastic
Downward bid (DB BSP1)	200	50	--
Downward bid (DB BSP2)	100	30	--
Upward bid (UB BSP3)	300	80	--

Table 3: Inputs of the Example

For the direct activation, as a first come first serve approach is followed, the AOF runs with the submitted balancing energy demand and the CMOL with the balancing energy bids of the same direction with the demand. Therefore, when the AOF runs to satisfy upward demand, the input to the AOF is the upward CMOL and the upward demand to be satisfied. On the other hand, when the AOF runs to satisfy downward demand, the input to the AOF is the downward CMOL and the downward demand to be satisfied.

- The input when the algorithm runs to satisfy the upward direction is the upward TSO demands and the CMOL (c)
- The input when the algorithm runs to satisfy the downward direction is the downward TSO demands and the CMOL (d)

3.1.3. Other Inputs

The balancing energy TSO demands are also inputs to the AOF and are described in detail in Chapter 2.4.

Furthermore, TSOs can send to the AOF, as inputs, requests for activation for the system constraint purpose, namely requests with the aim the result of the algorithm on a specific interconnection to be at a desired flow or within a desired flow range.

Figure 23: Example of System Constraint Purpose

Other inputs of the AOF include mFRR CBCL, operational security limits and may include HVDC loss factors (see further 3.3.3).

3.2. Optimal Outputs

The optimal clearing algorithm outputs are as follows:

- accepted bids per each area [MW];
- satisfied demand per each LFC area or bidding zone [MW];
- CB marginal prices per the smallest of an LFC Area or bidding zone bidding zone [€/MWh];
- optimal mFRR economic surplus [€];
- used mFRR CBCL, including flows at each border between LFC areas or bidding zones.

Note that this is the high-level description of the inputs and outputs of the AOF. The TSOs will follow the transparency and publishing obligations of European and national regulations. The results will be published at the same point in time for all market participants and close to real time as required by Art. 12 of the EBGL.

3.3. Criteria of the Clearing Algorithm

In this section, we elaborate on the criteria which will be considered in the AOF, i.e. the objective function which will be optimized and the constraints which will be respected. We assume that the optimization of scheduled bids and demands will be carried out within a single auction, and there will be only one independent auction per 15-minute period.

3.3.1. Objective Function: Maximizing mFRR Economic Surplus

The objective of the AOF is to maximize the mFRR economic surplus. In the context of the AOF, the mFRR economic surplus is the total surplus of all TSOs participating in the mFRR Platform obtained from satisfying their mFRR demands and the total surplus of BSPs resulting from the activation of their associated mFRR bids, as illustrated in Figure 24. The curve consisting of positive TSO mFRR demands and downward BSP mFRR bids constitutes the consumer curve (based on economic theory), and therefore indicates what price consumers (TSOs and BSPs) are prepared to pay for consuming mFRR balancing energy, based on their expectations of private costs and benefits. On the other hand, the curve consisting of negative TSO mFRR demands and upward BSP mFRR bids constitutes the producer curve (based on economic theory), and therefore shows the price they are prepared to receive for supplying mFRR balancing energy. mFRR economic surplus, is the total benefit available to society from an economic transaction, and therefore is made up of the red area in Figure 24 which is the sum of the consumer and the producer surplus.

For inelastic demand, the mFRR economic surplus cannot be determined (in theory infinite value), as the demand must be satisfied at any cost. For implementation purposes, a price will always be assigned, but for inelastic demands, this price will be higher than any mFRR offer and will represent the technical limit of the mFRR Platform AOF.

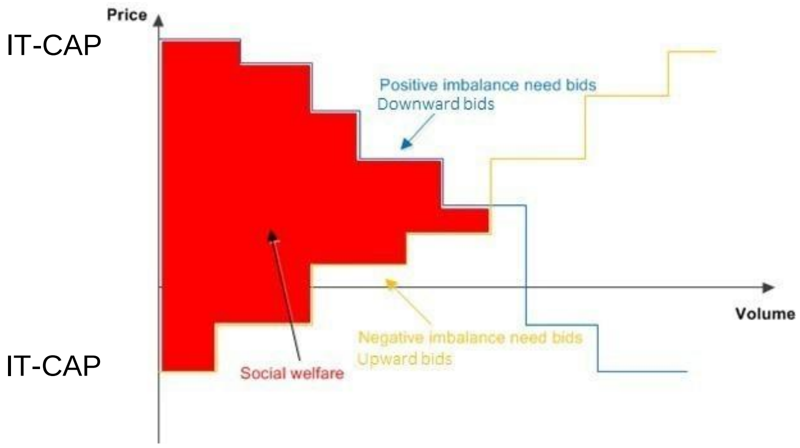

Figure 24: mFRR Economic Surplus

The following example illustrates how the AOF maximizes the mFRR economic surplus of a region consisting of two TSOs. The inputs of the example are presented in Table 4 and the outputs of the example are presented in Table 5.

