Consultation on the design of the platform for automatic Frequency Restoration Reserve (aFRR) of PICASSO region

21 November 2017

DISCLAIMER

This document is released on behalf of TSOs from Austria, Belgium, France, Germany, the Netherlands, Croatia, Czech Republic, Denmark, Hungary, Finland, Poland, Slovenia, Spain and Sweden only for the purpose of a stakeholder survey. The survey covers a first draft proposal for automatic Frequency Restoration Reserve (aFRR) market design of the future European aFRR platform region to integrate balancing markets. The European platform strives for, amongst others, fostering effective competition, non-discrimination, transparency, enhancing new entrants and liquidity while preventing undue distortions in accordance with final draft of commission regulation establishing guideline on electricity balancing and does not in any case represent a firm, binding or definitive individual TSOs' position on the content.

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1. Subject and Matter of consultation

In this consultation document the PICASSO TSOs present the scope and content of their project to integrate aFRR markets. It represents the current status of the design of a platform for the exchange of balancing energy from aFRR. The aim of the document is to provide insight to stakeholders and other interested parties into the design options on the table and choices made by the PICASSO TSOs, as well as actively engaging stakeholders in order to get their input into the project and benefit from their specific expertise. In a later stage the formal consultation process for the implementation framework, required by the Guideline on Electricity Balancing, will give stakeholders a further opportunity to give their opinion on the TSO proposals and to affect the future balancing markets.

The PICASSO project is a voluntary initiative to integrate balancing energy markets from aFRR that has been selected to be the reference project for the establishment of an aFRR platform by ENTSO-E. After the EXPLORE project gave the starting point for the future market design within the framework given by the guidelines, the eight founding member TSOs, the Austrian TSO APG, the Belgian TSO Elia, the Dutch TSO TenneT NL, the French TSO RTE and the German TSOs – 50Hertz, Amprion, TenneT DE and TransnetBW, established PICASSO. The project is also open for the participation of other TSOs and has already welcomed several observers[1]. The project name PICASSO stands for "Platform for the International Coordination of the Automatic frequency restoration process and Stable System Operation". In the context of GLEB implementation, the focus of PICASSO is the establishment of a platform for the exchange of balancing energy from aFRR.

The PICASSO project builds further onto the work done earlier in EXPLORE by the Austrian, Belgian, Dutch and German TSOs. The findings from EXPLORE can be reviewed in the EXPLORE report and the EXPLORE addendum[2]. Practical experience, such as that gained in the operation of the integrated German and Austrian aFRR markets, is also taken into account in PICASSO. PICASSO TSOs work in close alignment with their NRAs.

The PICASSO TSOs are designing a new market for the exchange of aFRR between European countries in line with Electricity Balancing Guidelines (GLEB)[3] and this is likely to lead to many changes for stakeholders. Changes will result from both harmonization efforts and as a result of the integration of the markets. Because of this, the feedback from stakeholders, in particular BSPs and BRPs, is especially valuable. PICASSO TSOs therefore request the feedback of stakeholders, both on the general design, as in response to specific questions posed throughout the document.

The structure of the document is as follows. After this general introduction, a bit more background is given on the context established by the GLEB. This is followed by a description of the PICASSO project and timelines.

Afterwards, in chapter 4, the PICASSO design is discussed. Furthermore, chapter 4 focuses on harmonization aspects, including the definition of standard products, common settlement rules, and the balancing energy gate closure time (BEGCT). Chapter 4 also describes the PICASSO process for further harmonization and improvement of the level playing field. Chapter 5 focus on aspects of

[1] More information about joining PICASSO (for TSOs) can be found here.

[2] EXPLORE publications can be found here.

[3] The GLEB and other network codes and guidelines can be found here.

integration, including the signal sent between TSOs and the usage of cross-zonal capacity and other aspects of congestion management.

Chapter 6 explains intermediate steps in coming to a target model, including possible smaller scale cooperations between PICASSO members.

In Chapter 8 of the document you can find definitions and list of abbreviations.

2. Introduction: aFRR market integration according to GLEB

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

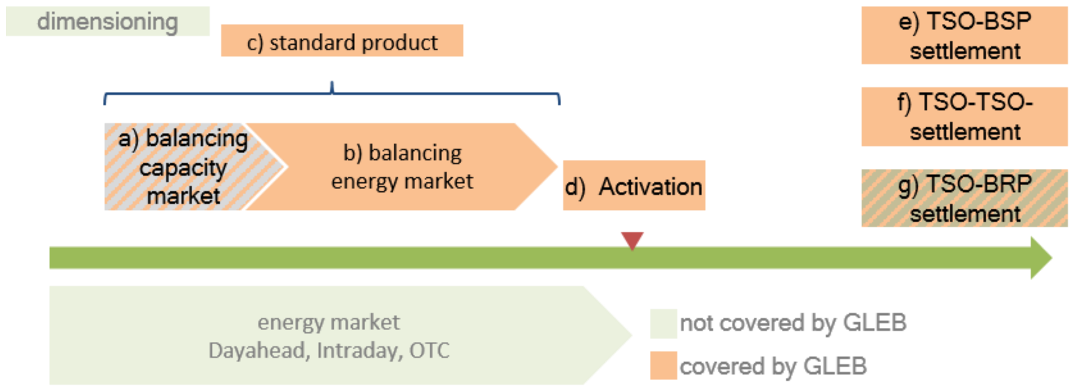


Figure 1: Scope of GLEB

The GLEB does not set out requirements for the dimensioning for aFRR, it still stays a local responsibility. Based on the dimensioning every TSO can organize its balancing capacity market. The GLEB does not require to integrate balancing capacity markets, however it describes possible options in case TSOs choose to voluntarily integrate their balancing capacity markets. Apart from the balancing capacity market, the GLEB obliges each TSO to introduce a balancing energy market in which balancing service providers (BSPs) can place energy only bids or update the energy price of their bids until the balancing energy gate closure time (BEGCT).

The aFRR bids placed in the balancing energy markets shall be exchanged between TSOs via an European platform, according to Article 21 of the GLEB. This platform serves to enable the exchange of balancing energy between all relevant member states. According to Article 21 of the GLEB the platform has to cover amongst others, the boundaries for the balancing energy market, a description of the standard product for aFRR, the common merit order list and the description of the algorithm for the operation of the activation optimisation function.

The GLEB requires the definition of standard products, which will be exchanged on the European platform. The definition of standard products is part of the platform definition and as such part of the PICASSO project as well. The aim of GLEB is to limit the amount of different products used in order to prevent a split of liquidity and to help ensure a level playing field. In chapter 4.1 further details are provided on the requirements on the standard product.

The defined standard products will be exchanged using a multilateral TSO-TSO model. Figure 2 displays the principle of the TSO-TSO model.

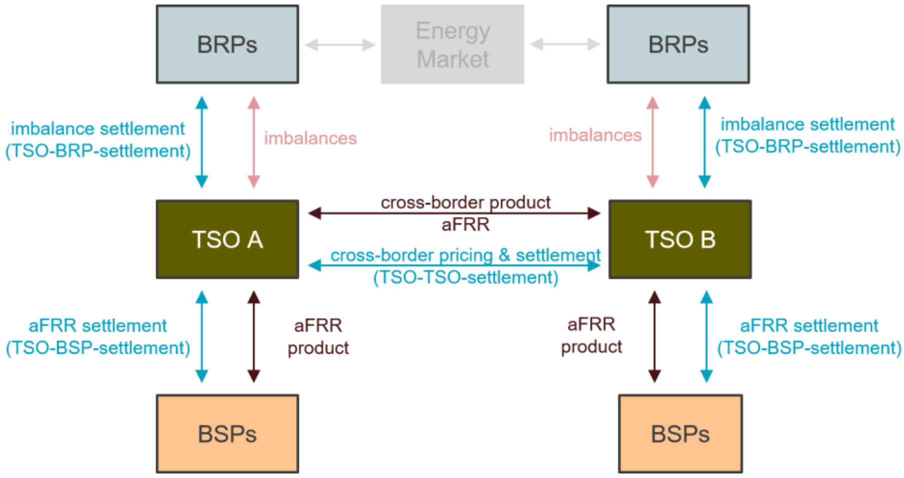


Figure 2: Scheme of TSO-TSO model

The GLEB requires a contractual and processual design where every BSP and every BRP has one dedicated partner on TSO level and all TSOs coordinate among themselves (TSO-TSO-model). In practice, each BSP will be activated and paid by one TSO and TSOs are responsible to transport balancing energy to the LFC areas where the respective ACE is located. Each market participant is connected to one LFC area where the responsible TSO is required to settle the position of each BRP for each imbalance settlement period (ISP). In a comparable manner where market participants can exchange energy cross-border organised by the power exchanges, TSOs will be enabled to exchange balancing energy organised by the common platform.

The exchange of balancing energy will influence the imbalance price of each imbalance price area. Moreover, imbalance netting, mFRR and RR will influence the imbalance price, too. That is mostly why the definition and level of harmonization of the imbalance price is considered as cross-project matter and is not part of the PICASSO project. This will be further investigated within a dedicated ENTSO-E working group.

For each defined standard product of the aFRR platform, a common merit order list (CMOL) will be established. A CMOL means a list of balancing energy bids, sorted in order of their bid prices and used for the activation of those bids. The GLEB requires the platform to activate the bids via the activation optimization function based on the CMOLs. To cover an aFRR demand the cheapest bids of the corresponding CMOL, which are needed to fulfil the demand, have to be activated taking into account the available cross-zonal capacity after previous markets and previous balancing measures. chapter 4.2 details further the creation of the CMOL and chapter 5.1 gives a deeper insight in the activation based on merit order list.

Based on the activation of the aFRR bids, TSOs perform the TSO-BSP settlement, the TSO-TSO settlement and the TSO-BRP settlement. The determination of the price of balancing energy used in all settlement processes has to be based on marginal pricing in accordance with the GLEB. Further requirements on the harmonization of the TSO-BSP and TSO-TSO settlement are set out in the GLEB and further detailed in chapter 4.3. Harmonization of the TSO-BRP settlement is not covered by this project as previously stated. Hence, this consultation does not cover the TSO-BRP settlement itself. More information on the settlement, including volume and price aspects, can be found also in Chapter 4.

3. Introduction: PICASSO project structure and schedule

In July 2017, the eight founding TSOs of PICASSO signed a Memorandum of Understanding (MoU) for the design, implementation and operation of a platform for common activation of automatic Frequency Restoration Reserves (aFRR platform) in order to, among others, integrate their aFRR balancing markets. Since then several European TSOs have joined the cooperation as observers. Figure 3 gives an overview on the current members and observers of the PICASSO project.

Figure 3: Current overview of members and observers

3.1. Memorandum of understanding (MoU)

The aFRR target platform is considered by the TSOs as a step in the fulfilment of GLEB provisions regarding aFRR balancing energy exchange. Since the beginning, TSOs have aimed at making this initiative the reference implementation project for the European aFRR platform, and this goal was completed with ENTSO-E Market Committee approval on 9 November 2017.

By agreeing on the MoU for an aFRR platform, the involved TSOs are showing their willingness to be front runners in the integration of national balancing markets for the benefit of all the involved market parties.

3.2. Project Schedule

In Figure 4 there is a timeline for PICASSO with its already named phases. Today PICASSO is in phase 1, where the design of the aFRR target platform is created. From earlier projects the TSOs are aware of the number of detailed questions that have to be answered to then start an implementation. Therefore two public stakeholder consultations will be organised – the first one before end 2017 and the second one around June 2018. After the successful implementation of phase 1 of the project, phase 2 starts and will bring PICASSOs TSOs to its aFRR platform with full GLEB compliancy.

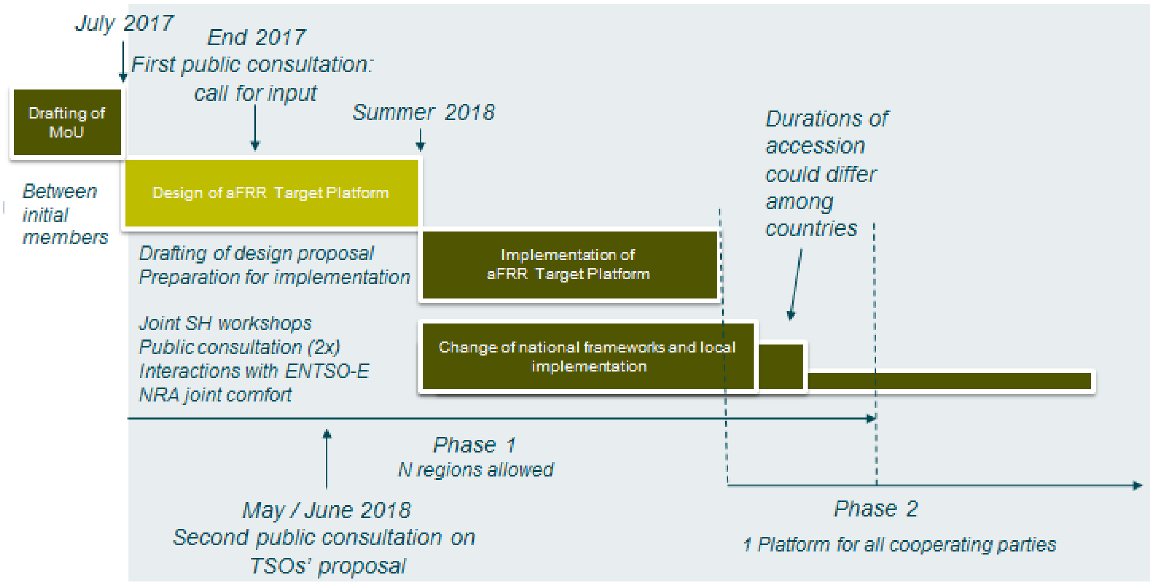


Figure 4: High level project timeline

In order to gather practical experience TSOs intend to implement intermediate aFRR cooperation(s), which is introduced in chapter 6.1.

3.3. Governance and Interaction with ENTSO-E

The establishment of the aFRR Platform is organised via the implementation project PICASSO, where technical details, common governance principles, and business processes are developed by the participating TSOs. Furthermore, PICASSO shall implement and make operational the European platform where all aFRR balancing energy bids from standard products shall be submitted to and the exchange of all balancing energy from aFRR shall be performed.

ENTSO-E (all TSOs) will develop the proposal for the implementation framework for the European Platform for the exchange of balancing energy from aFRR. The investigations in the PICASSO project and the stakeholders' input gather by the project will serve as input to ENTSO-E. Interactions between the aFRR platform with platforms for replacement reserves, frequency restoration reserves with manual activation and the imbalance netting process are coordinated by ENTSO-e via dedicated working groups.

Stakeholder management is performed with consultation rounds reported in consultation document.

4. Harmonising aFRR market

For a common aFRR market a certain degree of harmonization is necessary. However, experience from other markets, e.g. the energy spot-market, shows that a full harmonization of the regulatory and legal framework is hard to achieve, and not strictly necessary to form a common market and provide an acceptable level playing field. Based on these considerations PICASSO TSOs analysed the differences in the existing aFRR markets and propose a suitable target model for a common aFRR market. This chapter will first focus in more detail on the most important harmonization points according to PICASSO TSOs – whereas a listing and short description of other harmonization topics will be done at the very end of this chapter. Stakeholders' views are requested on all points in a separate question section.

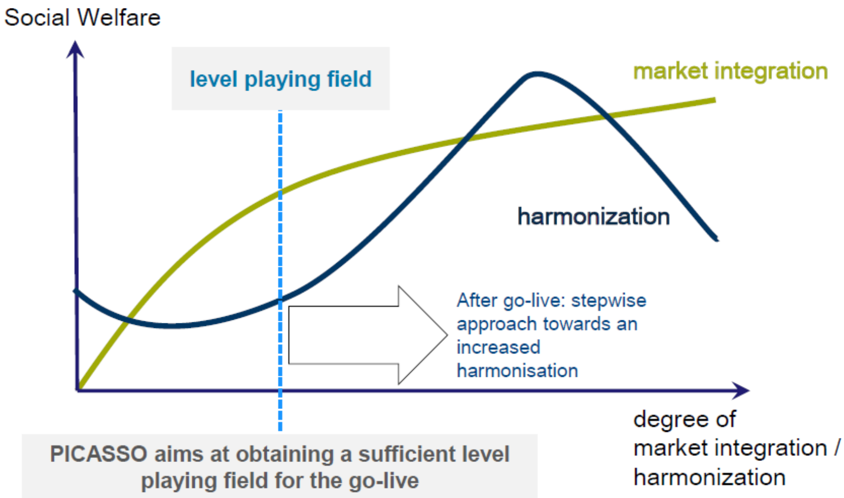


Figure 5: Schematic illustration of the relation between social welfare and degree of market harmonization

In the following subchapter, the foreseen target model for the aFRR market will be detailed. First, the aFRR product for PICASSO platform is introduced. Afterwards a general overview on the aFRR bidding process including the definition of contracted and uncontracted bids will be given followed by a discussion on the corresponding balancing energy gate closure time (BEGCT). In chapter 4 the foreseen pricing methodology of aFRR is explained and discussed.

4.1. Standard product

The terms and conditions of aFRR markets in European countries show significant differences. One explanation for the various historical developments is the heterogeneous generation structure within Europe. Figure 6 depicts the installed capacities of various European countries.

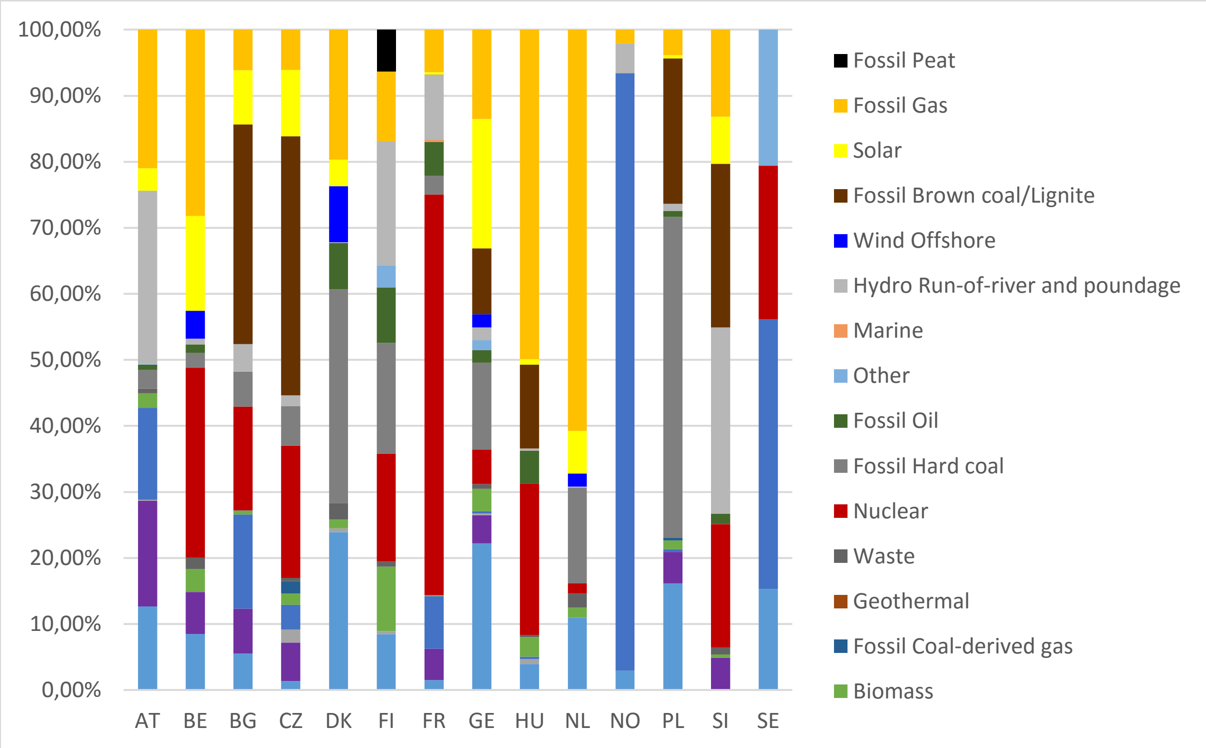


Figure 6: Installed capacities within PICASSO countries, source: ENTSO-E transparency platform 2017

Whereas the generation in Austria is mainly based on hydro, due to the geographical neighbourhood to the Alps, other countries base their generation mainly on nuclear power or generation from hard coal or lignite. Furthermore, Figure 6 shows the differences in the share of new technologies as generation from renewable energy sources such as wind or solar.

