Consumer Centric Market Design

Real Time Price Design note – Part I

December 2023

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CONTEXT

The next decade will be characterized by a fast increasing share of renewables and a massive electrification of industrial and residential appliances, all driven by the energy transition and accelerated by the recent energy crisis.

The ELIA Adequacy and Flexibility Study 2023 clearly identifies increasing needs for flexibility to cope with intermittency of renewable energy sources and to manage the electrification of many residential and industrial appliances, a.o. when it comes to balance the grid. One of the four key messages of this study was that : *"Any delay in unlocking flexibility or realising grid infrastructure will result in additional capacity needs. Investing in accelerated digitalisation is therefore as important as investments in the timely build-out of grid infrastructure"*.

Since 2020, ELIA is calling for an upgraded market design, the Consumer-Centric Market Design ("CCMD"), which addresses this major challenge in terms of system integration by making sure that all the flexibility finds its way to help the system, a.o. so that Elia can keep balance the system in an affordable and reliable way.

ELIA is convinced that the keys to unleash further flexibility consist in:

- giving an active role to the consumer, at all voltage levels while keeping its participation seamless;
- providing easy-access to digital platforms to support Energy Service Providers in the development of (new) energy services for the consumer.

The Consumer-Centric Market Design combines two main features:

- The first pillar is to allow a **decentralized exchange of energy**, on and behind the head-meter, between the consumer and any other market party, allowing him to benefit from dedicated energy as a service per appliance. This is expected to increase competition among Energy Service Providers and to reduce entry barriers for prosumers;
- The second pillar is **the evolution to a "Real-Time Price**". ELIA is engaged in a major reflection on the evolution of the imbalance price, that makes it easily interpreted by the consumer and/or its Energy Service Provider and facilitates the valorization of flexible assets in accordance with the real-time system needs. This is expected to allow market parties to better understand and anticipate the needs of the system and to optimize their consumption/production profile based on clear price signals at all times (e.g. DA, ID, RT)

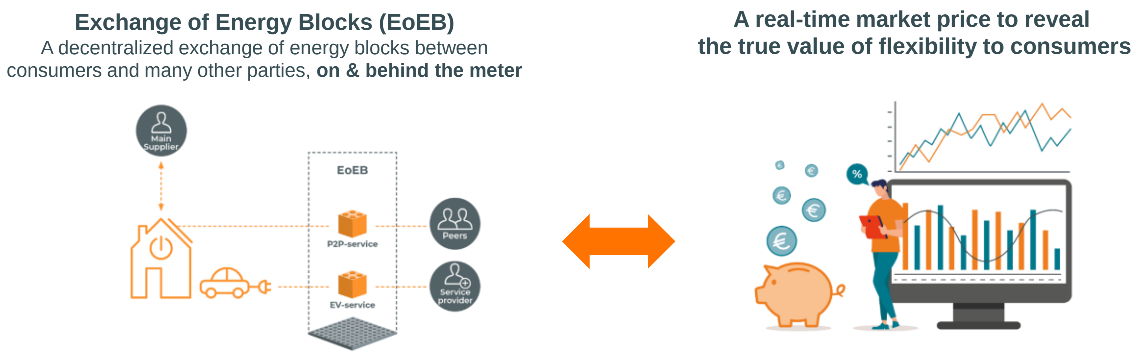


Figure 1 – Two pillars of Consumer Centric Market Design

This design note focuses on the second pillar and aims at clarifying the rationale for imbalance price evolutions, as well as the concrete improvements that ELIA has in mind. This document is the first part of a series of design notes that, together, will provide the complete view of the design envisaged by ELIA for the future real-time price and its related publication.

This first design note intends to clarify the basis of the vision that ELIA is building around the real-time price, as part of a co-construction process with the stakeholders. With full transparency, ELIA will therefore indicate in this note the elements for which challenges and/or open questions persist. With this approach, ELIA hopes to involve the stakeholders and collect their feedback all along the co-construction process and not only once the final design is established

Besides, the developed vision is not constrained by a specific GO-live or timing. Therefore, ELIA tries (and encourages the stakeholders to do the same) to think out of the box to develop the vision that seems to be the most appropriate to address the challenges of the energy transition, and this even if the implementation of this vision would require some pre-requisites that are not yet available today (in terms of tools, legal framework, etc.).

LIST OF ABBREVIATIONS

aFRR	Automatic Frequency Restoration Reserve (FRR that is activated automatically)
BRP	Balance Responsible Party (as defined in Article 2(7) of EBGL)
BSP	Balance Service Provider (as defined in Article 2(6) of EBGL)
CCMD	Consumer Centric Market Design
DA	Direct Activation (as defined in article 2(1) of the mFRR Implementation Framework)
FRR	Frequency Restoration Reserve (as defined in Article 3(7) of SOGL)
ISP	Imbalance Settlement Period
MTU	Market Time Unit
mFRR	Manual Frequency Restoration Reserve (FRR that is activated manually)
RTP	Real-Time Price
SA	Scheduled Activation (as defined in article 2(1) of the mFRR Implementation Framework)
SBC	Smart Balancing Controller

STRUCTURE OF THIS DOCUMENT

The objectives of this design note are twofold:

1. It first aims at clarifying the **reasons why** ELIA engaged in a major reflection on the evolution of the imbalance price;
2. It then explains the concrete imbalance price **evolutions** that are envisaged by ELIA and demystifies the concept of 'real-time price'.

To do so, it is structured around 5 sections. **Section 1** describes the role of the imbalance price to mobilize and steer flexibility in accordance with real-time system needs while **section 2** discusses the flaws and limitations of the current imbalance price design, justifying the need for evolutions towards a clear and robust real-time price signal.

Section 3 demystifies the concept of real-time price by providing more insights on what real-time price means, and above all on what real-time price is not. This is essential for the reader to clearly understand and follow the reasoning exposed in the rest of the document, as well as in the following design notes. **Section 4** explains the concrete evolutions that ELIA has in mind to make the imbalance price evolve towards such a real-time price.

Finally, **section 5** provides a first overview of how ELIA intends to integrate these evolutions in the future real-time price design. This section also highlights the challenges that come with these evolutions, as well in terms of design as in terms of implementation, and it raises the important questions that will need to be addressed in the next design notes.

Figure 2 – Structure of the document

1 The role of imbalance price

Figure 3 – Structure of the document

1.1 The paradigm shift

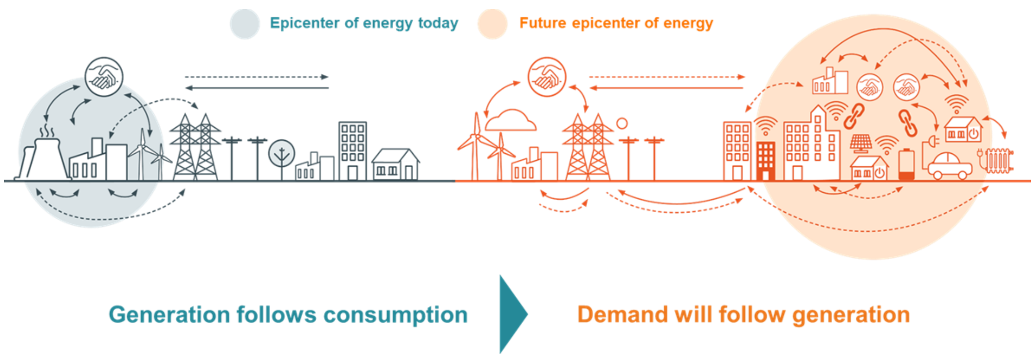


Figure 4 – The paradigm shift

High and volatile renewable energy integration is creating additional pressure on power system operators to balance the grids. In order to continue efficiently operating the system, a **paradigm shift** needs to happen: the historical way of working, where generation was constantly adjusted to consumption, needs to evolve towards a new way of working, where the **consumption adapts itself to the available generation.**

This evolution can only happen if the flexible assets receive **clear signals** to determine the right moment to engage their flexibility in the system. In the balancing timeframe, such clear signals can be of two types:

- Either the asset reacts to an **explicit activation request** which is sent by the TSO (via a **BSP**) when its flexibility is called to balance the grid. This activation request specifies the **volume** to be activated and the direction of the activation. The activated flexibility is at least valorized at the price specified in the explicit bid through which the flexibility was offered to the TSO.

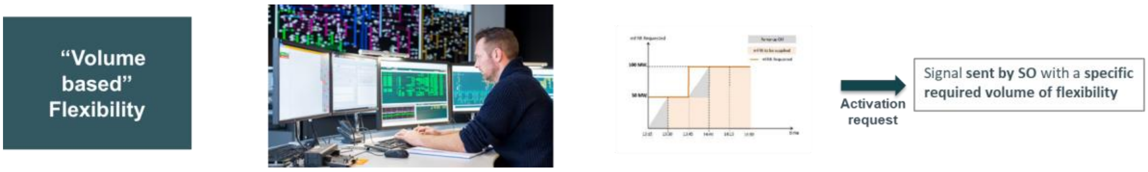


Figure 5 – Illustration of explicit activation

- Or the asset reacts **implicitly** (i.e. on its own initiative, not directly controlled by the TSO) to an imbalance **price signal** (via a **BRP**) which, in some balancing models, may provide financial incentives to deviate from its baseline in real-time and engage its flexibility in order to help balance the system. The flexibility engaged in the system is valorized at this imbalance price. Today, in Belgium, the imbalance price already strives to provide a financial incentive to BRPs to balance their portfolio or even deviate from a balanced position to help the system.

Figure 6 – Illustration of implicit reaction to price signal

1.2 Balancing models

These two types of signals (i.e. 'explicit activation request' on the one hand and 'price signal' on the other hand) can be used and combined in several ways to balance the grid in real-time. Even though each balancing model has its own specificities, they can be categorized in two clusters according to their main balancing philosophy:

- **Central[1] balancing** models exclusively rely on explicit activations to balance the grid in real-time. This means that the TSO needs to take full control on grid balancing actions as from a few minutes to hours before delivery (e.g. in France, this happens one hour before delivery).

[1] 'central balancing' should not be confused with 'central dispatch' as defined in article 2(18) of EBGL : 'central balancing' and 'decentral balancing' models are balancing models that can be used by the TSO to balance the grid in a zone where **self-dispatching**, as defined in article 2(17) of EBGL, is applied.

Once the TSO has taken full control on grid balancing, BRPs are no longer allowed to take actions to balance their portfolio or help balance the system.

- **Decentral balancing** models use a combination of both explicit activations and price reactions to balance the grid up to real-time. In these models, BRPs are allowed and encouraged, through the imbalance price, to take balancing actions up to real-time to balance their portfolio. In some decentral balancing models (such as in the models applied in Belgium or in The Netherlands), BRPs are even allowed and incentivized to deviate from equilibrium to help balance the system. Today, TSOs applying this model mostly rely on explicit activations to solve the *residual* imbalances of the grid, after giving the market as much time and as many opportunities as possible to balance the grid on its own.