Type	Volume (MWh)	TSO demand price/Bid price (€/MWh)	Divisibility of Bids
Positive demand (TSO 1)	+100	1000	--
Positive demand (TSO 2)	+100	1000	--
Upward bid (UB BSP1)	100	10	Divisible
Upward bid (UB BSP2)	100	20	Indivisible
Upward bid (UB BSP3)	200	5	Indivisible

Table 4: Inputs for Example - Activation of Bids with the Aim of Maximization of mFRR Economic Surplus

Type	Activated volume/Satisfied demand (MWh)
Positive demand (TSO 1)	+100
Positive demand (TSO 2)	+100
Upward bid (UB BSP1)	0
Upward bid (UB BSP2)	0
Upward bid (UB BSP3)	200
mFRR economic surplus (€)	Marginal Price (€/MWh)
100·1000 - 100·5 + 100·1000 - 100·5 + 200·5 - 200·5 = 199'000	5

Table 5: Output for Example

Generally, one can conclude that the maximisation of the mFRR economic surplus ensures the following objectives:

1. satisfaction of inelastic demand is implicitly prioritised since this maximises the mFRR economic surplus the most;
2. implicit netting of inelastic demand is generally implicitly prioritised because it maximises the mFRR economic surplus the most – thus the counteractivation of mFRR bids are in general minimised;
3. activation of most cost efficient mFRR bids, which are the cheapest upward and the more expensive downward bids in order to satisfy mFRR demand.

3.3.1. Schedule Counteractivations

With the term scheduled counteractivations, we refer to the simultaneous activation of an upward and a downward bid by the AOF in order to satisfy the inelastic demand as much as possible and thus also increase mFRR economic surplus. Due to the fact there may be some downward bids with higher prices than some upward bids, i.e. if some BSPs would be willing to pay higher prices to reduce their production than the prices that some other BSPs would be willing to receive to increase their production, schedule counteractivations could occur. Figure 25 presents two common merit order lists, i.e. if a downward bid had a higher price than an upward bid then these two bids would be simultaneously activated, as this would result in a higher mFRR economic surplus.

