Explanatory document to all TSOs' proposal for a methodology to determine prices for the balancing energy and cross-zonal capacity used for exchange of balancing energy or for operating the imbalance netting process pursuant to Article 30 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

18 December2018

DISCLAIMER

This document is submitted by all transmission system operators (TSOs) to all NRAs for information purposes only accompanying the all TSOs' proposal for a methodology to determine prices for the balancing energy and cross-zonal capacity used for exchange of balancing energy or for operating the imbalance netting process pursuant to Article 30 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing.

Table of Contents

List of Figures

List of Tables

Definitions and Abbreviations

Definitions

'aFRR-Platform'	means European platform for the exchange of balancing energy from frequency restoration reserves with automatic activation.
'aFRR balancing border'	means a set of physical transmission lines linking adjacent LFC areas of participating TSOs. The optimisation algorithm calculates the automatic frequency restoration power interchange for each aFRR balancing border. For the purposes of the optimisation, each aFRR balancing border has a mathematically defined negative and positive direction for the automatic frequency restoration power exchange.
'balancing energy pricing period'	means a time interval for which cross-border marginal prices are calculated.
'balancing market time unit'	means the longer of the two imbalance settlement periods on either side of an mFRR balancing border, except for where at least one of the two imbalance settlement periods are longer than 15 minutes, in which case the balancing market time unit means 15 minutes, starting right after 00:00 CET. The balancing market time units shall be consecutive and not overlapping.
'cross-border capacity limits'	means the limits which serve as constraints for the exchange of balancing energy on bidding zone borders and/or LFC areas and are determined in accordance with the implementation frameworks for the exchange of balancing energy from replacement reserves, from frequency restoration reserves with manual and automatic activation or for the imbalance netting process.
'demand'	means a TSO demand for activation of any balancing standard product bids.
'direct activation'	means a mFRR-Platform process that can occur at any point in time to resolve large imbalances within the Time To Restore Frequency
'divisible bids'	means a characteristic of a bid which enables its partial or fully activation.
'implementation project'	means the project which implements the RR, mFRR, aFRR and IN-Platforms, pursuant to Article 19, 20, 21 and 22 of the EBGL respectively.
'implementation framework'	means the proposal for the European platforms pursuant to Article 19, 20, 21 and 22 of the EBGL.
'mFRR-Platform'	means European platform for the exchange of balancing energy from frequency restoration reserves with manual activation;
'mFRR balancing border'	means a set of physical transmission lines linking adjacent bidding zones, where an LFC area consists of more than one bidding zone, or LFC areas of participating TSOs. The optimisation algorithm calculates the cross-border manual frequency restoration power exchange for each mFRR balancing border. For the purposes of the optimisation, each mFRR balancing border has a mathematically

	defined negative and positive direction for the manual frequency restoration power interchange.
'non-AOF volume'	means the volume rejected by the AOF but accepted locally for TSO-BSP settlement within a validity period.
'price indeterminacy'	means that there is no unambiguous intersection point between the consumer and supply curves.
'selected bid'	means a bid that is selected by the AOF and must be fully or partially activated.
'standard balancing energy product'	means the standard product for balancing energy from replacement reserves or frequency restoration reserves with automatic or manual activation.
'rejected bid'	means a bid which is part of the common merit order list of the AOF but is not a selected bid.
'RR-Platform'	means European platform for the exchange of balancing energy from replacement reserves.
'RR balancing border'	means a set of physical transmission lines linking adjacent bidding zones, of participating TSOs. The optimisation algorithm calculates the cross-border reserve replacement power exchange for each RR balancing border. For the purposes of the optimisation, each RR balancing border has a mathematically defined negative and positive direction for the manual frequency restoration power interchange.
'uncongested area'	means the widest area, constituted by bidding zones and/or LFC areas, where the exchange of balancing energy and the netting of demands is not restricted by the cross-border capacity limits calculated in accordance with the implementation frameworks for the exchange of balancing energy from replacement reserves, from frequency restoration reserves with manual and automatic activation as well as for the imbalance netting process.
'validity period'	means the period during which a balancing energy bid can be is submitted.

Abbreviations

List of abbreviations used in this document:

aFRR	automatic frequency restoration reserve
AOF	activation optimisation function
APP	activation purposes proposal
BSP	balancing service provider
BEPP	balancing energy pricing period
BRP	balance responsible party
CMOL	common merit order list

CP	clearing price
CZC	cross-zonal capacity
DA	direct activation
DDO	divisible downward offer
DUO	divisible upward offer
EBGL	guideline on electricity balancing
FAT	full activation time
FRCE	frequency restoration control error
ISP	imbalance settlement period
IPN	inelastic positive need/demand
LFC	load frequency control
LMOL	local merit order list
MARI	Manually Activated Reserves Initiative
mFRR	manual frequency restoration reserve
MOL	merit order list
MCP	market clearing price
MP	marginal price
MW	megawatt
MWh	megawatt hour
NRA	national regulatory authority
PICASSO	Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
PP	pricing proposal
QH	quarter hour
RR	replacement reserves
SA	scheduled activation
SOGL	guideline on electricity transmission system operation
TERRE	Trans European Replacement Reserves Exchange
TSO	transmission system operator
TTRF	time to restore frequency
UAB	unforeseeably accepted bid
URB	unforeseeably rejected bid
CBMP	cross-border marginal pricing

1 Introduction

This document gives background information and rationale for the all TSOs' proposal regarding the development of a proposal for a methodology to determine prices for the balancing energy and cross-zonal capacity used for exchange of balancing energy or for operating the imbalance netting process in accordance with Article 29(3), Article 30 and Article 50(1) of the Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (hereafter referred to as "EBGL").

The explanatory document accompanies the proposal for the methodology to determine prices for balancing energy and cross-zonal capacity which is submitted for approval by all regulatory authorities in accordance with Article 30 of the EBGL and Article 5 of the EBGL.

Both the proposal and the explanatory document, consider and include results previously developed by the implementation projects MARI, PICASSO, TERRE and, with respect to the pricing of cross-zonal capacity, IGCC. These include input provided by the stakeholders during previous consultations.

The proposal cannot be considered completely independent from the implementation frameworks for the European platforms for the exchange of balancing energy from replacement reserves (RR), frequency restoration reserves with manual (mFRR) and automatic activation (aFRR) as well as imbalance netting (IN). The implementation frameworks define the standard balancing energy products, the basic business processes and the principles of the optimisation algorithms which will provide the input data necessary to calculate the prices.

Obviously, the proposal has to be considered in context of the EBGL as well. In particular, Article 30 of the EBGL provides the boundary conditions for the proposal. Chapter 2 analyses the requirements of the relevant EBGL articles and provides an interpretation where needed.

Following the structure of the proposal, Chapter 3 introduces the general principles of the pricing methodology which are cross-border marginal pricing (CBMP), differentiation between products, activation types and time frames, different pricing for different activation purposes and settlement based on the principles of the EBGL.

The following three chapters focus on specific aspects of CBMP calculation:

Chapter 4 deals with the pricing for scheduled mFRR and RR balancing energy bids including an explanation of price indeterminacy, price divergence and pricing of system constraints.

Chapter 5 explains the pricing of mFRR with direct activation type.

Chapter 6 provides the background on the pricing of balancing energy from aFRR. Due to the fact that aFRR is a closed-loop process where the calculation of the aFRR request by the TSOs does not only depend on imbalances but also on actual aFRR delivery by the balancing service providers (BSPs), the pricing methodology for aFRR requires a fundamental understanding of the underlying technical process and signals. The respective background information is summarized in Chapter 6.2.

Chapter 7 summarizes the remaining aspects of the pricing methodology, such as pricing of the specific products (Chapter 7.1) and pricing of cross-zonal capacity (Chapter 7.3). Moreover, Chapter 7.2 provides a short explanation regarding the treatment of the central dispatching models.

Together with the all TSOs' proposal for the implementation frameworks, the PP will lead to a new European market for RR, mFRR and aFRR. This will increase the efficiency of the balancing energy markets and competition but also lead to many changes for stakeholders, both from harmonisation efforts and as a result of the integration of the markets. Therefore, the TSOs encourage and appreciate valuable feedback from the stakeholders.

2 EB GL Requirements for Balancing Energy Pricing Methodology

Article 30 of the EBGL requires the TSOs to develop a proposal for pricing of balancing energy bids and pricing of cross-zonal capacity used for balancing energy exchange. This section provides a summary of the core EBGL requirements for the PP.

2.1 Pricing Proposal (Article 30 of the EBGL)

Article 30(1) of the EBGL states the requirement to develop "[…] *a proposal for a methodology to determine prices for the balancing energy that results from the activation of balancing energy bids for the frequency restoration process* […], *and the reserve replacement process.*"

Besides the obligation to develop a proposal, Article 30(1) of the EBGL defines boundary conditions for the pricing methodology.

"*Such methodology shall:*

(a) be based on marginal pricing (pay-as-cleared);

(b) define how the activation of balancing energy bids activated for purposes other than balancing affects the balancing energy price, while also ensuring that at least balancing energy bids activated for internal congestion management shall not set the marginal price of balancing energy;

(c) establish at least one price of balancing energy for each imbalance settlement period;

(d) give correct price signals and incentives to market participants;

(e) take into account the pricing method in the day-ahead and intraday timeframes."

By stating the boundary condition (a) EBGL already gives a clear prerequisite to use marginal pricing. Although Article 30(5) of the EBGL leaves a possibility to "[…] *request an amendment and propose a pricing method alternative to the pricing method in paragraph 1(a)*", there is hurdle to overcome with "[…] *a detailed analysis demonstrating that the alternative pricing method is more efficient*."

An obligation of the EBGL is to avoid that out of merit-order activation which would be due to the activation of a specific bid for internal congestion management sets the marginal price for balancing energy bids. In this context (b) uses the formulation that "*at least balancing energy bids activated for internal congestion management shall not set the marginal price*." As the implementation frameworks of the different platforms do not foresee to have local activation, but only activation at the level of the relevant areas, this condition is naturally fulfilled. There is no other requirement related to the different activation purposes.

The requirement (c) provides a degree of freedom for the number of prices. The methodology shall "*establish at least one price of balancing energy for each imbalance settlement period*." The TSOs interpret this requirement in the following way:

- the EBGL allows more than one price for balancing energy bids for each imbalance settlement period (ISP) as long as other boundary conditions are respected.
- the EBGL does not provide a limiting requirement how exactly to set the prices, i.e. the number of prices could be set based on the processes frequency restoration and reserve replacement, the respective sub-processes or products.
- Moreover, the methodology could establish more than one price for one process, sub-process or product for one imbalance settlement period (ISP).

At the same time, the number of prices should be chosen with respect to the objectives of the EBGL and, in particular, taking into account the boundary condition (d) which requires the methodology to "*give correct price signals and incentives to market participants*" and (e) which refers to the "*pricing method in the day-ahead and intraday timeframes*":

- The pricing in the day-ahead market is based on cross-border implicit allocation via a single clearing with congestion rent. There is one price for each market time unit.
- The intraday market is based on continuous trading, i.e. there could be as many prices for one market time unit as trades, thus there will be multiple prices for each market time unit.
- The intraday market does not set nor explicitly influence the prices for the day-ahead market or vice versa.

The pricing methodology in the day-ahead and intraday markets support the preference for several prices for one ISP based on the number of clearings. The TSOs have followed this approach in the proposal (see Sections 3.1.2 and 6.3).

Article 30(3) formulates the requirement for pricing of cross-zonal capacity which shall "*reflect market congestion*" and "*be based on the prices for balancing energy.*"

It is worth mentioning, that the pricing methodology shall also include "*the pricing of cross-zonal capacity* […] *for operating the imbalance netting process*" although the settlement of imbalance netting is treated by the proposal to be submitted in accordance with Article 50.

2.2 Interaction with the National Terms and Conditions for BSPs (Article 18 of the EBGL)

While the pricing methodology is a common proposal of all TSOs, the determination of the balancing energy volumes to be settled with the balancing service providers (BSPs) is part of the national terms and conditions which are developed on national level and are approved by the national regulatory authority.

The respective requirement is stated in Article 18(5)(h) of the EBGL. The terms and conditions for BSPs shall contain "*the rules for the determination of the volume of balancing energy to be settled with the balancing service provider pursuant to Article 45*".

The approval at national level also applies to imbalance adjustment. The terms and conditions shall contain "*rules and conditions for the assignment of each balancing energy bid from a balancing service provider to one or more balance responsible parties pursuant to paragraph* 4*(d)*" (Article 18(5)(e)), while the referred paragraph obliges the terms and conditions for BSPs to "*require that each balancing energy bid from a balancing service provider is assigned to one or more balance responsible parties to enable the calculation of an imbalance adjustment pursuant to Article 49.*"

The TSOs have proposed a roadmap for harmonisation of terms and conditions for BSPs in the implementation frameworks. Nonetheless, EBGL clearly puts the methodologies for balancing energy volume determination and imbalance adjustment at national level. This boundary condition must be taken into account by the pricing methodology which means must be compatible with more than one methodology for volume and imbalance adjustment determination. Requirements for Balancing Energy Settlement (Articles 45 – 49 of EBGL)

Articles 45 - 49 of the EBGL define requirements for balancing energy settlement with BSPs. Article 45 of the EBGL contains the general requirement for TSOs to calculate and to settle balancing energy. The calculation can be based on metered or requested activation.

Table 1 summarizes the articles which define the obligations regarding the volume calculation and settlement for the single processes. The differences between the articles are underlined. Obviously, the requirements differ in the mentioning of the processes. Moreover, the settlement of the balancing energy for the frequency containment process is optional which is indicated by the word "*may*" in Article 46(1) of the EBGL.

Article Number	**Text**
Article 46(1)	"*Each connecting TSO may calculate and settle the activated volume of balancing energy for the frequency containment process with balancing service providers pursuant to paragraphs 1 and 2 of Article 45.*"
Article 47(1)	"*Each connecting TSO shall calculate and settle the activated volume of balancing energy for the frequency restoration process with balancing service providers pursuant to paragraphs 1 and 2 of Article 45.*"
Article 48(1)	"*Each connecting TSO shall calculate and settle the activated volume of balancing energy for the reserve replacement process with balancing service providers pursuant to paragraphs 1 and 2 of Article 45.*"
Article 46(2)	"*The price, be it positive, zero or negative, of the activated volume of balancing energy for the frequency containment process shall be defined for each direction as defined in the Table 1.*"
Article 47(2)	"*The price, be it positive, zero or negative, of the activated volume of balancing energy for the frequency restoration process shall be defined for each direction pursuant to Article 30 as defined in the Table 1.*"
Article 48(2)	"*The price, be it positive, zero or negative, of the activated volume of balancing energy for the reserve replacement process shall be defined for each direction pursuant to Article 30 as defined in the Table 1.*"

TABLE 1: ARTICLES 46 – 48 OF THE EBGL

It is worth noting that calculation and settlement of balancing energy for the frequency containment process (Article 46 of the EBGL) is not part of the PP in accordance with Article 30. Nonetheless, this article has relevance for the PP since it includes Table 2 which is referenced by the subsequent articles on the frequency restoration (Article 47(2) of the EBGL) and reserve replacement (Article 48(2) of the EBGL) processes.