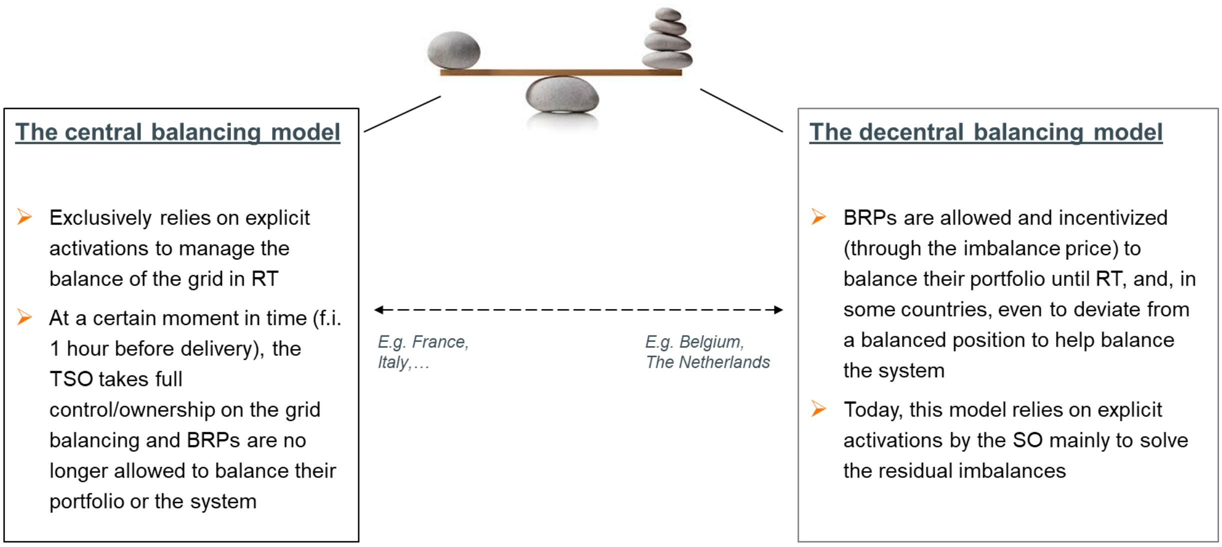


Figure 7 – Two categories of balancing models

Nowadays, most of the TSOs applying a decentral balancing model follow a so-called **reactive FRR activation strategy**, meaning that:

- they let the market balance the grid first;
- they let the aFRR (automatic Frequency Restoration Reserve) controller solve the residual grid imbalances;
- it is only when the aFRR available resources are largely consumed that the TSO activates mFRR (manual Frequency Restoration Reserve) in order to desaturate the aFRR.

In contrast, most of the TSOs applying a central balancing model **proactively activate** manual reserves in order to solve the expected real-time grid imbalance and mainly use aFRR to cover the residual 'ripple' around the equilibrium.

Therefore, the terminology 'reactive balancing' is sometimes used to refer to a 'decentral balancing model', as opposed to 'proactive balancing' which is then used to refer to a 'central balancing model'.

In the future, with the connection to the European balancing platforms, the FRR activation strategies will need to adapt to the timing imposed by the mFRR platform. For the readers who would not be familiar with the mFRR European balancing platforms, a short introduction, based on the MARI Algorithm Optimization Function Public Description available on ENTSO-e website, is included below.

Short introduction to mFRR platform

The mFRR European balancing platform MARI foresees two activations processes: the Scheduled Activation (SA) process, and the Direct Activation (DA) process.

The timing and activation profile imposed by the Scheduled Activation process are described on Figure 8. First, BSP bids are received up until the BSP gate closure time at T-25 min, and processed by TSOs. Then, each TSO computes their own demands. At T-10, all bids and demands have been submitted to MARI platform. This is the TSO gate closure time. The market clearing of the Scheduled Activation run can then be triggered. The market clearing information is transferred to BSPs at T-7.5 which will ramp up or down according to the activation direction within 12.5 minutes. The TSOs exchange the trapezoidal shape, with full delivery/ power exchange between T+5 and T+10.

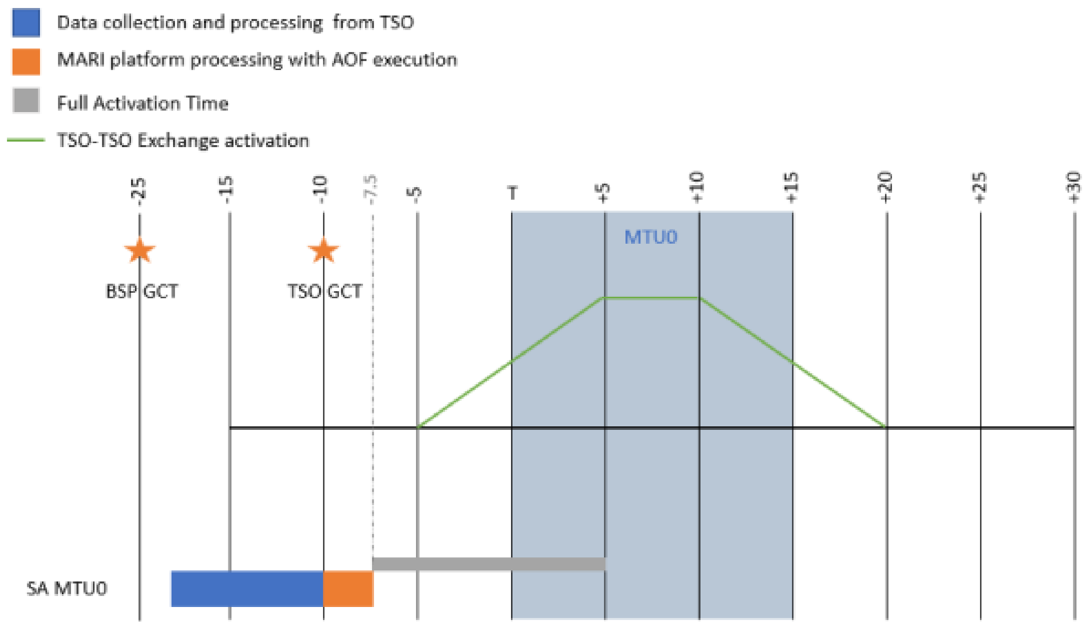


Figure 8 - Timing and activation of a mFRR bid that has been accepted during a Scheduled Activation process for Market Time Unit MTU0 (extract from the MARI AOF Public Description available on ENTSO-e website)

The timing and activation profile imposed by the Direct Activation process are described on Figure 9. After T-10 min, TSO may submit a demand to trigger one Direct Activation where all bids eligible for DA and not activated in the previous activation run of the same MTU period can be used. Depending on the timing of the DA process, information is transferred to BSPs between T-7.5 min and T+7.5 min, and the bid duration last until the end of the next MTU period (MTU 1).

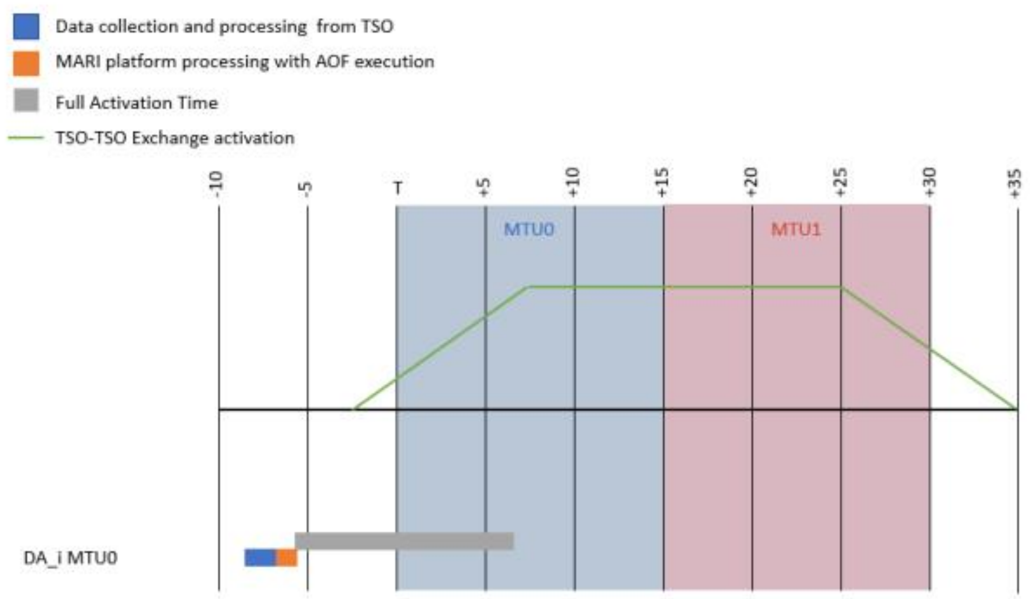


Figure 9 - Timing and activation of a mFRR bid that has been accepted during a Direct Activation process for Market Time Unit MTU0 (extract from the MARI AOF Public Description available on ENTSO-e website)

Due to the timing imposed by the Scheduled Activation process of the mFRR European balancing platform MARI (which requests the mFRR demand to be sent by the TSO to the platform at T-10 at the latest, as illustrated above), any TSO which relies on mFRR to balance its grid and which wants to benefit from the European balancing integration might need to make its FRR activation strategy evolve towards a more 'proactive' activation strategy. One could argue that a TSO which wants to use mFRR reactively (i.e. to desaturate its aFRR) could sent its mFRR demand to MARI through the Direct Activation process. However, this comes with two important drawbacks:

- Mainly relying on Direct Activations to balance the grid decreases the benefits from the European balancing integration, since the netting of simultaneous demands in opposite direction can only be executed in SA and not in DA;
- Besides, DA last for two MTUs, which is not efficient to cover imbalances that are not expected to be long-lasting.

As a result, even countries applying a 'decentral balancing model', such as Belgium, might need to activate mFRR more proactively than today. It will therefore be important, in the future, and to understand the rest of these design notes, to differentiate the balancing model (central vs decentral) and the applied FRR activation strategy (proactive vs reactive).

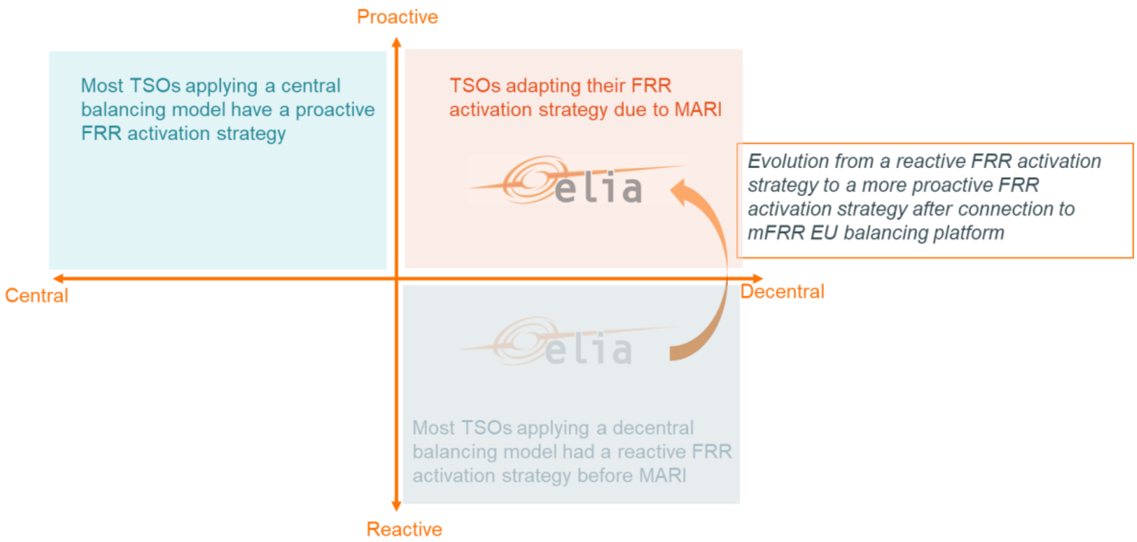


Figure 10 – Evolutions of FRR activation strategies due to connection to MARI

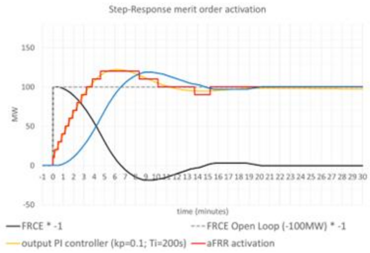
1.3 The most efficient balancing model to unlock the real power of flexibility

From a pure theoretical perspective, a central balancing model, for which the TSO has full control on the resolution of the RT imbalance could seem quite appealing. Indeed, in such a model:

- The TSO constantly has a perfect view on the availability and the price of the flexibility willing to participate in the system, since this flexibility is offered to the TSO through explicit bids.