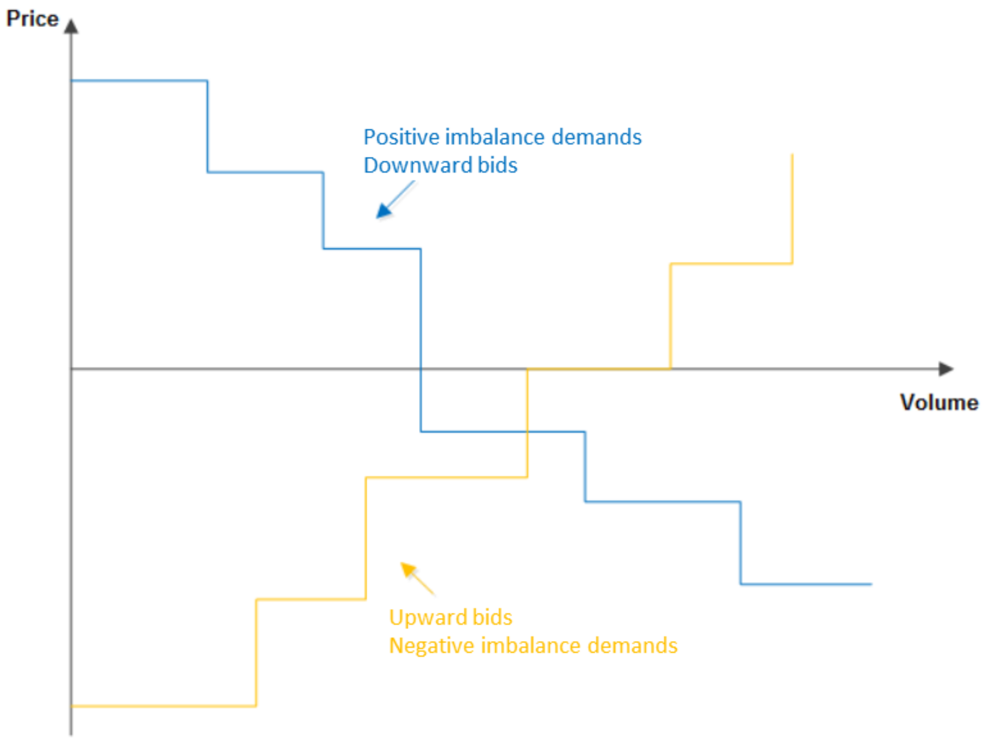

Figure 25: Interaction between two CMOLs – Downward & Upward bids

Here we note that allowing counteractivations will result in higher mFRR economic surplus and simplify the complexity of the algorithm as no additional constraints are added in the optimization algorithm, which will result in lower computation time. Further it will increase the opportunity of BSPs to be activated and gives non-distorted price signals that will promote price convergence.

Further, the occurrence of a downward mFRR bid with a higher price than an upward mFRR bid is expected to be observed when the energy prices in the smallest LFC area or scheduling area of the downward mFRR bid is higher than the energy prices in the scheduling area or LFC area of the upward mFRR bid. Therefore, in order for having such price differences, we expect that the mFRR cross border capacity limit will already mostly have been used from the previous timeframes and therefore the probability of schedule counteractivations to occur is low and is expected to become even lower given the price convergence signal within a marginal pricing scheme and particular when allowing counteractivations.

Moreover, it has to be noted that schedule counteractivations can also be helpful in two further cases. The first one is to activate more cost-efficient indivisible bids, and the second case is to increase the satisfaction of demand by allowing activation of indivisible bid. This would be the case when only a part of the indivisible bid would be needed for the satisfaction of demand, and in the absence of counteractivations, because it would be skipped and a less cost-efficient would have to be activated in the first case, or in the second case the demand could remain unsatisfied. An example is shown in the figure below:

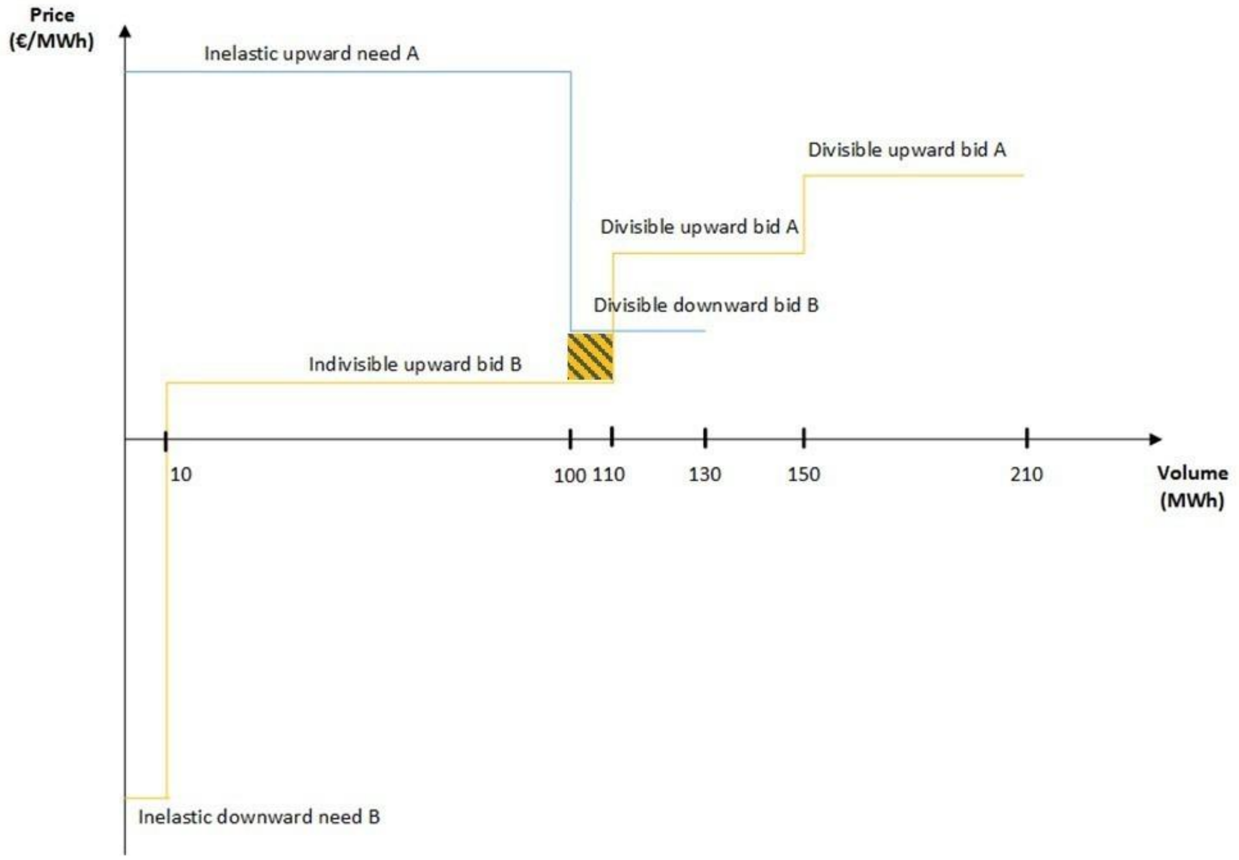

Figure 26: Interaction between two CMOLs – Downward & Upward bids

Due to schedule counteractivation, the indivisible upward bid B is selected together with a small part of the divisible downward bid B. In the absence of schedule counteractivations the indivisible upward bid B would be skipped, and the two divisible upward bids A would have been activated instead resulting in a much higher price.

From the above one can conclude that the simple maximisation of mFRR economic surplus results also in the following:

- in case counteractivation maximises the mFRR economic surplus, i.e. upward bid is cheaper that a downward bid, the activation of those bids will take place.

Any suppression or restriction of counteractivation is not straightforward due to the nature and complexity of the optimisation problem. Due to the existence of indivisible bids and links between bids, the optimisation algorithm needs to handle integer (binary) decision variables (therefore the algorithm need to account for non-convexities), which classifies the problem as integer programming (belonging to problems that are computational very hard to solve). However, allowing counteractivations, make the optimisation problem a standard maximisation of mFRR economic surplus, which is a problem that has already been studied extensively in the literature and is used in practice. Even though it is not a trivial problem, it can be formulated as a single mixed-integer linear program (MILP), for which there is a wide range of commercial solvers available, relying on years of experience and proven efficiency and robustness[4].

For supressing or restricting the counteractivations, one would need to add additional penalty terms in the optimisation objective function, leading to some approximations as well as additional constraints. One the one hand tuning such penalty terms will affect the results, and it could therefore lead to sensitivity in the solution. Also, since these approaches may produce results which are less transparent and easy to understand, and therefore raise challenges with the operation of the platform. On the other hand, finding prices that are compatible with the accepted and rejected offers and needs will be algorithmically challenging considering day-ahead market pricing rules. Thus, changing the objective function implies that the day-ahead-style pricing rules would need to be enforced explicitly as additional constraints, that have a challenging mathematical nature. Therefore, obtaining results that are consistent between outputs of accepted bids, satisfied needs, mFRR interchanges on the mFRR balancing borders and the price discovery can be problematic, given the class of optimization problem, the target run times and scales of problems that need to be tackled in MARI.

Therefore, the use of other objective function except for surplus maximisation complicates matters, because – due to fundamental properties of optimization and economic theory – the surplus maximising objective specifically ensures coherence between results (i.e. acceptance of bids, satisfaction of needs and prices, based on the submitted mFRR bid prices, bid volumes and TSO needs). The TSOs, given the algorithmic aspects as well as the positive elements identified from market point of view (consistent pricing, activation of cost efficient bids in presence of indivisibilities as well as maximisation of inelastic demand satisfaction), propose to have as main algorithm objective the maximisation of mFRR economic surplus (with allowing counteractivations), which to their opinion is the best choice to ensure the implementation of the algorithm for the go-live of the platform.

Finally, given the diverging views (both positive – consistent pricing, market attractiveness and liquidity, understandability of results – and negative – not the role of the platform, potential interfere with previous market) expressed around the expected market effects from NRAs and stakeholders, the TSOs will monitor during operation the market effects, notably during the yearly market monitoring reports, in order to identify the actual market effects of the algorithmic choice.

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[4] A classical algorithmic approach used for this problem is a branch-and-bound algorithm, with possible Benders decomposition . Note that, for efficiency reasons, it can be expressed through separate primal and dual problems instead of a single primal-dual formulation, using callbacks in the branch-and-bound algorithm.