The table defines the sign conventions and resulting financial flows between TSOs and BSPs. In particular, the table shows that negative balancing energy prices are possible in which case the financial flow is inverted and the TSO would receive (make) a payment from (to) the BSP in case of positive (negative) balancing energy delivery.

	Balancing energy price positive	Balancing energy price negative
Positive balancing energy	Payment from TSO to BSP	Payment from BSP to TSO
Negative balancing energy	Payment from BSP to TSO	Payment from TSO to BSP

TABLE 2: PAYMENT OF BALANCING ENERGY (SOURCE – ARTICLE 46 OF THE EBGL)

All three articles use the formulation "*The price, be it positive, zero or negative, of the activated volume of balancing energy […] shall be defined for each direction pursuant to Article 30 as defined in the Table 1.*"

The usage of singular in "*the price*" can be considered as a contradiction to the formulation in Article 30(1)(c) of the EBGL which requests a calculation of "*at least one price*". This contradiction resolves itself by taking the following into account:

- The formulation "*the price*" refers to the price of the settlement amounts and the table defining the sign conventions. The respective text is identical for frequency containment, restoration and reserve replacement processes.
- At the same time the formulation refers to the methodology of Article 30 of the EBGL which will define "*the price*".

- The understanding of "*the price*" as a limit to the number of prices per process, product or per imbalance settlement period (ISP) would indeed contradict the formulation "*at least one price*" in Article 30(1)(c) of the EBGL. On the other hand, if the EBGL set a limit to the number of prices, the respective requirements would have formulated this explicitly instead of a formulation allowing a degree of freedom.
- The understanding in the sense of a limit would also neglect other requirements of Article 30(1) of the EBGL, i.e. the objective to set correct price signals and the aim for consistency to the day-ahead and intraday market timeframes.

Due to this, the TSOs understand the formulation "*the price*" in Articles 46 – 48 of the EBGL as the price which will be used to remunerate balancing energy bids for the delivery of balancing energy for each process, both directions and each BEPP, and not as a limiting requirement for the methodology to be developed in accordance with Article 30 of the EBGL.

2.3 Interaction with the Activation Purposes Proposal (Article 29(3))

Article 30(1)(b) of the EBGL requires the pricing methodology to define pricing of balancing energy bids activated for purposes other than balancing. This requirement is a reference to the activation purposes proposal (hereinafter referred to as "APP") in accordance with Article 29(3) of the EBGL which states that all TSOs "*describe all possible purposes for the activation of balancing energy bids*" and "*define classification criteria for each possible activation purpose*."

2.4 Specific Products

Each TSO may propose specific products which must be approved by the regulatory authority on national level. From the perspective of the PP, specific products fall into two categories:

- specific products which are converted to standard products and are activated from the common merit order list of the platforms in accordance with Article 26(3)(a) of the EBGL and
- specific products which are activated locally in accordance with Article 26(3)(b) of the EBGL.

In accordance with Article 30(4) of the EBGL, the pricing methodology will apply to specific products which are converted to the standard products.

By default, it also applies to specific products which are activated only locally. Still, in accordance with Article 30(4) of the EBGL, for "[…] *specific products pursuant to Article 26(3)(b), the concerned TSO may propose a different pricing method in the proposal for specific products pursuant to Article 26*." This proposal is an optional proposal of the respective TSO and, therefore, is not part of the PP in accordance with Article 30(1) of the EBGL.

2.5 Conversion of Bids in a Central Dispatching Model

Article 27 of the EBGL sets out the requirements for TSOs using central dispatching model.

Article 27(2) of the EBGL requires that each TSO applying a central dispatching model uses "[…] *the integrated scheduling process bids available for the real time management of the system to provide balancing services to other TSOs, while respecting operational security constraints*" and, in accordance with Article 27(3) of the EBGL converts "*as far as possible the integrated scheduling process bids pursuant to paragraph 2 into standard products taking into account operational security*."

Moreover, Article 27(3) of the EBGL mentions boundary conditions for the conversion rules which must be "*fair, transparent and non-discriminatory*", shall "*not create barriers for the exchange of balancing services*" and shall "*ensure the financial neutrality of TSOs.*"

In the context of pricing, the standard balancing energy product bids which result from the integrated scheduling process bids will be treated in accordance with the methodology of Article 30(1) of the EBGL for the settlement of intended energy exchange between the TSOs. The price used for TSO-BSP settlement in the central dispatching model is subject to the national terms and conditions related to balancing.

3 General Principles

3.1 Principles of Cross-Border Marginal Pricing

3.1.1 Marginal Pricing

As requested in the EBGL and outlined in Chapter 2, the methodology to determine prices for balancing energy shall be based on marginal pricing. Generally, the marginal price represents the price of the last bid of a standard product that has been selected to cover the demand for balancing purpose within a specified area. An illustrative example for the determination of the marginal price is shown in Figure 1.

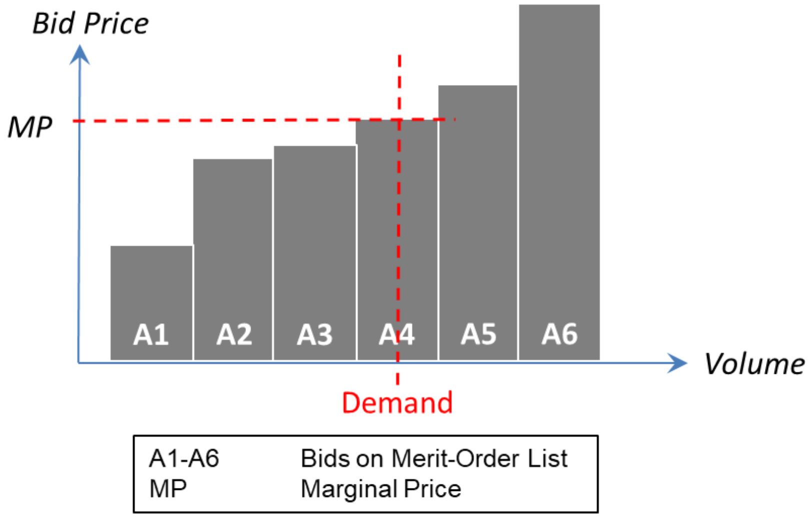


FIGURE 1: MARGINAL PRICING - GENERAL PRINCIPLE

Under marginal pricing and the assumption of perfect competition, BSPs' optimal strategy is to bid their marginal costs which ensures the maximisation of their earnings and the efficiency of the auctions. Therefore, it is expected that bid prices are lower compared to other pricing schemes (i.e. pay-as-bid). Moreover, marginal pricing reduces the complexity of bidding for BSPs in auctions compared to bidding under pay-as-bid schemes that requires forecast skills and dedicated tools. As such, marginal pricing makes the participation of new entrants easier and reduces the operating costs.

3.1.2 Cross-Border Marginal Pricing and Uncongested Areas

In all implementation projects for the European platforms for the exchange of balancing energy, TSOs propose to use cross-border marginal prices to determine the price for the respective balancing energy.

This means:

- All exchanged balancing energy that results from the activation of standard balancing energy bids within an uncongested area is priced with the same marginal price for providing the same service (this general rule has to be considered in context of the dynamics of aFRR described in Chapter 6.3, differentiation between products and time periods described in Chapter 3.2 as well price indeterminacy described in Chapter 4.3).

- In case of cross-zonal capacity limitations between adjacent areas, a price split can occur meaning that in each uncongested area the highest selected bid sets the marginal price for the respective area. The price for cross-zonal capacity corresponds to the price difference between the adjacent uncongested areas (in the following, this scenario is also referred to as "congested" while the scenario without a price split is called "uncongested").

The same principles to determine prices for energy and cross-zonal capacity are also applied in the day-ahead market timeframe.

An example for the price determination is shown in Figure 2. For the sake of simplicity, it is assumed in this example that the platform consists of two areas (area A & area B) both forwarding their bids for balancing energy in a given validity period to a common merit order list (CMOL).

In the uncongested case the price is determined by the highest selected bid necessary to cover the demand of both areas ($Demand_{A+B}$) resulting in a marginal price of MP_{AB}.

In the congested situation it is assumed that bid B4 cannot be exchanged between the areas due to limited available cross-zonal capacity. Therefore, a higher priced bid in area A needs to be activated (A2). For the price determination the aforementioned price split occurs leading to different marginal prices in the two areas (MP_A and MP_B).

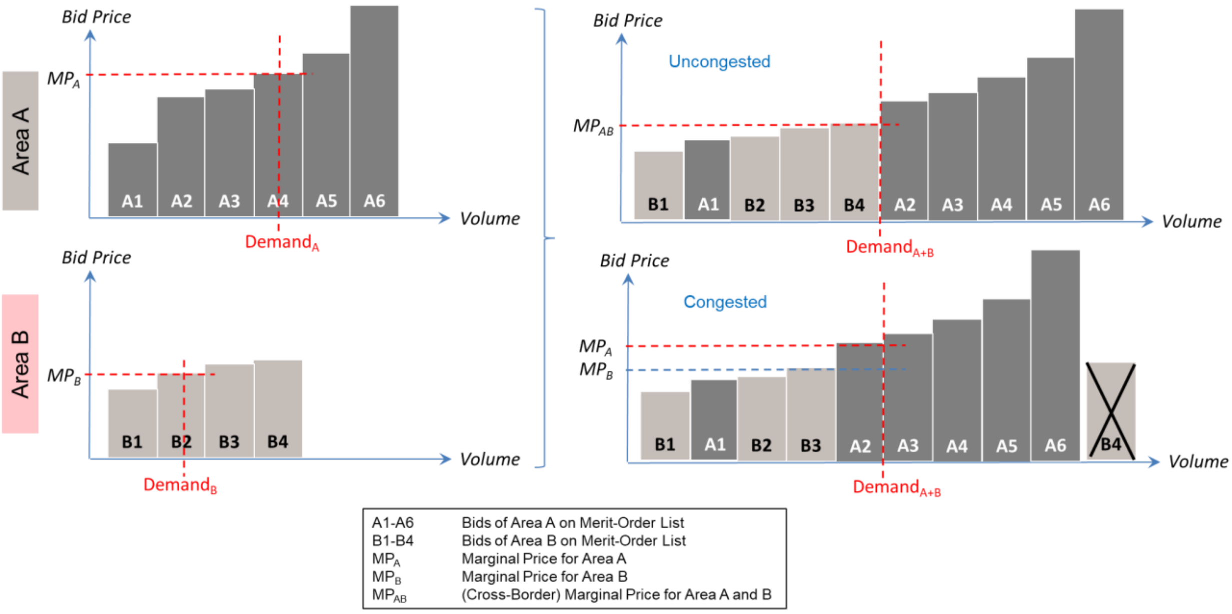


FIGURE 2: PRINCIPLE OF CROSS-BORDER MARGINAL PRICING IN UNCONGESTED AND CONGESTED SITUATION

In the congested situation the price for the cross-zonal capacity can be derived from the price spread between the adjacent uncongested areas. In the abovementioned example, the price of cross-zonal capacity is equivalent to the difference between MP_A and MP_B.

The principle to determine uncongested areas can also be applied taking into account multiple areas exchanging balancing energy as shown in Figure 3. In this example, the limited cross-zonal capacities between area B and area C, area B and area E as well as area D and area E leads to a split into two uncongested areas.

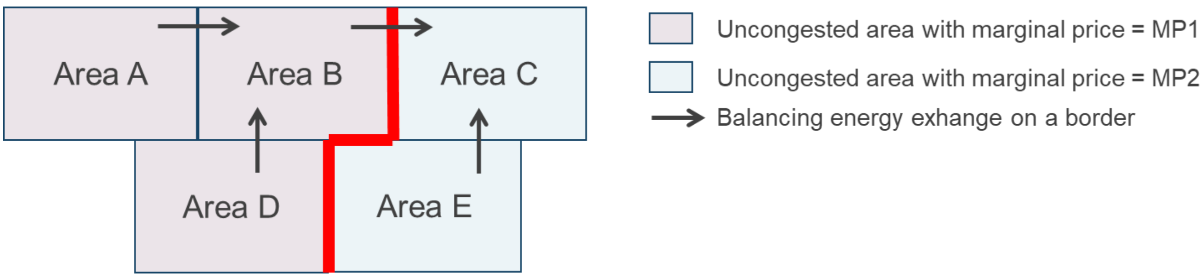


FIGURE 3: DETERMINATION OF UNCONGESTED AREAS - MULTIPLE AREAS

As congestions can evolve in the wake of exchanging balancing energy for different processes, the uncongested areas can be different for the different balancing processes. E.g. the uncongested areas for RR activation could be different from uncongested areas for mFRR activation. Also, the uncongested areas for mFRR activations can be different from the uncongested areas for aFRR activation. Moreover, as mFRR with direct activation and aFRR are (quasi) continuous process, the definition of the uncongested areas for this process may change at any point in time, also within an ISP or the quarter of an hour for which the bid is submitted.

3.1.3 Calculation of the Cross-Border Marginal Price

Figure 4 illustrates the basic schematic principle for the cross-border marginal price calculation. The TSOs submit the common merit order list, the balancing energy demand (both, elastic and/or inelastic) as well as the available cross-zonal capacity to the activation optimisation function (AOF). The AOF performs the optimisation which can also be understood as a balancing energy market clearing. There are two outputs of the optimisation that are important for the pricing:

- the balancing energy bids which must be activated in order to satisfy the demand (selected bids)
- the uncongested areas, i.e. the areas where the exchange of balancing energy was not effectively restricted by the available cross-zonal capacity or allocation constraints.