- The participation of the flexibility in the system can be considered as firm. There is a contractual agreement between the TSO and the BSP putting the flexibility at the TSO's disposal: explicit activations come with an obligation to deliver - which is monitored through activation controls - and any missing energy can be subjected to penalties.

- The TSO can regulate the system with great precision. Some balancing products have a very short regulation step (for instance the aFRR demand can be adapted on a 4 seconds basis) which allows the TSO to balance the system very accurately.



These are clear advantages of explicit activations compared to implicit reactions to the imbalance price signal. In the latter, the TSO has no explicit view on the flexibility willing to react. Besides, even if the TSO can expect some reactions to a price signal, these reactions are never guaranteed: the implicit flexibility only participates in the system if and when it wants to. And finally, the TSO can only steer these reactions on a quarter-hourly basis considering the current Imbalance Settlement Period (ISP) of 15 minutes.

At first sight, the central balancing model therefore seems to be very comfortable from a TSO perspective. However, in the practice, this balancing model comes with several weaknesses:

- It excludes some flexible assets from system participation;
- It creates a loss of social welfare;
- It causes inefficiencies (e.g. overshoots) in the real-time balancing process.

1.3.1 The central balancing model excludes some flexible assets from system participation

Under a central balancing model, not all the flexible assets can help balance the system until real-time, even when they have the ability to do so[2]. In such a model, only explicit flexibility can participate in the system up to real-time. However, not all assets can participate explicitly in the system in the balancing timeframe, and this for (at least) the three following reasons:

- **Explicit participation in the system comes with strict technical requirements and important technical setup to which not all types of flexible assets can, or want, to accommodate**. For instance, participating to a balancing product is only possible if a flexible asset complies with some metering and with some communication requirements; and if it can follow specific activation profiles and respect strict activation times. Besides, explicit bidding can be burdensome and time-consuming, especially in the context of European integration of balancing products. Not all the flexible asset owners are willing to develop a complex explicit bidding process for their flexibility. Finally, the process to be allowed to participate explicitly in the system contains much more steps than for an implicit participation and must be anticipated (it entails several pre-requisites).

[2] Note that this statement was confirmed by stakeholders during the informal interviews held in 2022 to prepare the development of a real-time price vision

Figure 11 – Overview of the process to participate explicitly in the system

In general, explicit participation in the system comes with a series of tasks and requirements, as well as with a lead time which are almost inexistent for implicit participation. As a result, some flexible assets are not able, or not willing to participate explicitly in the system. For instance, some assets of which the core business is not to be active on electricity markets might be able/willing to help the system in the balancing timeframe but only very occasionally (for instance a few times per year). For these assets, it is quite clear that it is not worth investing in the administrative path described above to participate explicitly in the system. Implicit participation is much more accessible for these types of assets.

ELIA has been intensively (and will continue) working on reducing the barriers for participating explicitly in the system. By doing so, ELIA limits the number of assets that cannot or do not want to participate explicitly in the system. However, ELIA cannot reduce the complexity of balancing products to zero. Lowering the technical requirements to the extreme would decrease or even remove the added value of the FRR products because it would make them much less reliable and firm. For instance, lowering even more the requirements in terms of activation profile and time to allow more assets to participate in FRR products would strongly affect the quality of the balancing regulation, and is hence not desirable. In the end, a trade off needs to be found between making the explicit participation in the system as accessible as possible while still keeping the FRR products reliable. As a consequence, no matter how hard the TSOs work to reduce the entry barriers to their balancing products, there will always remain some flexibility which cannot or which does not want to participate explicitly in the system.

- Another reason for not participating explicitly in the system is when there are **so many parameters that need to be taken into account** to decide whether flexibility can be engaged in the system at a given moment in time, that it is **impossible to translate them in explicit bids**. This is typically the case for flexible assets of which the core business is far away from electricity markets. For instance, more and more flexibility is emerging on industrial sites due to the electrification of some industrial processes. Those industrial processes are sometimes flexible to a certain extent, but the availability and the valorization of this flexibility strongly depends on non-electrical related business and constraints. An industrial site of which the main business is to produce industrial goods (such as cement, steel, etc.) could for instance need to take into account parameters such as the residual margin in the production planning, the tear and wear induced by possible short successive flexibility activations, etc. to decide on the availability and on the price of its flexibility. Those parameters are extremely complex or even impossible to reflect in explicit bids.

- Finally, in a central balancing model, each flexible asset which is **too slow to participate to balancing products** (i.e. with a full activation time longer than the 12,5 minutes required to participate in mFRR), but which is however fast enough to still adapt its position after the moment when the TSO takes the full control on balancing actions (f.i. 1 hour before delivery in France), is **by definition excluded from system participation**. Besides, in such models, BRPs with good forecasting abilities and tools are not allowed to make healthy arbitrage until (close to) real-time, hence preventing efficient back-propagation from the real-time value of energy to previous timeframes. Therefore, even when they are still allowed to adapt their positions, slower units will not necessarily do so because they don't receive the signal to deviate from their position when the price on the Intraday market does not reflect the expected real-time imbalance situation. This leads to suboptimal real-time dispatch of slower flexible assets.

1.3.2 The central balancing model creates a loss of social welfare

As a consequence of the exclusion of some flexible assets from system participation, the real-time dispatch of resources is de-optimized, which creates a loss of social welfare.

This is illustrated on Figure 12 :

- In a central balancing model, any imbalance that occurs after the moment when the TSO takes full control on balancing actions is covered by explicit activations of BSPs and no implicit reaction is allowed from the BRPs (the BRP imbalances are supposed to be perfectly inelastic… which, in practice, is not the case as will be demonstrated in 1.3.3). In such a model, the volume V_{cb} is activated explicitly to cover the imbalance represented by the black arrow on Figure 12. The price of the marginal resource dispatched to balance the system in real-time is equal to 'Marginal FRR price CB'. If the explicit flexibility is remunerated with a pay-as-cleared[3] mechanism, which is the target model for remuneration of aFRR and mFRR (once connected to the European platforms), the balancing costs amount to V_{cb} * Marginal FRR price CB.

- In a decentral balancing model, implicit reactions from BRPs are possible until real-time. In decentral balancing models that incentivize BRPs to deviate from their balanced position to help the system in real-time, it is possible to benefit from the whole flexibility available in the system, even the one which is excluded from explicit participation (as explained in 1.3.1). Indeed, if implicit reactions are encouraged and efficiently steered through an appropriate price signal, they should perfectly complement the explicit activations of the BSPs, so that the less expensive resources available in the system are dispatched to cover any imbalance that occurs after the closure of the wholesale markets. This time, the BRP imbalances are no longer inelastic and the BRP price elasticity is represented by the solid blue line on Figure 12. In such a model, the volume V_{db} is activated explicitly to complement the implicit reaction from the market to the price signal. The price of the marginal resource dispatched to balance the system in real-time is this time equal to 'Marginal FRR price DB'. If the explicit flexibility is remunerated with a pay-as-cleared mechanism, the balancing costs amount to V_{db} * Marginal FRR price DB.

- Both V_{db} and 'Marginal FRR price DB' are smaller than V_{cb} and 'Marginal FRR price CB'. As a consequence, the central balancing model creates a loss of social welfare which is equal to (V_{cb} * Marginal FRR price CB - V_{db} * Marginal FRR price DB). This loss of social welfare is represented by the solid light orange area on Figure 12.

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[3] Meaning that all the activated flexibility is remunerated at the price of the marginal bid that has been activated

- Also, Figure 12 clearly illustrates the de-optimization of the real-time dispatch caused by the central balancing model, since the price of the marginal resource dispatched to balance the system is higher than in the decentral balancing model. This is explained by the fact that the central balancing model ignores the possible implicit reactions from assets that are less expensive but that don't offer their flexibility explicitly to the TSO.

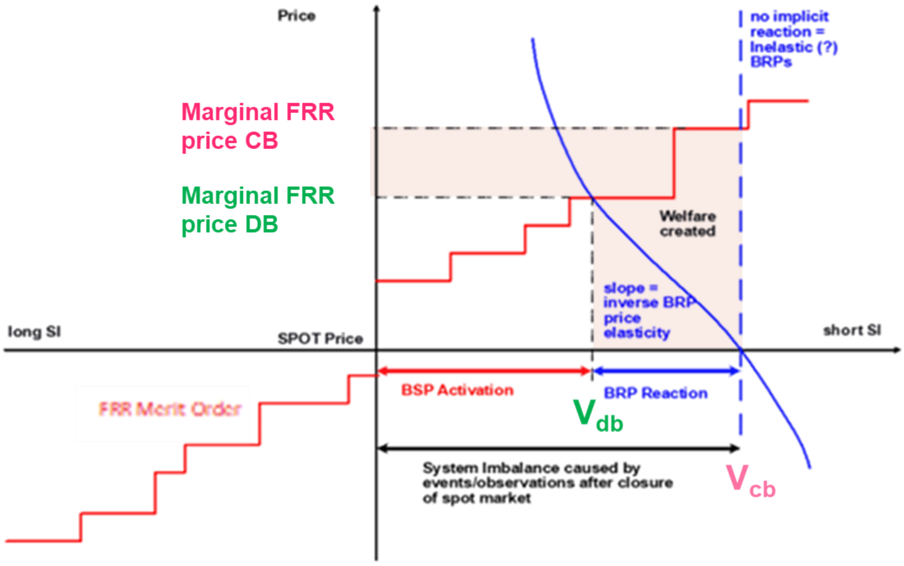


Figure 12 – Illustration of the loss of social welfare in a central balancing model

Note that this loss of social welfare was demonstrated by actual observations in the Belgian system[4]. The average implicit reaction at demand side was estimated over the year 2022 and used as input to assess the impact of implicit reaction on the mFRR volumes and mFRR marginal prices of activations performed in the upward direction. This analysis showed that, without implicit reaction from these demand facilities, an overall increase in both the mFRR activated volume and the mFRR marginal price could be expected in the upward direction. More specifically, in the absence of implicit reaction, the 95th percentiles of the mFRR volumes and prices distributions would increase by (respectively) 50MW and 60€/MWh.