3.3.2. Unforeseeably Rejected bids

Currently it is foreseen to disallow the rejection of Unforeseeably Rejected divisible Bids (URdB's) to provide incentive to BSP's to bid divisible bids. However, the impact of constraints on the algorithm will need to be further evaluated. For the implementation phase TSOs will have to set in the AOF the market rules required with priorities (as the AOF shall be able to distinguish what is the primary rule in the specific cases of uncertainties). Treatment of URdB is one of them amongst maximizing demand satisfaction, maximizing mFRR economic surplus, etc.

Minimization of the amount of manual frequency restoration power exchange on each mFRR balancing border In case multiple optimal solutions exist that result into the same mFRR economic surplus, the one with the minimum frequency restoration power exchange on each mFRR balancing border is prioritised.

3.3.3. Constraints of the Optimization Algorithm

The power balance equation is a constraint that is formulated for each LFC area or scheduling area. The constraint ensures that the cross border mFRR exchanges (mFRR induced flows on the respective border), the mFRR balancing energy bid activated within the LFC area or scheduling area and the satisfied mFRR demand are summed up to zero. In case of a common estimated mFRR demand for an LFC block, the power balance equation is set up with the demand of the LFC block and the aggregation of mFRR bids of the corresponding LFC areas.

The sum of all manual frequency restoration power interchanges is equal to zero means that in each time the algorithm is used, the resulted mFRR balancing energy exchanges are such that they sum up to zero.

The manual frequency restoration power exchange on a border shall not exceed the available mFRR cross border capacity limit.

The activation of bids for system constraint purpose may result in additional constraints in the algorithm in the situation this is expressed as a certain flow or a flow range for a specific interconnection. This can be for example in a HVDC line, as it has been shown in Figure 23 in this document.

The constraints concerning the indivisible bids or minimum technical requirements, and the technical and economic links, ensure that these technical characteristics are respected by the algorithm. This means for example that an indivisible bid can either be accepted completely or not at all. Furthermore, the linking expressed as mutual exclusive link between bids, mean that only one bid out of a group of offered bids can be selected. In a similar manner a linking expressed as a parent-child relation means that the child bid can be selected by the algorithm only and only if the parent has been selected as well.

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 speaking there are three options around the treatment of HVDC losses

1. The losses will not be considered by the algorithm, which may however lead to additional imbalances allocated to the TSOs around the HVDC line
2. The losses will be considered looking only at the marginal flow, i.e. MARI induced flows on the HVDC line, which may however lead to potential double counting of losses across the different timeframes,

3. The losses will be considered taken into account the total flow from previous timeframe, which may avoid double counting but may require more complex implementation and investigation on how it should be implemented.

MARI TSOs will investigate during the implementation if the HVDC losses should be taken into account and how, in order to avoid double counting, while considering the experience from previous timeframes as well as the practice on each HVDC interconnector in the previous market timeframe

In the following example, only the MARI flow is considered and may lead to double counting. The losses on the HVDC link are characterized by a percentage (4 %) of the circulating flow inside the interconnector. This percentage entirely determines the line's losses, and should be applied in both directions, whether A or B is the exporting area. Thus, when A wants to export 1000 MWh, only 960 MWh actually reaches market area B.

Figure 27: Example of Power Flow Losses on an HVDC Link

In this example, the power flows verify the following equation, which should be taken into account in the algorithm:

$$Flow_{received \to B} = Flow_{sent \to B}(1 - losses)$$

To illustrate the impact on prices that this feature may have, let us assume that there is no congestion on the HDVC line supporting this exchange. Then the congestion rent should be equal to zero, and prices should then verify the following equation:

$$Price_A Flow_{sent \to B} = Price_B Flow_{received \to B}$$

By computing the two previous equations, we obtain the relation:

$$Price_A(1 - losses) = Price_B$$

If the losses didn't exist, we would find again in this relation the common result that prices should be equal in the absence of any congestion. But here, with a loss coefficient of 4%, there is a remaining spread induced by the losses. Indeed, assuming that the price in area A is 10.00 €/MWh, we obtain the following output:

Figure 28: Example of the Losses' Impact on Prices

In conclusion, to take into account these physical losses, the algorithm should provide two specific features: some specific power flow constraints, and a specific output price computation. They should also be completed with an appropriate settlement process regarding the congestion rent management, as in the example of the Euphemia algorithm, which is outside of the scope of the IF and this ED.

3.4. Publication of Information

The inputs and outputs of the AOF and for the mFRR process in general will be made public as required by the Article 12 of the EBGL. The publication of the information will follow the EBGL recommendation and could be made through the mFRR Platform to the relevant European and/or local publication tools.