Due to these significant differences in the generation structure and the corresponding differences of historical development of the individual aFRR markets a harmonization of terms and conditions has to be assessed carefully. A full harmonization of all parts of the European aFRR product is associated with high costs to change the system and might even lead to a reduction of social welfare in case market integration is insufficient.

Hence PICASSO TSOs propose a stepwise approach for the definition of the aFRR product in which the parallel harmonization of terms and conditions and the necessary market integration will be ensured. The minimum level of harmonization is an acceptable level playing field, which will arise from the usage of a standard product as defined by GLEB. Further harmonization beyond the requirements to set up the aFRR platform will then assessed by taking into account gained experiences.

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

The list of standard products for balancing energy and balancing capacity ***may* set out at least** *the following characteristics of a standard product bid:*

(a) preparation period;

(b) ramping period;

(c) *full activation time;*

(d) *minimum and maximum quantity;*

(e) *deactivation period;*

(f) *minimum and maximum duration of delivery period;*

(g) *validity period;*

(h) *mode of activation.*

These parameters are optional. The subsequent paragraph, 25(5), lays down the obligatory parameters for standard products:

The list of standard products for balancing energy and balancing capacity ***shall set out at least*** *the following variable characteristics of a standard product to be determined by the balancing service providers during the prequalification or when submitting the standard product bid:*

(a) *price of the bid;*

(b) *divisibility;*

(c) *location;*

(d) *minimum duration between deactivation period and the following activation*

Additional to the mandatory parameters of 25 (5) PICASSO TSOs additionally deem it necessary to harmonize the full activation time, the minimum and maximum quantity and the validity period. PICASSO TSOs consider the preparation period, the ramping period and the deactivation period as not applicable to the aFRR process. The mode of activation for aFRR is by the nature of the aFRR process automatic. The following subchapters lay out the foreseen harmonization on full activation time, validity period and bid sizing.

4.1.1. Full Activation Time (FAT)

The FAT is used in the prequalification process and monitoring process of PICASSO TSOs. To get prequalified, a BSP has to be able to activate the total volume, which should be prequalified, in the given FAT. In case of activation, a bid of a BSP has to reach a given setpoint within the FAT to be compliant. Figure 7 shows the compliant (green lines) and non-compliant (red lines) reaction of an aFRR provider on a given TSO request (blue line).

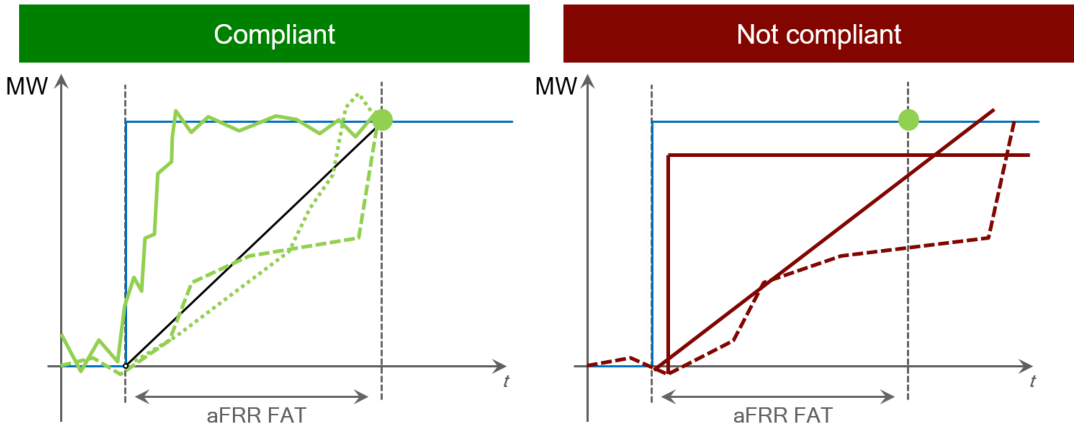


Figure 7: Definition of FAT

In practice, PICASSO TSOs want to have a reaction of BSPs equal or faster than the dynamic requirement defined by the linear fulfilment of the request within the FAT (black line in Figure 7). This can be achieved by different approaches. First, to limit the rate of change of the setpoint sent to the BSPs and require the BSP to follow the setpoint in a narrow tolerance band. This is displayed in Figure 8. On the left part of the figure a ramped setpoint (blue line) is sent to the BSP. The BSP has to follow the sent setpoint in the given tolerance band (grey area). BSP settlement can consider the requested energy volume defined by the controller output. TSOs can incentivize the BSP to stay within the tolerance band by applying penalties and additionally by a consistent TSO-BRP settlement (right side). Furthermore, the BRP has always the incentive to deliver more energy (green area) to gain in the BRP settlement. However, TSOs cannot consider this amount as guaranteed.

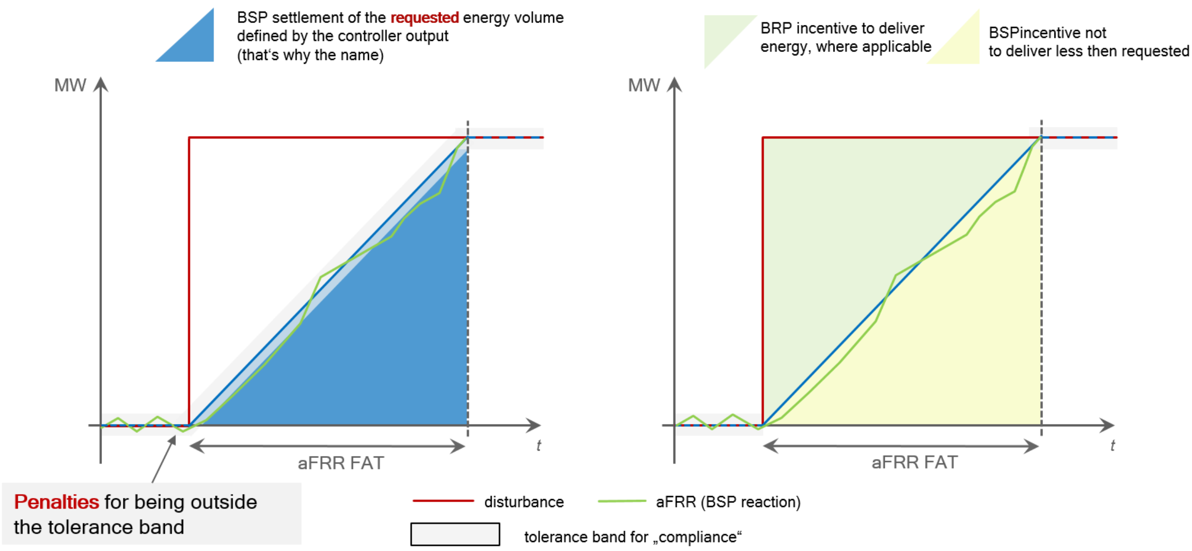


Figure 8: Ramping approach with option of remuneration (left) and given incentive to BSP (right)

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

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

The second approach does not foresee a limited rate of change for the setpoint sent to the BSP. BSP settlement considers the energy volume based on the delivered aFRR. This approach is depicted in Figure 9.

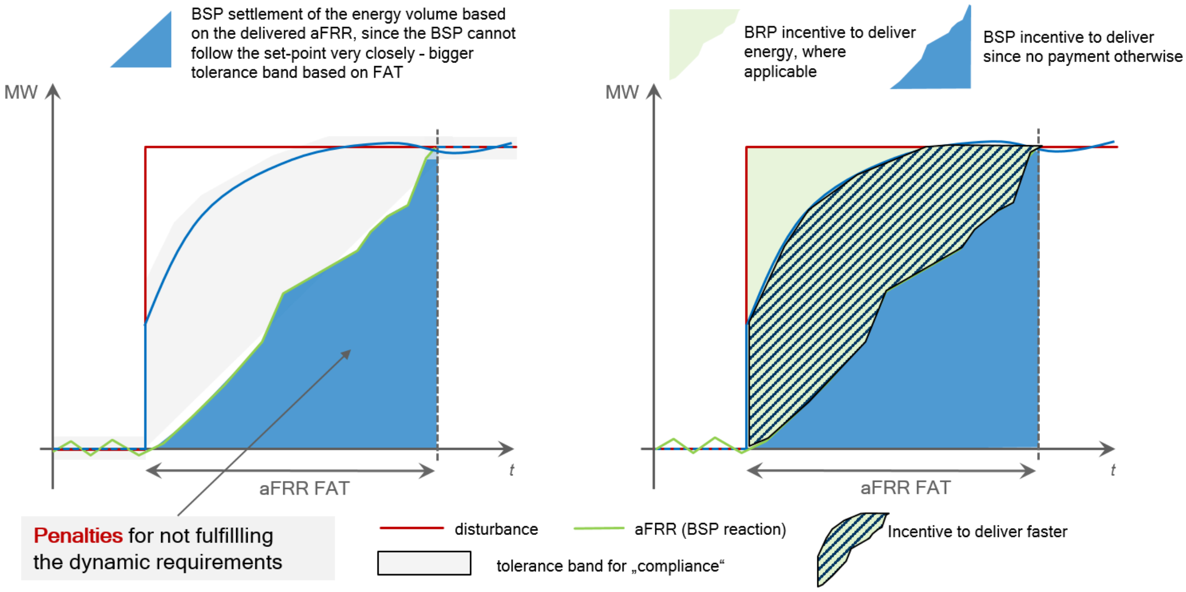


Figure 9: FAT-approach with option of remuneration (left) and given incentive to BSP (right)

Due to the unramped setpoint BSPs cannot exactly follow the given request and by this the tolerance band is bigger than in the previous approach. The given TSO-BSP settlement implicitly incentivizes BSPs to activate as fast as possible and by this increase the volume to be settled (blue shaded area). Additionally TSOs can incentivize BSPs to at least deliver the minimum dynamic requirements by applying penalties in case of „underfulfilment“.

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

However, in practice both approaches should lead to similar results and both allow to facilitate the TSO-TSO exchange proposed by PICASSO TSOs – see subchapter 5.3. Both approaches also allow valorising fast flexibility. Moreover, giving the flexibility for each country to keep its historical approach allows avoiding the adaptation of all existing interfaces between TSOs and BSPs, and possibly adaptations of controllers at BSP side. Hence, PICASSO TSOs agreed not to harmonize this part of the product characteristic and by this give every TSO the opportunity to apply the appropriate method corresponding to the existing generation structure of its LFC area.

The duration of activation of balancing products has a direct impact on the resulting frequency restoration control error (FRCE). The FRCE is the frequency in case the LFC area equals the synchronous area. In case the LFC area is smaller than the synchronous area then the ACE defines the FRCE. Hence, the maximum FAT has to be short enough to guarantee the required FRCE target parameters. On the other hand, the FAT has to be long enough to ensure the availability of the required capacities and facilitate a liquid aFRR market.

From previous ENTSO-E discussions, the number of feasible candidates was limited to 5 and 7.5 min. Simulations within PICASSO supported this. The values higher than 7.5 minutes were leading to too important deterioration of FRCE quality.

In addition to the technical assessment, PICASSO TSOs are performing an economical assessment to identify the impact of the FAT on volume of offered bids and the impact on the balancing capacity prices of the bids. This assessment aims to be generic and relatively easy to be applied by each TSO. Therefore, assumptions with a certain degree of simplifications have been identified. PICASSO TSOs consider these assumptions as valid for a change of FAT in a range between 5 and 15 minutes.

- Linear relationship between the FAT and the offered aFRR volume for thermal units (CCGT, coal fired, nuclear)
- No impact on offered aFRR volume for non-thermal units (PV, demand side, hydro, wind)
- Relative price effect due to expected setpoint changes of units and corresponding increase of opportunity costs, in particular when units are facing a must-run situation.
- Impact of setpoint changes on efficiency and corresponding impact on costs are neglected

4.1.2. Validity period

The validity period defines the amount of time in which a bid is valid and firm. This means that activation requests from the TSO to the BSP can only happen within the bid validity period. A shorter validity period gives a BSP the opportunity to adapt the price and volume of their bids closer to the boundary conditions given by the market. However, a short validity period leads to more often changes of the CMOL. Frequent changes of the CMOL sets high requirements on the technical process. Furthermore, changes of the CMOL lead to up- and downramping of aFRR bids and might deteriorate the FRCE quality. Figure 10 gives an example of changing CMOL and the resulting impact on the aFRR activation and deactivation. It can be observed that deactivations of previous activation requests can happen within or outside of the validity period.

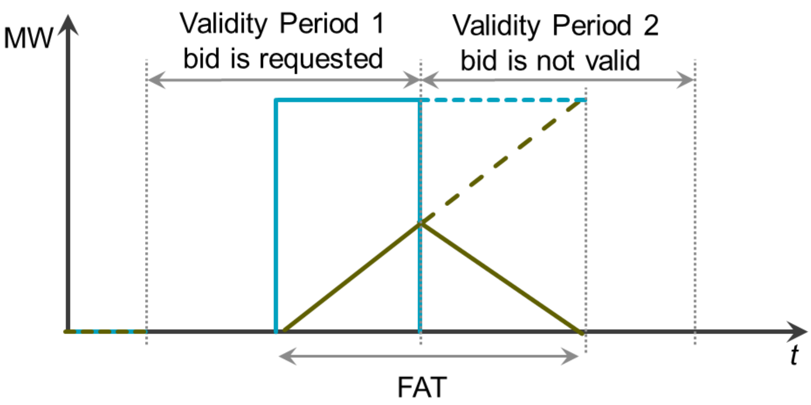


Figure 10: Example of bid activation in case of a CMOL change

In this example in validity period 1 the activation of one bid is requested, however, the CMOL changes during the activation of the bid. In the following validity period 2, the previously requested bid is no longer valid, or at a different position of the merit order list. Hence, this bid is deactivated. The request is transferred to a different bid, which will then start the activation. The resulting time from the beginning of the request until the request is fulfilled by an activation is longer than the required FAT. This might result in a lower ACE and frequency quality.

However, as a starting point, PICASSO TSOs assume a validity period of 15 minutes, in line with expected validity period for mFRR. In case the impact on frequency and or ACE is not acceptable, PICASSO TSOs will consider a multiple of 15 minutes but not more than 1 hour. PICASSO TSOs are still discussing the exact methodology to make such assessment in more detail.

4.1.3. Bid definition

This subchapter will specify the bid related characteristics that are required by GLEB and how PICASSO TSOs envision the setup of these.

One parameter for the bid definition is the divisibility, it means whether a minimum bid volume constraint during activation applies or not. By nature of the aFRR process, energy bids have to be divisible to be activated continuously.

The current bid sizing of PICASSO TSOs are relatively similar. The minimum bid size, which defines the minimum size of the offered bid volume, is in the range between one and five MWs. The minimum bid size affects the number of bids in the CMOL and therefore has an IT and administrative impact. On the other side, the minimum bid size impacts the barriers for new market entries. The lower the minimum bid size is the lower the barrier for new market players is.

As bids are divisible, PICASSO TSOs consider the maximum bid size mostly as an IT limitation, which will be set to 9999 MW.

The bid granularity defines the possible increment of offers above the minimum bid size. PICASSO TSOs apply a maximum bid granularity of 1 MW.

According to Article 31 (4) in GLEB, bid prices should be expressed currency of EURO and market time units.

GLEB requires the standard product to specify the location of a bid. PICASSO TSOs require at least the LFC area to be indicated for each bid; however it is not excluded that locally more detailed geographical location might be required.

GLEB requires the standard product definition to specify the minimum duration between the end of a deactivation period and the following activation. PICASSO TSOs consider a value of zero for this minimum duration feature, as we consider aFRR to be a product continuously available for activation. BSPs having resting constraints should consider offering only balancing energy bids not related to a contract for balancing capacity in order not to offer the bids for certain period when a resting is needed.

It is currently not envisioned that a BSP can offer the same flexibility for multiple processes at the same time indicating any cross product relations (linked bids between different platforms) - as this would have both major transparency and impacts on implementation complexity. However, the latter is subject to further discussion between different balancing products and processes (aFRR, mFRR and RR).

Furthermore, PICASSO TSOs do not foresee the possibility of complex bids, such as linked or exclusive bids. Considering such bids in the aFRR optimization would make it impossible to solve the optimization problem within the time needed for the aFRR process.

4.1.4. Questions to stakeholders

Questions to stakeholders regarding the general standard product design
1. Do you agree with the choice of parameters for the standard product (FAT, validity period, divisibility, minimum and maximum bid size)? ▪ yes ▪ no, in case of no please explain yourself and provide an overview on missing or unnecessary parameters (free textbox) ▪ no opinion 2. Do you agree with the TSOs conclusion of not harmonising the ramping approach and FAT approach ▪ yes ▪ no, please explain (free textbox) ▪ no opinion 3. Do you support the incentive to react faster ▪ yes, if yes would you use this opportunity (free textbox) ▪ no, if no, please explain (free textbox) ▪ no opinion
Questions to stakeholders regarding economic FAT assessment (only for BSPs)
4. Do you agree with the assumption of a linear impact on offered aFRR volumes of thermal units? ▪ yes ▪ no, in case of no please provide a reasoning and if possible a more suitable approach (free textbox) ▪ no opinion 5. Do you agree with the assumption of no impact on offered aFRR volumes of non-thermal units for FAT in the range of 5 and 15 min? ▪ yes ▪ no, in case of no please provide a reasoning and if possible a more suitable approach (free textbox) ▪ no opinion 6. Do you agree with the assumption that power output changes (due to a FAT change) and their effect on relative efficiency have negligible impacts on bidding price changes? ▪ yes ▪ no, in case of no please provide a reasoning (free textbox) ▪ no opinion

7. What is your current minimum FAT (required for providing aFRR)? In case you are active in more than one country, please provide one answer per country, including the names of countries you are active in.

8. Please provide us an estimation on the impact of a FAT change to 5 minutes on the offered volumes and prices – both in percentage and absolute values. In case you are active in more than one country please provide one answer per country including the name of the countries you are active

- Volume impact: (free textbox) %, (free textbox) MW
- Price impact: (free textbox) %, (free textbox) MW

9. Please provide us an estimation on the impact of a FAT change to 7.5 minutes on the offered volumes and prices – both in percentage and absolute values. In case you are active in more than one country please provide one answer per country including the name of the countries you are active

- Volume impact: (free textbox) %, (free textbox) MW
- Price impact: (free textbox) %, (free textbox) MW

Questions to stakeholders regarding validity period

10. Which is your preferred validity period? – please give the reasoning for your answer

- 15 min
- 30 min
- 45 min
- 60 min
- other – please specify (free textbox)
- no opinion

-

Questions to stakeholders regarding bid sizing

11. Which minimum bid size do you prefer?

- 1 MW
- 5 MW, with an option for each BSP to at least offer one bid with 1 MW or bigger. By a BSP has the possibility to have one bid within a range of 1-5 MW.
- >5 MW
- Other – please specify (free textbox)
- no opinion

12. Which granularity do you prefer?

- 0.1 MW
- 1 MW
- 5 MW
- other – please specify (free textbox)
- no opinion

4.2. Bidding process and balancing energy gate closure time (BEGCT)

This chapter describes the bidding process flows and concept of the BEGCT, the difference between contracted and non-contracted bids and finally the GLEB requirements together with the techno-economic considerations for harmonizing the aFRR BEGCT. A link between this aFRR bidding process and the design of the other balancing processes for mFRR (MARI) and RR (Terre) is acknowledged and will be further investigated in a coordinated way.

4.2.1. Introduction and general overview of bidding process

This subchapter illustrates the future aFRR bidding process flow between BSPs and TSOs. The timeline in Figure 11 also shows the interactions between:

(a) The intraday cross-zonal gate closure time (IDCZGCT)
(b) The balancing capacity gate closure time (BCGCT)
(c) The balancing energy gate opening time (BEGOT)
(d) The balancing energy gate closure time (BEGCT)

Besides the relevant market gate closure times, a TSO bid submission gate closure time (TSOGCT) is also highlighted which is the point in time local TSOs will have to submit their local merit order list (LMOL) to the common merit order list (CMOL) containing at least the standard product bids. The resulting CMOL will contain all bids which are valid to be used by the common activation optimization function (AOF) during the respective validity period (VP).