1.3.3 The central balancing models causes inefficiencies in the balancing process

In a central balancing model, the BRP imbalances are supposed to be inelastic after the moment when the TSO takes full control on balancing actions: balancing actions from the BRPs is no longer allowed after that moment. However, in the practice, BRP implicit reactions until real-time are unavoidable, even when legally forbidden. This statement has been concretely experienced by

[4] Those observations were presented to the stakeholders during the WG CCMD meeting of 14th November 2023 ([20231114 meeting (elia.be)](https://www.elia.be))

neighboring countries (such as Germany) trying to prevent that BRPs keep open positions until RT, and can be explained by two factors:

- In the end, BRP imbalances are subject to the imbalance price which can hardly be totally neutral (it will inevitably provide some kind of financial incentives to the BRPs). This becomes even truer with the connection to the European balancing platform. Indeed, article 55.4 of EBGL requires that: "The imbalance price for negative imbalance shall not be less than the weighted average price for positive activated balancing energy from frequency restoration reserves and replacement reserves". After the connection to the European balancing platform, the "price for positive activated balancing energy" is the clearing price of the corresponding balancing platform when this platform is regulating in the upward direction. The boundary condition expressed in article 55.4 therefore requests that the imbalance price for negative imbalance is higher than the average of… the marginal prices of the upward activations performed by the platforms. This means that the imbalance price is always close to the price of the marginal unit explicitly activated in the system, which provides strong incentive to the remaining flexibility which is not offered explicitly or activated at that moment* and of which the marginal cost is lower than the price of the marginal activated unit, to participate in the system.

  * It is indeed totally possible that units that are offered explicitly to the TSO are not activated even though they have a marginal cost below the marginal price of the upward activated bid. This can be the case for several reasons, the most obvious one being the fact that there are several balancing products (aFRR and mFRR) with totally separate bidding, selection and activation processes (i.e. there is no interaction or inter-optimization between the aFRR and mFRR European balancing platforms). It is therefore very realistic that the aFRR European balancing platform is regulating in the downward direction (hence leaving all the upward flexibility of units offered in aFRR available), while, at the same moment, the mFRR European balancing platform is regulating in the upward direction, with a clearing price potentially much higher than the price of the first bids offered in the aFRR upward Merit Order List. This explains that, even in the unrealistic (as demonstrated in 1.3.1) case where no flexible asset would be excluded from participation to balancing products, financial incentive for implicit reactions would remain.

  Of course, since the imbalance price is calculated and published ex-post, one could argue that implicit reactions to a (marginal) imbalance price can be avoided by withholding from market participants any information that could be used to forecast this imbalance price. Experience from neighboring countries show that there will always be some BRPs which, for instance due to their market power or to the size/composition of their portfolio, are able to forecast the imbalance price and are hence incentivized to adjust their position to this price signal. Withholding information therefore only creates non-level playing field between BRPs and is not an option to prevent implicit reaction.

- If the financial incentive exists for implicit reaction, no legal interdiction will be able to totally eradicate these price-based reactions. This can be explained by the fact that this kind of legal provision is very difficult or even impossible to monitor for many BRPs. Indeed, in many situations, BRPs with load or with intermittent production in their portfolio could allege that their open position in real-time is unintentional and relates to load/renewables forecast errors.

Applying a central balancing model that denies the existence of implicit reaction and hence does not rely on appropriate design and tools to efficiently steer this reaction therefore causes inefficiencies in the balancing process. For instance, a TSO denying the existence of implicit reaction or a TSO having poor view on what he considers as 'parasitic' and 'illegal' implicit reactions might regularly overactivate reserves, making the system switch in the opposite direction.

> Considering the fact that implicit reactions to the imbalance price are necessary to unlock the whole flexibility available in the system and create social welfare, and considering the fact that implicit reactions are unavoidable whatever the chosen balancing model, it is deemed more efficient to allow and actively steer these implicit reactions rather than having to deal with unexpected, uncontrolled and illegal implicit reactions causing inefficiencies in the system.

ELIA therefore believes that a decentral balancing model, where BRPs are allowed and sufficiently informed to help balance the system in real-time and where the implicit reactions perfectly complement the explicit activations performed by the TSO, is the most efficient model to unlock the real power of flexibility.

1.4 The role of imbalance price in a decentral balancing model

In such a model, explicit and implicit participations in the system co-exist and are both facilitated as far as possible. This is the reason why ELIA:

- Is constantly working on the reduction of the entry barriers to FRR products on the one hand;
- While seeking to make the imbalance price signal as clear and accessible as possible on the other hand, so that the implicit reactions are efficiently steered.

> According to ELIA, the imbalance price signal will play a crucial role in the success and efficiency of the energy transition, and this explains why ELIA has engaged in the discussions and evolutions presented in these design notes.

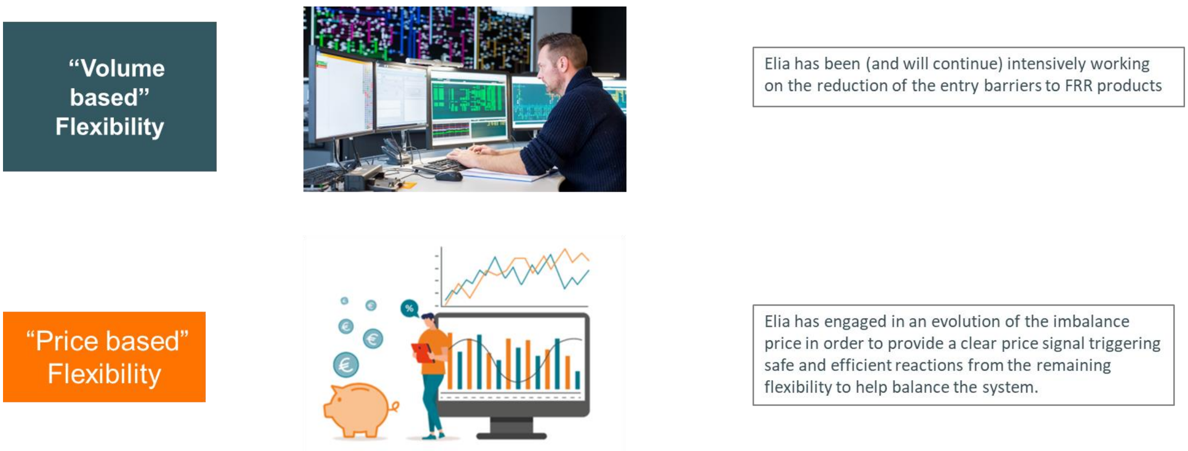
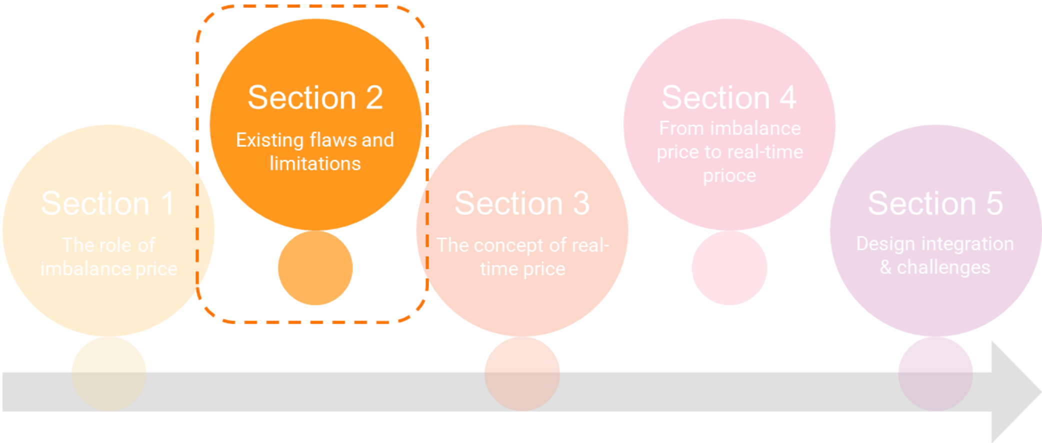


Figure 13 – The most efficient balancing model relying on the co-existence of explicit and implicit participations in the system, both should be facilitated as far as possible, hence the importance of a clear imbalance price signal

2 Flaws and limitations of the existing imbalance price signal



In Belgium, the applied balancing model is already quite close to the one described as the most efficient one in previous section:

- Implicit reactions are already allowed until real-time in order to help balance the system;
- The main objective of the imbalance price is to provide correct financial incentives to the BRPs (and not to recover balancing costs, such as in other models);
- ELIA is considered as one of the most transparent TSO in Europe in terms of close to real-time publications of balancing related information (e.g. system imbalance, imbalance price, activated balancing energy volumes and prices, etc.).

However, informal interviews with stakeholders and internal analysis have shown that, despite all the actions already undertaken, there exist some flaws in the current design and there is a real need to improve the quality of the imbalance price signal if we want the balancing model to remain as efficient and if we want to accelerate the energy transition as well as the integration of new electrified appliances.

2.1 The current imbalance price does not always reflect the imbalance situation

As observed on Figure 14, the correlation between the Belgian system imbalance and the Belgian imbalance price is generally quite satisfying, meaning that the imbalance price usually correctly reflects the imbalance situation and hence provides appropriate incentives to the BRP to help balance the system.

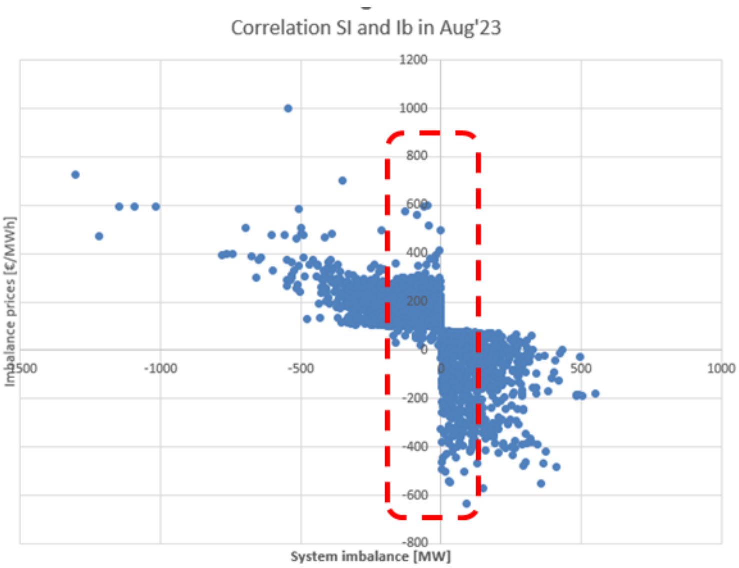


Figure 14 Correlation between system imbalance and imbalance price in August 2023

However, we see on Figure 14 that this correlation is much lower for small system imbalances, when the Belgian system is close to be balanced. For these situations, the imbalance price regularly reaches quite extreme values which no longer reflect the imbalance situation of the system.

This de-correlation is due to specificities of the aFRR design which, coupled to the currently applicable imbalance price formula, lead to extreme imbalance prices while the system is, in average over the ISP, balanced. It has several consequences:

- It is experienced by BRP as a mere penalty instead of a correct incentive: BRPs have, in an aggregated way, correctly made their job but still the ones with larger imbalances in their portfolio (f.i. due to a high proportion of renewables[5]) incur very important imbalance costs;
- As observed on Figure 15, it leads to inefficient oscillations in the system: BRPs only looking at the imbalance price to calibrate their implicit reaction strongly react to the extreme imbalance price and immediately make the system switch in the other direction. This makes the imbalance price jump to a very different value, which, again, triggers a huge readjustment of the BRPs' positions and a switch of the system in the opposite direction.