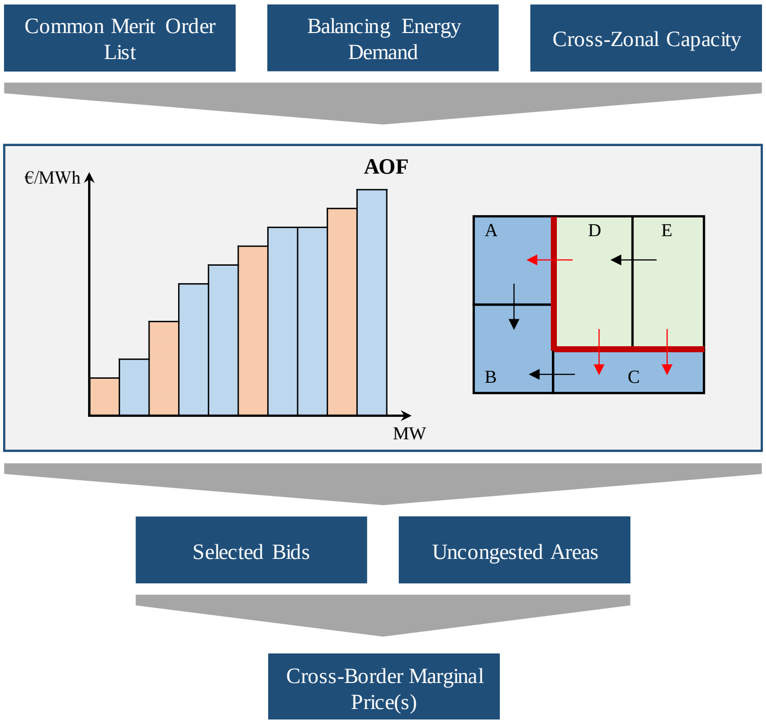


FIGURE 4: CALCULATION OF THE CROSS-BORDER MARGINAL PRICE – BASIC PRINCIPLE

The uncongested areas are identified in each optimisation, by determining a marginal price for each bidding zone/LFC area as output of the optimisation, whereas the bidding zones (or LFC areas) that form an uncongested area will all have the same price. The process illustrated in Figure 4 can be applied for one optimisation, i.e. market clearing.

The reason to for the usage of LFC areas, in addition to bidding zones, in the context of the uncongested area stems from the different possible area configurations:

- There exist configurations such that a bidding zone include more than one LFC areas and also configurations where LFC area can include more than one bidding zone. I.e. depending on the configuration, bidding zone can be smaller area than LFC area and vice versa.

- In accordance with Article 141(4) of the SOGL, the frequency restoration process is organised on the basis of LFC areas. This is of particular importance for aFRR which is operated in a closed-loop manner with FRCE of the LFC area as input to the calculation of the aFRR demand.
- Therefore, the locational scale for optimisation inputs as well as outputs, including the prices, are LFC area for aFRR, the smallest of the bidding zone and LFC area for mFRR and bidding zone for RR.

It is worth mentioning that the cross-border capacity limits for the exchange of balancing energy shall be set for the exchange on the respective area borders in accordance with the rules determined in the IFs and are not part of the pricing proposal.

3.2 Differentiation Between Products and Time Periods

In practice, there are additional aspects which must be considered in the pricing proposal:

- Firstly, there are different optimisations, for RR, mFRR with scheduled activation, mFRR with direct activation and aFRR activation.
- Secondly, there is more than one market clearing for each ISP:
  - There is one optimisation for the activation of RR balancing energy bids.
  - There is one optimisation for the activation of mFRR with scheduled activation type.
  - There can be more than one optimisation for the activation of mFRR with direct activation type.
  - There are 900 optimisations for aFRR activation if an optimisation cycle of 1 second is assumed (in case of a 4 second optimisation cycle there are 225 optimisations).

The requirement to perform the optimisations separately results directly from the different activation processes (scheduled and direct activation, manual and automatic activation). For RR and mFRR with scheduled activation, the necessity for separated clearings results from different product parameters (such as full activation time, gate closure times). mFRR with direct activation is required to fulfil the requirement of Time To Restore Frequency (TTRF) arising from the SOGL as many TSOs use mFRR to cover their dimensioning incident.

The respective differences are treated by having separate clearings for different processes.

3.2.1 Differentiation Between Products

Figure 5 illustrates the approach of the proposal regarding the number of prices. There will be different CBMP calculations for RR, mFRR with scheduled activation, mFRR with direct activation and aFRR.

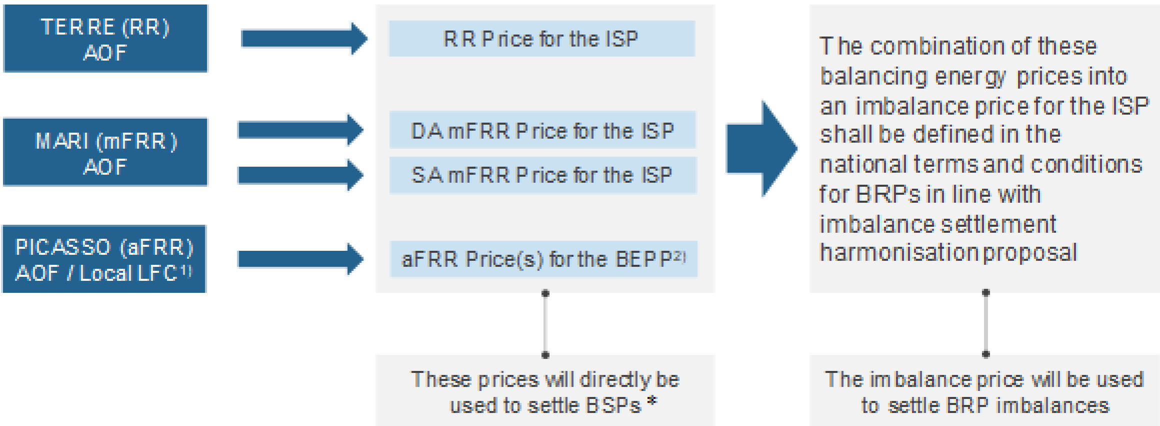


FIGURE 5: MULTIPLE PRICES FOR EACH IMBALANCE SETTLEMENT PERIOD

* Prices used directly to settle BSPs with exception of integrated scheduling process bids as described in 2.5.

This differentiation is consistent with the differentiation between the day-ahead and intraday market.

The TSOs have evaluated the so called cross-product marginal pricing methodology:

- The basic principle of cross-product marginal pricing is, that the upward balancing energy bid with the highest price sets the marginal price not only for the balancing energy bids from the same merit order but for all upward selected balancing energy bids, even if these bids represent a different product. Conversely for downward activation, the lowest price would be retained.
- E.g., a selected upward aFRR balancing energy bid could set the price for all selected upward mFRR and RR balancing energy bids (or vice versa, depending which bids have the higher price).

Besides the questionable advantage in context of imbalance pricing, cross-product pricing is not in line with the boundary conditions which Article 30 of the EBGL defines for the PP due to the following reasons:

- The technical product requirements increase from RR to mFRR with scheduled activation and then to mFRR with direct activation as well as to aFRR. At the same time the gate closure times decrease. Different prices for the different technical and commercial product properties provide a proper valuation of the respective bids.
- The activation of balancing energy bids with manual activation (RR and mFRR) requires a lead time and is always based on an expectation that an imbalance will appear in the future or that an observed imbalance will not disappear. The activation of aFRR, on the other hand, is a direct result of the preceding sequence of the measured imbalances. The different CBMPs for RR, mFRR with scheduled activation, mFRR with direct activation and aFRR provide a proper valuation of the different lead-times.
- Since different platforms use the same available cross-zonal capacity updated in a sequential way, the situation will regularly occur when the uncongested area for one product is different from the uncongested area of the other product. In this scenario, cross-product marginal pricing would provide wrong price signals to the market participants and wrong valuation of cross-zonal capacity. This effect can be demonstrated by the following scenario:
    - There is one uncongested area for the exchange of balancing energy from mFRR which would results in the one CBMP P_{mFRR}.
    - There are two uncongested areas (A and B) for aFRR.
    - The resulting CBMPs are $P_{\mathrm{aFRR,A}} < P_{\mathrm{aFRR,B}} < P_{\mathrm{mFRR}}$.
    - In cross-product pricing, the mFRR CBMP P_{mFRR} would also set CBMP for aFRR, i.e. all selected bids would receive $P = P_{\mathrm{mFRR}} = P_{\mathrm{aFRR,A}} = P_{\mathrm{aFRR,B}}$.
    - Although cheaper aFRR bids in area A would be replaced by more expensive aFRR bids in B, the impact of the limited cross-zonal capacity for the aFRR balancing energy exchange would not be visible in a price spread. The cross-zonal capacity would have the price 0 €/MWh.
- With cross-product marginal pricing, a situation would occur where bids not selected in a market clearing have a price which is lower than the final marginal price. This is counterintuitive and could incentivise mark ups in the bidding strategy.
- Cross-product pricing would be inconsistent with the approach for day-ahead and intraday market timeframes. Neither does the intraday market set the price for the day-ahead market nor vice versa.

In conclusion:

- Cross-product pricing is not in line with the requirements of the EBGL to provide correct price signals to market participants, to take into account the pricing method in the day-ahead and intraday timeframes and to reflect market congestions.

- The proposed approach, on the other hand, provides correct price signals by respecting the different properties of the processes, taking into account congestions in a correct way and being consistent with the day-ahead and intraday markets.

3.2.2 Balancing Energy Pricing Period

The balancing energy pricing period (BEPP) is defined in the proposal as a time interval for which CBMPs are calculated. The reason for the introduction of this concept is that Article 30(1)(c) requires the methodology to establish at least one price for the ISP. While there is only one market clearing for balancing energy from RR and mFRR with scheduled activation for each quarter of an hour, there can be more than one market clearing for mFRR with direct activation and up to 900 market clearings for aFRR. This mismatch between the number of market clearings and the ISP requires a mapping between the CBMPs which were determined in each market clearing to the ISP, i.e. the BEPP.

The BEPP aggregates one or more market clearings for the determination of the CBMP. It is obvious, that in case of mFRR with direct activation and aFRR the aggregation can either contain one market clearing or all market clearings which are related to the ISP. The respective choices are explained in Chapter 5 and Chapter 6.4.

3.3 Settlement of Balancing Energy

As stated in Chapter 1, the EBGL obliges the TSOs to settle the balancing energy with the prices defined in accordance with the PP. This obligation is considered in the proposal in Article 3(4). The balancing energy volume determination is part of the national terms and conditions for BSPs in accordance with Article 18 of the EBGL.

4 Pricing Methodology for RR and mFRR with Scheduled Activation

4.1 Basic Principles

The activated RR and scheduled mFRR bids will be priced with the cross-border marginal price as described in Chapter 3:

- For the LFC areas or bidding zones within each uncongested area, there will be a single cross-border marginal price per BEPP (the exception from this rule are described in Section 4.5).
- The BEPP is equal to 15 minutes, therefore there will be a unique price per 15 minutes.

The prices result from the market clearing which is calculated by the AOF in accordance with the principles of the optimisation algorithm proposed as part of the implementation framework for the European platform for the exchange of balancing energy from replacement reserves or the implementation framework for the European platform for the exchange of balancing energy from frequency restoration reserves with manual activation.

In order to determine the prices, the AOF considers the prices of all selected and, in case of price indeterminacy, rejected bids, as well as the prices of the elastic demands submitted by the TSOs.

This section explains the calculation of the cross-border marginal price for RR and mFRR with scheduled activation type focusing on the specific aspects for these processes.

4.2 Elastic Demand

The elastic demands are treated similarly to fully divisible bids for the price determination. A market with only fully divisible bids and elastic demands could be straightforwardly cleared by following a merit order of all bids (upward bids and negative demands ranked by increasing prices, downward bids and positive demands ranked by decreasing prices). Such a market could be described by step-wise supply and consumer curves that intersect at the market clearing point (Figure 6). As elastic demands are treated as bids, in this particular example, the price of the (positive) elastic demand 2 defines the price of the uncongested area.

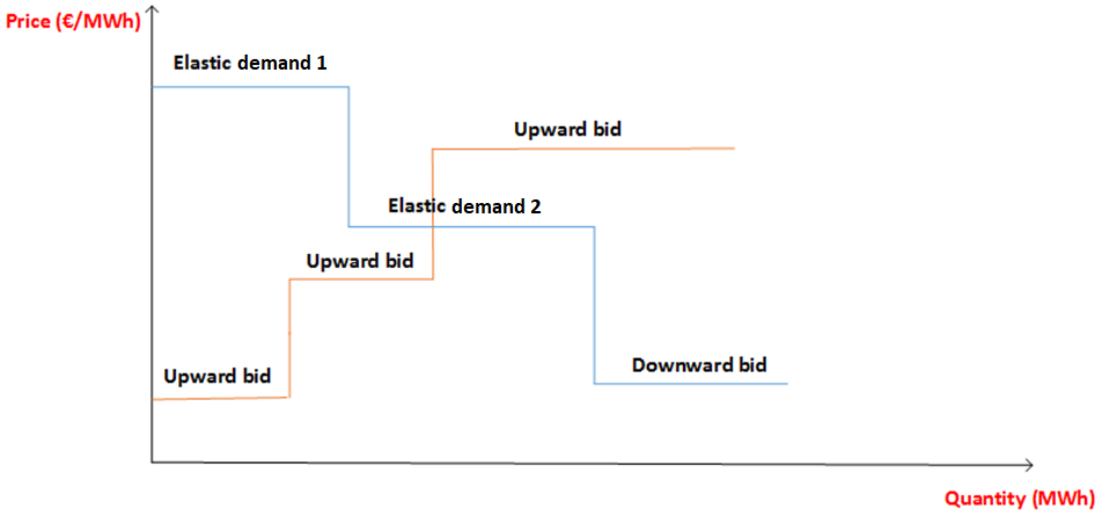


FIGURE 6: CALCULATION OF CROSS-BORDER MARGINAL PRICE WITH ELASTIC DEMAND

4.3 Price Indeterminacy

A price indeterminacy is a special situation when identical bid and demand selection leads to multiple optimal clearing price solutions, as depicted in Figure 7.

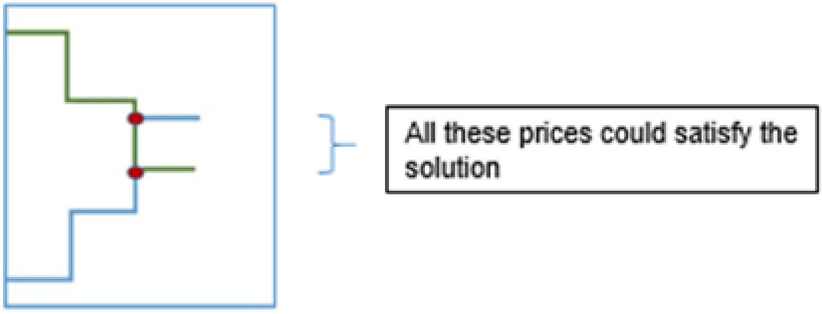


FIGURE 7: PRICE INDETERMINACY ILLUSTRATION

In this case, all solutions have an identical platform surplus. Therefore, it is necessary to define a rule to choose a single price from the set of the optimal prices.