The IDCZGCT is determined to be one hour in advance (currently but subject to change) and the BEGCT needs to be shorter than or equal to the IDCZGCT (GLEB Art. 24). Therefore, Figure 11 shows an example where this requirement is respected. In addition, a BCGCT is illustrated, which is always longer than or equal to the BEGCT - in the example, week-ahead (W-1) is shown – the concept will be explained in subchapter 4.2.2. Finally, a BEGOT is illustrated, which should always be before the BEGCT– the concept will be explained in subchapter 4.2.3.

In the remaining subsequent chapter, the focus and considerations of the PICASSO TSOs on the BEGCT will be further detailed.

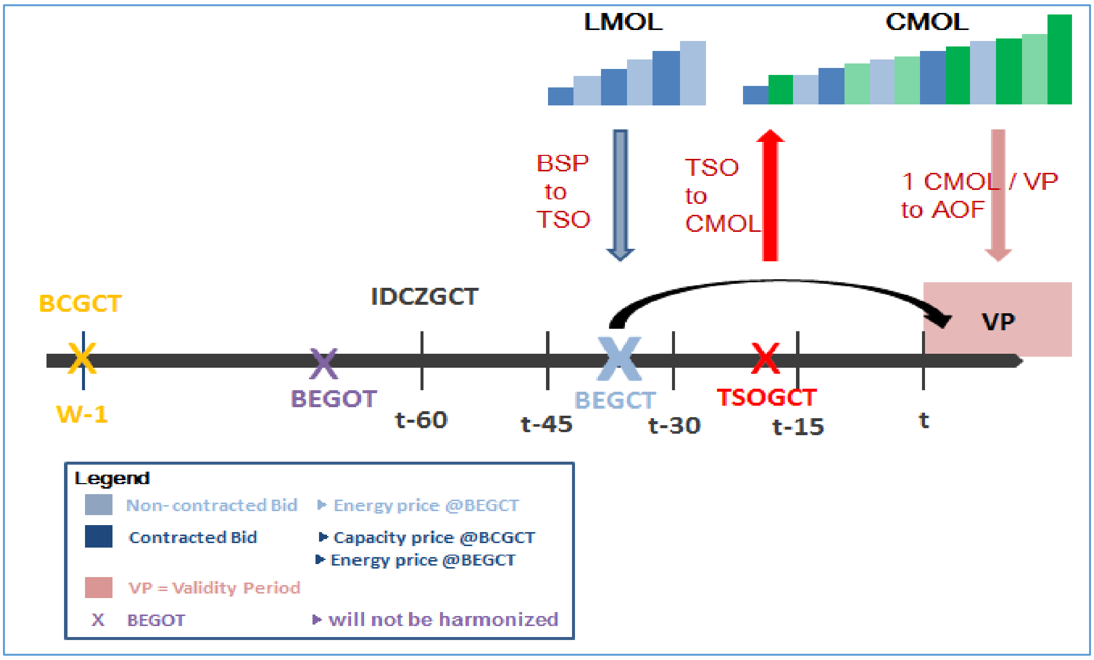


Figure 11: Different gates time sequence

4.2.2. Contracted vs non-contracted bids

This subchapter will explain the difference between contracted and non-contracted bids and link it to the BCGCT and BEGCT.

Timewise, the process for the future bidding situation is as follows – as illustrated in Figure 12. Each TSO procures a certain amount of balancing capacity. The moment in time at which the capacity is procured (at BCGCT) will not be harmonised within PICASSO, and currently varies from yearly to daily procurement. At the time of procurement of balancing capacity, the related balancing energy price for remuneration of potential energy activations during the delivery period will not necessarily be requested. During the procurement, only the amount and allocation of required balancing capacity bids is determined and only the balancing capacity price is awarded. This approach is different of some current situations where BCGCT and BEGCT coincide, e.g. in Germany and Austria.

Afterwards, for a certain period until the BEGCT, balancing energy bids can be sent from the BSP to the local TSO. Each BSP who has been awarded a capacity contract (during procurement) is obligated to offer at least the procured volume to the balancing energy market. These bids are referred to as contracted bids, i.e. bids that are related to a contract for balancing capacity. In addition and according to GLEB Art. 16, every qualified BSP is allowed to send in balancing energy bids even if it has not been selected in the procurement for balancing capacity –. These bids are called non-contracted bids (or free/voluntary bids). Such bids can be offered by BSPs with remaining flexibility, which was not known ex-ante, not able to be committed up-front at the moment of BCGCT or which has not been selected during procurement.

The volumes and the prices for the balancing energy bids (both contracted and non-contracted) may be set or changed until the BEGCT by the BSPs, which is the moment when both their volumes and prices become firm.

The mentioned process is illustrated in Figure 12.

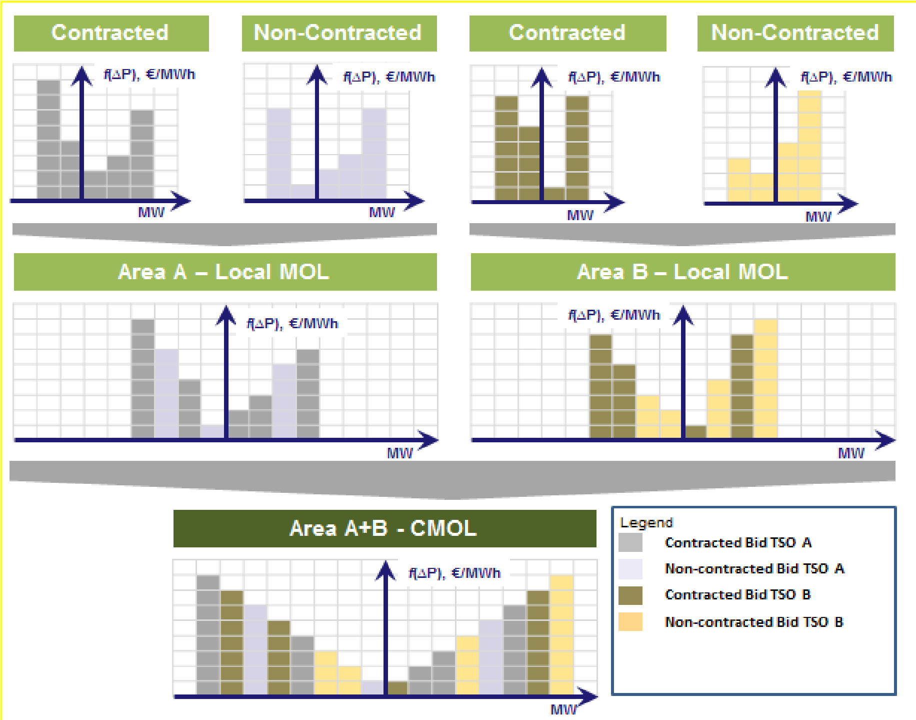


Figure 12: Bidding process flow for contracted and non-contracted bids

Figure 12 shows an example where all received local bids are forwarded to the CMOL by the local connecting TSOs. An exemption however is allowed for certain TSOs so that a limitation of the number of forwarded bids can be obtained. According to GLEB Art. 29(10), TSOs that apply a self-dispatching model and which are operating within a scheduling area with a local intraday gate closure time (local IDGCT) after the BEGCT may develop a proposal towards their NRA to limit the number of bids that is forwarded to the European CMOL. This proposal should respect certain rules and requires certain specifications:

(a) The cheapest bids shall always be forwarded to the CMOL
(b) The definition of the minimum volume that has to be sent to the AOF needs to be specified and should be larger than or equal to the sum of the reserve capacity requirements for its LFC block.
(c) The rules to release bids that are not submitted to the European CMOL and the point in time BSPs shall be informed

Above-mentioned TSOs might prefer to perform such bid limitation in order to maximize liquidity on their local intraday market and avoid potential locked-in and unused flexibility on the CMOL.

The concept is graphically illustrated in Figure 13 – which can be compared to Figure 12 where no restrictions were applied.

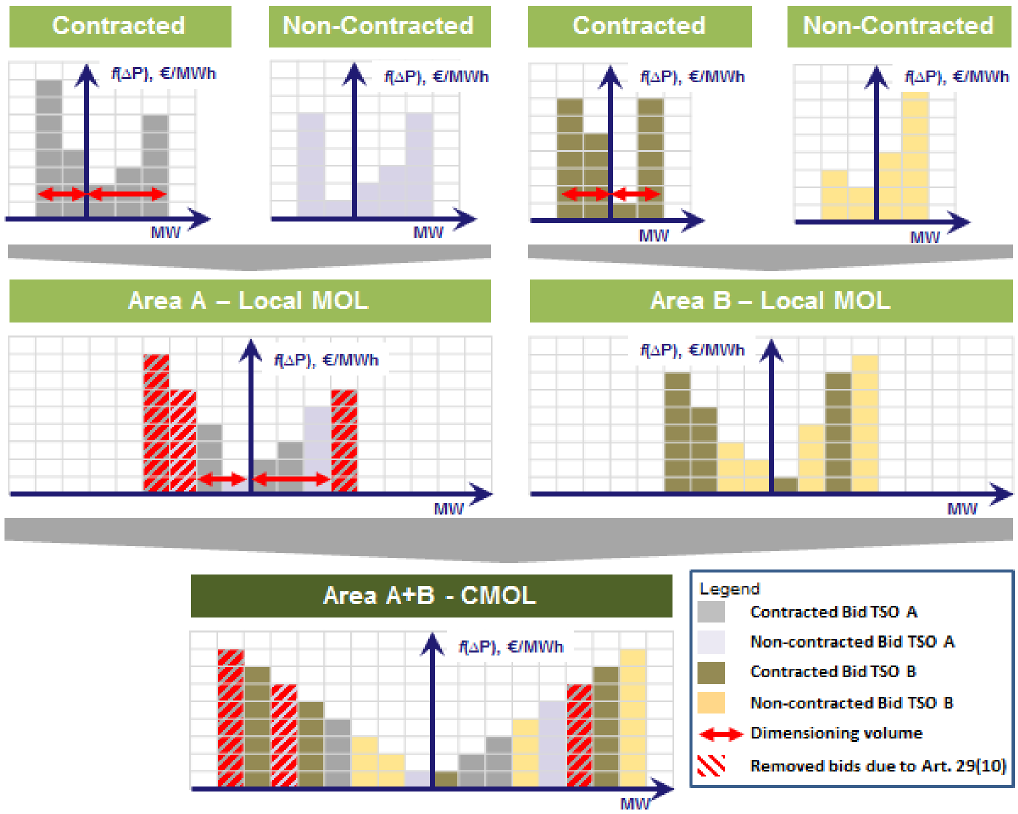


Figure 13: Bidding process including non-shared bids

TSO A limits its total aFRR volume of the local MOL to the dimensioned volume (red arrows). Hence, two bids of the negative MOL and one bid of the positive MOL are capped and removed from the local and the common MOL (red shaded bids)

4.2.3. Balancing Energy Gate Opening Time (BEGOT)

Even though unspecified in GLEB, similarly as the BEGCT, the BEGOT is a parameter that TSOs will also consider for each of the balancing energy processes (aFRR, mFRR and RR). The BEGOT means the point in time as of which BSPs can start to offer their balancing energy bids to their connecting TSOs for minimally one validity period.

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

PICASSO TSOs are currently not considering harmonizing the value of the BEGOT.

4.2.4. Balancing Energy Gate Closure Time (BEGCT)

The subchapter explains the BEGCT in more details, shows the current differences between BEGCT and validity periods between PICASSO TSOs and identifies market and technical considerations for choosing the aFRR BEGCT. A link with other balancing processes mFRR/RR exists and is subject to further investigation between PICASSO-MARI-TERRE projects, with the coordination of ENTSO-E.

4.2.4.1. Definition of BEGCT

The GLEB defines the BEGCT as the point in time after which submission or update of a balancing energy bid is no longer permitted. This implies the submitted balancing energy bids become firm from the BSP towards the local connecting TSO for a certain bid validity period at the moment of BEGCT.

GLEB requires a harmonised unique BEGCT for each of the balancing processes (aFRR, mFRR and RR) – which could hence overlap or differ between those processes. For a given process, each local BEGCT for the BSPs must hence be the same point in time across different LFC-areas. The TSOs should afterwards align between themselves on a required TSO bid submission closure time (TSOGCT) for forwarding these balancing energy bids towards the CMOL, after having performed all required local processes on the bids received at BEGCT (eg. business consistency checks, congestion management analysis, IT fall-back...).

4.2.4.2. Link between BEGCT and length of bid validity period

The PICASSO TSOs take a bid validity period of 15 min as a starting point. This means that each 15 min a new BEGCT would occur – considering the frequency of BEGCTs is dependent on the validity period length (e.g. 96 gates per day in this case). There is no link between the bid validity period length and the minimum BEGCT lead time.

As TSO would like to avoid overlaps of validity period for aFRR product, a maximum validity period length of one hour would be preferable (with 24 gates per day in such a case), since GLEB requires a maximum lead time of one hour.

According to Art. 24(4) in GLEB, BSPs should notify the local connecting TSO of unavailability of the bid after BEGCT without undue delay. This could happen for example if a forced outage would occur between BEGCT and the moment of delivery. TSOs might need to know which bids, how long and for what reason they have become unavailable. TSOs will need to use this information as soon as possible for updating the local MOL and common MOL in the AOF. TSOs themselves have the option to indicate some bids as unavailable between the BEGCT and the TSO bid submission gate closure time(TSOGCT) in order to avoid anticipated congestions.

4.2.4.3. Illustration of current BCGCT, BEGCT and validity periods

An overview of the current situation regarding gate closure times in different countries can be found in Table 1.

Country	Austria	Germany	Belgium	France	Netherlands
BCGCT	W-1 Wednesday 11am	W-1 Wednesday 11am	W-2 Thursday 9am	D-1 17:00	Quarter of year ahead
BEGCT	W-1 Wednesday 11am	W-1 Wednesday 11am	D-1 3pm	H-1	H-1
Validity Period (VP)	12h peak / 12 or 24h offpeak	12h peak / 12 or 24h offpeak	15 minutes	1 hour	15 minutes

Table 1: Current BCGCT, BEGCT and validity period in several countries

Two observations are:

- Germany and Austria have harmonized their local BEGCTs for their cross border aFRR cooperation pilot project. Both BCGCT and BEGCT will evolve to day-ahead during July 2018. The allowed bid validity periods will also change from peak/off-peak products to 6 times 4-hourly products.
- Other TSOs are also moving to more close to real-time BEGCTs (e.g. the Netherlands).

4.2.4.4. Harmonization of aFRR BEGCT

This subchapter will explain the market, technical and legal considerations that TSOs are considering for the definition of the aFRR BEGCT. Indeed, a trade-off is to be made between giving maximum flexibility for BSP for bidding close to real-time for all balancing products and for TSOs that still have to ensure the stable and secure system operation, to perform the necessary calculations close to real-time (assessment of congestion impacts, fallbacks in case of business or IT-problems...). Finally, legal requirements from GLEB have to be respected at all times.

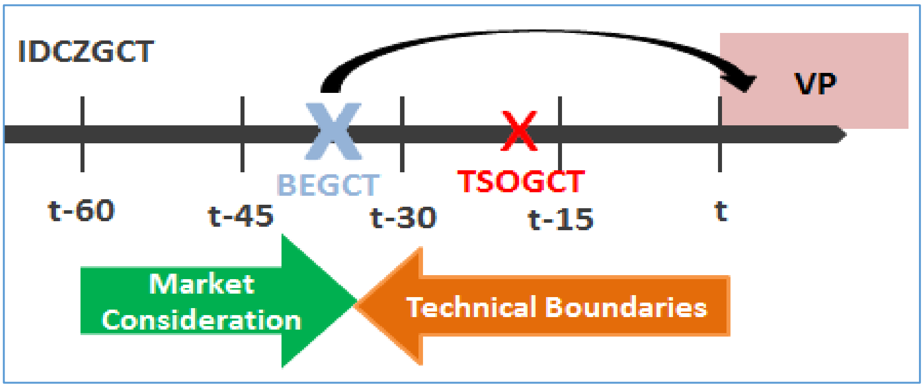


Figure 14: Relation between market and technical considerations on BEGCT

In general, there are three considerations and GLEB requirements regarding the BEGCT from a market perspective. From a market perspective, the BEGCT should:

(a) Be as close as possible to real time;
(b) Not be before the intraday cross-zonal gate closure time;
(c) Ensure sufficient time for the necessary balancing processes.

The first requirement intends to maximize the liquidity for the balancing product at the lowest cost since this way a lowest risk premium can be included by BSPs, due to better portfolio and market price oversight near real-time.

The second requirement implies an intraday cross-zonal gate closure time (IDCZGCT) not longer than one hour before real-time, as specified in Capacity Allocation and Congestion Management Guideline (CACM). Please note that the local ID GCT could still be before or after the BEGCT.

The third requirement ensures TSOs are still able to make the necessary calculations in order to continue to guarantee a secure and stable grid operation, by performing the necessary local business and IT checks and give TSOs the possibility to set bids as unavailable in case this is needed to ensure stable system operation.

A strong link with the other balancing processes is to be considered as all processes for aFRR, mFRR and RR have to run between one hour before and the real-time.

PICASSO TSOs current considerations on interrelation between the balancing processes:

- There might be a possibility to release the non-selected RR balancing energy bids for reoffering by BSPs as aFRR or mFRR balancing products since TERRE estimates its results to be known around 35 min before real-time (cfr. TERRE documentation), whereas MARI estimates its mFRR BEGCT somewhere the sooner 30 min before real-time (cfr. MARI consultation).
- PICASSO TSOs are aware that BSPs may have some lead-time constraints to offer again unused capacity from previous market processes.
- An overlap between aFRR process and mFRR process might be difficult to avoid considering the limited timeframe available for balancing purposes.

Next to the market considerations, there are also four technical considerations regarding the BEGCT. These considerations are:

(a) Technical feasibility
(b) Fallbacks
(c) Congestion management

The first technical consideration relates to both local and common cross-border TSO business and IT processes for the checking the consistency of the received bids – related to the contractual obligations such as allowed offered BSP volumes (linked to prequalification), offered prices (), maximum IT price caps and manifest errors in BSP bidding. Based on these consistency checks, TSOs might reject or adapt bids.

The second technical consideration relates to the required local IT fallback processes for example in case not sufficient volumes has been offered to the local TSO.

The third technical consideration relates to the local congestion management that TSOs want to apply between the BEGCT and the TSO bid submission gate closure time. TSOs might anticipate certain congestion risks – thereby setting the status of certain bids to unavailable, (e.g. some upward bids might be declared unavailable in a certain area to limit congestion risks).

Based on all these technical considerations, a lower limit on the closest BEGCT possible towards real-time will be present which will affect the market considerations that are being considered.

4.2.5. Questions to stakeholders

About contracted vs non-contracted bids
1. Do you intend to <u>offer non-contracted bids?</u> Could you choose one of following options and explain reasoning: ▪ No, only contracted bids – (free textbox) ▪ Yes, only non-contracted bids – (free textbox) ▪ Both – (free textbox) ▪ no opinion
About aFRR BEGCT and link with other balancing processes
2. What would be your preferred aFRR BEGCT (<= 1hour before realtime)? Please explain your reasoning: ▪ 60 min ▪ 45 min ▪ 30 min ▪ 15 min ▪ <15 min ▪ other, please specify ▪ no opinion 3. Considering interrelation with other balancing products, what would be your preferred sequence of BEGCTs for the different balancing energy products (aFRR, mFRR, RR): ▪ 1. RR, 2. mFRR, 3. aFRR – and why (free textbox) ▪ 1. RR, 2. mFRR and aFRR and why (free textbox) ▪ 1. RR, 2. aFRR, 3. mFRR and why (free textbox) ▪ other, please specify (free textbox) ▪ no opinion 4. How long would you need after the moment when the results of one balancing process are known to acknowledge these results and possibly re-offer the flexibility related to your non-selected bids of the preceding process in the next process? ▪ t < 5 min ▪ 5 min ≤ t < 10 min ▪ 10 min ≤ t < 15 min ▪ t ≥ 15 min ▪ other ▪ no opinion

5. Can you based on the relevance of the market and technical considerations for BEGCT determination prioritize (higher number gives higher priority)? In case some are missing, please add and prioritize.
   - Be as close as possible to real time; (free textbox)
   - Not be before the intraday cross-zonal gate closure time; (free textbox)
   - Ensure sufficient time for the necessary balancing processes; (free textbox)
   - Technical feasibility; (free textbox)
   - Fallbacks; (free textbox)
   - Congestion management; (free textbox)
   - no opinion

6. In case BEGCT of aFRR and mFRR coincides, which market would you rather choose?
   - mFRR
   - aFRR
   - no opinion

7. Do BSPs agree the BEGOT should not necessarily be harmonised?
   - yes
   - no, please explain
   - no opinion

8. Do BSPs intend to offer for multiple bid validity periods at the same time – if the BEGOT allows for this?
   - If yes, please explain why it would be needed and for how many hours? (free textbox)
   - no
   - no opinion

4.3. Pricing and Settlement

This chapter covers the pricing and settlement related aspects of activated aFRR balancing energy bids, which are selected in the PICASSO project. It relates to the pricing of activated balancing energy between the individual TSOs and their balancing energy service providers (TSO-BSP pricing) as well as to the settlement between the TSOs for cross-border activated balancing energy (TSO-TSO settlement). Aside from the pricing component, the determination of volumes relevant for settlement is a key component, and therefore a dedicated subchapter (see Chapter 4.5) will deal with the issue. PICASSO TSOs also started investigating potential effects of cross-border marginal price (XB MP) on imbalance pricing and have listed possible issues that need more attention.