[5] Most of the disturbances observed in the balancing timeframe being due to forecast errors, renewable technologies are often subject to large imbalances in the direction that does not help the system

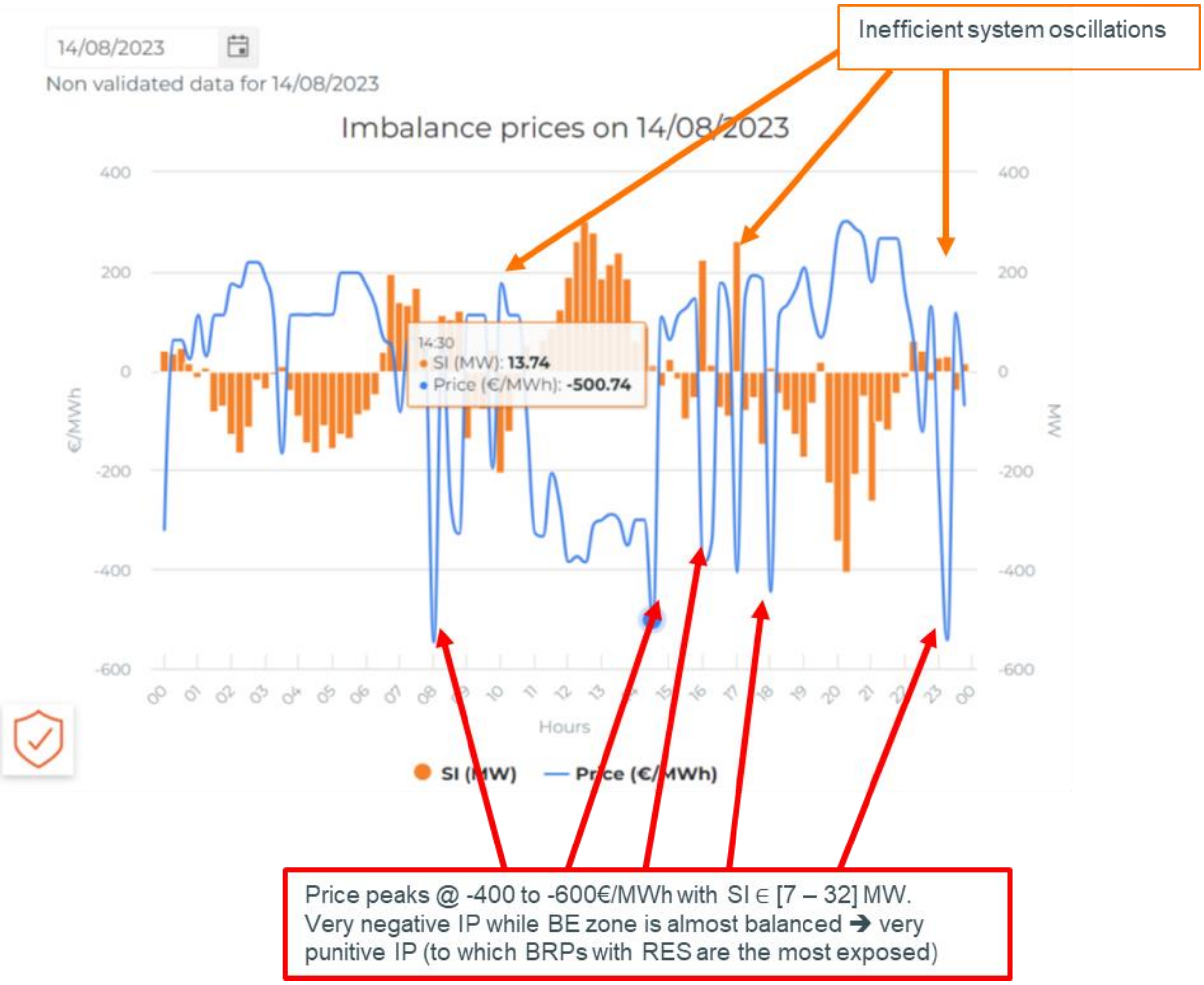


Figure 15 – Consequences of the de-correlation of system imbalance and imbalance price illustrated on actual observations from 14/08/2023

2.2 The imbalance price signal can be volatile and unpredictable

As illustrated in section 2.1, the imbalance price can be quite different from one quarter hour to the other, even for small variations of the system state. This volatility is also present in the close to real-time information that ELIA publishes within the quarter-hour.

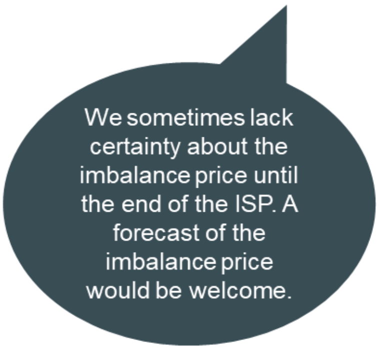
On Figure 16, the one-minute imbalance price publications oscillate between -272€/MWh and 534€/MWh within the considered quarter-hour. Besides, it switches from -168€/MWh to +152€/MWh at the last minute of the quarter-hour.

Start	NRV [MW]	SI [MW]	Alpha [EUR/MWh]	MIP [EUR/MWh]	MDP [EUR/MWh]	IP [EUR/MWh]	MIP of MDP?	GUV [MW	IGCC+ [M	R2+ [MW]	GDV [MW	IGCC- [M\	R2- [MW]
14/08/2023 22:00:00	-76,973	40,869	0,000	130,000	-272,190	-272,190	MDP	0,949	0,949	0	77,922	25,775	52,147
14/08/2023 22:01:00	-54,211	-8,520	0,000	130,000	-257,950	130,000	MIP	6,795	6,795	0	61,006	12,96	48,045
14/08/2023 22:02:00	-45,274	-34,462	0,000	130,000	-231,740	130,000	MIP	4,978	4,978	0	50,252	8,64	41,612
14/08/2023 22:03:00	-38,250	-55,819	0,000	300,000	-207,210	300,000	MIP	3,805	3,801	0,004	42,055	6,48	35,575
14/08/2023 22:04:00	-32,586	-57,355	0,000	440,490	-190,560	440,490	MIP	3,201	3,108	0,093	35,787	5,285	30,503
14/08/2023 22:05:00	-28,089	-47,100	0,000	528,390	-182,450	528,390	MIP	3,137	2,605	0,533	31,227	4,969	26,258
14/08/2023 22:06:00	-37,377	-25,650	0,000	534,310	-177,450	534,310	MIP	3,054	2,233	0,821	40,431	17,456	22,975
14/08/2023 22:07:00	-42,597	-11,299	0,000	515,180	-175,980	515,180	MIP	2,743	1,954	0,79	45,341	25,115	20,226
14/08/2023 22:08:00	-55,049	6,857	0,000	514,820	-170,870	-170,870	MDP	2,44	1,736	0,703	57,489	39,119	18,37
14/08/2023 22:09:00	-61,194	16,655	0,000	459,790	-169,320	-169,320	MDP	2,301	1,563	0,738	63,495	46,852	16,643
14/08/2023 22:10:00	-62,819	22,574	0,000	320,910	-169,000	-169,000	MDP	2,58	1,421	1,16	65,399	50,249	15,15
14/08/2023 22:11:00	-59,239	16,113	0,000	256,310	-168,830	-168,830	MDP	3,445	1,838	1,607	62,684	48,786	13,898
14/08/2023 22:12:00	-51,984	9,560	0,000	196,120	-168,800	-168,800	MDP	5,88	3,047	2,833	57,863	45,033	12,831
14/08/2023 22:13:00	-45,141	3,540	0,000	167,060	-168,800	-168,800	MDP	8,612	3,918	4,694	53,753	41,839	11,914
14/08/2023 22:14:00	-37,046	-4,441	0,000	152,990	-168,800	152,990	MIP	13,124	6,062	7,062	50,169	39,05	11,12

Figure 16 – Illustration of the instability of the one-minute publications of ELIA on actual observations from 14/8/2023

Consequently, BRPs with very flexible assets might create intra quarter-hour oscillations in the system by reacting very fast and strongly to these large price variations. On the other hand, BRPs with less flexible assets might stop reacting to the price signal due to its volatility and hence to its unpredictability.

The need to stabilize the imbalance price signal and increase its predictability was confirmed by stakeholders.



2.3 The imbalance price signal is not stand-alone

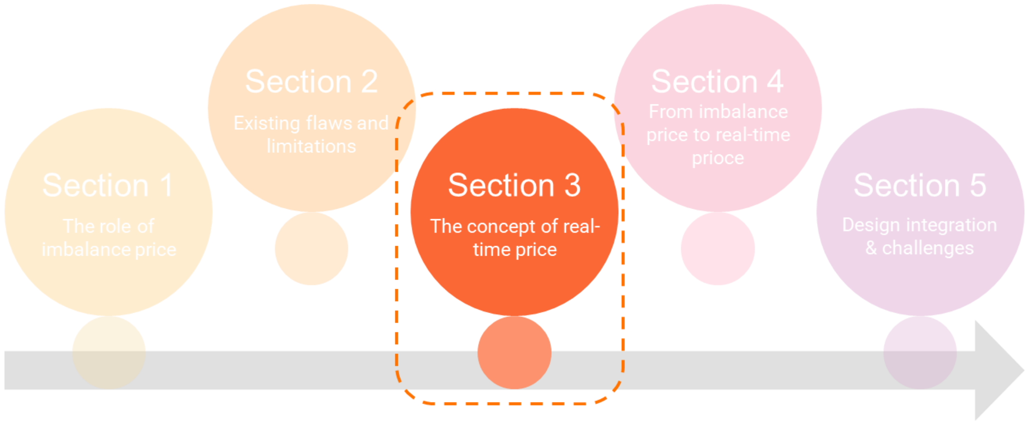
As illustrated in 2.1, BRPs often need to look at other information than imbalance price publications to calibrate their implicit reaction. On the situation illustrated on Figure 15, the BRPs would have needed to look at the system imbalance (which was very limited) to determine their reaction, and not only at the imbalance price. From the oscillations observed on Figure 15, we can deduce that not all the BRPs have correctly taken the state of the system into account when defining their implicit reaction.

In the practice, many other parameters need to be considered by the BRPs when calibrating their implicit reaction, some of them being much more complicated to account for than the system imbalance. One example of a parameter which might be difficult to anticipate for a BRP is the expected implicit reaction of the other BRPs that can deviate from their position until real time. If the volume of flexibility participating implicitly in the system increases, or if the reaction of the flexible assets becomes much more dynamic (f.i. because performed by assets of which the core business is not to participate in the electrical system), it might become more complicated for BRPs to know how much flexibility they can engage without making the system switch in the other direction. This concern was clearly shared by stakeholders during the informal interviews.

It becomes more and more complicated and risky to react to the imbalance price. Even when the initial SI is large, system switches occur within the ISP. The price signal should account for the expected market price reaction in order to avoid overshoots and instabilities

As well the feedback collected from stakeholders as the internal analysis performed by Elia highlight the need for the current imbalance price signals to evolve towards clear real-time price forecasts which reflect the expected real-time value of energy and account for the expected implicit reactions in the system.

3 The concept of real-time price



Before explaining the concrete improvements that ELIA has in mind in order to make this evolution from the current imbalance price (and related publications) towards a real-time price (and related forecasts), it seems important to clarify what the real-time is, and above al,l what it is not. To do so, a set of popular beliefs will be confirmed or refuted in the rest of this section.

TRUE/FALSE

The real-time price and the imbalance price are two different prices that will co-exist.