The description of the requirements of the AOF developed or when amended will be published according to the EBGL requirements at least 1 month before the application. However, MARI TSOs would like to stress that the details on the implementation of the AOF and thus the intellectual property rights are considered as TSOs' and constitute confidential information that will not be made public.

4. Congestion Management

TSOs have a responsibility to make sure that bids that are activated in the mFRR Platform will not endanger the system's security. The TSOs shall design an mFRR process and a platform which guarantee that the system constraints are fully respected.

This chapter tackles the issues and questions concerning congestion management, building on the provisions of the EBGL on CZC calculation (Art. 37), i.e.:

1. *After the intraday-cross-zonal gate closure time, TSOs shall continuously update the availability of cross-zonal capacity for the exchange of balancing energy or for operating the imbalance netting process. Cross-zonal capacity shall be updated every time a portion of cross-zonal capacity has been used or when cross-zonal capacity has been recalculated.*

2. *Before the implementation of the capacity calculation methodology pursuant to paragraph 3, TSOs shall use the cross-zonal capacity remaining after the intraday cross-zonal gate closure time.*

3. *Five years after entry into force of this Regulation, all TSOs of a capacity calculation region shall develop a methodology for cross-zonal capacity calculation within the balancing timeframe for the exchange of balancing energy or for operating the imbalance netting process. Such methodology shall avoid market distortions and shall be consistent with the cross-zonal capacity calculation methodology applied in the intraday timeframe established under Commission Regulation (EU) 2015/1222.*

4.1. Determination of mFRR cross-border capacity limits

In accordance with Article 4(2) of the mFRRIF, each TSO shall be responsible for determining the mFRR cross-border capacity limits applicable to each of his mFRR balancing borders and providing these limits to the optimisation algorithm.

Updated values for mFRR cross-border capacity limits will be provided to the mFRR-Platform. The TSO will do this by following the step-by-step process from Article 4(2) in the mFRRIF:

(i) First determining the capacity remaining after intraday (Step 1).

(ii) 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 mFRR balancing border (Step 3).

(iii) 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 mFRR cross-border capacity limits. The order in which these steps are taken can differ.

4.1.1.1. 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.

If the mFRR balancing border correspond to a bidding zone border or set of bidding zone borders, the mFRR 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 there are mFRR 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 mFRR balancing borders within Germany. In accordance with the zonal model defined by CACM, the available capacity on these internal mFRR balancing borders is assumed to not be limiting the balancing energy exchanges determined by the AOF. For this reason, the mFRR 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 a bidding zone border or set of bidding zone borders. Because the granularity of the mFRR market is the bidding zone it is not possible to take the cross-zonal capacities in these borders into account. For the mFRR 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 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[5].

4.1.1.2.Step 2: First-come, first-serve

In the second step, the mFRR 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 mFRR cross-border capacity limits are corrected for the replacement power interchanges on the mFRR 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 RR)
  - any corrections done for activated remedial actions (reducing limits of both RR and mFRR) in accordance with Article 4(2)(c) of the mFRRIF
  - any allocation of cross-zonal capacity to the mFRR process (reducing limits of RR to keep limits for mFRR high enough), as explained below
- This, with the corrections on remedial actions and additional limitation, then defines the mFRR cross-border capacity that are the input to the AOF.
- These mFRR cross-border capacity limits are input to the AOF used for both mFRR balancing energy exchange, as described below.

[5] Norwegian (NO), Swdish (SE) and Dannish (DK) bidding zones

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 mFRR, 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 mFRR cross-border capacity limits. The mFRR cross-border capacity limits should always at least be equal to the allocated cross-zonal capacity for those mFRR balancing borders that correspond to the bidding zone borders on which the allocation for mFRR has been done. This affects the RR cross-border capacity limits.

Figure 29 shows a timeline of the different processes which shows the points of attention for the first-come-first serve approach and the distribution of cross-zonal capacity between the platforms in general. Special points of attention for mFRR 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.