Different pricing and settlement options were exhaustively discussed within the EXPLORE report[4].

[4] For further information and a full list of possible settlement options, the interested reader is referred to EXPLORE report (here)

4.3.1. TSO-BSP pricing

Balancing energy pricing deals with the price that BSPs receive for activated balancing energy (TSO-BSP settlement – balancing energy price). Based on previous investigations and under the legal requirements arising from GLEB[5], several marginal pricing options were investigated in PICASSO as shown in Figure 15.

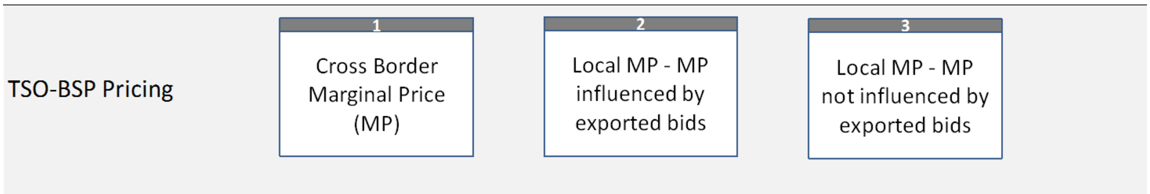


Figure 15: Investigated TSO-BSP Pricing options

4.3.1.1. Cross border marginal pricing (XB MP)

Due to its superior characteristics from a market theory point of view, PICASSO TSOs decided to select XB MP as the preferred solution for the target model. Under marginal pricing in general and under the assumption of perfect competition, BSPs optimal strategy is to bid their marginal costs which ensures the efficiency of the auctions. 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 reduce the operating costs of small BSPs.

These advantages of marginal pricing become even more pronounced under XB MP, as it increases the number of competing BSPs and mitigates the possibility of strategic bidding behaviour by single market actors. Additionally, within an uncongested area, it provides the most accurate reflection of the value of balancing energy from aFRR.

An additional argument affecting the choice of XB MP for the target model is the consistency with other timeframes in energy trading. Already today, day-ahead market coupling uses the same approach in determining the prices. In the respective platform projects for replacement reserves (RR) and mFRR XB MP has been chosen as well.

4.3.1.2. General functioning of XB MP

Under XB MP all BSPs in a non-congested area[6] receive the same marginal price. The marginal price is the price of the most expensive bid activated in the non-congested area. With congestions, the marginal price is the highest activated bid per uncongested area. Figure 16 illustrates the mechanism for finding the XB MP in the uncongested and congested situation for an example of two cooperating TSOs.

[5] Specifically GLEB Art. 30 and 50.

[6] Subset of one or more areas that have no congestions between them..

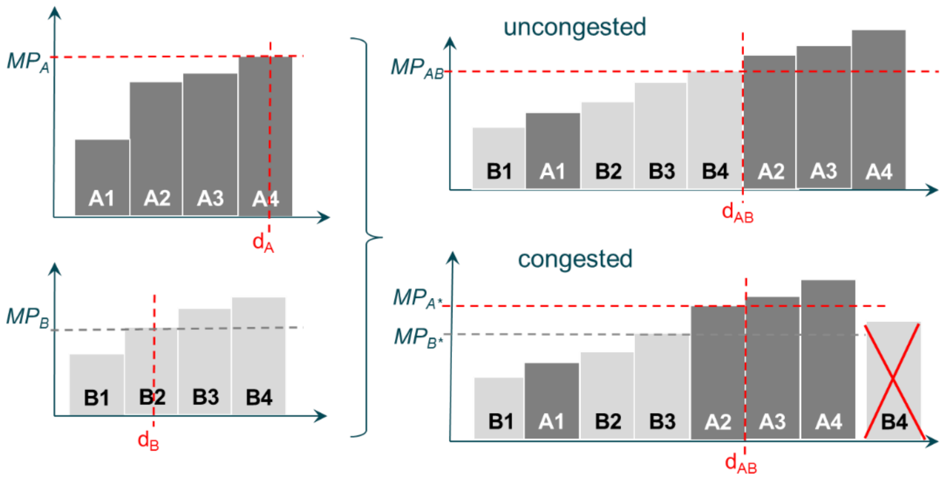


Figure 16: XB MP in uncongested and congested situation

In the uncongested example, all activated bids in A and B receive MP_{AB}. In the congested example all bids of A receive MP_{A*} and all bids of B receive MP_{B*}. Bid B4 is unavailable for export because of limited cross-zonal capacity.

4.3.1.3. Effect of XB MP on imbalance pricing

According to GLEB Art. 55 (5) and (6) the imbalance price of each imbalance area is directly connected to the price for balancing energy within the same area. However, for a given imbalance in an imbalance area, the price for balancing energy will range between values not necessarily defined by the imbalance situation within the same area due to e.g. imbalance netting and needs for other TSOs affecting the XB MP[7]. This effect might become obvious in areas with typically small deviations (e.g. due to their stable energy mix) and resulting small demands. These areas could be exposed to higher aFRR balancing energy prices than in local solutions. Respectively BRPs could be exposed to higher imbalance prices caused by a higher overall demand for aFRR within uncongested areas, though competition on the CMOL may keep prices low. The higher imbalance price may not be representative for the local imbalance situation and could therefore lead to inadequate local economic signals towards BRPs in the imbalance area. Moreover, the regional price signal through the XB MP could have a redistributive effect from BRPs towards BSPs especially within structurally exporting countries.

However, as the demand for aFRR can change rapidly within the imbalance period and the exchange of aFRR is limited by ATCs and/or operational limits the occurrence of congested situations will likely mitigate the described effects. BRPs trying to gain from higher balancing energy prices by activating own flexibility are also affecting the local imbalance situation increasing the uncertainty about the imbalance situation and correspondingly the imbalance price. For instance, a BRP trying to help a short area by taking deliberately a long position might become exposed to an imbalance price reflecting a long area if his area was already close to be balanced. Instead of helping his TSO to recover the balance and be rewarded for his contribution, he will be penalised as he is worsening the balance of the area.

[7] At current balancing energy prices reflect only local activation of balancing energy. This is influenced by local imbalances and exchanges between TSOs, such as through imbalance netting. Under XB MP balancing energy reflect activation of balancing energy in the entire uncongested area.

Within PICASSO, TSOs agreed to analyse potential consequences of XB MP on imbalance pricing and thus local imbalance in the design of the aFRR target platform. Issues identified therein will be addressed and should be mitigated as much as possible.

4.3.2. TSO-TSO settlement and congestion rent

The role of the TSO-TSO settlement is to allocate the balancing cost to the TSOs with the activation causing demand that result in a financial flow between the TSOs. However, TSOs will not win or lose money from the TSO-TSO-settlement – they act as router for cost-allocation.

Members of the PICASSO project investigated different options for the TSO-TSO settlement, as shown in Figure 17.

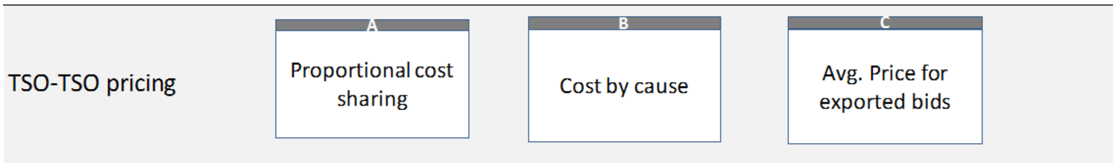


Figure 17: Investigated TSO-TSO settlement options

4.3.2.1. Proportional cost sharing

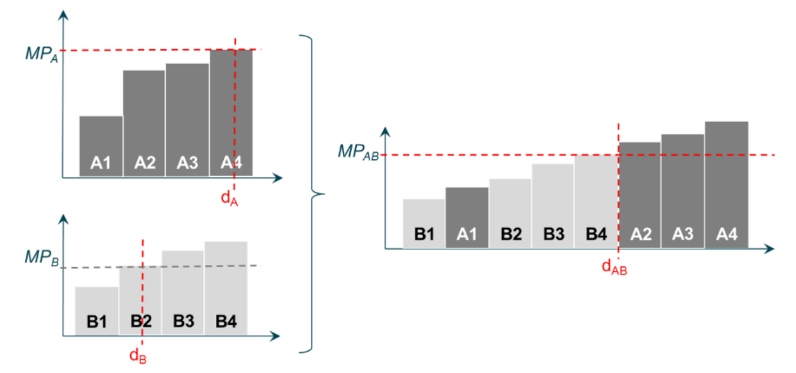
PICASSO TSOs decide to strive for proportional cost sharing for the TSO-TSO settlement. The general idea is that the costs of the common activation are shared proportional to the individual demand of each LFC area and/or block. Therefore, the actual costs for each TSO are calculated based on local activation for the platform. In an additional step, the target costs for each TSO are calculated based on the respective local demand. The difference between costs for activation (actual costs) and the costs caused by each TSO due to its respective demand (target costs) is compensated between the partners.

In combination with XB MP for the TSO-BSP pricing the settlement, method ensures that no countries lose in terms of social welfare from being within the cooperation. Therefore, situations in which countries can be better off in a local solution are ruled out.

Moreover, proportional cost sharing allows for an explicit creation of congestion rents in congested situation (see next subchapter) whereas the other investigated options allocate the congestion rent implicitly towards TSOs. This congestion rents will be shared additionally between the TSOs, however the distribution of the congestion rent requires further discussions as explained in subchapter 4.3.2.3.

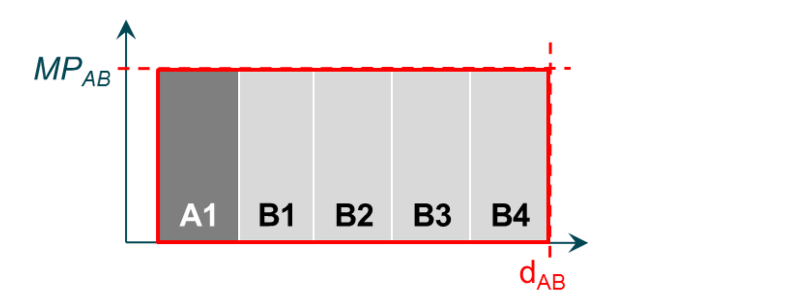
4.3.2.2. General functioning of proportional cost sharing

For the sake of clarity, the following example, based on XB MP, illustrates the basic concept of proportional cost sharing.



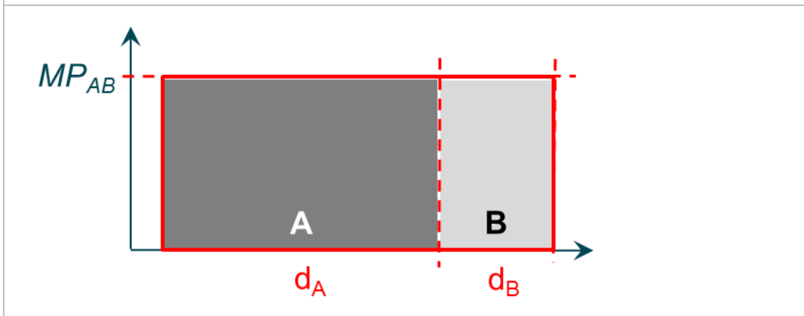
TSO-BSP pricing (XB MP)

In case no congestion applies, every BSP within the cooperation receives the same marginal price (MP_{AB}) for the delivery of balancing energy.



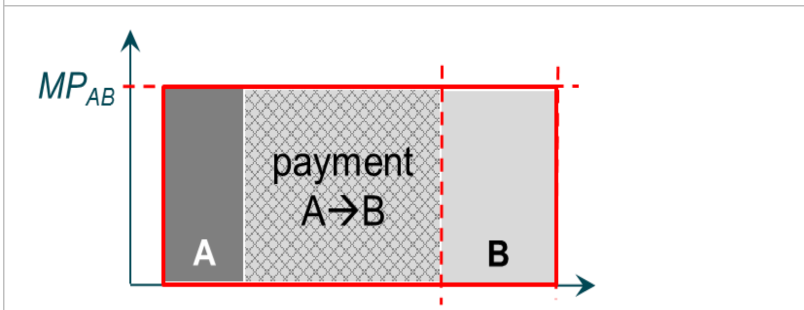
Calculation of actual costs

Every TSO pays the local activated bids with the settlement price (MP_{AB}). The actual costs for the cooperation are given by the red rectangle.



Calculation of target costs

Based on the local demand (d_A, d_B) and the settlement price (MP_{AB}) the target costs for each TSO are calculated.

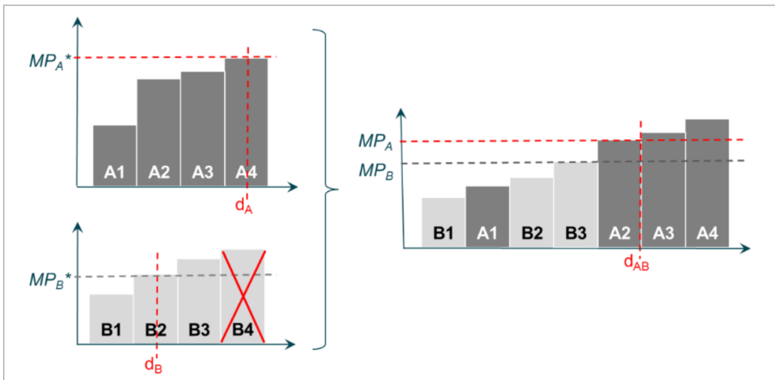


TSO-TSO settlement

The difference between the actual costs and the target costs of each TSO is settled between the cooperating partners.

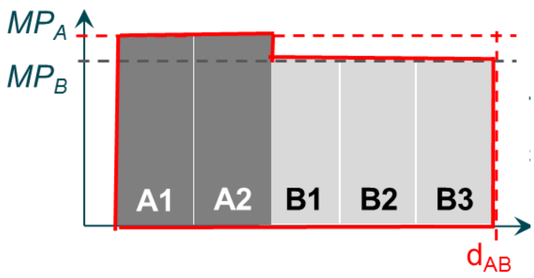
Table 2: Illustration of the concept of proportional cost sharing

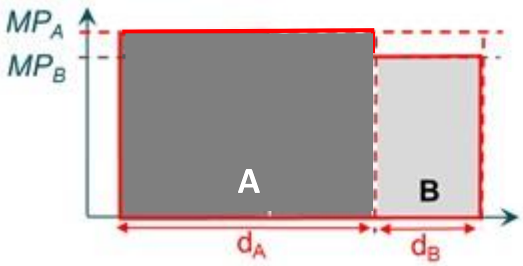
In case of congestion, the general principle of the settlement stays the same. An additional congestion rent is calculated. The following example illustrates it.

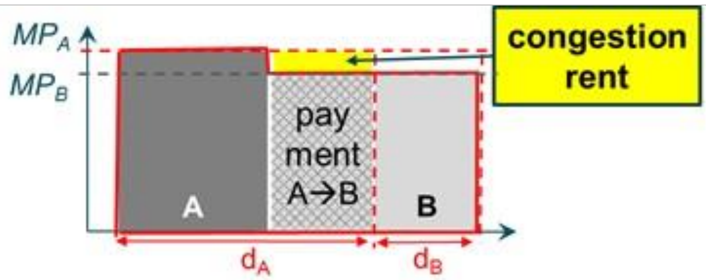


TSO-BSP pricing (XB MP)

In case of congestion, marginal prices differ between uncongested areas. In this example bid B4 is unavailable for export due to limited cross-zonal capacity (CZC). Therefore BSPs in LFC block A receive marginal price

<table>
<tr><td></td><td>(MP_A), whereas BSPs in LFC block B receive marginal price (MP_B) for the delivery of balancing energy.</td></tr>
<tr><td>
</td><td>Calculation of actual costs

Every TSO pays the local activated bids with the respective settlement price (MP_A for LFC block A and MP_B for LFC block B). The actual costs for the cooperation are given by the red area.</td></tr>
<tr><td>
</td><td>Calculation of target costs

Based on the local demand (d_A, d_B) and the settlement prices (MP_A, MP_B) the target cost for each TSO is calculated.</td></tr>
<tr><td>
</td><td>TSO-TSO settlement

The difference between the actual costs and the target costs of each TSO is settled between the cooperating partners.

Due to price spreads between LFC block A and B a congestion rent is explicitly calculated.</td></tr>
</table>

Table 3: Illustration of the concept of congestion rent

4.3.2.3. Congestion rent distribution

The cross-border exchange of balancing energy is restricted by ATC or other operational limits. In case ATCs or other operational limits are not sufficient to exchange the optimal amount of aFRR, prices across areas will be different (see example from previous chapter). In this regard GLEB Art. 30(3) states:

> *"3. The proposal pursuant to paragraph 1 shall also define a methodology for pricing of cross-zonal capacity used for exchange of balancing energy or for operating the imbalance netting process. Such methodology shall be consistent with the requirements established under Commission Regulation (EU) 2015/1222, and:*
>
> *(a) reflect market congestion; (…)"*

As stated in chapter 5.4 the choice of TSO-TSO settlement in the PICASSO project allows for the explicit calculation of congestion rents in case of occurring price spreads. The price for cross-zonal capacity is therefore explicitly defined by the chosen methodology.

Before discussing the distribution of congestion rent the topic of use/destination of the congestion rent has to be solved. The use of congestion rents is a regulatory issue, which falls under the scope of the Member States and NRAs. The TSOs will cooperate with the NRAs in any related aspect that would be required regarding this issue.

One possibility would be to consider the congestion rent resulting from aFRR activations as a congestion income, assumed as the result from an implicit allocation of available capacity in the context of balancing services. This interpretation would be similar to the one used in other timeframes such as day ahead market (Multi Regional Coupling) and the current approach of the project TERRE (RR). Under this assumption the use of congestion rents would fall under the application of the existing regulation about this topic (Regulation 714/2009 article 16-6), and the possible future treatment under the proposal of Clean Energy for All Europeans.

However, the applicability of the Art. 16-6 for the exchange of balancing energy is unclear as well as effects on social welfare. Therefore, additional possibilities for the usage of generated congestion rents are possible. One alternative would be to interpret congestion rents as increases (for the higher price countries) in balancing energy costs that need to be distributed to guarantee the financial neutrality of TSOs.

For the moment, no concrete decision on the possible distribution option has been taken in PICASSO. However, the issue will be discussed at a later stage in the project.

4.3.3. Questions to stakeholders

Questions on pricing and settlement
1. Do stakeholders support the design choice for cross-border marginal pricing in combination with proportional cost sharing? ▪ Yes ▪ No, please justify (free textbox) ▪ no opinion 2. Considering the effects of XB MP on imbalance pricing outlined in subchapter 4.3.1.3, can you order the effects, starting with the most relevant for you? Apart from the outlined effects, do you see additional ones that should be taken into account? (free textbox) 3. Do stakeholders see potential issues for incentives on BRPs functioning under cross-border marginal pricing? • Yes, If yes, which issues (free textbox) • No, please justify (free textbox) • no opinion

4.4. Balancing Energy Pricing Period (BEPP)

4.4.1. Introduction

TSOs are responsible for maintaining the frequency and ACE within given parameters. Market participants carry responsibility for their energy imbalances. The ACE and therefore the aFRR demand of TSOs can change significantly within seconds. Unlike mFRR or RR, aFRR is activated continuously and follows these power fluctuations in control cycles. That is why a period has to be explicitly defined for the pricing of balancing energy from aFRR: the BEPP. The price of the most expensive bid activated during this period in a given uncongested area will set the marginal price for the whole BEPP.