To calculate the price, an upper and a lower price bound will be determined, and the price will be set at the middle of these bounds. If only one bound is available, then the price will be set at this bound. To define the bounds, the prevention of unforeseeably accepted bids and the prevention of unforeseeably rejected bids for fully divisible bids and elastic demands are taken into account.

The following example illustrates a price indeterminacy situation with fully divisible bids (simplest scenario).

We consider the following balancing energy needs and bids (Figure 8):

- IPN: upward demand of 10 MWh and 100 €/MWh
- DDO1: fully divisible downward bid of 10 MW and 80 €/MWh
- DDO2: fully divisible downward bid of 10 MW and 0 €/MWh
- DUO1: fully divisible upward bid of 20 MW and 20 €/MWh
- DUO2: fully divisible upward bid of 10 MW and 40 €/MWh

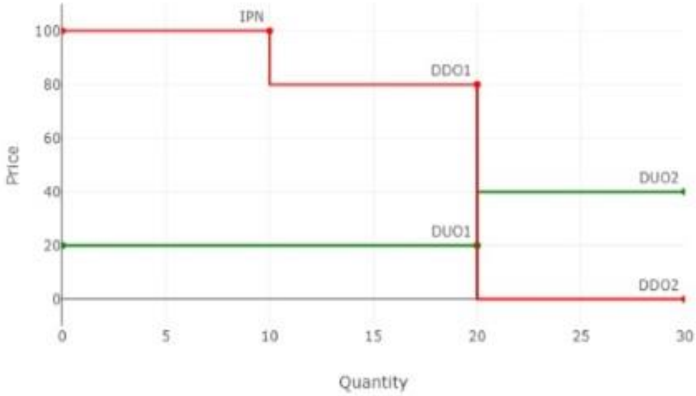


FIGURE 8: ILLUSTRATION OF THE DATA PROVIDED IN THE EXAMPLE FOR THE PRICE INDETERMINACY

In this example the bids "DUO1" and "DDO1" as well as the inelastic need "IPN" are accepted and the price bounds are defined as follows:

- MCP ≥ 20€/MWh (UAB rule for DUO1)
- MCP ≤ 80€/MWh (UAB rule for DDO1)
- MCP ≥ 0€/MWh (URB rule for DDO2)
- MCP ≤ 40€/MWh (URB rule for DUO2)

Therefore, the final upper price bound is 40€/MWh and the final lower price bound is 20€/MWh. The price is set at the middle point and is therefore equal to 30€/MWh.

4.4 Pricing for Bids Activated for System Constraint Purposes

RR and mFRR bids can be selected for system constraints purposes. In order to use the bids for system constraint purposes, the TSO can define a minimal desired exchange in a specific direction (e.g. a desired import) on a border. In this case, the AOF will constrain the flow on this specific border, considering the desired exchange submitted by the TSO.

This tool can be used in cases, where the cross-zonal capacity which was already allocated to market participants in the previous time frames exceeds the physically available cross-zonal capacity. Such situations can occur due to forecast errors in the capacity calculation time frame or due to outages.

The bids that will be selected by the optimisation algorithm, and hence, will be activated, will respect the constraint of the desired exchange.

It is worth noting that the design of the different platform does not include the possibility to make locational activation. There can therefore not be an "out-of-merit-order" activation, but only an extension of the part of the merit-order which is selected.

The pricing proposal foresees that:

- CBMP for bids selected for balancing purposes will be calculated based on the result from the algorithm without considering the desired exchange constraints.
- The bids selected to respect the constraint of the desired flow range (and not selected without considering such constraint) will be remunerated based on pay-as-bid in case their prices are higher than the CBMP (for balancing purpose). In case their bid prices are lower than the CBMP (for balancing purpose) they will be remunerated with the CBMP (for balancing purpose).

The following example illustrates this approach by providing a scenario where a TSO sets a desired flow on a border which leads to selection of bids for system constraints purposes:

- There are three TSOs, each of the TSOs has an inelastic demand (**Figure 9**). TSO 1 has a demand of 20 MW, TSO 2 has a demand of 50 MW and TSO 3 has a demand of 50 MW (all upward).
- The available cross-border capacity limit between TSO 2 and TSO 3 is sufficiently large that it does not influence the results.
- The cross-border capacity limit between TSO 1 and TSO 2 is 50 MW for the direction (1 -> 2) and 0 MW for the opposite direction (2 -> 1).
- TSO 1 submits a desired minimum flow of 30 MW on the border to TSO 2.

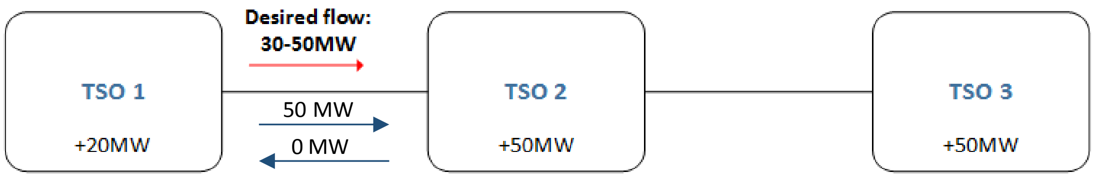


Figure 9: Scenario for System Constraints (Example)

The available bids and the respective prices are shown in Table 3.

TSO	Bid direction	Bid quantity (MW)	Offer price (€/MWh)
1	Upward	40	50
1	Upward	50	60
2	Upward	60	70
2	Downward	50	-35
3	Upward	80	30
3	Upward	90	40
3	Downward	50	-5

TABLE 3: SUMMARY OF THE BIDS FOR EACH TSO (EXAMPLE)

The AOF considers the desired flow of 30-50MW and gives the results presented below in Figure 10 and Table 4.

FIGURE 10: RESULT WITH SYSTEM CONSTRAINTS (EXAMPLE)

TSO	Bid direction	Bid quantity (MW)	Offer price (€/MWh)	Selected quantity (MW)
1	Upward	40	50	40
1	Upward	50	60	10
2	Upward	60	70	0
2	Downward	50	-35	0
3	Upward	80	30	70
3	Upward	90	40	0
3	Downward	50	-5	0

TABLE 4: SELECTED QUANTITIES WITH SYSTEM CONSTRAINTS (EXAMPLE)

The AOF will be executed once more (sequentially or in parallel with the first run), without considering the minimum desired flow constraint. The results of the second run without the activation for other purpose than balancing is presented Figure 11 and Table 5.

FIGURE 11: RESULT WITHOUT SYSTEM CONSTRAINTS (EXAMPLE)

TSO	Bid direction	Bid quantity (MW)	Offer price (€/MWh)	Activated quantity (MW)
1	Upward	40	50	20
1	Upward	50	60	0
2	Upward	60	70	0
2	Downward	50	-35	0
3	Upward	80	30	80
3	Upward	90	40	20
3	Downward	50	-5	0

TABLE 5: SELECTED QUANTITIES WITHOUT SYSTEM CONSTRAINTS (EXAMPLE)

The green colour indicates the marginal bids in the scenario without system constraints:

- Since the is no available cross-zonal capacity on the border from TSO 2 to TSO 1, TSO 1 cannot import the cheaper bids from TSO 3.
- Hence, the price at the area of the TSO 1 will be 50€/MWh, and the price at the areas of the TSO 2 and TSO 3 will be 40€/MWh.
- These prices are the CBMPs for bids selected for balancing purposes.

At the same time, as explained above, this optimisation serves only one purpose, namely the calculation of the CBMP. The result which will be physically implemented is the result with the desired flow. As aforementioned, some uplifts will be given to BSPs that were activated but had a higher submitted price for upward bids (or lower submitted price for downward bids) than the CBMP. More specifically, these BSPs will be paid with pay-as-bid.

In the above example, this holds only for one bid:

- From the area of TSO 1, a bid with submitted price 60€/MWh (marked in blue colour in Table 4) was selected, but the marginal price is 50€/MWh.
- This offer will thus be paid with 60€/MWh instead of 50€/MWh.

All the other selected bids will be remunerated with the CBMP.

It is worth mentioning, that the proposal on the settlement of intended exchanges of balancing energy between TSOs ensures that, the TSOs requesting the activation of bids for system constraints purpose bear the resulting additional costs. The illustration of the TSO-TSO settlement approach is provided in the explanatory document to the proposal in accordance with Article 50(1) of EBGL.

4.5 Impact of Complex Bid Formats

In presence of indivisible bids as considered for RR and mFRR, the AOF may select bids that, considered in isolation, would not be economically matching, but are still part of the optimal set of bids that contributes to the maximisation of the social welfare optimisation under the constraints of the algorithm.

In other words, it may happen that a selected upward bid has a higher bid price than a selected downward bid. This implies that there is no unique price that allows meeting the requirement that the CBMP is higher than all selected upward bids and lower than all selected downward bids. This situation is also referred to as unforeseen acceptance of bids, even if formally there is a need to determine the pricing approach to accurately identify the bids that are accepted in an unforeseen way. An unforeseeably accepted bid is an upward (downward) bid with a higher (lower) bid price than the resulting CBMP.

Figure 12 illustrates how indivisible bids can lead to unforeseeably accepted bids on a simple example:

- In this example, although there is an intersection of the supply and consumer curves, this intersection is not a valid clearing result since it is not possible to activate only a part of the indivisible bid.

- Hence, there are two possible solutions how to satisfy the (inelastic) demand:
  - Option 1: The indivisible upward bid is selected. Additionally, a part of the fully divisible downward bid (*X* MWh) is selected in order to offset the part of the indivisible upward bid which exceeds the demand.
  - Option 2: The indivisible upward bid is not selected and the next (more expensive) fully divisible upward bid is selected instead.

In this example option 1 results in a higher platform surplus, however it has the following consequences:

- Any CBMP (P) for the indivisible upward bid would need to fulfil $P_1 \leq P$.
- At the same time, for the downward bid, the CBMP would need to fulfil $P_2 \geq P$.
- Since $P_2 \leq P_1$, it is impossible to fulfil the equation $P_1 \leq P \leq P_2$ resulting from the conditions stated above.

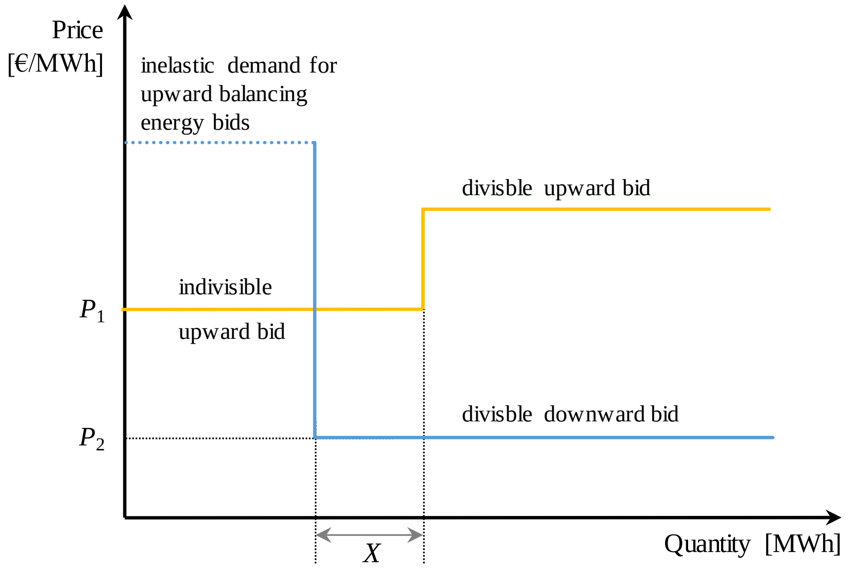


FIGURE 12: EXAMPLE OF A MARKET CLEARING WITH AN INDIVISIBLE BID

In general, the occurrence of unforeseen acceptance of bids is influenced in the following manner:

- If there is a constraint in the algorithm to avoid unforeseen acceptance of bids, there is no UAB;
- If there is a tolerance in volume in the TSO demand (i.e. if TSO demand can be expressed as 100 MW ± 5 MW for instance), the occurrence is reduced.

This proposal does not deal with these design elements. It is worth highlighting that the unforeseen acceptance cannot be completely blocked but only avoided in case the TSO demand has to be fulfilled[1] or to accept nothing and to apply a fall back procedure (for instance in presence of only indivisible bids in one direction, it may be the only feasible solution to have an unforeseen acceptance). Such case is really rare, as it would mean very little divisible volume for all uncongested area. Independently from the design choices in the algorithm, there is a need to determine how the situation will be dealt with from a pricing and settlement perspective.

[1] Which is not necessarily the case in TERRE.

The BSPs that have offered the concerned bids can naturally not be penalised, and those BSPs shall at least receive their bid prices. The same rule should also apply to TSOs' elastic demands (which means that TSO would accept to pay more than need price to satisfy their need).

Instead of deriving a unique CBMP per uncongested area, separate CBMPs for different areas within the same uncongested area can be determined to avoid unforeseeable accepted bids. However, the current idea in TERRE is that for the particular LFC area or bidding zone there can be only one CBMP and in order to avoid unforeseeable accepted bids it may happen that the TSO demand is not satisfied. Hence the settlement price is always the same for all BSPs belonging to the same LFC or bidding zone area and is sufficiently high or low to remunerate the selected bids, respectively for upward or downward bids. The price divergence is allowed only if it does not cause counter-intuitive flows (flows from a high price area to a low price area). The main implications are:

- Always one settlement price for all BSPs belonging to the same LFC area or bidding zone;
- Possibility of having more than one CBMP in the uncongested area consisting of several LFC areas or bidding zones. This may result in the rent similar to the congestion rent that has to be settled between TSOs;
- Possibility of not satisfying the TSO demand because of avoidance of the unforeseeable accepted bids and assurance of the single CBMP within LFC area or bidding zone;

5 Pricing Methodology for mFRR with Direct Activation

5.1 Direct Activation Price determination

The cross-border exchange shape is standardized and firm. The exchanged product can be activated in the time period defined as ±7.5 min around the quarter hour (QH) shift (Figure 13).

- BEPP is defined as QH, i.e. the period for which bids were submitted.
- Since several direct activations can take place during the quarter hour for which the bid is submitted, it is proposed to apply one CBMP for all activated upward DA-bids of a respective QH MOL and one CBMP for all activated downward DA-bids of a respective QH MOL.
- These prices will be determined after the point in time of the last possible direct activation (i.e. >7.5 minutes after the beginning of the respective QH the bids were submitted for).
- In case the congested areas change during the quarter hour for which the bid is submitted, the final price for a specific LFC-area will take into account all CBMPs of direct optimisations that have occurred in uncongested areas this LFC-area was part of.