FALSE. What we call 'real-time price' in this document is nothing else than an evolution towards an improved version of the imbalance price. The 'real-time price' will therefore be the (unique) settlement price for the imbalances of the BRPs. We use the terminology 'real-time price' instead of 'imbalance price' to emphasize the fact that this settlement price reflects in the best possible way the real-time value of energy so that it encourages, at all times, flexible assets to help balance the system (whereas the imbalance price is, historically, rather considered as a penalty for imbalances in the wrong direction).

The real-time price aims at reflecting the true value of energy on a quarter -hourly basis.

TRUE. The 'real-time price' strives to capture the value of energy **on a 15-minute basis** (i.e. on a time unit aligned with the current Imbalance Settlement Period) and not on an instantaneous basis. As a result, an important forced outage that occurs at the very end of the ISP should barely impact the real-time price of this ISP (as illustrated in section 4.2). This is consistent with the main purpose of the real-time price which is to provide correct financial incentives to BRPs to adapt their position and help balance the system **on a 15-minute basis**.

The real-time price is the price which is expected to reduce the 15 minutes average system imbalance to zero

FALSE. The 'real-time price' does not aim to reduce the 15 minutes average system imbalance to zero. It is based on the cost of the explicit activations and aims at triggering an implicit reaction that perfectly complements the explicit activations so that the 15 minutes average ACE is reduced to zero (as illustrated on Figure 12). Other constraints (e.g. to take congestions, or the impact on reserve dimensioning, into account) may be considered when finding the most efficient equilibrium between implicit reactions and explicit activations.

The real-time price is totally decorrelated from the prices of balancing energy activations

FALSE. The 'real-time price' may slightly differ from the marginal price of balancing activations (see concrete reasons for slight decorrelations in section 5.2.1) and might not take the price of all types of balancing activations into account. However, there will always remain a strong link between the real-time price and the price of balancing energy activations.

The final real-time price used for the settlement of the BRPs is only known ex-post

TRUE. The final settlement price is only known ex-post and depends on the balancing events and activations that effectively occur during the ISP. However, ELIA has the ambition to compute and publish a first forecast of this final settlement price even before the start of the ISP and to update this forecast within the ISP.

Note that the possibility to expose BRPs to a firm ex-ante real-time price was analyzed but eventually rejected due to the risks it entails in terms of market manipulation, and the inefficiencies that it carries. This analysis was presented in the WG CCMD of 27/9/2023.

All the flexible assets (including f.i. residential batteries, heat pumps or EVs) need to be **directly** exposed to this real-time price (through RTP contracts) for this price to efficiently steer implicit reactions

FALSE. ELIA is working hard on other initiatives (e.g. Multiple BRPs/Supply split, DiMaX,…) in order to make it possible to split the site's flexible and non-flexible assets so that BRPs can offer a tailor-made financial optimization for each type of asset, and in order to increase competition for energy services behind the meter. This way, we can expect many flexible assets to be **indirectly** exposed to the real-time price through their service provider and there is no need to expose end consumers directly to the real-time price for the balancing model to be efficient.

For instance, a heat pump could be subject to a different contract than the rest of the household consumption. This contract could be (voluntarily) concluded at a flat tariff too, but with a much lower rate provided that the service provider can valorize the intrinsic flexibility of the heating process (e.g. by reacting to the real-time price).

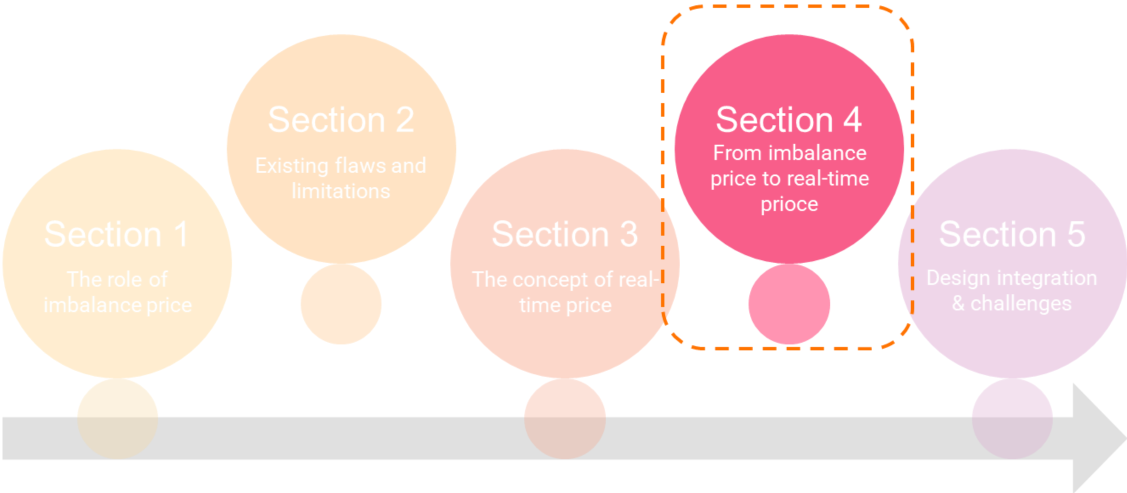
The added value of the real-time price will significantly decrease with the connection to MARI because ELIA will need to evolve towards a more 'proactive' balancing model

FALSE. As explained in 1.2, the timing imposed by the Scheduled Activation process of MARI, as well as the constraints coming with Direct Activations in MARI, require ELIA to evolve towards a more proactive FRR activation strategy. However, contrary to the popular belief, a 'proactive FRR activation strategy' is not to be confused with a 'central balancing model' : ELIA will continue applying a decentral balancing model, and hence allowing implicit reactions until real-time, even after the connection to MARI. The added value of the real-time price will therefore remain unchanged, even after the connection to the EU balancing platforms. However, since ELIA will need to decide on the mFRR volume to be activated in Scheduled Activation well before delivery, it means that ELIA will need to forecast quite early the residual system imbalance, taking into account the expected market reaction until the end of the concerned quarter-hour, in order to make a sound decision. This explains why ELIA has actively been working on system imbalance forecaster over the last few years.

Since ELIA has the ambition to publish forecasts of the real-time price that may be used, in a stand-alone manner, by BRPs to calibrate their implicit reaction, ELIA intends to stop publishing other information (such as system imbalance, activated balancing energy volumes and prices, etc.) close to real-time.

FALSE. ELIA is willing to be as transparent as possible regarding the real-time state of the system and the undertaken balancing actions and does certainly not intend to withhold information that could be useful for the market parties. ELIA's ambition is to put one price forecast at the disposal of all the BRPs to complement their existing forecasting tools. ELIA does absolutely not want to prevent BRPs to develop their own price forecast if they can and want to.

4 From imbalance price to real-time price



To make the transition happen from an imbalance price to a real-time price, ELIA is working on two streams:

- First of all, ELIA wishes to make the imbalance price formula evolve in order to address the shortcomings of the current imbalance price explained in section 2, and to make this imbalance price evolve towards a price that, at any moment, reflects in the best possible way the real-time value of energy.

- Besides, ELIA also aspires to compute and publish forecasts of this real-time price, as from a few minutes before the start of the ISP, followed by updates during the ISP.

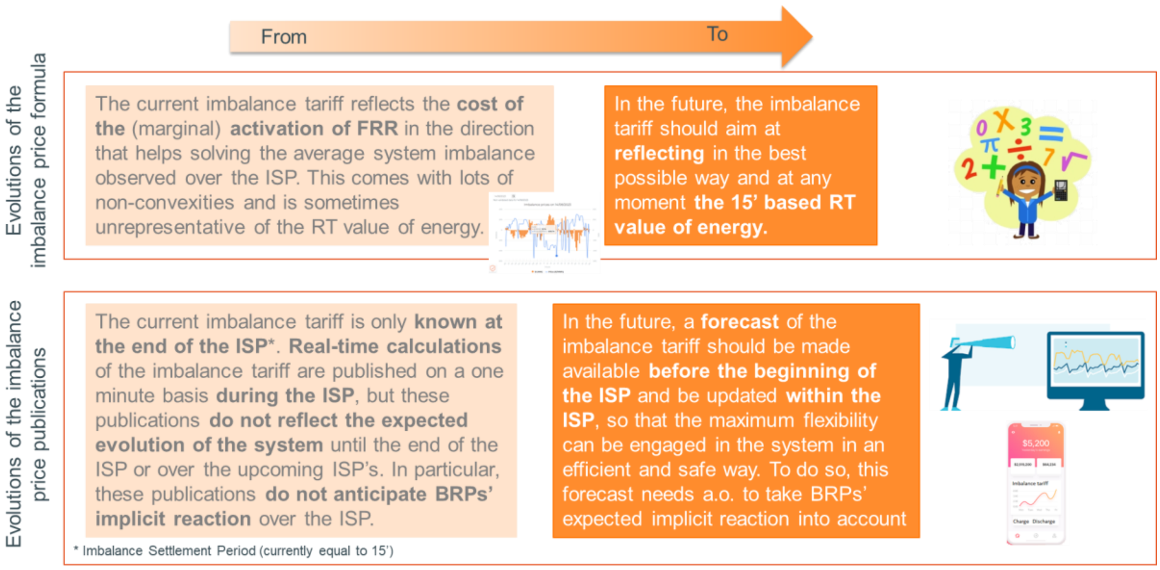


Figure 17 – Evolution from an imbalance price to a real-time price

These two initiatives combined should allow solving the flaws identified in section 2 and facilitate the implicit participation in the system from assets that cannot, or don't want to participate explicitly.

Indeed, if BRPs have access to a forecast of their settlement price, and if this settlement price reflects in the best possible way the real-time value of energy, it means that:

- BRPs have access to one unique and self-sufficient indicator to calibrate their implicit reaction instead of systematically needing to compile several complex indicators not always easily available (e.g. ATCs, reaction of other BRPs, …)

- Since the price forecast is supposed to reflect the expected real-time value of energy, BRPs always receive financial signals to help balance the system in real-time;

Besides, providing BRPs with forecasts of the final settlement price instead of the current one minute publications of the imbalance price should allow stabilizing the price signal and the resulting implicit reactions.

4.1 Evolution of imbalance price formula

The exact proposal for the evolution of the imbalance price formula will be the subject of a next design note. However, some first thoughts are already shared in this document to illustrate the types of evolution that Elia is considering.

As discussed in section 2, the current price formula, together with the non-convexities that are inherent to the aFRR product, can lead to imbalance prices that do not reflect the real-time imbalance situation. To address this issue, Elia is questioning the role of (4 seconds based) aFRR prices in the imbalance price construction and wonders whether these prices correctly represent the real-time value.

The reasoning behind is twofold:

- The purpose of the aFRR product is to balance the grid with a much higher resolution than what can be targeted with implicit reaction to the 15 minutes based real-time price. The assets that participate in this product therefore only represent a small subset of the assets that are able to react to the real-time price to help balance the system on a quarter-hourly basis. The specificities of this subset of (fast reacting) assets can, under certain circumstances, have as consequence that their price is very different from the price of the remaining flexibility which is able to react within the ISP. It therefore seems legitimate to call the use of these dynamic and specific aFRR prices in the construction of a quarter-hourly price signal into question.