The discussion on the BEPP is a fundamental discussion due to the link between the TSO-BSP and TSO-BRP settlement prices, the relationship with incentives on BSPs and BRPs and the large effect on the TSO-BSP, TSO-BRP and TSO-TSO settlement as well as congestion rent.

Some analyses have been performed to support the evaluation. They can be found in Appendices I-III, along with some simplified examples of the effects of different BEPPs.

4.4.2. General illustration of the options

Picasso is investigating two options for the BEPP, the control cycle[8] and 15 minutes. Options longer than 15 minutes were discarded, because GLEB foresees 15 minutes for the length of ISP as target. Both options have advantages and chances as well as disadvantages and risks. Stakeholder feedback is requested to support TSOs in the process of coming to a final design proposal and help NRAs to take a decision.

The two options being investigated for the BEPP are:

(a) Pricing on control cycle basis (control cycle BEPP)
Each control cycle can be interpreted as one auction covering the aFRR demand and should have one (marginal) clearing price.

(b) Pricing on quarter hour basis (quarter hour BEPP)
All control cycles within a certain 15-minute period are settled with one marginal price. Therefore, the balancing energy pricing period for BSPs is equal to the imbalance settlement period (ISP) for BRPs. The ISP is in this chapter assumed as the target value of 15 min. Currently some countries still have longer ISPs.

For purposes of illustration, the options are combined with TSO-BRP settlement options as shown below, unless indicated otherwise. Other variants for TSO-BRP settlement are also possible.

[8] Not harmonised between TSOs and generally ranging between 2 to 5 seconds. Could be also the optimization cycle of the AOF, which is the same for all TSOs.

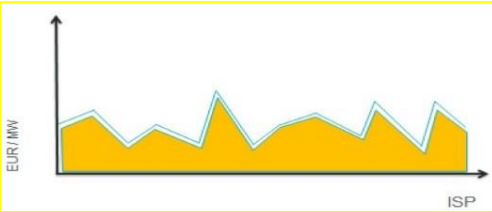
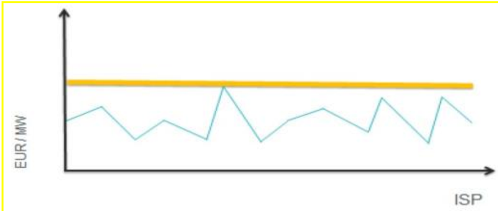
Control cycle BEPP	Quarter hour BEPP
▪ The BSP settlement is settled on a control-cycle basis (e.g. 4 seconds) ▪ All BSPs activated at a control cycle receive the same (marginal) price of the highest activated bid ▪ The BRP settlement is done on the volume weighted average of the TSO-BSP marginal prices	▪ The BSP settlement is done on each 15 minutes ▪ All BSPs activated during this period receive the same (marginal) price ▪ The BRP settlement is done with the BSP settlement price of the respecting quarter hour (e.g. for ISPs longer than 15 minutes an average of the quarter hours of the ISP)
	

Table 4: Comparison of the two options for BEPP

4.4.3. Evaluation of options

The discussion on the BEPP is complex, as there are many factors that influence the occurrence of the price peaks on the one hand, and many consequences of the choice on the other. There are also some concerns on whether or not a pricing period shorter than the ISP is allowed by GLEB, specifically by Articles 30, 44 and 45. NRAs have been requested to clarify this point.

Some discussion points addressed in this subchapter are the reasons for activation peaks and price peaks, reflection of scarcity of the different options, the incentives on BRPs and BSPs, and the effects on congestions.

4.4.3.1. Spikes in aFRR demand and resulting prices

Spikes in the aFRR demand lead to the activation of the most expensive aFRR bids for only a small duration. In case of a quarter hour BEPP, the whole quarter hour will be settled with the highest activated bid price regardless of the duration of activation.

Spikes in the aFRR demand occur daily for all TSOs because of power fluctuations within the ISP, which have different causes such as fluctuating demand, differences between physical cross-border flows and virtual tie-lines, and ramping of units. Such power fluctuations are the responsibility of the TSO and need to be managed in the future as well.

aFRR demand spikes in combination with (relatively) high prices at the end of the merit order lead to price spikes for the activation. The graphs in Figure 18 show the aFRR demand of Germany on a typical summer day (thin orange line) on the left and a typical CMOL for the Austrian-German aFRR cooperation on the right side.

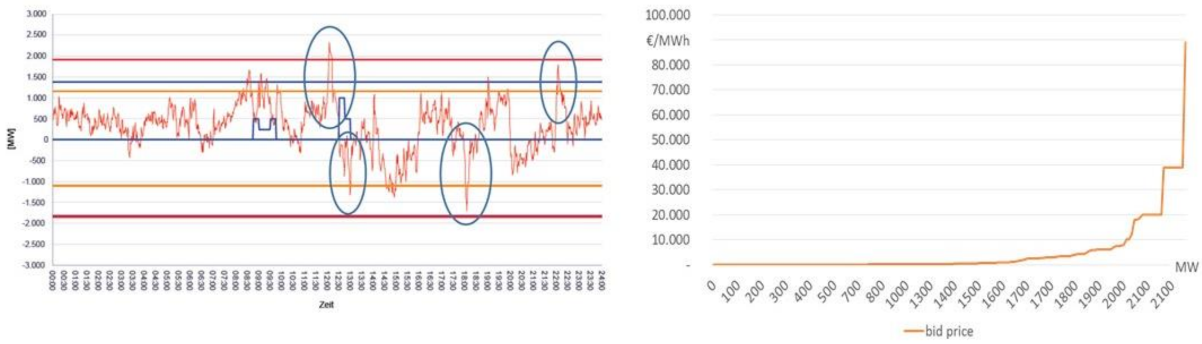


Figure 18: aFRR demand in Germany on a typical summer day

Considering the situation from the example in combination with the presented CMOL and assuming that current prices (based on pay-as-bid) would still appear after the implementation of the European platform:

- Control cycle BEPP: the aFRR demand spike will increase the imbalance price, but only volume weighted. The longer the activation of the higher priced bids, the higher the imbalance price. The effect on the imbalance price depends on the volume delivered by the higher priced bids. If the aFRR demand is constant during the whole quarter hour, this option leads to the same result as the option "quarter hour BEPP".
- Quarter hour BEPP: aFRR energy prices and therefore imbalance prices of several thousand €/MWh occur several times. Having an imbalance of 20 MWh at a price of 90,000 €/MWh causes imbalance costs of 450,000 € for the BRP for that single ISP. With XB MP this could set an extremely high imbalance price in the whole uncongested area.

The choice between these options leads to the question whether peak prices in imbalance settlement are justified to set the correct incentives towards BRPs, if they are caused by activations of relatively short duration. This is explained in the next subchapter.

For BSPs the choice between the options is important as well. The longer the period chosen for the definition of the marginal price is, the higher the incomes for the BSPs are. A discussion between TSOs is ongoing whether option B leads to unjustified inframarginal rent for BSPs that BRPs have to pay for[9].

[9] TSOs have no financial interest for the one or the other option. TSOs are glad if BSPs benefits are incentivizing to participate in the market and offer balancing services. But TSOs are also aware that the resulting costs need to be reasonable towards BRPs (and possibly grid users) who have to pay for these services.

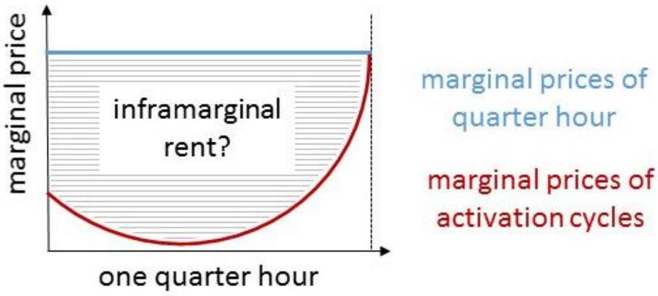


Figure 19: Illustration of inframarginal rent

There are concerns that BSP would increase bid prices if they would be settled each activation cycle in regard to being settled for quarter hours. Mark-ups are a sign for market power or collusive behaviour, which should be avoided with increased competition. If marginal pricing applies, there should be no bidding strategy with a higher expected profit than bidding at marginal costs[10].

Further there are discussions how relevant the current bid prices of the Austrian-German cooperation are, if several changes in market design occur in the upcoming years. It is uncertain what will happen, whether there will be sufficient free bids and where they will come from[11]. Will the competition across congested borders create sufficient competition? The very high prices are assumed to be caused by fixed costs for start-ups or less production outcome of demand side BSPs.

TSOs could allow for more flexibility on the MOL than they need and hereby prevent activation of the most expensive bids, but then they would have to justify why they take more flexibility from the market than needed for technical reasons and show that the welfare is higher if the TSO has access to this flexibility instead of it being used by market participants on wholesale markets or for the portfolio optimization. Picasso TSOs do not intend to propose price caps, but maybe this needs to be discussed.

Major differences between the options occur in the combination of activation spikes and steep merit order lists. Because activation spikes occur at most a few times a day, most of the time both options lead to very similar results.

Some analysis on the effects on prices and BSP income can be found in Appendix II.

4.4.3.2. Reflection of scarcity

One of the main questions related to the discussion around the BEPP is whether or not a BEPP equal to the ISP correctly reflects the scarcity in the system, given that the TSO-BSP settlement is then based on the highest price of a bid that may not be activated for very long.

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[10] TSOs are aware that, especially for aFRR, restrictions like start-up cost or limited energy availability exist that impacts the set up of bid prices.

[11] To provide positive balancing energy, a power plant need to run below the optimal set point. If it is more beneficial to sell the full amount of energy to the wholesale markets and there is no capacity remuneration to cover this loss of opportunity costs, there might be a very limited potential for more balancing energy bids than procured by the TSO as balancing capacity.

As can be gleaned from an analysis performed in Appendix II, the question on whether or not scarcity is correctly reflected mainly boils down to the question whether or not the height of the prices correctly reflects the scarcity, as the main impact of changing the BEPP is to change the average TSO-BSP price, lowering it in case of a shorter BEPP. There are two opposing points of view on this matter:

- The first view is that scarcity is properly reflected by taking the peak price of any activation within an ISP as sampling is done on 15-minute basis and the energy from the expensive bid is needed within those 15 minutes. This supports a quarter hour BEPP.
- The second view is that power peaks within an ISP do not reflect energy scarcity for the whole ISP and should therefore not set the scarcity price for energy. This supports a control cycle BEPP.

4.4.3.3. Incentives

Article 44 GLEB requires that the settlement process shall provide:

- Incentives to BRPs to be in balance or help the system restore its balance
- Incentives to BSPs to offer and deliver balancing services to the connecting TSO

The presence of these incentives helps with the consistency and the efficient functioning of balancing markets and helps prevent arbitrage between imbalance and balancing energy, thereby protecting system security. A lack of incentive to deliver balancing energy could lead to a reduced ACE quality, the necessity for penalisation, and higher prices due to activation of more balancing energy bids. A lack of incentive to place bids could reduce the available volume of non-contracted bids, reduce competition on balancing energy markets, and raise balancing energy prices. It could also lead to reduced liquidity of balancing capacity markets and higher prices for balancing capacity.

It can be argued that in order to provide the correct incentives to BSPs, the imbalance price and TSO-BSP price should be equal, as:

- TSO-BRP price < TSO-BSP price: lack of incentive for BSPs to deliver as it is more profitable to be activated and suffer the imbalance if requested volume is settled
- TSO-BSP price < TSO-BRP price: lack of incentive for BSPs to offer balancing services as it is more profitable to support the system in imbalance where applicable

As it is impossible to in all cases have equal prices for imbalance and balancing energy when applying the control cycle BEPP, since there is not one single price for balancing energy per quarter hour, a control cycle BEPP could be seen as incompatible with the requirement from GLEB to provide the correct incentives through the settlement process. The compliancy of the control cycle BEPP is currently investigated by the NRAs. However, a counterargument considers that an imbalance price based on the weighted average price of activated balancing energy, coupled with an appropriate aFRR monitoring/penalty process also provides correct incentives. Whether or not a penalty process should be considered as part of the settlement process in regard to the requirement from Article 44 is a point of discussion.

Although harmonisation of TSO-BRP settlement is out of scope of PICASSO, the definition of the imbalance price is thus important to see whether or not the settlement process provides the correct incentives also on BSPs. In order to ensure that BRPs are able to support the system in imbalance on a level playing field, imbalance price information should be made available during the ISP to which it applies. This is difficult when using an average price for imbalance as it is not possible to show a minimum price to which BRPs can respond, leading to higher uncertainties for BRPs, which add to the uncertainties caused by application of cross-border marginal pricing. For this reason some parties might prefer an imbalance price equal to the highest priced bid that was activated in the entire ISP, even if the TSO-BSP pricing would be based on a control cycle BEPP.

Further some TSOs fear overreaction by BRPs in case of deterministic ACE deviations in case a quarter hour BEPP is applied, and therefore suggest that a quarter hour BEPP does not provide the correct incentives on BRPs. However, such behaviour carries significant risk for market participants, which could be increased by the introduction of dual pricing in case of two-sided regulation.

4.4.3.4. Considerations on cross-zonal capacity

Due to fluctuating aFRR demand, different borders could be congested at different moments within the same 15 minutes. Control cycle BEPP determines prices for TSO-BSP settlement and TSO-TSO settlement, including the congestion rent, on cycle basis. The ratio of price divergence is the same as the ratio of cycles in which a congestion occurs for activation cycle marginal pricing. In case of a quarter hour BEPP, any occurrence of a congestion somewhere within this quarter hour will lead to price divergence over the whole BEPP. Due to the differences in price convergence between a quarter hour BEPP and a control cycle BEPP, there is an impact on the congestion rent. Congestion rent for a quarter hour BEPP is larger than congestion rent for control cycle BEPP.

An analysis investigating the effect of limited cross-border capacity over the period of 2016 is provided in Appendix III. Two scenarios were investigated, in which respectively 100 % and 25 % of aFRR balancing needs (Pdemand) are covered by imports. For the two BEPP options considered, it can be shown how often a price divergence will occur.

The investigation shows the ratio of the control cycles of a year (in percentage) that will be settled at different prices and therefore cause congestion rent:

aFRR demand covered by imports	Control cycle BEPP	Quarter hour BEPP
25 %	5 %	10 %
100 %	10 %	20 %

Table 5: Relation between aFRR demand covered by import and the percentage of cycles that experience price divergence due to congestion for the two options considered

The ratios of the control cycles shown in Table 5 give a representative order of magnitude for most countries. Detailed figures for different countries can be found in the Appendix. The overall conclusion valid for most countries is that applying a quarter hour BEPP would result in approximately twice as many cycles in which price divergence occurs as applying a control cycle BEPP.

Furthermore, applying a quarter hour BEPP will lead to higher TSO congestion rents in comparison to a control cycle BEPP, which might be considered unjustifiable. More importantly, there are some concerns that a higher rate of price divergence caused by congestions might decrease the benefits of cross-border competition. In some cases it could be considered whether a control cycle BEPP would improve the competition and as a result increase economic efficiency.

4.4.4. Alternative measures

Aside from shortening the BEPP, other measures could be envisioned to avoid the situation in which price peaks which do not correctly reflect scarcity overly affect the marginal price. However, these measures are not straightforward or guaranteed, and have complications of their own. All measures should of course be checked for compliancy with different regulations as well. These measures include:

- Filtering out price peaks in the settlement by not including activations of short duration and/or limited volume in the determination of the marginal price for TSO-BSP settlement – this creates incentives for mark-ups at the end of the merit order list
- As part of the transition to a quarter hour BEPP, temporarily adjusting the determination of the imbalance price downwards on occurrence of price peaks in order to give market participants time to adjust their balancing energy bid prices. This means that for this transition period BRPs are shielded from the consequences of high balancing energy bid prices. This method was successfully applied in the Netherlands upon switching to marginal pricing[12]. It may however require multiple complicated alterations to the market design to be effective.
- Investigating the causes of extreme peaks in aFRR demand and addressing these with technical or market mitigation measures, for instance reducing the market time unit on spot markets to address deterministic frequency deviations or reducing dimensioned aFRR
- Re-discussion of price caps – currently not allowed by GLEB other than for technical reasons
- Introduction of other incentives to deliver, for instance metered settlement – can create delays in settlement and other complications in IT systems and workload
- Obligation to bid free flexibility to the TSO to ensure competition through non-contracted bids – only works if flexibility is available, might interfere with local ID markets

4.4.5. First Conclusion

In summary, the BEPP is a complex topic with large impact on stakeholders. Two main options were discussed in order to provide stakeholders with a clear view on the subject. Table 6 shows the main effects of a choice between the options.

	control cycle BEPP	**quarter hour BEPP**
BSP income	Lower	Higher
BRP cost of imbalances	Lower (when applying a weighted average imbalance price)	Higher
Congestion rent	Lower	Higher
Occurrence of price convergence	Higher	Lower

Table 6: First conclusion regarding the two options for the BEPP

Some other conclusions:

[12] Thesis by F.A. Nobel provides more information on page 62-64 and can be found here.

- The BEPP is a market design and redistributive question. The same aFRR bids are activated in case of a shorter or longer BEPP.
- There will always be power fluctuations within an ISP and they can always lead to activation peaks of aFRR due to the character of the product.
- The choice of a BEPP affects the incentives on both BSPs and BRPs. How these incentives are affected is a complex discussion.
- Due to the differences in price convergence between 15 minute and cycle-based marginal pricing, there is an impact on the congestion rent. Congestion rent for quarter hour BEPP is larger than congestion rent for control cycle BEPP.

4.4.6. Questions to stakeholders

Questions regarding BEPP

1. Which pricing period for aFRR do you prefer? Please justify your answer
   - Control cycle BEPP
   - Quarter hour BEPP
   - No opinion

2. Do you believe that either the control cycle or the quarter hour BEPP would lead to entry barriers for participating in the aFRR balancing markets? Please explain your answer. (free textbox)

3. Do you consider the inframarginal rent incurred in case of a quarter hour BEPP to be justified?
   - Yes
   - No, please explain
   - No opinion

4. PICASSO TSOs presented two views with respect to reflection of scarcity of energy within the ISP in relation to activations of short duration. Which view do you support?
   - Scarcity is properly reflected by taking the peak price of any activation within an ISP
   - Power peaks within an ISP do not reflect energy scarcity for the whole ISP
   - No opinion

5. There are concerns that BSPs would add mark-ups in case of a control cycle BEPP due to reduced income in comparison to a quarter hour BEPP as well as imbalance risks. Otherwise, mark-ups are usually a question of the level of competition in the market. Do you consider BEPP as relevant for mark-ups in light of competition? Please explain your answer.
   - Yes (free textbox)
   - No (free textbox)
   - No opinion

6. If the control cycle BEPP with average imbalance pricing is chosen, the average aFRR settlement price over an ISP will differ according to the individual activation of each BSP.
   a. Do you think the aFRR price is required to be equal to the imbalance price for each ISP to incentivize BSPs to place (especially uncontracted) bids?
      - Yes
      - No
      - No opinion

b. Do you think the aFRR price is required to be equal to the imbalance price for each ISP to incentivize BSPs deliver on their bids?
   - Yes
   - No
   - No opinion

7. In countries where BRPs are allowed to support the system balance, BRPs need near real-time information on the system state and the imbalance price they can expect. To help ensure this information, do you think that each activated bid price should set the minimal imbalance price for the respective ISP? If you have further thoughts on BRP balancing and necessary incentives, please share. (free textbox)

8. The quarter hour BEPP will lead to price divergence in a larger percentage of the time than the control cycle BEPP (TSOs estimated two times more congested situations). Do you think these additional congestions are justified?
   - Yes
   - No
   - No opinion

9. Do you have any further comments on the BEPP? (free textbox)

4.5. TSO-BSP Volume determination

The second component of each settlement principle is the determination of volumes that are relevant for the TSO-BSP settlement. Independently of the chosen product, the settlement volume can be determined based on:

(a) Metered values
(b) Requested values

For option A different sub options are thinkable. Furthermore, the determination of volumes for the BSP settlement is highly interconnected with the determination of the imbalance adjustment. In general, for the determination of the imbalance adjustment, the same options are feasible but the choices for both settlements need to be consistent to ensure that all energy is settled. The choice for a settlement principle, being either metered or requested, is also relevant for the discussion on the balancing energy pricing period. The requirement from TSOs towards their BSPs to follow a specific ramp rate or not, as described in subchapter 4.1.1, provides an additional link influencing the choice for the volume determination. Figure 20 provides an overview of investigated volume determination options for TSO-BSP settlement. The implications of the BSP volume determination on imbalance settlement and its incentive towards BRPs will be taken into account by TSOs when choosing the volume determination for TSO-BRP settlement.