Furthermore, it has been defined as a principle to cap/floor the CBMP for direct activations by incorporating CBMPs of schedule activations into the price formula.

Pricing of Direct Activations can take into account the following three price components:

- $MP_{DA}QHi$ … CBMPs of all direct activations of the main QH MOL (QH_i, corresponding to the quarter hour for which the bids were submitted).
- $CP_{SA}QHi$ … CBMP of scheduled activated bids of the main QH MOL
- $CP_{SA}QHi+1$ … CBMP of scheduled activated bids of the subsequent QH MOL

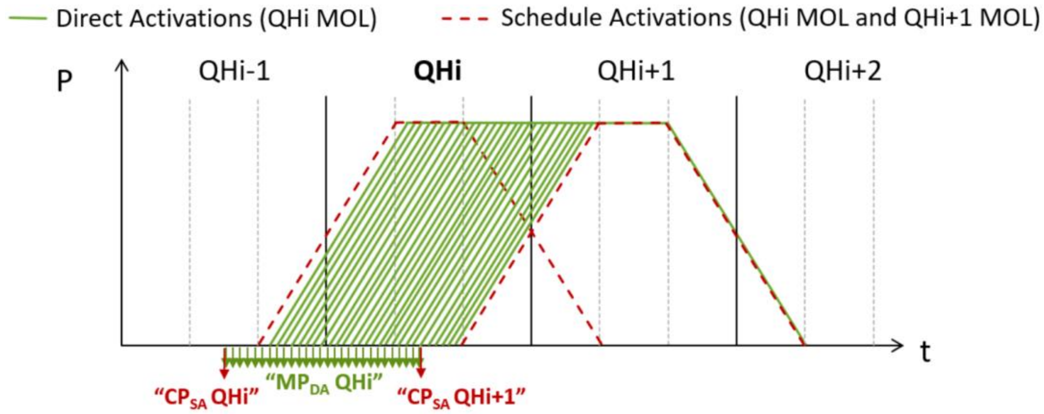


FIGURE 13: PRICE COMPONENTS FOR SETTLEMENT PRICE OF DIRECT ACTIVATIONS

Several options have been evaluated and it is proposed to determine the Settlement Price for energy of a direct activated bid of a given MOL (QHi) as follows:

For the delivered energy attributed to QHi the following formula applies:

- For upward activation: MAX (CP_{SA} QHi; MP_{DA} QHi)
- For downward activation: MIN (CP_{SA} QHi; MP_{DA} QHi)

For the delivered energy attributed to the subsequent QH the following formula applies:

- For upward activation: MAX (CP_{SA} QHi+1; MP_{DA} QHi)

- For downward activation: MIN (CP_{SA} QHi+1; MP_{DA} QHi)

In comparison to other investigated combinations of the price components this solution is considered to provide the best trade-off between the conflicting objectives of low balancing cost and sufficient incentive to submit bids for direct activation. Furthermore, this option would not influence prices of other quarter hours in the case of congestions.

5.2 Direct Activation Volume Distribution

Bids capable of being directly activated can be activated within the validity Period of 15 minutes (i.e. between 7.5 minutes before and 7.5 minutes after a BEPP). The energy volume, acc. to the specified TSO-TSO standard exchange profile, is distributed over two BEPPs (e.g. Quarter Hours, as illustrated in Figure 14). For the subsequent, i.e. second, BEPP (i.e. QH+1) the assigned amount equals 15 minutes times the requested power. The remaining volume (max. 14.9¯ times the requested power (s. example shown in Figure 14)) is attributed to the first (main) BEPP (i.e. QHi).

Hence, 2 blocks of volumes will be settled (and may be remunerated differently as specified in the proposal document).

Prices of QHi-1 and QHi+2 are not affected.

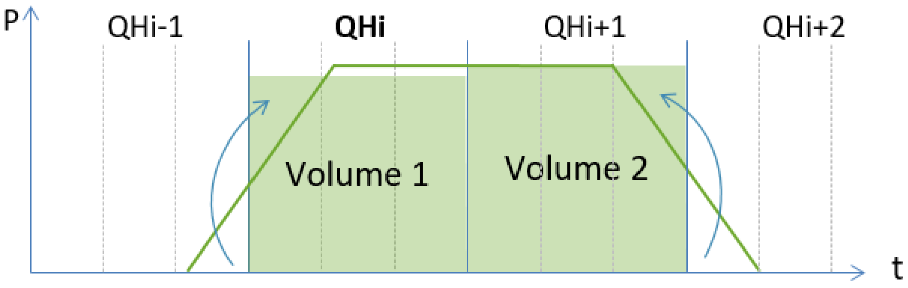


FIGURE 14: EXAMPLE FOR DA VOLUME DISTRIBUTION TO BEPPS

Note: The illustrated shape of delivery and distribution of volumes refer to the standardized profile for TSO-TSO exchange and settlement. The shapes of accepted physical delivery and the calculation of/acceptation of volumes for TSO-BSP settlement and Imbalance Adjustment remains subject to national provisions.

6 Pricing Methodology for aFRR

6.1 Merit-Order and Cross-Border aFRR Activation

The main target for the pricing methodology is to identify a CBMP for settlement of aFRR energy delivered by BSPs and exchanged between TSOs. For aFRR, the pricing methodology needs to consider specific aspects of the aFRR process in regard to:

(1) the principle of merit order activation of aFRR product

(2) the control demand model used for coordinated optimisation of aFRR cross-border activation.

While the more detailed information on the control demand model is provided in the implementation framework for aFRR and its explanatory document, this section summarises the main principles in order to facilitate the understanding of the pricing methodology.

6.1.1 General working of an aFRR controller and merit-order activation principle

The objective of the aFRR process is to regulate the FRCE to 0 MW automatically:

- By adapting for each control cycle (from 1 to 5 seconds) the aFRR request signal to the BSP in order to cover the real time imbalances.
- The aFRR process implies a close-loop regulation via a proportional-integral controller in order to remain stable. This controller continuously calculates the proper amount of aFRR to be activated in order to cover the imbalances.
- This proper amount of aFRR to be activated (also called "target volume") usually differs from the observed imbalances. In merit order activation, the selection of bids is performed based on the target volume.
- Finally, the effective delivery performed by the BSP takes several minutes up to the full activation time (FAT) of the aFRR product to raise the aFRR amount selected for activation.

Figure 15 provides an illustration of the different volumes with the different dynamics existing in the aFRR process.

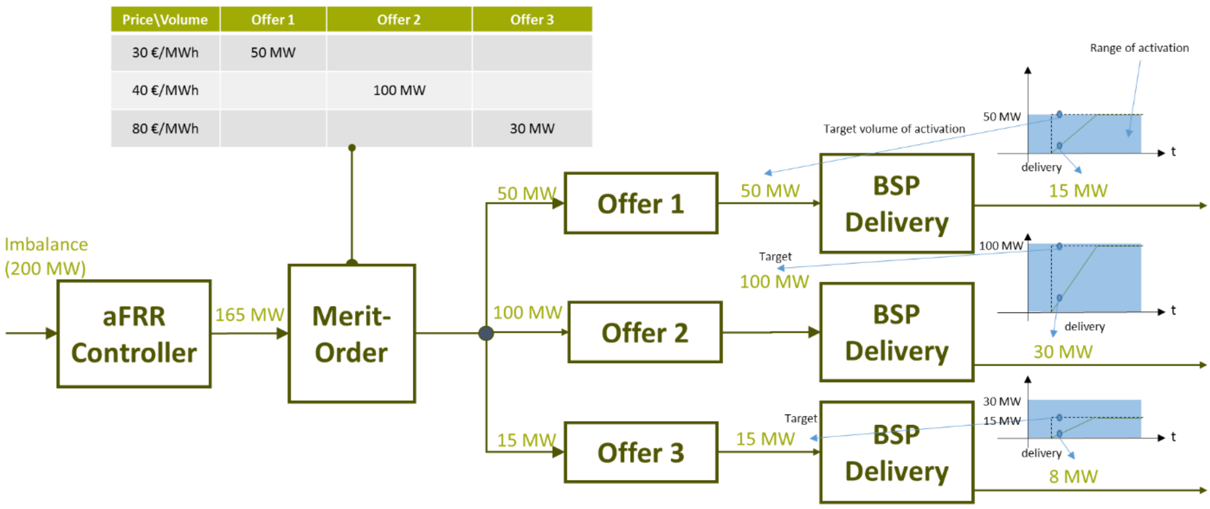


FIGURE 15: ILLUSTRATION OF MERIT-ORDER BASED ACTIVATION

6.1.2 Control Demand Model for Cross-Border aFRR-Activation

The implementation of the cross-border aFRR-activation using the control demand approach can be summarised as follows, and further illustrated in Figure 16:

- Each TSO calculates for each control cycle (from 1 to 5 seconds) and each of its LFC areas the aFRR demand, which is the sum of the currently activated aFRR and the local FRCE of the corresponding LFC area. The activated aFRR can be derived by measurement, estimated by simulation of the activation or the sum of requested values from BSPs.
- The AOF simply, when possible, replaces a potentially activated bid with a cheaper bid outside the LFC area, bearing in mind the capacity between LFC areas. Input to the AOF is the aFRR demand. Output from the AOF are global aFRR correction values per LFC area.
- The aFRR correction value is directly included within the aFRR control loop of each participating LFC area (as an input to the aFRR controller). By this, the individual controller input of each LFC area is adapted according to the outcome of the aFRR AOF. The sum of the aFRR demand and the aFRR correction value is the so-called corrected aFRR demand and reflects the amount of aFRR, which the individual LFC area has to provide according to AOF results. The correction value from the AOF is sent, without taking into account any characteristic of the local aFRR controller neither of the delivery such as possible ramping constraints related to the locally activated bids.
- The results of local aFRR bid selection on each control cycle will then lead to effective activation and exchange of aFRR between the TSOs. The actual local activation of aFRR is delayed compared to the AOF selection, due to local controller dynamics and BSP dynamics. The set-points are sent from each TSO to its BSPs. The minimum speed of activation of the BSPs is determined by the FAT (Full Activation Time).

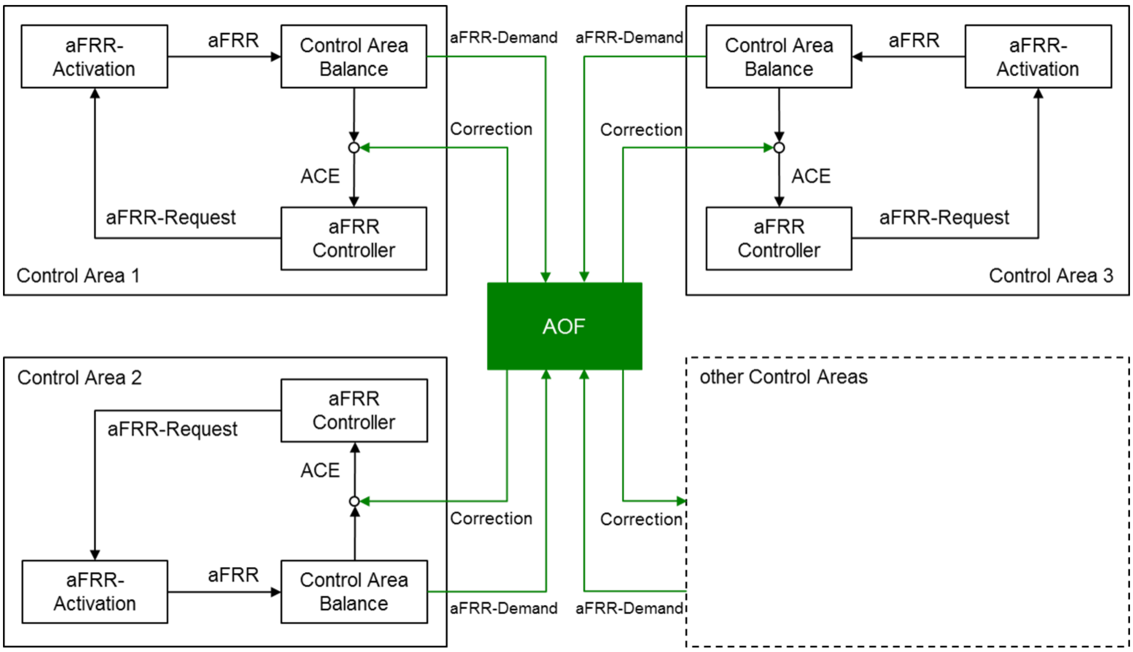


FIGURE 16: SCHEMATIC DIAGRAM OF THE CONTROL DEMAND MODEL FOR AFRR ACTIVATION

The aFRR process follows to the same principles as for the others balancing processes, in which aFRR bids are selected by AOF on each optimisation cycle to satisfy aFRR demands formulated by TSO. Contrarily to other balancing processes (RR and mFRR) the AOF in the aFRR process does not send a direct activation request per bid to TSOs. Instead it sends an overall correction in MW to the aFRR demand subsequently leading to adjustments to aFRR activation in the respective LFC areas based on local merit order activation.

The other difference compared to other balancing processes is that for RR or mFRR process, the period of the TSO demands is mostly matching with the quarter hour for which the bid is submitted for the optimisation.

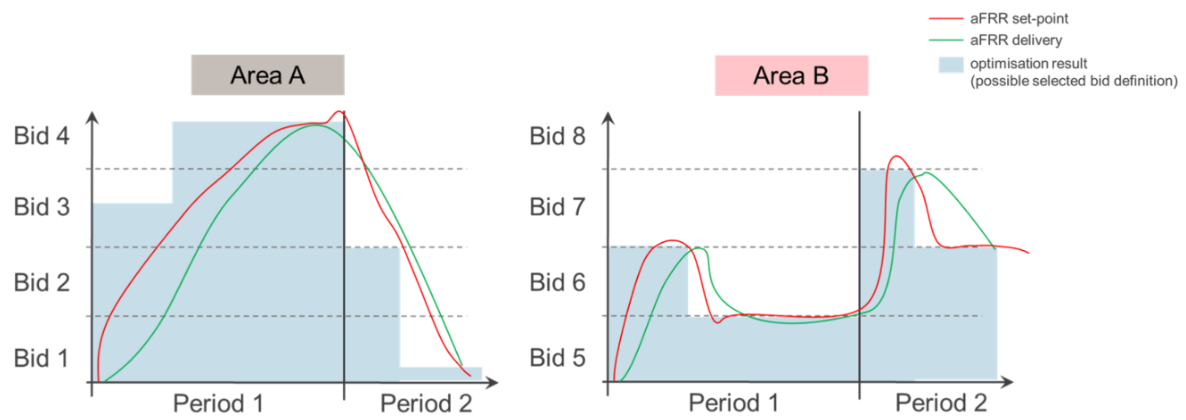
For aFRR process, the TSO demands which are optimised are immediate needs whereas the aFRR bids delivery will occur several minutes later. This may lead to situations where the aFRR demand of the TSOs at one moment could even be in opposite direction to the current state of aFRR delivery of the BSP.