- Besides, when applying a proactive FRR activation strategy, the main purpose of the aFRR product becomes to cover the intra quarter-hour variations of the system imbalance, whereas the 15 minutes average system imbalance is supposed to be covered by mFRR activations. In theory (i.e. if the residual system imbalance forecasted by the TSO when sending its mFRR SA demand is correct), the activated aFRR energy over the ISP should be equal to zero. In the practice, this will never be perfectly the case since forecast errors will always persist. However, in case the average aFRR activated volume over the ISP is different from zero, it can be questioned whether aFRR prices should be used to 'valorize' this volume in the real-time price. Another perspective consists in considering that this non-zero average aFRR activated volume should ideally (i.e. in the absence of forecast errors) have been covered by mFRR activations (in other words, those are "mFRR-like" activations of the aFRR product) and that they should hence be valorized at an "mFRR-like" price. This way, the aFRR non convexities would not impact the real-time price, but the average aFRR activated volume would still be taken into consideration in the price formation.

Of course, the pros and cons of an evolution of the aFRR contribution to the imbalance price should be analyzed in a deep and comprehensive way before leading to concrete design changes proposal. Besides legal compliancy of such an evolution – or the legal adjustments that would be required to make this evolution compliant - should also be analyzed. This will be done in a next design note.

4.2 Price forecasts

As explained in 1.2, with the connection to the MARI platform, ELIA will need to send its mFRR demand in scheduled activation to the platform at the latest 10 minutes before the start of the ISP. In order to define this demand in the best possible way, ELIA will hence need to forecast the expected residual system imbalance for the next quarter-hour, considering all the implicit reactions that are allowed and encouraged until the end of this quarter-hour. Since these implicit reactions depend on the price signal, ELIA will inevitably need to compute a first forecast of the real-time price at the moment it calculates its mFRR demand in scheduled activation (for instance 13 minutes before the concerned quarter-hour, at T-13).

ELIA's objective is to define the mFRR SA demand and the RTP forecast that balance the system using the cheapest available resources (possibly under additional constraints, for instance if impact on congestions or on balancing capacity costs are taken into account).

For the sake of simplicity, this exercise will first be explained and illustrated in a local situation (i.e. before the connection to the EU balancing platforms). Besides, for the sake of clarity, the example on Figure 18 considers that the system is a copper plate and does not take any impact on balancing capacity costs into account. Under these assumptions, and as explained in 1.3, the most efficient real-time equilibrium can be found by intersecting the supply curve of balancing energy (made of balancing energy bids) and the BRP sensitivity curve, after shifting this curve to the expected disturbance (i.e. the expected ACE if no balancing explicit or implicit actions are undertaken). The abscissa of this real-time equilibrium then defines the mFRR volume to be activated through the SA process, while the ordinate of this equilibrium defines the real-time price forecast (relatively to the price of the last market equilibrium reached at the end of the wholesale markets).

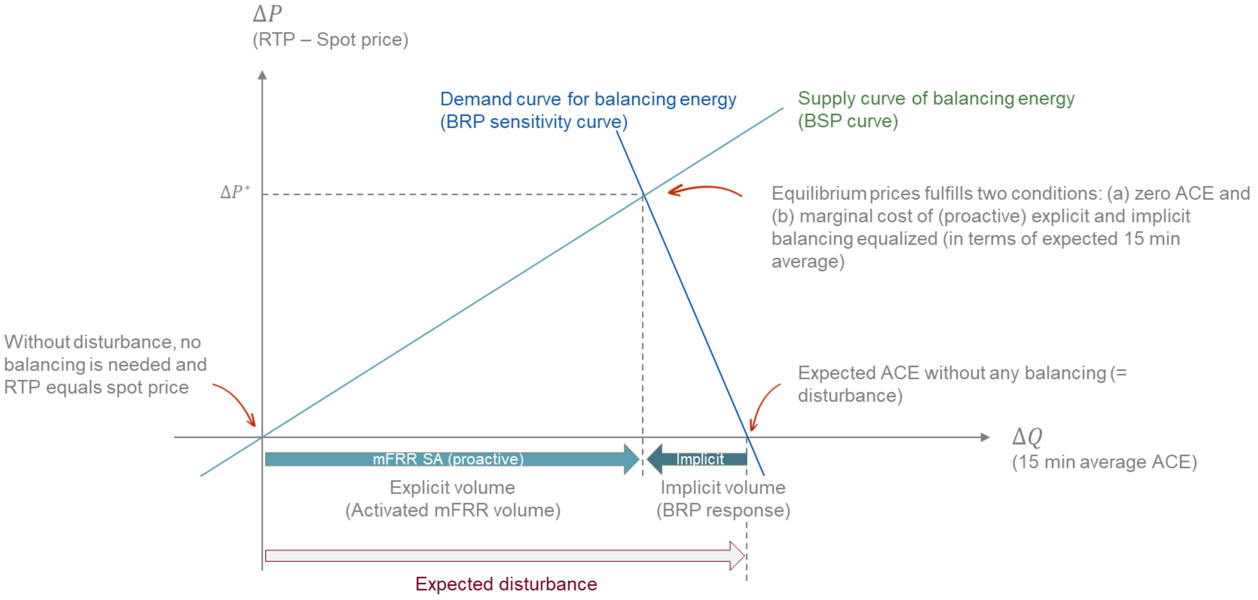


Figure 18 - most efficient real-time equilibrium calculated at T-13, defining the mFRR volume to be activated in SA and the RTP forecast

Note that the simplified example of Figure 18 considers that both the supply and the demand curves are continuous and differentiable functions, without indivisibilities. This is of course not the case of 'real-life' curves (at least for the supply part). The implications of dealing with 'real-life' curves will be explained and addressed in section 5.

Of course, the forecasts used to define this real-time equilibrium at T-13 will always entail errors and additional disturbances (such as a forced outage occurring within the ISP) can never be excluded. This will cause a deviation from the real-time equilibrium that was expected at T-13: the BRP sensitivity curve is, again, shifted to reflect the additional disturbance and the new intersection between this BRP curve and the supply curve sets the new expected real-time equilibrium. This new equilibrium defines the impact of the additional disturbance on both the FRR volumes to be activated and the expected RTP.

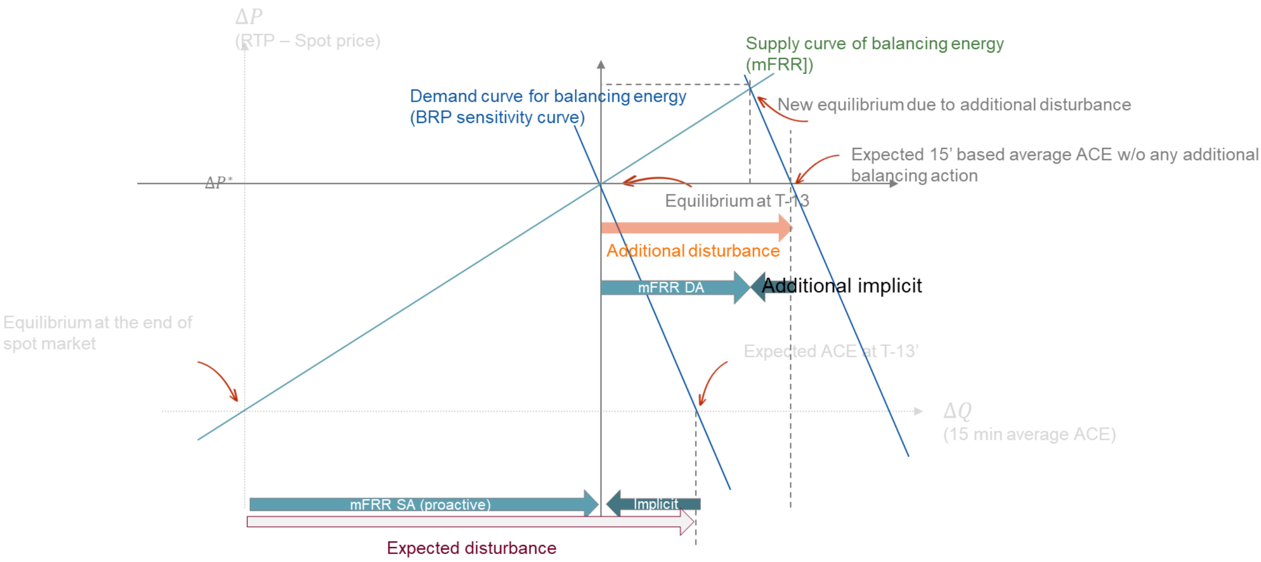


Figure 19 – Deviation from the last real-time equilibrium (calculated at T-13) due to forecast errors/additional disturbance

According to the magnitude of the forecast errors/the additional disturbances, the additional FRR volume required might be activated in mFRR or aFRR :

- in case of an important disturbance which is not expected to be solved by the end of the ISP, mFRR might be activated through the direct activation process within the ISP (this is the case illustrated on Figure 19);
- if the disturbance is small and/or non-persisting, automatic FRR activations will be used to cover the residual system imbalance (this is the case illustrated on Figure 20).

Besides, the forecast of the real-time price is updated to stimulate the adequate implicit reaction that perfectly complements the explicit activations in order to cover the new expected 15 minutes based average ACE.

ELIA has in mind to recompute the expected real-time equilibrium on a one-minute basis, based on updated forecasts of the 15 minutes based imbalance situation. This would allow ELIA to publish regular updates of the real-time price forecasts, until the end of the ISP where it would then converge towards the settlement price.

Note that if a large forced outage (e.g. loss of an industrial site consuming 200MW) occurs at the very end of the quarter-hour (e.g. 30 seconds before the end of the ISP), the impact on the real-time price will be quite limited. The expected 15 minutes based average ACE would then only change by a few MW which would barely affect the real-time equilibrium. This is consistent with the fact that the real-time price aims at stimulating implicit reactions on a quarter-hourly basis and not at triggering aFRR-like implicit reactions in the system. It would hence be inappropriate and unfair to still largely impact the real-time price at the very end of the quarter-hour, when most BRPs no longer have the means to significantly adapt their (15 minutes-based average) position.

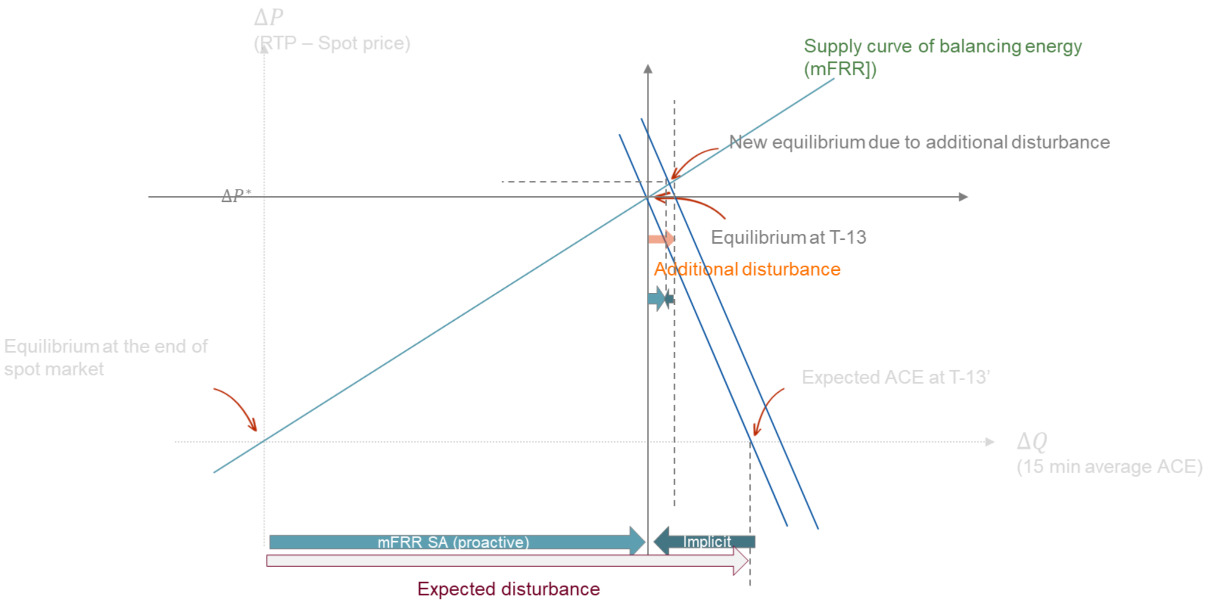


Figure 20 – Limited impact on real-time equilibrium of a force outage occurring just before the end of the ISP

With this approach, ELIA hopes to provide a much more stable and accessible price signal to the BRPs than with its current imbalance price publications. The exact and detailed design of these real-time price forecasts needs to be thoroughly analyzed and discussed with the stakeholders and will be the object of a next design note.