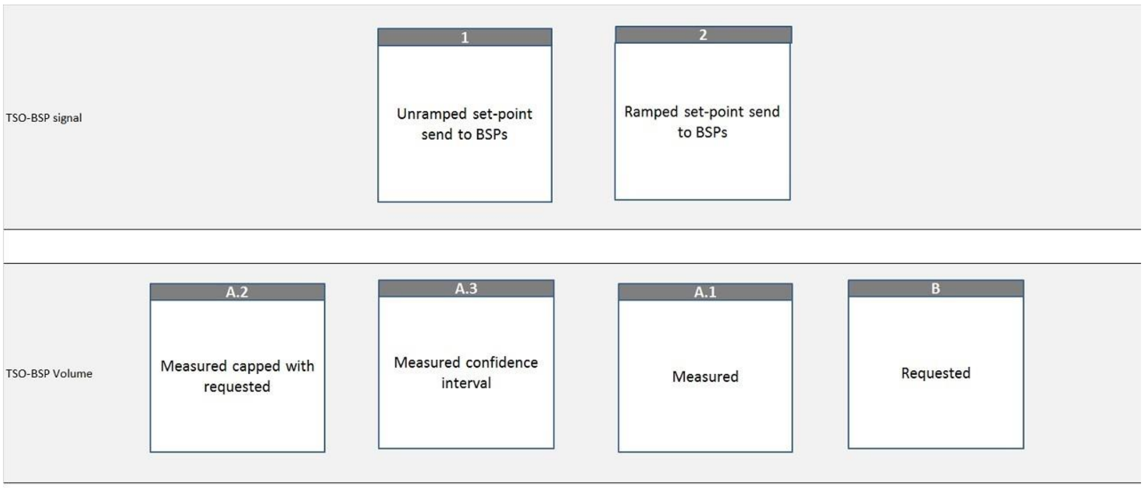

Figure 20: Investigated volume determination options for BSP and BRP settlement

Option A.1 considers simply metered values for the volume determination. Under option A.2 the volume relevant for settlement is based on the metered value but capped by the requested volume. Option A.3 is slightly more complex than the previous options where the activation of aFRR that is within a predefined tolerance band is seen as compliant. Option B in this context is the least complex and considers only the TSO's requested volumes as relevant for settlement.

As the choice of volume determination is highly interrelated with choice to send ramped or unramped set-points to the BSPs, PICASSO TSOs concluded that the determination will not be harmonized across the PICASSO countries as long as the TSO-BSP signal will not be harmonized and different determination options do not pose an imminent threat to the level-playing field for BSPs.

4.5.1. Settlement of dummy energy

TSOs using ramped TSO-BSP signals usually provide their BSPs with a downward ramp for deactivation of their bids similar to the upward ramp in case of activation. The downramping of BSPs can apply within or outside the validity period of the respective bid, however, in both cases the still delivered energy from BSPs is referred to as dummy energy. If a bid is activated in validity period *t* but later not needed anymore, due to changes in e.g. demand or BSP's bid position in the CMOL for validity period *t+1*, BSPs are required to follow a downward ramp. The volume still delivered during this downramping is called "dummy energy". Figure 21 shows an example for dummy energy when a BSP is ramped down outside of the applicable validity period *t*.

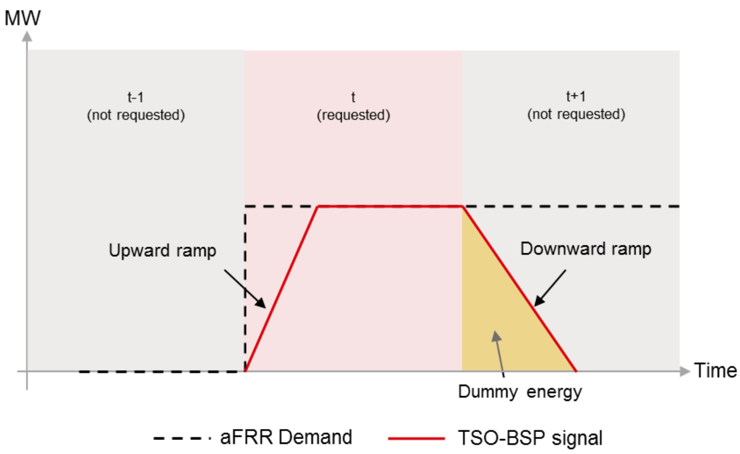

Figure 21: Determination of dummy energy

Depending on the length of the validity period and the composition of the CMOL, the dummy energy could amount to not negligible volumes that need to be remunerated properly. The dummy energy topic also needs to be investigated for TSOs using unramped TSO-BSP signals. The determination of dummy energy in this case is more challenging because unramped TSO-BSP signals do not define the slope for deactivation.

PICASSO TSOs currently investigate the topic and try to find a suitable scheme to settle the related volumes. In any case, the settlement principle for dummy energy shall avoid wrong incentives and discriminatory effects towards BSPs.

4.5.2 Questions to stakeholders

Questions regarding volume determination
1. Is it a priority for you to harmonize the volume determination?

4.6. Other harmonization topics

One important objective of PICASSO is to create a common level playing field for market participants. Hence, a certain harmonization of the national terms and conditions has to be realized, which is also a requirement of the GLEB. But today the European aFRR-markets are still significantly different due to different generation structures, levels of centralization etc. Changes in the local aFRR markets have a cost, so harmonization of terms and conditions must be done carefully in order not to decrease social welfare.

4.6.1. Potential harmonization topics

Additional to the previously listed design points in chapter 4, a list of five other potential harmonization topics is presented here:

(a) Unit-based versus portfolio-based bids:

Both options are allowed but not mandatory to be implemented by TSOs – hence, it is a local TSO choice, which PICASSO TSOs are not planning to harmonise.

(b) Monitoring:

Is there both an availability check and a delivery check? Are controls systematic or occasional? What are the criteria for such checks? In some countries there are two separate checks: one for availability, and one for delivery, while in other countries only delivery check is performed. With regard to the delivery check, in some countries these are systematic while in others they are only done occasionally. The technical criteria for both families of checks are different in each country.

(c) Penalty:

Penalties in case of non-availability; penalties in case of non-delivery; period during which there is a penalty exemption. In some countries, there are different penalty regimes for non-availability and non-delivery. The penalty regimes are different between countries; they are either based on bid price, spot price or clean spark spread. In some countries, there is a period for penalty exemption after an outage.

(d) Prequalification:

Prequalification criteria are the tests that the BSP have to pass and the success criteria to be met, in order to obtain prequalification.

(e) Energy availability requirements:

What are the energy availability requirements for units with limited reservoir such as run-of-river or batteries? Some countries have different energy availability requirements depending on the system state (normal, alert).

4.6.2. Questions to stakeholders

Questions regarding other harmonization topics
2. What issues should in your opinion get priority for harmonization? Please prioritize the above-mentioned by applying a number (higher number defines a higher priority). In case a topic should be missing, please add and prioritize. If possible please quantify their effect on the level playing field and on pricing. ▪ Unit-based versus portfolio-based bids (free textbox) ▪ Monitoring (free textbox) ▪ Penalty(free textbox) ▪ Prequalification (free textbox) ▪ Energy availability requirements (free textbox)

The TSOs will create a roadmap for further harmonization beyond the obligations necessary to set up the aFRR platform.

5. Integrating aFRR markets

This chapter, and in particular the subchapter 5.2 and subchapter 5.3, are primarily a TSO matter only affecting indirectly the market parties. They are given here for the sake of completeness and transparency. Their understanding requires some knowledge of control theory and secondary controller design.

5.1. High level scheme of PICASSO platform input/output

This chapter describes the high level scheme of the aFRR platform with the main functions the PICASSO platform shall provide, including their interaction:

- aFRR Activation Optimization Function (AOF): the function containing the activation optimization algorithm which determines the bids that are activated.
- TSO-TSO aFRR exchange function: the function which determines the TSO-TSO exchange based on clearing results. The FRCE induced on the connecting TSO follows from this exchange.
- TSO-TSO settlement: the function which calculates the TSO-TSO settlement of aFRR exchanges based on the optimization results and TSO-TSO exchanges.

A high-level scheme of the interaction of the different functions of the aFRR Platform with each other and with other processes is shown in Figure 22.

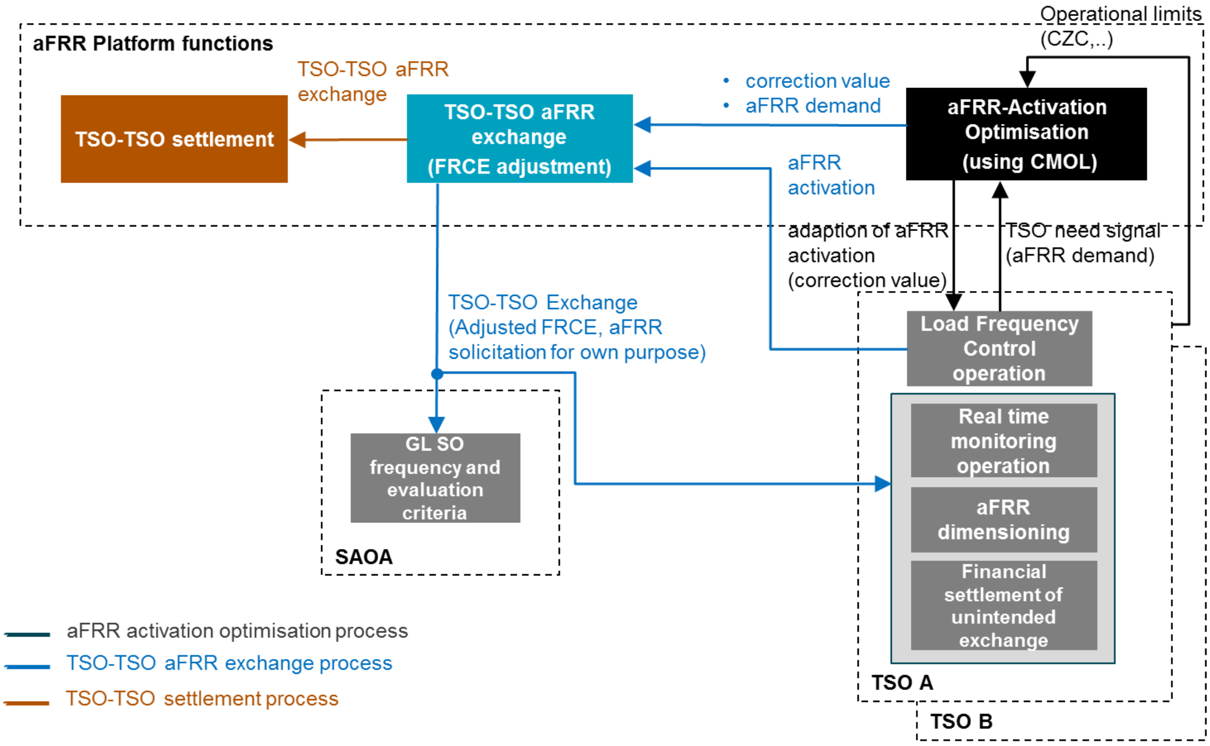

Figure 22: High level scheme of aFRR platform

5.1.1. Control demand model

PICASSO TSOs agreed to use the control demand approach for the AOF. The method of exchange of control demand is explained in detail in the EXPLORE report[13]. It is the same approach as currently used within IGCC and shown schematically in Figure 23. In principle, the concept works as follows.

Each TSO calculates for each optimization cycle the aFRR demand, based on currently activated aFRR in its local area and the local FRCE. The activated aFRR can be derived by measurement or by simulation of the activation. The aFRR demand is provided as input to the AOF, which then uses it to determine the aFRR correction value for each TSO based on the CMOL and available CZCs. The aFRR correction value is directly included within the aFRR control loop of each participating TSO (see Figure 24). By this, the individual FRCE of each TSO 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 TSO has to provide.

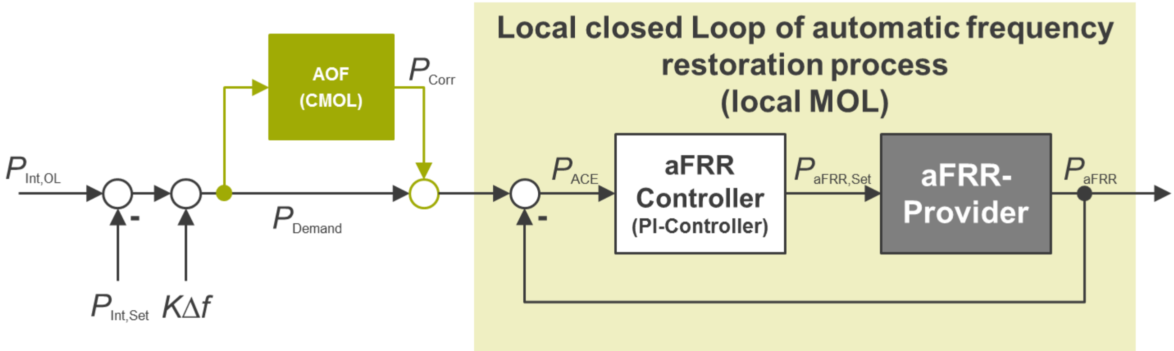

Figure 23: Scheme of the control demand process

The correction value from the AOF is sent, without taking into account possible ramping constraints related to the locally activated bids. In case of a step change in the aFRR demand of the requesting TSO, the full step change would be introduced in the FRCE of the connecting TSO. Figure 24 shows on a high-level basis the basic functioning of the AOF within the control demand model.

[13] See chapter 4.2 in EXPLORE report.

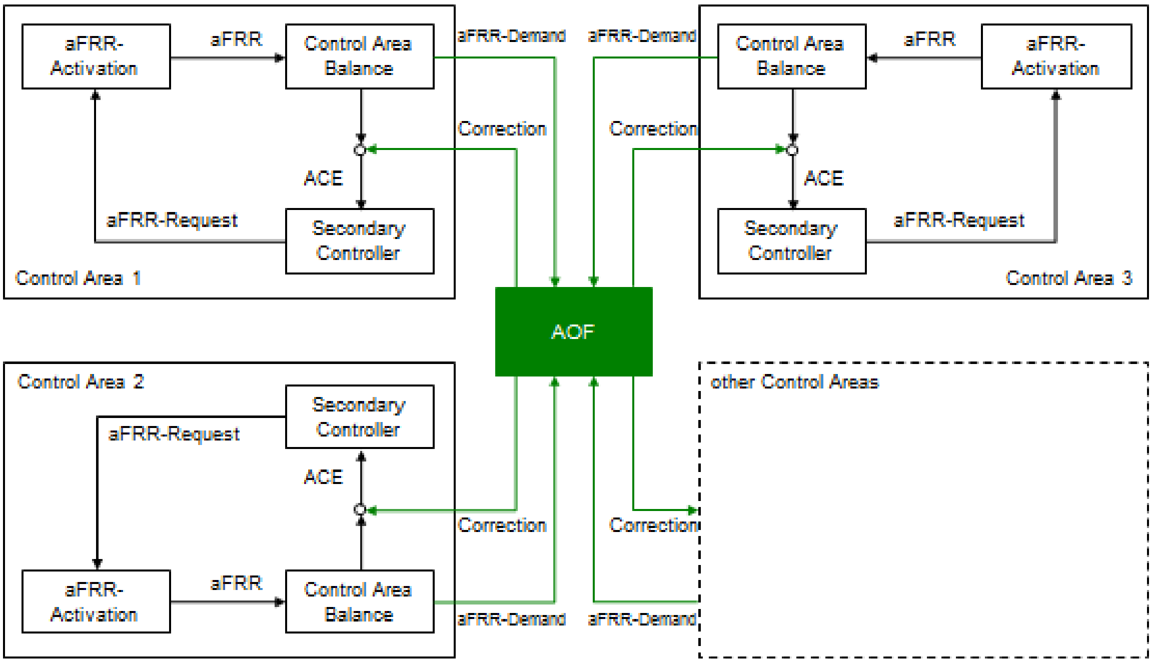

Figure 24: Activation optimization function with Control Demand

The main reasons PICASSO TSOs go for such a control demand model are:

- The control demand model is already under operation in IGCC cooperation and German-Austrian aFRR cooperation. It has proven to work in stable way for several years.
- It enables to maintain the local responsibility of TSO towards the monitoring of its own LFC area and BSP local aFRR delivery.
- It enables TSO to parametrize their controller in respect to local generation.
- Robustness is enhanced because it does not directly interfere with the local aFRR process.

Investigations have been carried out on the control request model as identified in the Explore report. The control request model considers as input to the AOF not the aFRR demand, but the output of the local controllers. The output of the AOF changes the local control request. It appeared that the dynamic stability of the controller would require a much greater effort in terms of harmonization of all interconnected controllers, without even being a guarantee of stability. This model is therefore not seen as a relevant model to start with to ensure timely implementation of the aFRR platform. Its implementation on the longer term, subject to further investigation, is however not excluded.

5.2. Activation Optimization Function (AOF)

5.2.1. AOF main principles

The optimization function shall fulfil the following high-level principles in one optimization step leading to a global optimum:

(a) Control FRCE to zero

- The amount of aFRR to be activated according to the AOF should cover the aFRR demand of each LFC Area (full access to the CMOL)

(b) Netting of aFRR demand

- The amount of activated aFRR should be minimized

(c) Minimize the cost of activation
- Activate lowest priced bids

(d) Operational Security
- Respect transmission limits

The algorithm will ensure the netting of aFRR demands within the limits of available CZC. Unlike the imbalance netting platform, the aFRR algorithm will implicitly ensure that the activation of the most expensive bids is prevented by the netting. In case the geographical region of the imbalance netting platform and the aFRR platform are the same, both platforms can be merged. Before this, a deep interaction of both platforms is seen as unavoidable.

The algorithm will aim at minimizing aFRR exchanges, everything else being equal, meaning that as little CZC as possible will be used.

The AOF will ensure merit order activation from the CMOL through an optimisation cycle with a fixed interval of less than 10 seconds, using inputs received by each participating TSO. The outcome of the AOF is a correction signal sent to each participating TSO, describing the amount of aFRR they should activate locally. The signal is based on the control demand model described in subchapter 5.1.1.

In case of aFRR cross-zonal activation, two further comments can be made in regard to the algorithm.

First, as mentioned before, the cheapest bids from the CMOL should be activated. Since aFRR is the last activated reserve in the process to keep the system balanced and restore the frequency, PICASSO TSOs are currently not intending to allow the algorithm to select bids in opposite directions. However, in case of congestions counter activations in different uncongested areas will be necessary and allowed. Activations of aFRR bids shall only be allowed to satisfy TSO aFRR demands.

Second, especially in case of aFRR as the last possible reserve to be activated by TSOs, it is possible for the local demand of a TSO to be higher than the number of bids forwarded to the common platform. TSOs are not excluding the possibility to provide full access to the CMOL for each participating TSO, meaning that in case of a higher demand, more bids can be activated than they forwarded themselves. The conditions for this are being discussed by PICASSO TSOs, however, they will include prior access to local aFRR volumes in case of local demand, even if the total demand of another TSO also requests it (taking into account CZC).

5.2.2. Input of the AOF

- aFRR energy bids: Bids are sent to the platform at each TSO bid submission GCT and could be updated close to real time depending on real time situation. A list of the features of bids can be found in chapter 4.1 on standard product.

- aFRR demand per LFC area: TSO aFRR demands are inelastic (i.e. no price limit) for aFRR since a TSO shall always activate aFRR to regulate its own FRCE to zero MW. The aFRR demands for a TSO will solely be for balancing purposes. Other purposes such as activating bids for congestion management are not in the scope of PICASSO project. The aFRR demand is updated at every TSO internal optimization cycle (between 1 to 10 seconds). The AOF uses at every optimization cycle the last update received from a TSO.