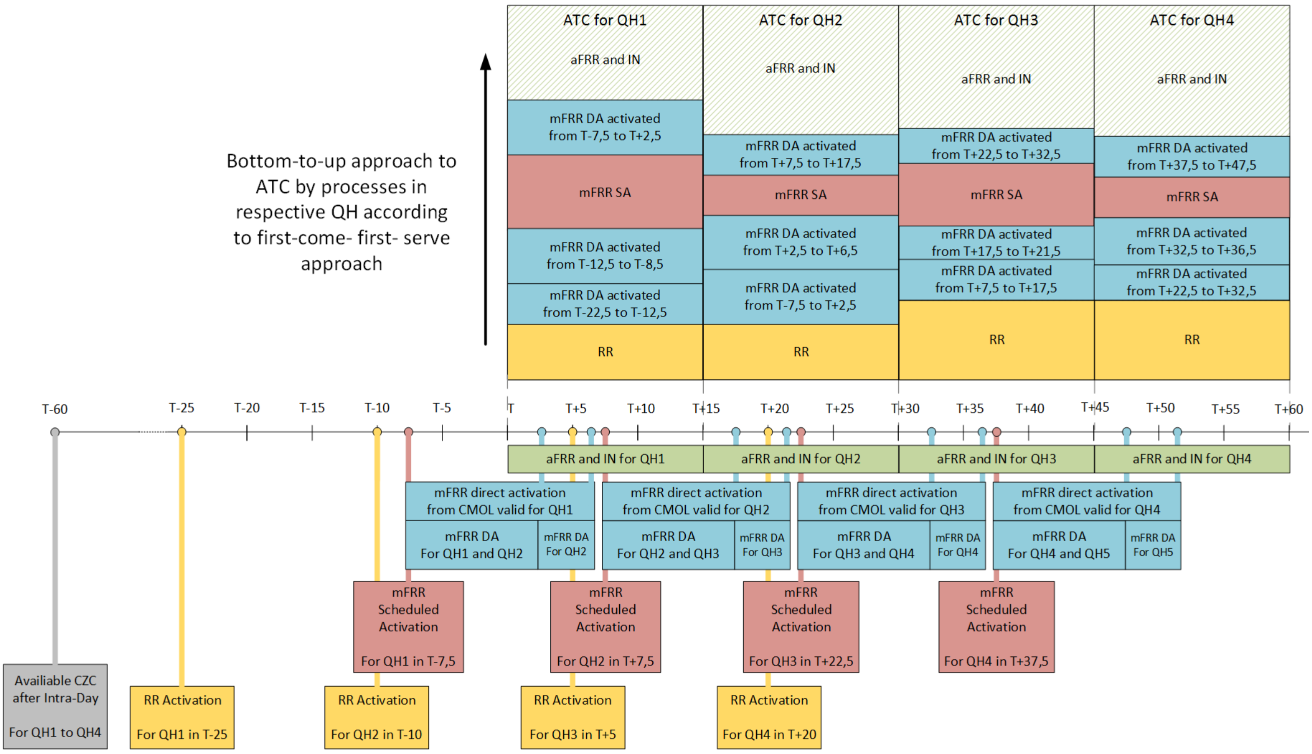

Figure 29: Timeline of activation in platforms with first-come-first-serve approach to capacities

The simultaneous use of mFRR cross-border capacity limits by mFRR and aFRR is handled. As described in chapter 3, both processes are perfomed in the same optimization cycle but in separate optimisation steps.

4.1.1.3.Step 3: Updates due to remedial actions

Step 3 of the process presented in mFRRIF 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 Article 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 mFRR 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 the RR balancing platforms, these limitations must be respected by the cross-border capacity limits for the subsequent processes.

4.1.1.4.Step 4: Operational security constraints

The mFRR cross-border capacities can be further restricted by operational security considerations. The mFRR cross-border capacities can be restricted upon request by TSOs participating in the mFRR 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 mFRR 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 mFRR 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 mFRR interchange over another area
- The total exchange in or out of an area can lead to congestions within an LFC area
- Exchange of mFRR between two synchronous systems can lead to frequency deviations. See Chapter **Error! Reference source not found.** for more on HVDC
- An outage or another sudden event in the power system can reduce the available capacity out of an area

4.1.1.5.Step 5: Technical constraints

Step 5 takes into account that not all mFRR balancing borders consisting of HVDC interconnectors have the technical ability to exchange mFRR, 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 mFRR interchange.

Some connections might not be available for mFRR at all, while some might have restrictions related to zero-crossings, minimum volumes, maximum ramping rates or other technical restrictions..

4.1.2. Treatment of mFRR cross-border capacity limits in the AOF

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

If the mFRR cross-border capacity limits does not constrain the optimization the entire MARI 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 mFRR balancing borders where the congestion occurred. When forming two uncongested areas the power interchange between the areas will always equal the mFRR 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

CBMP will be *lower* in the exporting uncongested area, while for down-regulation the CBMP will be *higher* in the exporting area[6].