For the aFRR process, the cross-border marginal pricing will be applied for the settlement with BSPs, implying that within an uncongested area all BSPs delivering aFRR receive the same marginal price (see chapter 3.1.2) for one balancing energy pricing period (BEPP). Within this context also the balancing energy pricing period needs to be defined.

6.2 Technical Aspects of the aFRR Activation Related to Pricing

Because of the specific dynamics of the aFRR process and the control demand model, the AOF result will not correspond to the local aFRR set-points and the local set-points will not necessarily correspond to the locally delivered aFRR. Figure 17 shows an example considering two cooperating areas (Area A and Area B):

- The blue shaded area reflects bid selection performed by the AOF based on the aFRR demand, CMOL and CZC limitations.
- The red line in each area indicates the aFRR set-point sent by the LFC controller. Based on the local configurations of the LFC controller the ramping varies across LFC areas. Illustrated as the green line is the assumed aFRR activation in each LFC area that follows the aFRR set-point with some delay due to BSP dynamics.
- The numbering of the bids reflects their ranking in the CMOL: the bid with the highest number is the last bid in the CMOL.



Bid No.	Period 1			Period 2		
	Selected (by AOF)	Accepted (by TSO)	Activated (by BSP)	Selected (by AOF)	Accepted (by TSO)	Activated (by BSP)
Bid 1	yes	yes	yes	yes	yes	yes
Bid 2	yes	yes	yes	yes	yes	yes
Bid 3	yes	yes	yes	no	yes	yes
Bid 4	yes	yes	yes	no	yes	yes
Bid 5	yes	yes	yes	yes	yes	yes
Bid 6	yes	yes	yes	yes	yes	yes
Bid 7	no	yes	no	yes	yes	yes
Bid 8	no	no	no	no	yes	no

FIGURE 17: DYNAMICS OF THE AFRR PROCESS

The dynamics of the aFRR process and the resulting discrepancies between selected (by the AOF), requested (by the TSO) and activated (by the BSPs) bids a priori allow for different pricing methodologies to be applied for the aFRR process.

In practice the applicable CBMP can be determined based on one (or several) type(s) of the following signals:

1. Centrally selected bids for activation (e.g. by AOF)
2. Locally requested bids activation (e.g. control target)
3. And/or locally activated bids (e.g. aFRR activation estimated or real) from LMOL.

The chosen signal or combination of signals has an effect on the way CBMP per uncongested area is calculated, price sensitivity towards changes in aFRR demand as well as local remuneration of accepted aFRR bids.

Moreover, the chosen pricing methodology interacts strongly with the chosen balancing energy pricing period (BEPP). If the BEPP is longer than the optimisation cycle, certain effects, such as the determination of the (un)congested areas or the cost risk related to the demand sensitivity of the price, are either introduced or become more pronounced.

For the aFRR process, TSOs investigated both approaches for cross-border marginal pricing determination: the "centralised price determination" and the "decentralised[2] price determination", with subsequent sub-options for the pricing methodology. An overview of both investigated approaches including the sub-options is provided in Figure 18

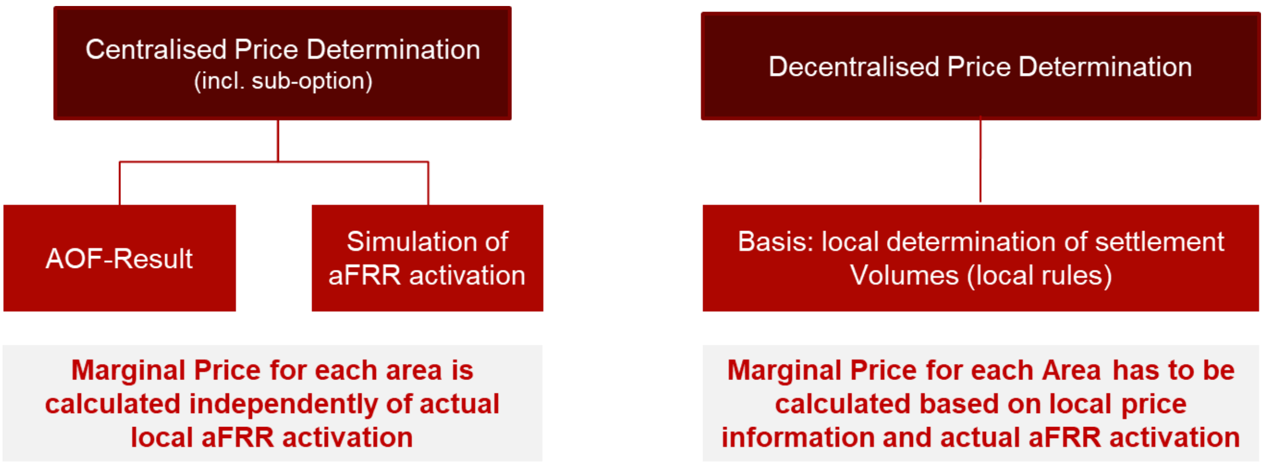


FIGURE 18: APPROACHES INVESTIGATED FOR THE PRICING METHODOLOGY

In the first approach the applicable CBMP is determined centrally based on the bids selected for activation by the AOF. As a consequence, the CBMP price obtained with this approach is independent of LFC controllers and local aFRR activations and their dynamics.

As this approach neglects the aFRR dynamics of the LFC controllers and BSPs, an additional sub-option was investigated for the "centralised price determination", called "Simulation of aFRR activation":

[2] In the decentralised price determination approach, the CBMP is still determined in a central manner but based on local marginal pricing scheme, whereas in the centralised approach the CBMP is determined in central manner based on central AOF-Results.

- Within this sub-option, the aFRR activation for each LFC area is simulated based on the LFC input corrected by the AOF, taking into account the parameters of the LFC controller of the area, the local MOL of the area, and an average BSP behaviour for the area.
- Based on these simulations, a local marginal price per LFC area can be calculated.
- The applicable CBMP per uncongested area can then be obtained by taking the maximum (in case of upwards activation in the uncongested area) or the minimum (in case of downwards activation in the uncongested area) of the local marginal prices of all the LFC areas part of the uncongested area.
- In short, the overall aFRR activation, including the specificities of the bid selection by the controller, is simulated for each LFC area to determine the centralised CBMP.

The second approach investigated, called "decentralised price determination", is based on local rules for BSP settlement volume determination. The idea behind this approach is that the pricing methodology has to work for local activation, i.e. consequent to AOF but without direct use of AOF results for pricing, only looking at the final output of the aFRR process:

- The local marginal prices are determined by each LFC area based on actual aFRR activation. A bid is locally price setting as long as this bid delivers energy that is accepted by the connecting TSO.
- In the second step, the applicable CBMP per uncongested area is calculated centrally based on the prices that were calculated locally: for each uncongested area as defined by the AOF, the applicable CBMP is the maximum (in case of upwards activation in the uncongested area) or the minimum (in case of downwards activation) of the local marginal prices calculated in the previous step for each LFC area part of the uncongested Area
- This approach is valid for any methodology of BSP settlement volume determination (e.g. settlement based on requested or metered volumes).

It is apparent that the sub-option "Simulation of aFRR activation" was investigated since it would lead to volume and pricing determination closer to the decentralised price determination approach but calculated centrally by the platform based on a common methodology.

The legal basis for compliancy with the EBGL for all considered and investigated options was checked. All options are compliant with the legal requirements arising from Article 30 of the EBGL as they are all based on marginal pricing, establish at least one price for aFRR balancing energy for each ISP and take into account the pricing method in the day-ahead and intraday time-frames. Furthermore, all options allow for the pricing of CZC based on the prices for aFRR balancing energy and are reflective of market congestions.

6.3 Application of the General Pricing Principles to aFRR

After an evaluation of the approaches, TSOs propose to use the centralised price determination method, purely based on the AOF result without simulation of aFRR activation.

In each optimisation cycle the Platform calculates the following data to be used for the price determination of aFRR balancing energy and pricing of cross-zonal capacity:

- The marginal price for each LFC area (in €/MWh).
- The set(s) of LFC areas that form an uncongested area that will receive the same marginal price.
- The correction (in MW) of the aFRR demand for each area reflecting total import/export of one LFC area.
- The market flow (in MW) per border due to netting of aFRR demand and / or cross-border aFRR activation.

As mentioned in Section 3.1.1 the applicable CBMP is determined centrally based on the bids selected for activation by the AOF and therefore independently of LFC controllers settings and local aFRR activations.

The subsequent Figure 19 provides a schematic depiction of the price determination based on the AOF correction for three LFC areas A, B and C forming a single uncongested area:

- The numbering of the bids reflects their ranking in the CMOL: the bid with the highest number is the last bid in the CMOL.
- During BEPP 1, only area B has a non-zero aFRR demand (dotted green lines). The AOF will transfer this demand to area A because area A has the cheapest bids in that direction. This will result in a corrected demand, as shown by the red lines. The LFC controller of A will adjust its output (blue line) in order to follow the request, and aFRR will be activated in area A (orange line). For this first BEPP, the CBMP will be the price of the most expensive bid selected by the AOF, i.e. bid 1.
- During BEPP 2 and 3, the aFRR demand rises in the same direction in all 3 LFC areas. For this resulting total aFRR demand, the AOF determines that the most expensive bid to select is bid 6. Therefore, the CBMP for BEPP 2 and 3 will be the price of bid 6, despite the overshoot of actual aFRR activation in area B between BEPP 2 and BEPP 3. The LFC inputs (red lines) of all 3 areas will be adjusted by the AOF in order to trigger the expected activation in each area:
    - Bid 1, Bid 2 and Bid 6 in area A
    - Bid 3, Bid 4 and Bid 5 in area B
    - No bids in area C
- In BEPP 4, the aFRR demands of area B and C decrease. Facing this smaller total aFRR demand, the AOF will only select Bid 1, Bid 2 and Bid 3 for this BEPP. Therefore, the CBMP for BEPP 4 will be the price of bid 3, despite the fact that the LFC controller outputs and actual aFRR activation in area A and B still have to ramp down to meet the new AOF request. In this BEPP, Bids 6, 5 and 4 are delivering potentially locally accepted while having submitted a bid price higher than the CBMP for this BEPP. The way these volumes will be settled with BSP will be further explained later in this Section.

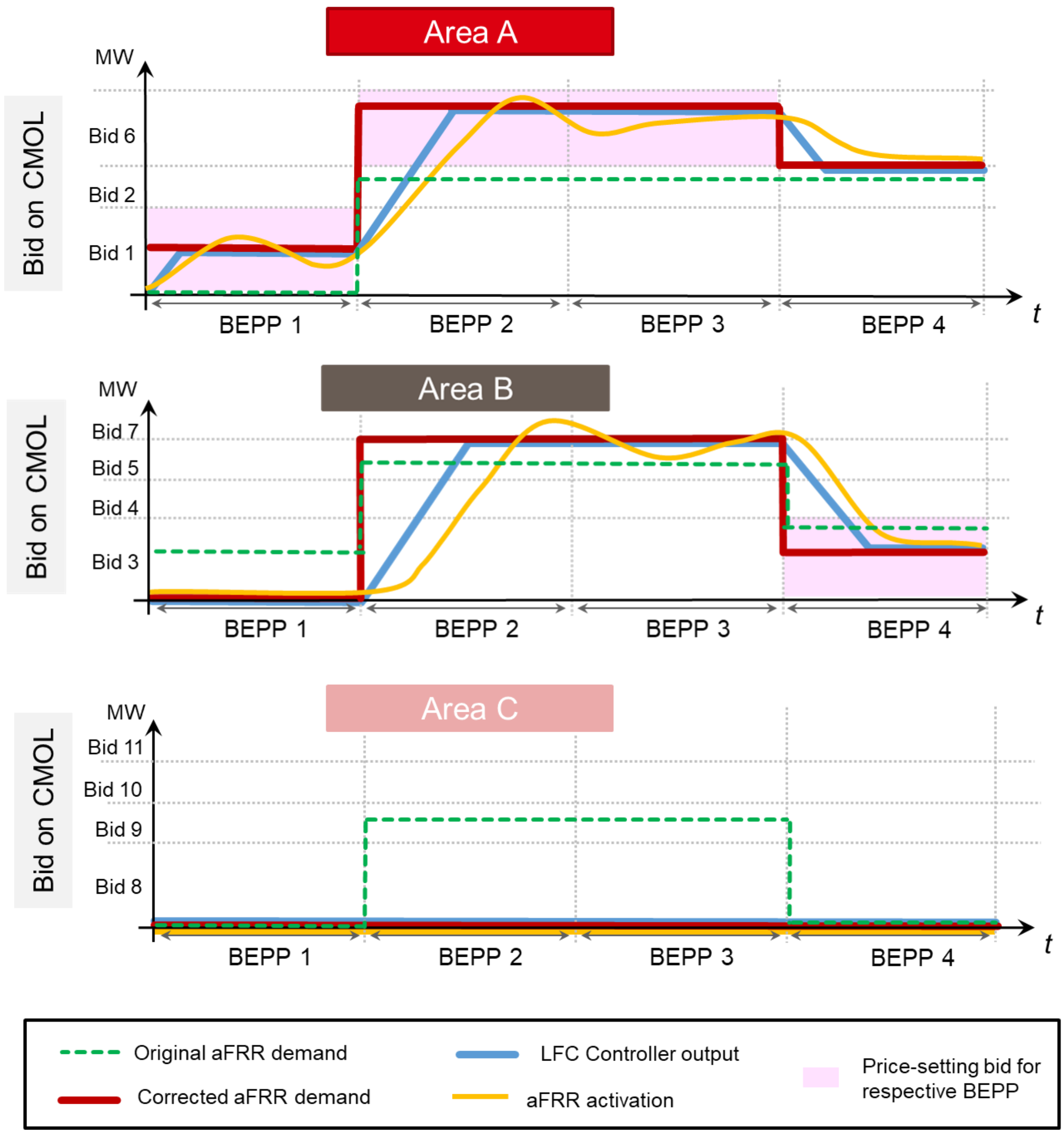


FIGURE 19: SCHEMATIC REPRESENTATION OF DETERMINATION OF MARGINAL PRICES BASED ON AOF

The advantages of the central price determination include transparency, auditability and robustness of the price determination approach. The price determination is not affected by local behaviour of TSOs or BSPs as it will be based on the AOF, following the control demand principles which were also consulted in the implementation framework for the aFRR platform.