- Operational limits: The operational limits used by the AOF will depend on the congestion management (see subchapter 5.4) methodology defined in the PICASSO project. The operational limits will be sent and updated in real time every few seconds. The AOF uses at every optimization cycle the last update received from a TSO or platform.

5.2.3. Output of the AOF

For every optimization cycle, the AOF will provide:

- The aFRR correction value in MW for each TSO (correction of local FRCE value that has to be controlled to zero).
- The current price of the highest priced activated bid (marginal price) in €/MWh for each uncongested area.
- Usage of CZC in MW

5.3. TSO-TSO exchange function description including FRCE adjustment

Due to the FAT of the aFRR product, as well as for the other cross-border balancing processes there is a delay between the TSO-TSO exchange and the actual delivery by the BSPs due to its physical ramping. The main objective of the TSO-TSO exchange function is to guarantee as much as possible physical neutrality of the connecting TSO in the aFRR process.

Complementary to the AOF, the aFRR platform will develop a TSO-TSO exchange function in order to provide the different processes, including settlement processes and aFRR exchanges between countries that are more representative of the physical reality of the BSP delivery.

The main objectives this function shall fulfil are:

- Maintaining the local responsibility of the TSOs among their LFC area in regards to their own imbalances in volume and in dynamic behaviour
- Guaranteeing the financial and physical neutrality of the connecting TSO in regards to the financial settlement of unintended exchange process and the dimensioning requirements of each TSO
- Ensuring the connecting TSO is responsible in case of under delivery compared to the minimum requirements
- Favouring each TSO to incentivize their BSPs to react faster than the minimum requirements

The main constraints for the TSO-TSO exchange function to be fulfilled are:

- To respect the CZC constraints
- To respect the sum of all exchanges is always equal to zero

The TSO-TSO exchange function can be based on adjustment of induced FRCE methodology. As mentioned in subchapter 5.1.1 on the control demand model, the exchange of aFRR demand will be a step function. As effective aFRR delivery follows a certain dynamic there will be FRCE induced by the TSO-TSO exchange as illustrated by the orange areas in Figure 25 and Figure 26 respectively. The FRCE Adjustment process (FAP) will aim at determining the induced FRCE for each TSO and subtract the impact of the aFRR activation for cross-border purpose. The FAP will integrate the possibility for a BSP to provide faster reaction compared to standard aFRR Full Activation Time. In case of faster reaction, the requesting TSO will benefit from it and obtain a faster correction of its FRCE. In case of non-compliant delivery by a too slow BSP (slower than the minimal requirement), the connecting TSO will remain responsible and the requesting TSO will receive a reaction corresponding to the minimal requirement.

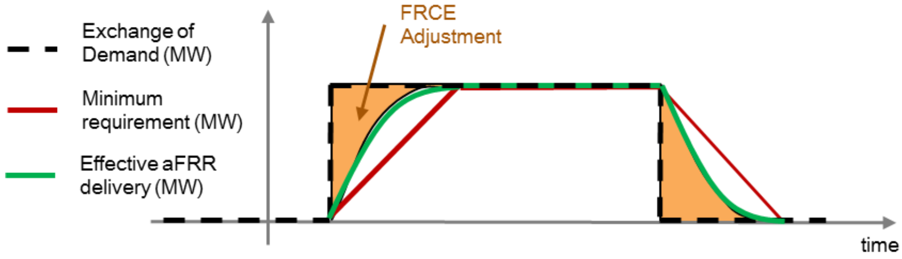

Figure 25: Example for FRCE adjustment volume and TSO-TSO exchange

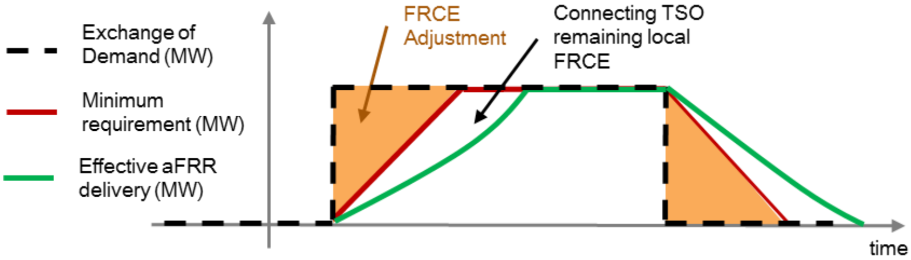

Figure 26: Example for FRCE adjustment volume and TSO-TSO exchange with non-compliant aFRR activation

The FAP will be included in a separate module that works sequentially after the AOF. Based on the aFRR correction signals for each TSO from the AOF and the level of aFRR activation provided by each TSO the module will provide FRCE values for each TSO induced by the aFRR activation for cross-border purpose. The final adjusted FRCE (subtracting FRCE induced by aFRR activation for cross border purpose) will reflect the locally caused responsibility of the participating TSOs towards their own imbalance and can be used for different purposes.

5.3.1. Questions to stakeholders

Questions regarding TSO-TSO exchange and FRCE adjustment
1. In a sense FRCE adjustment process objective is to determine the real aFRR exchange (linked to real aFRR delivery by BSPs) between TSOs, generally do you support its usage for TSO-TSO volume determination to be possibly used for publication and/or settlement? ▪ Yes ▪ No ▪ No opinion 2. Are the principles of the optimization function satisfactory? Please justify if there is any missing objective points. ▪ Yes ▪ No ▪ No opinion

3. Do you agree with the intended position of TSOs not to allow activation in opposite direction? Please justify your answer.
   - Yes
   - No
   - No opinion

4. Do you identify any negative impacts to the potential access to the full CMOL for one TSO? Please justify if there is any.
   - Yes
   - No
   - No opinion

5.4. Congestion management

This chapter tackles the issues and questions with regard to congestion management. Moreover, it provides an overview on the current approach to congestion management agreed in PICASSO, as well as an outlook towards possible future ways to tackle internal and cross-zonal congestions.

5.4.1. Description

Regarding the calculation and usage of CZC GLEB renders the scope for the TSOs by provisions in Art. 37:

> *After the intraday-cross-zonal gate closure time, TSOs shall continuously update the availability of cross-zonal capacity for the exchange of balancing energy or for operating the imbalance netting process. Cross-zonal capacity shall be updated every time a portion of cross-zonal capacity has been used or when cross-zonal capacity has been recalculated.*
> *Before the implementation of the capacity calculation methodology pursuant to paragraph 3, TSOs shall use the cross-zonal capacity remaining after the intraday cross-zonal gate closure time.*
> *By five years after entry into force of this Regulation, all TSOs of a capacity calculation region shall develop a methodology for cross-zonal capacity calculation within the balancing timeframe for the exchange of balancing energy or for operating the imbalance netting process. Such methodology shall avoid market distortions and shall be consistent with the cross-zonal capacity calculation methodology applied in the intraday timeframe established under Commission Regulation (EU) 2015/1222.*

Due to Art. 37, PICASSO TSOs currently intend to use cross-zonal capacity remaining after intraday for exchange of balancing energy, i.e. without a specific capacity calculation for the aFRR process. However, GLEB provides also the possibility to reserve CZC for the exchange of balancing capacity and sharing of reserves.

CZC can only be used by one balancing process at the same time, and this may lead to interference between aFRR and other balancing processes, e.g. mFRR. In this regard a trade-off between a chronological order of processes (XB ID > RR > mFRR > aFRR/IN) and prioritization between the platforms exists, which is subject to discussions among NRAs and on ENTSO-E level. For aFRR the prioritization of processes is even more relevant as the aFRR target platform should perform netting of TSO aFRR demands and optimize the activation of aFRR using CZC given to the aFRR target platform. Hence, there exists a strong link between aFRR target platform and imbalance netting Platform to be taken into account, as both processes work almost simultaneously.

The preferred approach is to have a consistency between the area for intraday market, mFRR and aFRR. Deviating from this path should be clearly motivated to stakeholders and NRAs. Recalculation of the CZC for balancing is outside the scope of PICASSO and will be done at a later stage on a capacity calculation region level.

The main objective of congestion management should be that the activation of a bid for balancing purposes, responding to TSO aFRR demands shall not endanger the system security. Apart from this target other objectives respected by the aFRR platform might be identified, e.g. a minimum aFRR activation level located in a LFC area or a minimum import/export exchange aFRR on a border. However, in a first step the proposal from PICASSO TSOs is to not include other purposes but focus on system security.

TSOs may also need to do countertrading and/or re-dispatch for congestion management. GLEB provides the possibility for TSOs to use the balancing platform for such counter measures. However, due to diverging requirements in terms of quality, FAT and monitoring between aFRR balancing and congestion management products, the usage of the aFRR platform for purposes other than the activation for balancing is not foreseen.

Summing up, the main objective of the PICASSO platform congestion management is to activate aFRR bids which respect operational security limits; to do so, it needs at least:

- to allow aFRR activations respecting the available cross-zonal capacity
- to allow aFRR activations respecting internal line capacity (mainly influenced by aFRR exchanges)

To respond to this objective, different options are being considered by PICASSO. This consideration is in an early stage of analysis and all options are not discussed here. However, two possible measures for handling congestion are:

- Limiting Available Transmission Capacity (ATC)

  A TSO may limit ATC for balancing cross-border exchange manually in order to handle and/or avoid congestion situations. This measure is well known and currently used for RR and imbalance netting process, when deemed necessary from an operational security point of view. Each TSO updates its ATC values and submit them to the platform. The platform algorithm is then required to take these manual limitations into account in the optimization result. If the method is used too widely, it may lead to a reduction in the efficiency of the common optimization. Transparency about the application of such measures is required and need to be further discussed among TSOs.

- Mark bids unavailable

  A TSO to filter bids that will create congestions by marking them unavailable before submitting them to the platform. This is a simple measure for which no additional mechanism in the algorithm and harmonization is needed. This requires sufficient time between BEGCT and TSO bid submission GCT, to let the TSO performing such filtering actions. Information on unavailable bids has to be reported according to GLEB Art. 12(3)(b)(v).

5.4.2. Questions to stakeholders

Questions to stakeholders regarding congestion management
1. Do you agree with the outlined objectives of the PICASSO platform congestion management? ▪ Yes ▪ No ▪ No opinion 2. Apart from the outlined objectives, do you see additional objectives which should be taken into account? ▪ Yes ▪ If yes, which ones (free textbox) ▪ No 3. Regarding the prioritized access to CZC for processes, do you have a preference for sequential prioritization (XBID > RR > mFRR > aFRR/IN), or do you see the necessity to prioritize certain balancing processes? Please justify your answer. ▪ Yes (free textbox) ▪ No (free textbox) ▪ No opinion 4. Does the available cross-zonal capacity has an impact on your bidding behaviour (e.g. pricing, liquidity, etc) ▪ Yes, please explain ▪ No ▪ No opinion

5.5. Exchange of aFRR energy between synchronous areas

The target model for PICASSO is a European aFRR market. Since there are several synchronous areas in Europe, the functionality of the platform must facilitate exchange of aFRR energy across HVDC cables. The PICASSO project plans to facilitate exchange of aFRR energy also between synchronous systems.

The PICASSO project has identified some topics related to exchange between synchronous areas and operation of HVDC cables:

- Alignment of BSP delivery and HVDC response

There is a potential deviation between the exported product from a synchronous area and delivered product from the BSP. Such a deviation would be an imbalance that belongs to the connecting TSO of the BSP, and unlike in the AC grid this will result in an imbalance in the other synchronous area and it is therefore also a system security issue because frequency is affected.

- Financial settlement of unintended exchanges & FAP

Both for the financial settlement of unintended exchanges as for the FRCE adjustment process (FAP) should be further detailed and make sure they also cover exchange between synchronous areas.

- Technical ability of the HVDC cables and control systems

HVDC cables are traditionally operated according to a set schedule. The control systems must be modified to allow the frequent aFRR changes with a sufficiently short delay.

5.6. CBA: Cost Benefit Analysis

PICASSO project decided to conduct a CBA, which is currently running, in order to assess the social welfare impact of CMOL activation via the PICASSO Platform. Even if the implementation of the aFRR platform is mandatory according to GLEB, the main purpose of the CBA for the PICASSO TSOs is discussion of the national implementation costs. One objective is to provide first insights regarding the expected exchange volume of aFRR in the cooperation.

5.6.1. Simulation description

The CBA methodology could be illustrated in the following way:

Figure 27: CBA methodology

The analysis currently aims at assessing the economic benefits of a common merit-order list (CMOL) of automatic FRR among PICASSO member TSOs, covering FR, DE, AT, BE and NL.

Two scenarios are considered:

- Reference case: Each country activates local aFRR offers for the needs of its country. AT and DE CMOL is simulated in the reference case respecting the AT-DE flow limitations. All countries activations are performed respecting the merit-order.
- Target case: aFRR offers are shared on a common merit-order list for aFRR, which activates the shared aFRR offers to satisfy the global need of TSO, respecting the merit-order and the cross-border capacities and AT-DE flow limitations. The AT-DE flow limitation will be considered as and referred to regular ATC.

The economic benefits of the aFRR CMOL will be assessed by comparing the balancing costs between the target case and the reference case

5.6.2. Simulation period

The analysis is out on the period from 01/08/2016 to 31/07/2017, in order to cover France participation in IGCC and AT-DE CMOL in the whole period.

5.6.3. Starting assumptions

Main common hypothesis for this CBA are the following ones:

5.6.3.1. IGCC

The imbalance netting performed by IGCC is taken into account as historical input in the reference case, in order not to include the imbalance netting benefits in the economic assessment of the aFRR CMOL. It is implicitly assumed that imbalance netting is performed before aFRR CMOL. The simulation will only capture the benefit of the CMOL. Imbalance netting is still performed but its benefit is out of the scope of the analysis.

The IGCC corrections for imbalance netting used in the analysis are the historical corrections. The analysis will not take into account a potential extension of IGCC to other countries (compared to historical situation) which would have an impact on the overall aFRR activation.

Note: This assumption is expected to underestimate PICASSO benefits as it would not capture the benefit from IGCC netting beforehand. The option to simulate again imbalance netting in the framework of this simulation has been discarded for the following reasons:

- In case the imbalance netting re-simulation would have been performed including countries outside PICASSO, the decrease of imbalance netting in countries outside PICASSO could not be accurately estimated.
- In case the imbalance netting re-simulation would have been performed ignoring countries outside PICASSO, the aFRR activated volume in the PICASSO countries would be overestimated, thus overestimating PICASSO benefit.

5.6.3.2. Merit-order activation in each country

It is assumed in the reference case that all involved TSOs perform a merit-order activation of aFRR (including France and Belgium, where activation is currently pro-rata). As a consequence, the benefits of an evolution from pro-rata to merit-order in France and Belgium are not included in the assessment of the aFRR CMOL.

As aFRR activation in France and Belgium is currently pro-rata (and paid at a regulated price), offers for France will be estimated as follows:

- volumes: based on historical aFRR volumes,
- prices: based on historical prices for mFRR/RR available on these units (offering is unit-based in both countries) with a pay-as-bid scheme.

5.6.3.3. FAT

The impact of the FAT reduction on the aFRR offer prices will not be taken into account. For example in NL, reducing the FAT could lead to a change in the offer prices, which will not be modelled in this study.

5.6.3.4. Regulation dynamics

Regulation dynamics will not be modelled in the analysis. The aFRR response of the units will be considered as instantaneous regarding the demanded volume after IGCC process. The effect of this assumption is difficult to estimate. One could however consider that the errors for activation and deactivation more or less compensate each other.

Frequency and ACE quality, FAT duration, and product type (ramping approach or FAT approach) are out of the scope of this study

5.6.4. Other assumptions

The analysis assumes a status quo regarding manual activations and their impact on available cross-border capacities: the implementation of RR/mFRR CMOLs is not taken into account, as the consequences on capacities are currently unknown and the simulation effort would be high.

The possibility of offering non-contracted bids in any country is not taken into account.

The bidding behaviour of the market participants is considered as unchanged.

5.6.5. Expected outputs of the study of the simulation

The results will be presented to stakeholders when all the simulations are finalized.

The expected outputs of the simulation are:

- The activated volume (energy) per country.
- The net position and the XB MP per country, calculated every 4 seconds, by applying a basic ATC market coupling pricing scheme.
- An estimation of congestion occurrence per border.
- The overall balancing cost in the reference case and in the target case. It will be calculated as [the sum of the activated volume] x [offer price of the activated offers]. The impact for BSPs and BRPs per country will be available. The difference between balancing costs in the two scenarios should represent the market welfare created by the aFRR CMOL.

5.6.6. Questions to stakeholders

Questions to stakeholders regarding CBA
1. Is there any other expectation or suggestion from your side regarding the CBA? If yes, please justify. ▪ Yes (free box) ▪ No ▪ No opinion

5.7. Transparency and Publication of information

5.7.1. Description

Article 12 of GLEB indicates that market participants are required to provide relevant information towards TSO to ensure their publication duties. It also indicates that TSO shall publish information regarding current system balance, balancing energy bids and balancing capacity within due time. Transparency aspects will be aligned with other balancing projects and discussed on ENTSO-E level.

5.7.2. Question to stakeholders:

Questions regarding publication of information
1. Regarding article 12 fulfillment, do stakeholders foresee any confidentiality issues or possible competitive advantage or disadvantage linked to the data to be published? Please justify your answer. ▪ Yes (free box) ▪ No (free box) ▪ No opinion

6. Intermediate version of the platform

6.1. Principles

The PICASSO TSOs believe that the aFRR target platform design and implementation may benefit from a pragmatic step by step approach, with the help of potential intermediate versions of the platform. TSOs are interested in gathering practical experience on some topics such as TSO-TSO exchange, FRCE quality, behaviour at the end of the bid validity period, and more. For that purpose, TSOs may set-up one or more intermediate version of the aFRR platform. Such intermediate versions may not be as advanced as the target platform. An intermediate version would allow faster implementation thus increasing social welfare. It should not slow down the progress towards the target platform as well, but on the opposite it should facilitate its efficient implementation and operation.

There is currently one intermediate version in operation, which is the Austrian-German aFRR cooperation. Besides the obvious social welfare benefit, this initiative has already provided some valuable inputs regarding control exchange design. TSOs are considering whether the implementation of another intermediate version or the extension of the Austrian-German cooperation towards other countries as intermediate version may make sense. If so, the definition and the progress of the implementation of any intermediate versions will be done on national level only. The progress and the implementation of any intermediate version shall be transparent towards the stakeholders regarding the choice made on the design points presented in this consultation document.

Figure 28: Intermediate version towards aFRR Platform

For these intermediate versions, TSOs intend to harmonise the FAT to a single value. The pricing method has to be harmonised, but not necessarily based on marginal pricing. Non-contracted bids are allowed but are not mandatory. The BEGCT does not necessarily require to be fully harmonised but the differences must remain limited. The validity period has to be identical.

6.2. Questions to Stakeholders

Question to stakeholders regarding support to intermediate version implementation

1. In general, do you support the implementation or extension of intermediate versions of the aFRR platform? Please justify your answer.

- Yes (free box)
- No (free box)
- No opinion

Question to stakeholders regarding the minimum level of harmonization for intermediate version

2. Do you agree with the listed minimum harmonization requirements intended for intermediate versions? Please justify your answer.

- Yes (free box)
- No (if no, please justify and add a list of priority for necessary requirements applying a number (higher number defines a higher priority), free box)
- No opinion

3. Do you see a beneficial interest compared to operational and implementation changes you could bear to implement an intermediate version of the aFRR platform? Please justify your answer.

- Yes (free box)
- No (free box)
- No opinion

Questions to concerned stakeholders regarding a potential extension case

4. In practice, a realistic example should be possible to extend the Austrian-German initiative to France and Belgium around 2020. Would you support such extension? Please justify your answer.