4.1.3. 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 2.7.2

4.1.4. Other measures for operational security

In addition to restricting the mFRR 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 mFRR 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 mFRR activation from one LFC area or bidding zones, or other measures that the TSO finds necessary.

4.1.5. 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 mFRR 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 mFRR cross-border activation process will take into account previous balancing processes. 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 mFRR-Platform.

4.1.6. Example

Consider the configuration as in Figure 30, and assume:

- The mFRR demand of LFC Area A is 0 MW and the mFRR demand of LFC area B is 200 MW (upward demand)

[6] This can be different when reverse pricing occurs (see chapter **Error! Reference source not found.**)

- 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

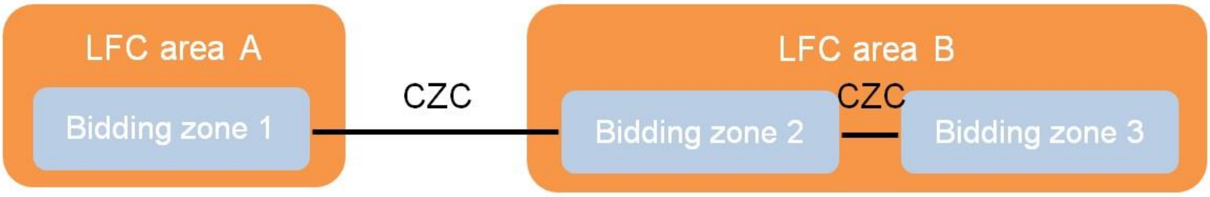

Figure 30: Example configuration of multiple bidding zones in one LFC are

The mFRR demand reflects the imbalance of the system in the LFC area or bidding zone. In this case, since the mFRR 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 mFRR 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 mFRR demand of LFC area B is located in BZ 3, the CZC between BZ 2 and 3 will not be respected.

5. Framework for further harmonization

Fragmented balancing market arrangements across Member States can distort the integration of European balancing markets. Therefore, the EBGL prescribes the implementation of a coherent set of terms and conditions related to balancing in each Member State. Article 16(1) of the Implementation Framework reiterates this TSOs terms and conditions responsibility, and the need to respect the European framework to safeguard consistency in market arrangements.

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 mFRR, this includes the balancing energy gate closure time, settlement price of balancing energy and the full activation time, which will be harmonised by the implementation date of the mFRR 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 mFRR 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 mFRR Platform, all TSOs will review their terms and conditions for BSPs related to balancing with the aim of harmonisation.

6. 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 mFRRIF. 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 mFRR-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.

7. List of Abbreviations

aFRR	Automatic Frequency Restoration Reserves
AOF	Activation Optimization Function
ATC	Available Transmission Capacity
BRP	Balance Responsible Party
BSP	Balancing Service Provider
BZ	Bidding Zone
CBCL	Cross Border Capacity Limit
CB	Cross Border
CBMP	Cross Border Marginal Price
CCR	Capacity Calculation Region
CMOL	Common Merit Order List
CZC	Cross-Zonal Capacity
DA	Direct Activation, directly activated, directly activatable
DB	Downward bid
EBGL	Guideline on electricity balancing
GCT	Gate Closure Time
HVDC	High Voltage Direct Current
IGCC	International Grid Control Cooperation
IF	Implementation Framework
LFC	Load-Frequency Control(ler)
MARI	Manually Activated Reserves Initiative
mFRR	Manual Frequency Restoration Reserves

MOL	Merit Order List
NRAs	National Regulatory Authorities
NTC	Net Transfer Capacity
QH	Quarter Hour
RR	Replacement Reserves
SA	Scheduled Activation, scheduled activated, scheduled activatable
SCADA	Supervisory Control and Data Acquisition
TERRE	Trans-European Replacement Reserves Exchange
TSO	Transmission System Operator
UB	Upward bid

Annex I: Settlement

In the course of the past conceptual design phases for a common mFRR Platform, the issues of settlement between TSOs have been dealt with by the MARI initiative alongside the main deliverables required for the all TSOs' proposal for the European mFRR Platform according to the EBGL, Article 20. Although Settlement is not an integral part of the corresponding Implementation Framework of this Explanatory Document but will be addressed in separate Implementation Frameworks in accordance with the respective Articles of the EBGL, i.e. Art. 30 (Pricing), Art. 50 (Settlement), Art. 29 (3) (Activation Purpose).