Moreover, during the latest stakeholder workshop on pricing and settlement, stakeholders also showed their preference for the AOF solution due to the simplicity of the approach and consistency with other market time frames, that also determine the prices based on the clearing result.

Neglecting the LFC and BSP dynamics in the aFRR price determination has several advantages but also some potential downsides.

Amongst the advantages, we will point out mainly:

- No local characteristic (speed of BSPs, LFC controller settings, activation method, volume acceptance rules…) has an influence in the price determination. The price is determined transparently by the AOF.

- Any individual erroneous behaviour of a LFC controller or BSP will have no consequences on the CBMP. Overreacting BSPs or LFC controllers will not lead to a higher CBMP during an activation phase, and slower LFC areas will not impose a higher CBMP to the whole uncongested area during the deactivation of a slow expensive bid.
- With this approach, bids in deactivation phase can never be price setting. This also ensures that expensive bids that were previously activated in one area because of a congestion that prevented the activation of a cheaper bid in another area, will not unjustifiably set a higher CBMP to the whole uncongested area once the congestion has disappeared.
- Because the dynamics are neglected, from the AOF point of view, there is no need to differentiate between netting of aFRR demand in opposite directions and aFRR activation. This simplification can be useful in a context where the AOF performs netting of demand and aFRR activation in a single-step optimisation as described in the aFRR Implementation Framework. Indeed, because of this single step optimisation, only the total amount of netted demand and the corrected demand of each TSO are known; the netting received by each TSO can however not be determined unambiguously. Therefore, making no difference between aFRR activation and netting of demand in TSO-TSO settlement prevents TSO to have to define an arbitrary distribution key of the total netting. Netting and activation are not differentiated and are both priced at the CBMP which is consistent with the approach in RR and mFRR.

On the other side, neglecting the LFC and BSP dynamics in the price determination has also three main potential downsides:

- Because AOF does not include the "filtering / smoothing effect" on prices introduced by the LFC and BSP dynamics, the cross border marginal price directly derived from AOF could be very sensitive to large variations of aFRR demand and / or netting possibilities. Therefore, large price variations and price spikes can be expected. This concern is closely related to the BEPP definition. Indeed, in case a quarter-hour BEPP is chosen, the biggest of these price spikes during each quarter-hour will set the marginal price for the whole quarter-hour, even if it this price spike has lasted for a few seconds and the local aFRR controller would never have selected the related bid due to its filtering dynamic. On the other side, with a BEPP based on the AOF optimisation cycle, the impact of the price spike is confined to the volume exchanged / activated during the related optimisation cycles only. This point will be further discussed in Section 6.4.
- Due to dynamic effects of the controllers and the aFRR delivery of locally accepted bids not selected by the AOF (referred to as non-AOF volumes) might either show a higher price than the cross border marginal price specified by the AOF or are in the opposite direction as the price-setting direction according to the AOF. The analysed ways to approach this issue were not to settle non-AOF volumes at all, to settle with CBMP, which does not consider non-AOF volumes and pay-as-bid approach. One of the features of marginal pricing according to Art. 30 (1(a)) of the EBGL is that BSPs receive at least their bid price. In these specific cases, this might not be ensured by applying CBMP resulting from the AOF. In PICASSO TSOs view, not remunerating non-AOF volumes at all, or remunerating them at a price lower than a bid price is not in line with Art. 30 (1(d)) of the EBGL, which requires to give correct price signals and incentives to market participants. Considering the above, PICASSO TSOs propose to use pay-as-bid as specific remuneration scheme for non-AOF volumes. In case there is no bid price available for the accepted bid volumes, e.g. in case a BSP has no valid bid in the CMOL for the respective validity period, each TSO will ensure the pricing of these bid volumes in accordance with the local methodology for volume determination (EBGL Art. 45 (2)) and the national remuneration scheme in accordance with national terms and conditions.
- Figure 20 provides a schematic representation of the application of a pay-as-bid specific remuneration scheme in a simple case with a single LFC area applying merit-order activation. When a bid is selected by the AOF during a BEPP, the accepted volume of this bid is priced at the CBMP set for this BEPP. When a bid is rejected by the AOF but locally accepted by the connecting TSO, the locally accepted volume is paid as bid; this is the case of Bid 2 and Bid 3 during BEPP 3. The extent of the energy volume

to be settled in pay-as-bid in each LFC area is extremely difficult to estimate and will be known precisely only after a few months of operation of the PICASSO platform. However, a first indication can be provided by experience gathered in the German-Austrian aFRR cooperation. Under the assumption that the proposed pricing scheme would already be applied in Germany, around 14 % of the activated aFRR would have to be settled with pay-as-bid remuneration. Simulations performed on basis of historical aFRR demands and bid prices confirm that this share would be between 6 % and 25 % for various LFC blocks.

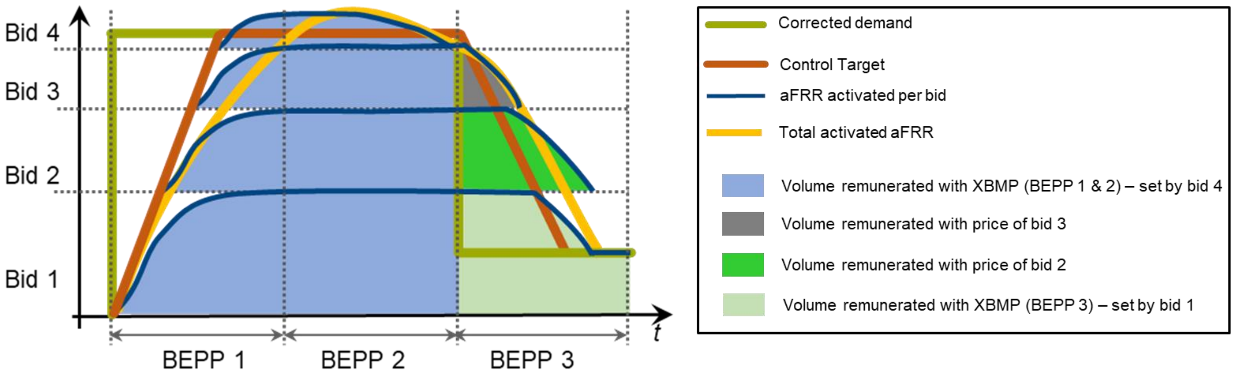


FIGURE 20: SCHEMATIC REPRESENTATION OF THE PROPOSED SPECIFIC REMUNERATION SCHEME

- As it will be further developed in the settlement proposal, the TSO-TSO settlement for the intended exchange of aFRR and imbalance netting will be based on the corrected demand as defined by the AOF for each optimisation cycle, while the aFRR TSO-BSP settlement for each LFC area will be based on locally accepted volume. Because of the temporal difference in profile of volumes used for TSO-TSO settlement and TSO-BSP settlement, the net outcome of these settlement processes for an LFC area could be substantially positive or negative, despite having no structural imbalance in the same direction. Similar to the question of volumes needing a specific remuneration scheme, only experience with the real platform and monitoring will allow TSOs to better assess the risk of unfair financial outcome.

Although the second sub-option for the centralised price determination based on a simulation of local aFRR activation would provide a more realistic approximation of locally activated aFRR (mitigating the share of specific remuneration but not solving it), it has been discarded mainly due to the absence of the aforementioned advantages for the AOF based pricing. Moreover, it is unsure whether the balance between the added value and the complexity is positive:

- As the option would require a simulation of aFRR activation per LFC area, it would reduce transparency of the approach.
- An additional drawback of this approach is the inconsistency between market flows as derived by AOF and the simulated prices based on estimated local characteristics. Therefore, the option will lead to inconsistencies between the definition of areas forming an uncongested area given by the AOF and the prices resulting from the simulation, requiring an additional approximation of cross-border flows between TSOs to ensure consistency.

Although the second option based on a decentralised price determination would avoid the need of specific remuneration scheme, it has been discarded mainly due to the lack of transparency of the approach:

- As the price determination would depend on local non-harmonised activation signals and local settlement rules, the determination of the cross-border marginal prices becomes less transparent and auditable.
- The non-harmonised determination of prices could also lead to complex ex-post correction processes between TSOs in case of contestations by BSPs at their connecting TSO. Furthermore, expensive bids activated locally due to congestions might impact the CBMP, leading to wrong prices in wider area.

- As the central price determination based on a simulation of local aFRR activation, the option would lead to inconsistencies between market flows as derived by AOF and the determination of prices based on local settlement rules.
- The option would therefore also require an approximation of aFRR exchange between TSOs deviation from the market result provided by the AOF.
- Moreover, a close to real-time price indication would need to be based on the prices given by the AOF and therefore deviate from the final settlement prices for BSPs.

Summing up, for aFRR, similar to the other balancing process, the balancing auction, matching of bids and demand performed by the AOF, will form the basis for the price determination. In the initial phase after the go-live of the aFRR platform TSOs will monitor the effects resulting from the price determination in combination with the TSO-TSO settlement volumes. Special attention will be paid to the proportion of bids remunerated with another price than the CBMP and to the effectiveness of the cost neutrality of participating LFC areas arising from the AOF-based price determination.

6.4 BEPP

As explained in Section 3.2.2, the BEPP is defined as the time interval for which CBMPs are calculated and used for TSO-BSP and TSO-TSO settlement. In the case of aFRR, each optimisation cycle of the AOF can be seen as a market clearing leading to setting a marginal price for each participating LFC area. Within a harmonised ISP of 15 minutes, there will be up to 900 aFRR market clearings and resulting marginal prices for each LFC area, depending on the duration of the aFRR optimisation cycle. Because there are multiple marginal prices available within the ISP, there are two main conceptual options to price aFRR requested / activated during the ISP:

- For each optimisation cycle, value the aFRR requested / activated by an LFC area during this optimisation cycle at the marginal price of this LFC area defined for this optimisation cycle. In this case, we will talk about optimisation cycle BEPP.
- Use only one of all the marginal prices resulting from all the aFRR clearings during the the quarter hour for which the bid is submitted to value the total aFRR requested / activated during the whole validity period of 15 minutes. Here, the quarter-hour BEPP was considered, since there is a direct correlation with ISP, when the target duration for the ISP is 15 minutes once harmonisation is completed. In this option, the main difficulty is to decide which single price is the most suitable for the aFRR settlement.

This BEPP choice has a significant impact on the aFRR TSO-TSO and TSO-BSP settlement and on the congestion rent. Because the aFRR balancing energy price contributes to the imbalance settlement price (as showed in Figure 5), it has also a significant financial impact for the BRPs.

Taking into account the selected aFRR price determination methodology (see Section 6.3), PICASSO TSOs considered two possible options for the BEPP:

1. Pricing on optimisation cycle basis (optimisation cycle BEPP): Each AOF optimisation cycle can be interpreted as one auction covering the aFRR demand and should have one (marginal) clearing price. In this first option, a price is defined and used for settlement on each optimisation cycle for each LFC area, for a single direction, based on the AOF result.
2. Pricing on quarter hour basis (quarter hour BEPP) with the most extreme prices: in this option, there will be only one marginal price per area and per activation direction for the whole quarter-hour. For each quarter-hour, the upward marginal price for area could be the maximum of the upwards marginal prices defined by the AOF during all the optimisation cycles inside this quarter-hour. The downwards marginal price for the quarter hour will be calculated accordingly, taking the minimum of the

downwards marginal prices defined by the AOF during all the optimisation cycles inside this quarter-hour.

As pointed out in Section 6.3, all the aFRR volumes for which the relevant marginal price is not applicable will have to be settled via a harmonised specific remuneration scheme that is not price setting. Because the most extreme price for upwards and downwards aFRR activation during the ISP are used for each LFC area in the quarter-hour BEPP, it can be expected that the volumes subjected to this specific remuneration scheme will be lower in the quarter-hour BEPP. As it will be further explained later on, the counterpart of this is that quarter-hour BEPP leads to less price convergence, higher aFRR prices and congestion rents.

Two main effects of the choice of the BEPP on the bid price have been identified:

- If the BEPP is 15 minutes, a discrepancy is introduced between the "activation"-congestion (established every optimisation cycle) and the "price"-congestions (15 minutes). In other words, if the activation of a very expensive bid is requested in a LFC area because of a congestion that happened only during a very limited number of optimisation cycles, this activation will be price setting for the whole ISP in this LFC area. This discrepancy can lead to a bidding strategy where increasing the bid price leads to more earnings even if there are less activations.
- If the BEPP is equal to the optimisation cycle, the self-regulating effect of BRP costs on the BSP price (the fact that the BSPs are incentivised to bid in at reasonable costs in order not to increase too much their costs as a BRP) is less present due to an averaging effect of the BSP settlement price over the ISP length. This could lead to an increase of the bid prices as there is hardly an impact on the BRP costs.

These effects show that both BEPP options present aspects that do not necessarily incentivise the BSPs to bid their marginal costs. Therefore, it is not possible to draw definitive conclusions on the effect of the BEPP choice on the bid price; practical experience is required in order to assess how these aspects will influence the bidding behaviour of BSPs.

Based on the considered effects and an investigation of the considered options, TSOs decided to propose an optimisation cycle BEPP.

This approach:

- **Provides a full consistency with the AOF results and the decision of using AOF results for the pricing determination.** Indeed, the AOF executes the bid selection on optimisation cycle basis, and prices are defined on the same time-period based on the aFRR demand and available cross-zonal capacity and possible congestions for this period.
- **Maximises the occurrence of price convergence.** Indeed, in a quarter-hour BEPP using extreme prices, a congestion between two LFC areas during a single optimisation cycle will cause a price divergence for the whole ISP. If we consider the whole PICASSO area and highly fluctuating aFRR demands, many congestions could realistically occur even during the same ISP, meaning that the price convergence might be really low for some ISPs with a quarter-hour BEPP. A higher price convergence will help in maximising the competition among the BSPs. This is seen as a critical element for markets with limited internal competition in order to efficiently apply a marginal pricing approach.
- **Is simple and transparent from an algorithmic perspective.** The price used for each time window is a good representation of the demand and congestion situation. In the case of quarter-hour BEPP, the fact that a single marginal price has to be selected for each LFC area for the whole ISP do not allow to identify the impact of congestions, whatever the way this unique price is chosen, being the extreme prices or any other price.
- **Avoids arbitrarily increasing the remuneration of BSPs at the expense of the BRPs.** Using the most extreme prices of the whole ISP to settle all aFRR volumes of the ISP in the quarter-hour BEPP will indeed be inappropriate in situation where these extreme prices happened for short periods of time compared to the ISP. These situations could not be qualified as scarcity situations, but more as temporary demand spikes that will in practice be filtered anyways by the dynamic of the aFRR activation process.