- Yes
- No
- No opinion

Questions regarding the progress of intermediate version:

5. Do you support a report on the gained experience of the intermediate platform project once a year?

- Yes
- No (if no, what would be the good pace according to you?, free box)
- No opinion

7. Any other business

Question to stakeholders regarding any missing topic in the consultation document
1. In general, do you have any remark or point you consider as missing in the consultation document and you would like to raise to PICASSO? Please justify your answer, if any. ▪ Yes (free box) ▪ No

8. List of abbreviations

ACE/FRCE	Area Control Error/Frequency Restoration Control Error
aFRR	Automatic Frequency Restoration Reserves
AOF	Activation Optimization Function
BEGCT	Balancing Energy Gate Closure Time
BEPP	Balancing Energy Pricing Period
BRP	Balancing Responsible Party
BSP	Balancing Service Provider
CACM	Capacity Allocation and Congestion Management
CBA	Cost-Benefit-Analysis
CMOL	Common Merit-Order List
EG	Expert Group
FAT	Full Activation Time
FCP	Frequency Containment Process
FCR	Frequency Containment Reserves
FRP	Frequency Restoration Process
FRR	Frequency Restoration Reserves
GLEB	Guideline on Electricity Balancing
GLSO	Guideline on System Operation
IG	Implementation Group
IGCC	International Grid Control Cooperation
ISP	Imbalance Settlement Period
mFRR	Manual Frequency Restoration Reserves
MOL	Merit-Order List
MoU	Memorandum of understanding
MP	Marginal Price
NRA	National Regulatory Authority
RR	Replacement Reserves
RRP	Replacement Reserves Process

SC	Steering Committee
TSO	Transmission System Operator
XB IP	Cross-border imbalance pricing
XB MP	Cross-border marginal pricing

Appendix I – Simplified examples of different BEPPs

In this subchapter, several simplified examples illustrate the effects of the BEPP. The examples have been developed using a weighted average imbalance price for the control cycle BEPP.

For the two options (control cycle and quarter hour BEPP), several scenarios will be shown as follows. The first three focus on the price effects. The final focuses on congestions and price divergence.

1. No peak prices, where the activated bids are the same for every minute in the ISP
2. No peak prices, where the activated bids are the same for the first fourteen minutes, and a higher priced bid is activated in the last minute
3. Price peak in minute 15, which is similar to scenario II, except in the last minute a very high priced bid is activated
4. Two involved TSOs with limited cross-zonal capacity. Price peak in minute 15 as in scenario II.

The first three scenarios will be analysed on the artificial merit order as shown in Figure 29.

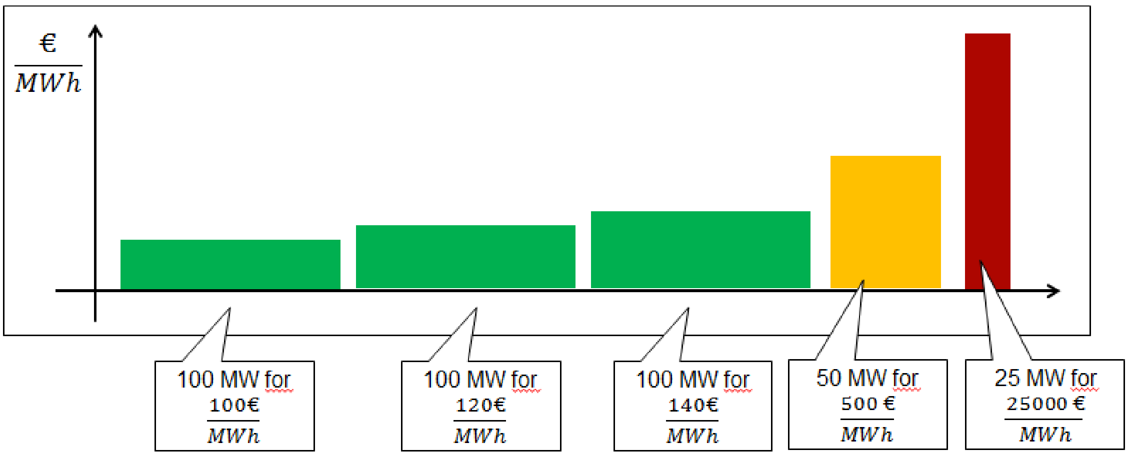

Figure 29: Artificial merit order used to analyse the scenarios

Analysis of scenario I

As described before, the first scenario is characterized by no peak price, where the activated bids are the same for every minute in the ISP. This scenario gives the following results based on the artificial merit order in Figure 29.

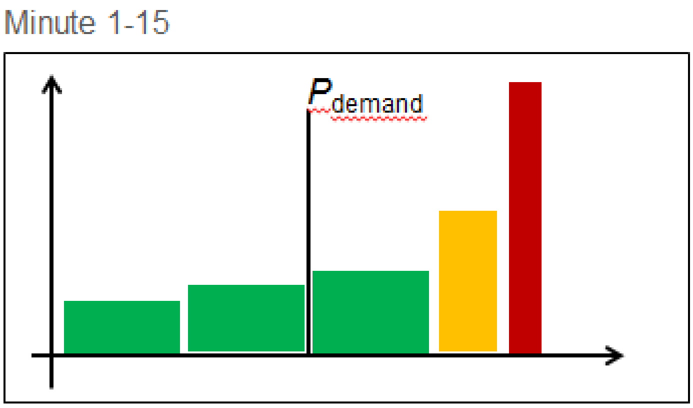

Figure 30: Merit order and power demand for scenario I

Control cycle BEPP:

- $Payment_{TSO \rightarrow BSP} \quad = \left(100\ MW \cdot \frac{120€}{MWh} + 100MW \cdot \frac{120€}{MWh}\right) \cdot \frac{15}{60} = 6000€ \ \left(or\ \frac{120€}{MWh}\right)$
- $SettlementPrice_{BRP} = \frac{6000€}{200MW \cdot 15\ min} = \frac{120€}{MWh}\ (or\ 6000€\ in\ total)$

Quarter hour BEPP:

- $Payment_{TSO \rightarrow BSP} \quad = \left(100\ MW \cdot \frac{120€}{MWh} + 100MW \cdot \frac{120€}{MWh}\right) \cdot \frac{15}{60} = 6000\ € \ \left(or\ \frac{120€}{MWh}\right)$
- $SettlementPrice_{BRP} = \frac{120€}{MWh}\ (or\ 6000\ €\ in\ total)$

Analysis of scenario II

The second scenario is characterized by no peak price, where the activated bids are the same for the first fourteen minutes, and a higher priced bid is activated in the last minute. This scenario gives the following results based on the artificial merit order in Figure 29.

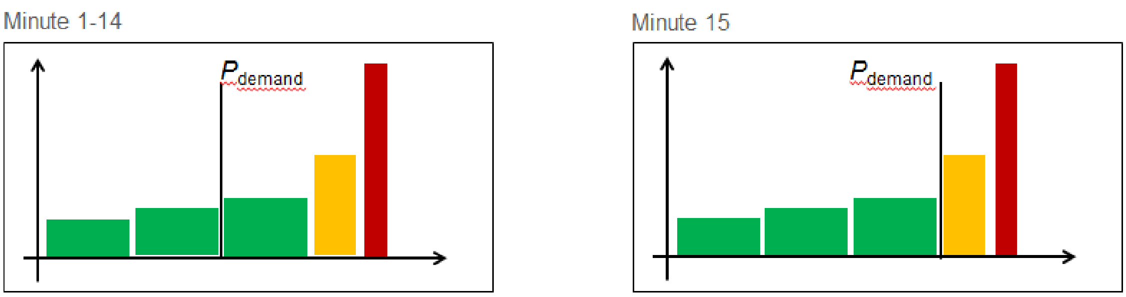

Figure 31: Merit order and power demand for scenario II

Control cycle BEPP:

- $Payment_{TSO \rightarrow BSP} \quad = \left(200\ MW \cdot \frac{120€}{MWh}\right) \cdot \frac{14}{60} + 300\ MW \cdot \frac{140€}{MWh} \cdot \frac{1}{60} = 6300€ \ \left(or\ \frac{122€}{MWh}\right)$

- $SettlementPrice_{BRP} = \frac{6300€}{200MW \cdot 14\,min + 300MW \cdot 1\,min} = \frac{122\,€}{MWh}\ (or\ 6300€\ in\ total)$

Quarter hour BEPP:

- $Payment_{TSO \to BSP} \quad = \left(200\ MW \cdot \frac{140€}{MWh}\right) \cdot \frac{14}{60} + 300\ MW \cdot \frac{140€}{MWh} \cdot \frac{1}{60} = 7233\ € \left(or\ \frac{140€}{MWh}\right)$
- $SettlementPrice_{BRP} = \frac{140€}{MWh}$

Analysis of scenario III

The third scenario is characterized by a price peak in minute 15, which is similar to scenario II, except in the last minute a very high priced bid is activated. This scenario gives the following results based on the artificial merit order in Figure 29.

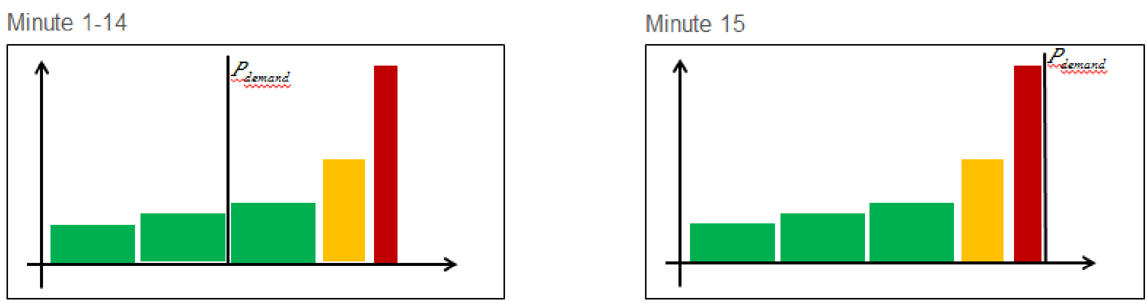

Figure 32: Figure 31: Merit order and power demand for scenario III

Control cycle BEPP:

- $Payment_{TSO \to BSP} \quad = \left(200MW \cdot \frac{120€}{MWh}\right) \cdot \frac{14}{60} + \left(375\ MW \cdot \frac{25000€}{MWh}\right) \cdot \frac{1}{60} =$ $161850€ \left(or \frac{3058€}{MWh}\right)$
- $SettlementPrice_{BRP} = \frac{161850}{200MW \cdot 14min + 375MW \cdot 1min} = \frac{3058\ €}{MWh}\ (or\ 161850\ €\ in\ total)$

Quarter hour BEPP:

- $Payment_{TSO \to BSP} \quad = \left(200MW \cdot \frac{25000€}{MWh}\right) \cdot \frac{14}{60} + \left(375\ MW \cdot \frac{25000€}{MWh}\right) \cdot \frac{1}{60} =$ $1{,}3\ Mio.€ \left(or\ \frac{25000\ €}{MWh}\right)$
- $SettlementPrice_{BRP} = \frac{25000\ €}{MWh}$

Summary of scenario I-III

Especially in case of price peaks, a quarter hour BEPP shows higher prices for both TSO-BSP and TSO-BRP settlement, as can be seen in Table 7 and Table 8.

TSO-BSP settlement

	Control cycle BEPP	Quarter hour BEPP
Scenario I	120 €/MWh	120 €/MWh
Scenario II	122 €/MWh	140 €/MWh
Scenario III	3058 €/MWh	25000 €/MWh

Table 7: TSO-BSP settlement

TSO-BRP settlement

	Control cycle BEPP	Quarter hour BEPP
Scenario I	120 €/MWh	120 €/MWh
Scenario II	122 €/MWh	140 €/MWh
Scenario III	3058 €/MWh	25000 €/MWh

Table 8: TSO-BRP settlement

Analysis of scenario IV

Two involved TSOs with limited cross-zonal capacity. Higher activation in minute 15 as in scenario II.

To show what occurs in case of congestions, the following scenario is studied:

- Situation with two areas: A and B
- aFRR demand all located in area A and equal to price peak scenario:
- In minute 1-14, 200MW
- In minute 15, 375MW
- Bid volumes and prices for area A and B as in the table below
- Cross-zonal capacity available for activation of one 100MW bid from area B for area A

Merit Order lists of TSO A and TSO B:

Volume A	Price A	Volume B	Price B
100	100	100	120
100	140	100	200
50	500		
25	25000		

Table 9: Merit order list of TSO A and TSO B

	CONTROL CYCLE BEPP				QUARTER HOUR BEPP	
Results	**TSO A** **Min 1-14**	**TSO B** **Min 1-14**	**TSO A** **Min 15**	**TSO B** **Min 15**	**TSO A**	**TSO B**
Activated volume (MWh)	100*14/60 = 23.33	100*14/60 = 23.33	275*1/60 = 4.58	100*1/60 = 1.67	100*14/60 +275*1/60 = 27.92	100*15/60 = 25
TSO-BSP price (€/MWh)	120	120	25000	120	25000	120
TSO-BSP settlement (€)	2800	2800	114583.33	200.4	697916.67	3000
TSO-TSO price (€/MWh)	0		25000		25000	
TSO-TSO settled volume (MWh)	23.33	-23.33	1.67	-1.67	25	-25
Congestion rent (€)	0		41466.67 = (25000 – 120)*1.67		622000	

Table 10: Results for control-cycle (left) and ISP (right)

Appendix II – Local analysis of BEPP effects

Analysis of the Dutch system

To illustrate the effects of the different BEPP options, as an example an analysis has been performed on the readily available data from the Dutch system, where marginal pricing per ISP is currently applied for both BSP and BRP. The analysis serves an illustratory purpose, and cannot be one on one translated in showing the future situation or that in other countries.

In order to investigate the effects of different pricing periods, two calculations have been done. This first is an assessment of the difference of the surplus of BSPs in comparison to day-ahead prices (main reference market in NL). The second is a calculation of the correlation between the settlement over the ISP and the imbalance within the ISP, to give an indication of the reflection of scarcity.

Effects on prices

A calculation has been done ceteris paribus to assess the difference of the surplus of BSPs in comparison to day-ahead prices. The comparison has been done by a simple calculation done on publically available data, comparing a 1-minute marginal price with a 15-minute marginal price. The comparison is shown in Figure 33 and Figure 34 for upward and downward activation respectively, and can be summarised as a reduction of the BSP income in comparison to day-ahead prices by between 20 and 25 percent when applying 1-minute marginal pricing as compared to the current situation.

As the figures show, this reduction of surplus is not limited to situations in which the abovementioned activation peaks occur, but is present at all price levels. Due to the decrease in BSP income in case the BEPP is shortened, there are concerns that BSPs will compensate by adding markups to their bid prices.

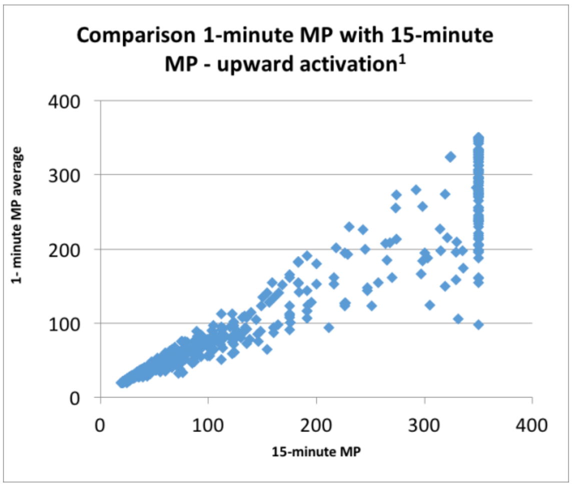

Figure 33: Comparison 1-minute marginal price (y-axis = €/MWh, x-axis = MWh)

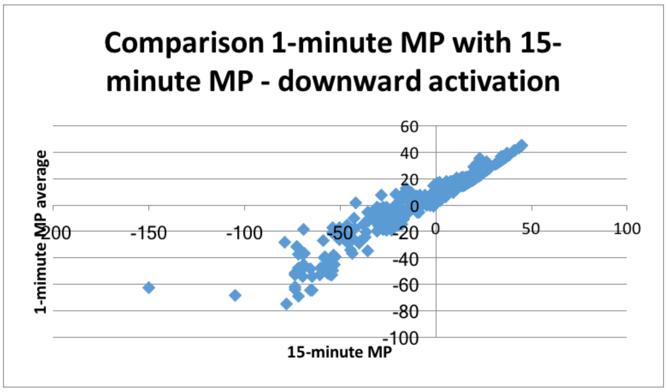

Figure 34: Comparison 1-minute marginal price (y-axis = €/MWh, x-axis = MWh)

Reflection of scarcity

Using the same data as in the price calculation above, the correlation between the activated volumes of balancing energy in respectively upward and downward direction and the difference between the TSO-BSP settlement price and the mid-price on the MOL for balancing energy has been calculated for the Dutch system for a 15-minute, a 5-minute and a 1-minute BEPP. This difference represents the value added through TSO-BSP settlement. In the calculation the mid-price has been used as a proxy for the spot price. The correlation gives an indication of how well the energy demand and scarcity is reflected in the balancing energy price ranges, as the volume of activated balancing energy is the same for the different TSO-BSP settlement methods, although it does not state anything on the absolute price.

Mathematically then, the correlation has been calculated between the total added value of TSO-BSP settlement (price * aFRR volume – midprice * aFRR volume) and the aFRR volume. The results are:

	Upward activation	Downward activation
1-minute	0.76	0.71
5-minute	0.78	0.71
15-minute	0.79	0.72

Table 11: Correlation between total added value of TSO-BSP settlement and the aFRR volume

These values are comparable, showing that power fluctuations within a period do not affect whether or not the energy demand is correctly reflected in the price ranges.

Appendix III – Analysis of BEPP cross-border effects

Price divergence in case of congestions

When applying a quarter hour BEPP, considering the cross-border marginal pricing option selected for TSO-BSP settlement, price divergence between the participating imbalance price areas/bidding zones occurs whenever a congestion is present somewhere in the ISP. When applying a control cycle BEPP, the percentage of cycles in which price divergence occurs is equal to the percentage of cycles in which congestions occur, as prices only diverge for those cycles in which there is a congestion.

It should, however, be noted that for the ISPs in which there is a price divergence, there will still be a difference in the average price paid over the ISP in case of a control cycle BEPP. The percentage of ISPs in which there is a price difference between imbalance price areas will be equal for both the control cycle and quarter hour BEPP. In both cases the same bids will be activated.

Due to the differences in price convergence, there is an impact on congestion rent. This is illustrated in scenario IV in Appendix I.

Occurrence of congestion

Using 2016 data from IGCC concerning LFC block imbalances as well as available ATCs after intraday trading, PICASSO TSOs have analysed for each LFC block in what percentage of the time, respectively of the cycles in a year and the quarters of a year, price divergence between the given LFC block and the remaining area would occur as result of congestions in the simplified situation in which the local demand of aFRR exceeds the sum of available ATCs for the following two cases:

- Case 1: 100 % of the local demand is met by activating bids located other LFC blocks
- Case 2: 25 % of the local demand is met by activating bids located in other LFC blocks

In both cases, the ratio between the amount of cycles to the amount of quarters in which price divergence occurred is approximately 2, as can be seen in the graphs in Figure 35.

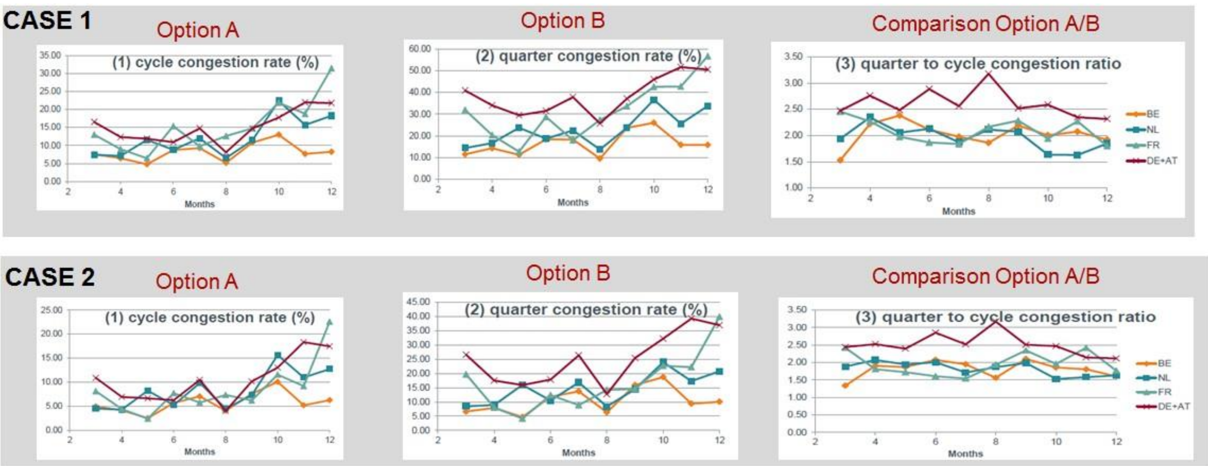

Figure 35: Ratio between amount of cycles and the amount of quarters with price divergence