Because this dynamic is not taken into account in the selected price determination option, it is important to opt for an optimisation cycle BEPP in order to avoid that these price spikes impact the aFRR settlement of the whole ISP. Specifically, on this topic, a quarter-hour BEPP with a different single price selection approach would help reaching a better balance between BRP costs and BSP revenues than a quarter-hour BEPP with the most extreme prices. For example, one could think about using a specific percentile of the marginal price distribution during the ISP, or the most (respectively less) expensive upwards (respectively downwards) bid that was selected at least for x minutes during the ISP by the AOF. However, despite this improvement, the other drawbacks of the quarter-hour BEPP will remain almost unchanged, and the transparency of the process could be even worsened. Moreover, many questions could be raised about the fairness and suitability of the selected single marginal price for the ISP.

- **Avoids cases where the congestion rent is artificially increased, and cases where the congestion rent is negative.** The increase of the congestion rent in quarter-hour BEPP is directly related to the lower price convergence already explained above. In case the biggest price divergence is applied on the whole ISP, congestion rent is obviously increased and will apply even on parts of the quarter-hour where the AOF identified no congestions. The situation with negative congestion rent is another paradox of the quarter-hour BEPP. Such a situation is illustrated on Figure 21 by a simple case with two LFC areas A and B having both four 20 MW bids in their LMOL.

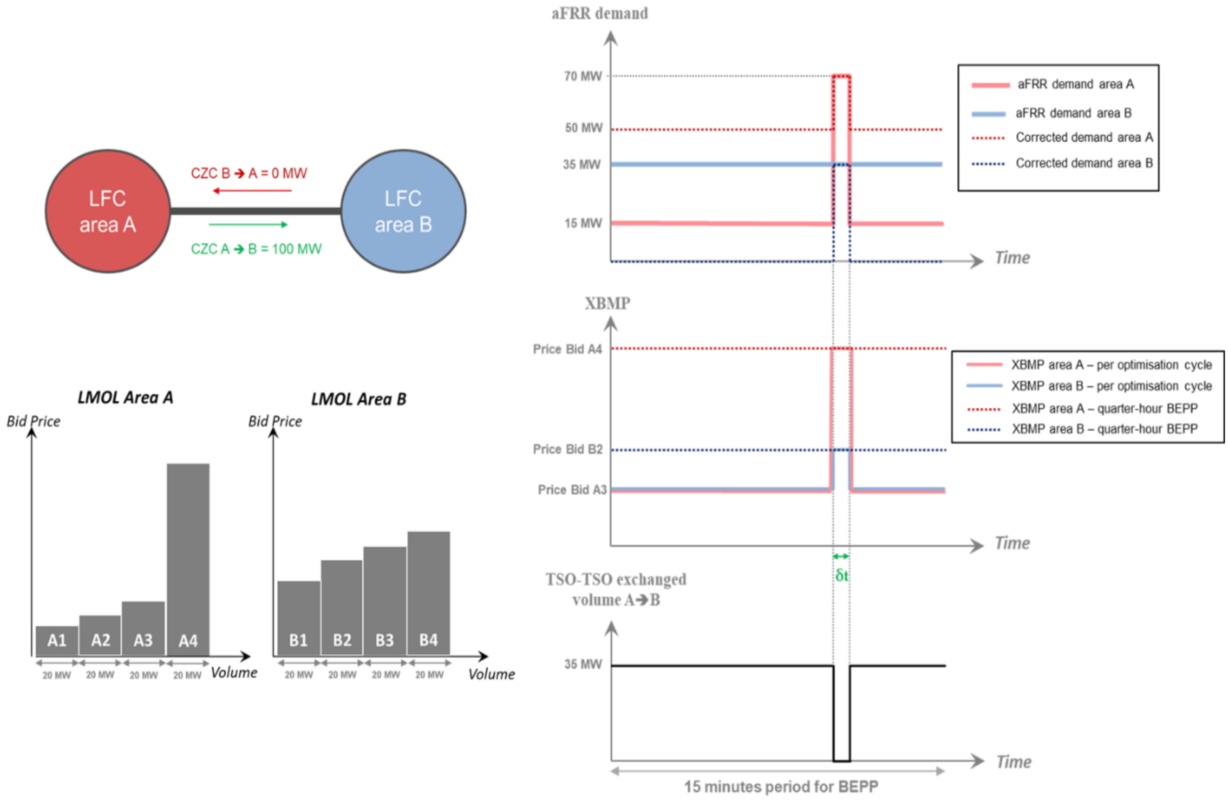


FIGURE 21: NEGATIVE CONGESTION RENT EXAMPLE

The first three bids of A are cheaper than the four bids of B, while the fourth bid of A is much more expensive. There is sufficient CZC from A to B, but no remaining CZC from B to A. The aFRR demand of B is constant at 35 MW during the whole quarter-hour; the aFRR demand of A is equal to 15 MW during the whole quarter-hour, except a short time period δt, where the demand shows a peak at 70 MW. During all the quarter-hour except δt, the aFRR demand of B will be shifted to A; A will have a corrected demand of 50 MW and the two areas will have the same CBMP (price of bid A3) during all the concerned optimisation cycle. During the short time interval δt, the demand spike of A cannot be answered by an aFRR import from B because no CZC is available in this direction. Consequently, the AOF has to select the bid A4 to satisfy the demand of A and bid B2 to satisfy the demand of B. The congestion during δt leads to a price divergence. If a quarter-hour BEPP using extreme prices is chosen, area A will have for this quarter-hour a higher CBMP than area B (price A4 versus price B2). The net energy flow, however, goes from A to B, despite A having a higher CBMP than B. This results in a negative congestion rent because B is expecting to pay imported energy from A at its marginal price (set by B2), while A is expecting to get paid exported energy to B at its own, higher marginal price (set by B4).

- **Does not provide a full consistency between settlement period for BRPs (ISP) and BSPs (BEPP) where ISP is equal to 15 minutes.** Note that also mFRR activation could deteriorate the consistency between the BSP and BRP prices depending on the chosen imbalance settlement design.
- **Entails a certain complexity in terms of data handling**. It is important to note here that price data on optimisation cycle basis will be available by the AOF and are required in quarter-hour BEPP as well. The data handling complexity increase lies instead in the fact that each participating TSO will have to determine the TSO-BSP volumes on optimisation cycle, in order to be able to multiply these volumes by the optimisation cycle marginal price for each BEPP. Potentially, if aggregators prefer using a single settlement result for the entire quarter-hour to remunerate their providers, they could always focus on the aggregated result of this calculation on 15 minutes.

6.4.1 Relation between BEPP and the ISP

Since TSOs decided to propose a BEPP for the aFRR process that deviates from the imbalance settlement period and therefore provides no full consistency with the ISP the relation between the BEPP and the determination of the imbalance price per ISP should be briefly addressed.

In accordance with the EBGL Article 52 (1) each TSO is responsible for the imbalance settlement with BRPs within the respective scheduling area. In accordance with the EBGL Article 52 (2) all TSOs will develop a proposal for the harmonization of the main components for the imbalance price determination.

Taking into account the optimization-cycle BEPP for aFRR, TSOs are in principle left with two main options how to map the aFRR balancing energy prices in the imbalance price per ISP.

Maximum of aFRR price to determine imbalance price

The first option available to each TSO assumes that per ISP the maximum of the aFRR CBMP per ISP is used (note that there can be up to 900 aFRR market clearings and resulting marginal prices for each LFC area, depending on the duration of the aFRR optimisation cycle). In terms of determination of the imbalance price this option comes quite close to choose of a 15 min BEPP since the highest determined marginal price per ISP also determines the imbalance price for the same ISP. A schematic illustration of the approach is shown in the Figure 22.

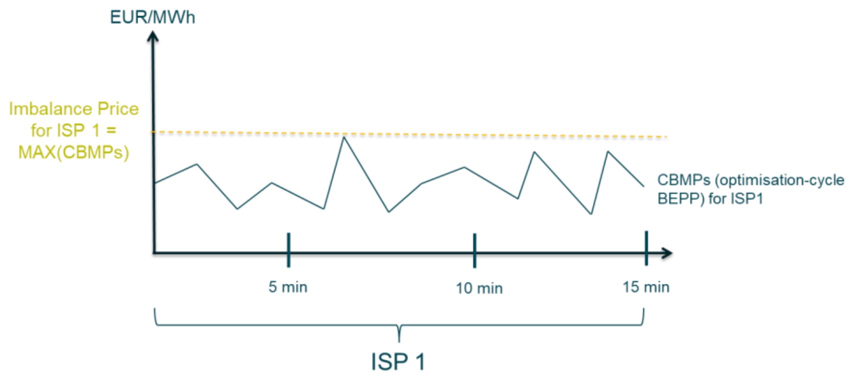


FIGURE 22: RELATION BETWEEN CBMP PER BEPP AND IMBALANCE PRICE PER ISP BASED ON MAXIMUM OF CBMPS PER BEPP

Volume-weighted average of aFRR price to determine imbalance price

The second option available to each TSO assumes that per ISP the volume-weighted average of the aFRR CBMPs per ISP is used to determine the imbalance price per ISP. A schematic illustration of the approach is shown in Figure 23.

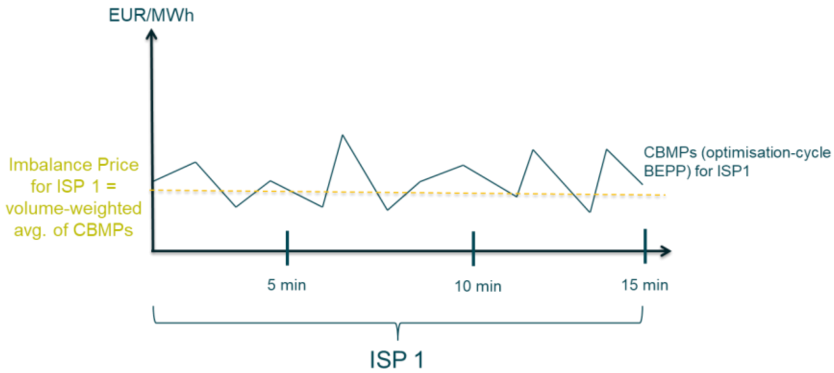


FIGURE 23: RELATION BETWEEN CBMP PER BEPP AND IMBALANCE PRICE PER ISP BASED ON VOLUME-WEIGHTED AVERAGE OF CBMPS PER BEPP

6.5 Price Indeterminacy

As explained in Chapter 4.3, a price indeterminacy is a special situation when identical bid and demand selection leads to multiple or no optimal clearing price solution. Unlike the mFRR and RR process, due to the fact aFRR demands are inelastic and bids are divisible, the only hypothetical case where price indeterminacy might occur corresponds to the case of perfect netting of aFRR demands of all participating TSOs: i.e. when there is no activation of aFRR bids needed to satisfy the aFRR demands. In such case, the rule for price determination is going to be the average price between the bid prices of the first bid in the upward CMOL and the first bid in the downward CMOL.

7 Other Components of the Proposal

7.1 Pricing of Specific Products

Specific products, according to Article 26 of the EBGL shall be implemented in parallel to the implementation of the standard products. Specific products can be used, when:

- standard products are not sufficient to ensure operational security and to maintain the system balance efficiently; or
- when some balancing resources cannot participate in the balancing market through standard products.

The EBGL Article 26(3) provides two possibilities to use specific products in context of the European balancing platforms:

- Specific products can be converted to standard products and then be activated from the common merit order list of the platforms, in accordance with Article 26(3)(a) of the EBGL.
- There can be specific products which are activated only locally, in accordance with Article 26(3)(b) of the EBGL.

By definition, specific products:

- are not standard and cannot be directly used for FRR cross-border activation unless they are converted,
- are defined on national level by each TSO and are approved by the respective regulatory authority,
- are not harmonised.

At the same time, Article 30(4) states: "*The harmonised pricing method defined in paragraph 1 shall apply to balancing energy from all standard and specific products pursuant to Article 26(3)(a)*".

The TSOs consider it as impossible to evaluate whether the application of the PP to a not known and not harmonised product would comply with the EBGL objectives and the boundary conditions of Article 30(1). E. g. it cannot be judged by the TSOs if the proposal would be non-discriminatory or set correct price signals and incentives. Nonetheless, in accordance with Article 30(4) of the EBGL, the pricing methodology will apply to specific products which are converted to the standard products.

As the TSOs were requested to propose a methodology for specific products which are activated only locally as well, the TSOs propose to apply the same methodology for these products. Still, in accordance with Article 30(4) of the EBGL, for "[…] *specific products pursuant to Article 26(3)(b), the concerned TSO may propose a different pricing method in the proposal for specific products pursuant to Article 26*." This proposal is an optional proposal of the respective TSO and, therefore, is not part of the PP in accordance with Article 30(1) of the EBGL.

7.2 Central Dispatching Models

In central dispatching model all market participants submit integrated scheduling process bids. Integrated scheduling process bids contain commercial data, complex technical data of individual power generating facilities or demand facilities and explicitly includes the start-up characteristics.

In accordance to Article 27 of the EBGL integrated scheduling process bids shall be used for the exchange of balancing services or for the sharing of reserves. In order to provide balancing services to other TSOs, those bids shall be converted into standard products taking into account operational security and, similarly to specific products, assuring that this conversion:

- is fair, transparent and non-discriminatory;

- does not create barriers for the exchange of balancing services.
- ensures the financial neutrality of TSO.

As stated in Chapter 2, the standard products which result from the conversion will be treated in the same way as other standard products. The TSOs will define the pricing and settlement of the respective bids in the national terms and conditions related to balancing.

7.3 Pricing of Cross-Zonal Capacity

The price of cross-zonal capacity for the exchange of balancing energy from RR, mFRR and aFRR is equal to the difference between the CBMPs of the respective uncongested areas. This includes the price for the exchange for balancing energy from the imbalance netting performed implicitly by the aFRR AOF.

The price of cross-zonal capacity for the exchange of balancing energy from imbalance netting performed explicitly by the imbalance netting AOF is 0 €/MWh. Due to the fact that there is no harmonised pricing methodology with the go live of the imbalance netting platform, a proper valuation of the cross-zonal capacity is not possible. At the same time, the impact of cross-zonal capacity limitations is implicitly part of the respective settlement of the intended energy exchange.

7.4 Absence of Price Caps

The TSOs do not propose any price caps to be applied on the CBMPs. This absence of such caps must not be confused with necessary IT limitations, e.g. 99,999.99999 €/MWh, for submission of the bid prices to the connecting TSOs.