Note that the discussions about the price formula and the price forecasts are strongly interlinked : for instance, the decision whether to take the aFRR prices into account in the price formation will directly influence the supply curve to take into account when computing the real-time equilibrium. This is the reason why these discussions will be gathered in a next design note.

5 Design integration and challenges

To balance the system in the most efficient way, where implicit reaction perfectly complements explicit activations, Elia intends to develop a Smart Balancing Controller (SBC). The objective of the smart balancing controller is to find the most efficient real-time equilibrium, as defined in section 41.3, by calculating the two following outputs:

- A proposal for the local TSO demand for mFRR Balancing Energy;
- A forecast of the real-time price

Note that ELIA's national control center has not waited for this tool to try and balance the grid in the most efficient way. Already today, when activating mFRR balancing energy, the dispatcher tries to anticipate the volume of price based reaction that will automatically be stimulated by the imbalance price rise that results from the mFRR activations. When facing a balancing disturbance such as a forced outage, the dispatcher does therefore usually not cover the full volume of the disturbance with mFRR activations because it relies on a certain volume of implicit reactions, which, as presented during WG CCMD of 14th November 2023, already exist today.

However, considering the fact that :

- The 'demand curve' of the BRP (reflecting the elasticity of BRP imbalances) will become more and more dynamic in the future (e.g. due to EVs that would be massively available during the night and barely available during home/work commutes);
- The 'supply curve' of the BSP will become integrated at European level;
- The decision regarding the mFRR volume to be activated in Scheduled Activation will need to be made much earlier than today (around T-13);

A decision-making tool is deemed necessary to continue balance the grid with the same efficiency.

As explained above, the output of this tool will furthermore allow ELIA to publish real-time price forecasts before and throughout the ISP.

5.1 The algorithm and building blocks of the SBC

To fix the ideas, a proposal of the algorithm that might be used to implement the smart balancing controller is depicted on Figure 21 (the example assumes a purely local balancing market under copper-plate conditions for the sake of visual illustration clarity).

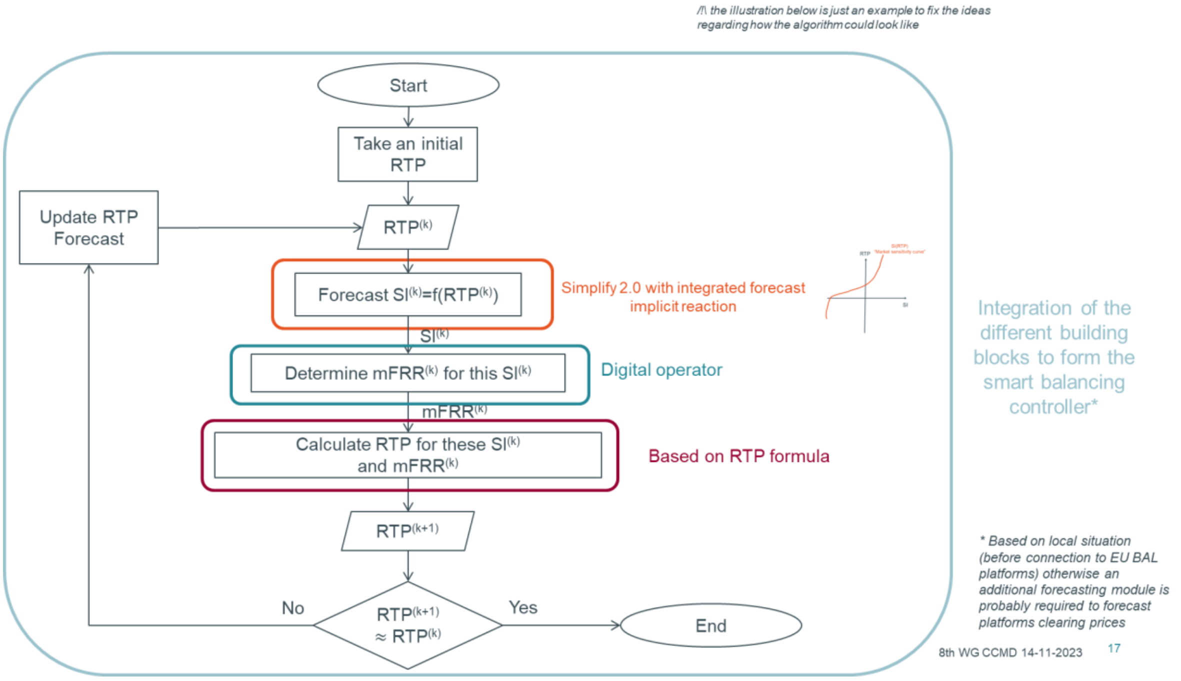
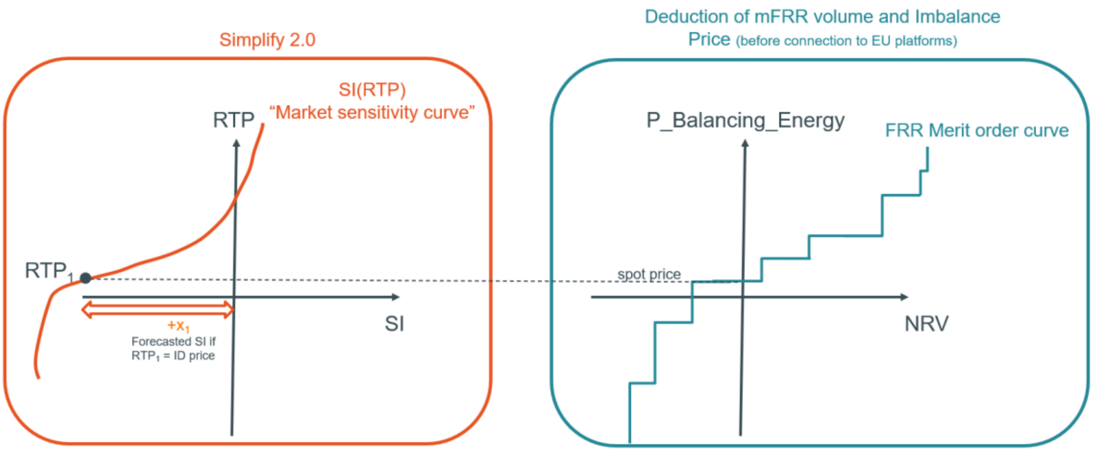


Figure 21 – Example of smart balancing controller implementation

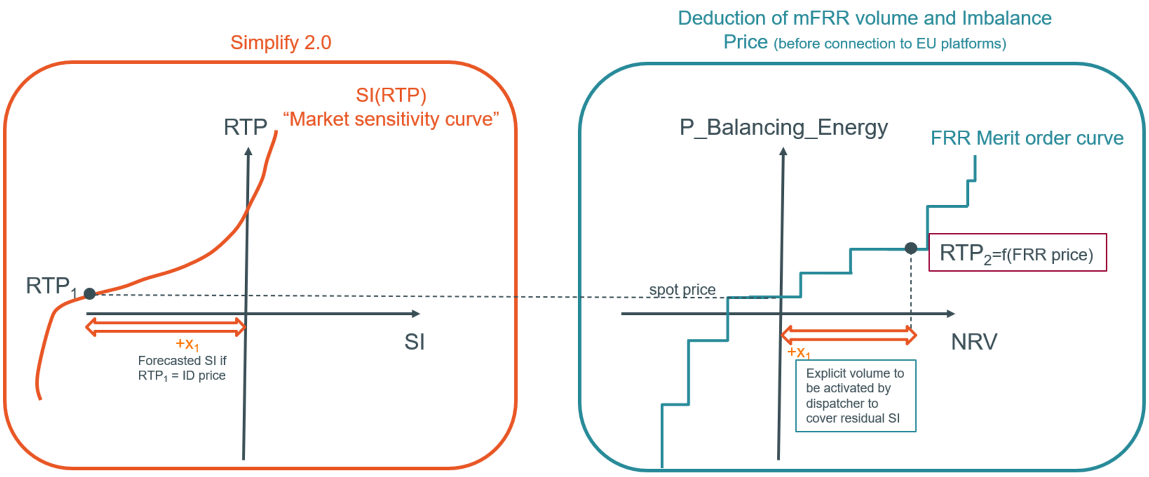
The smart balancing controller could be implemented as a loop that is first entered with a real-time price 'RTP1' which is close to the price of the last market equilibrium reached at the end of the wholesale markets.

Under this price condition, the forecaster of System Imbalance (ELIA's Simplify tool of which the first version is already live since 2022[6]) calculates a system imbalance equals to 'x1' (in this case, no additional implicit reaction is expected in real-time since the RTP is equal to the price of the last market equilibrium, and x1 is therefore equal to the expected real-time disturbance/forecast error).

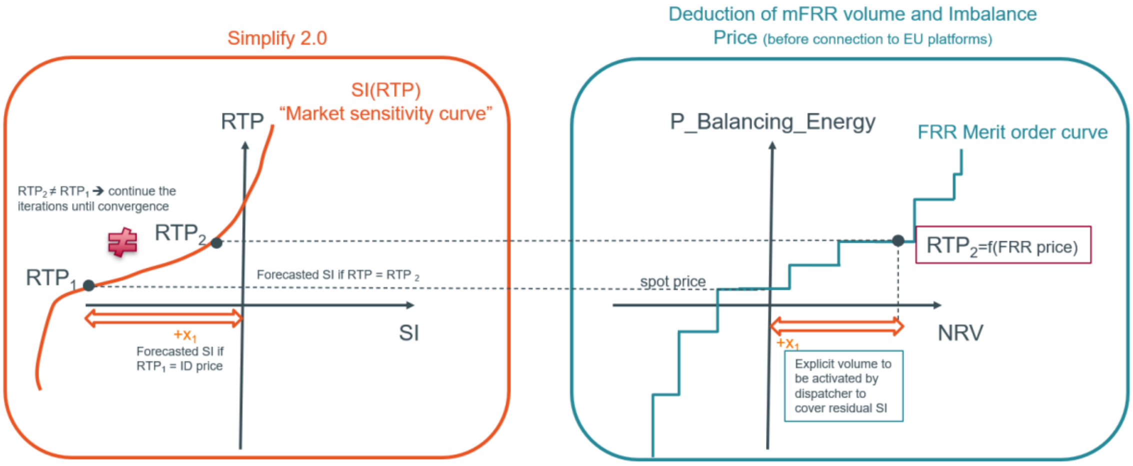
[6] System imbalance forecasts (elia.be)



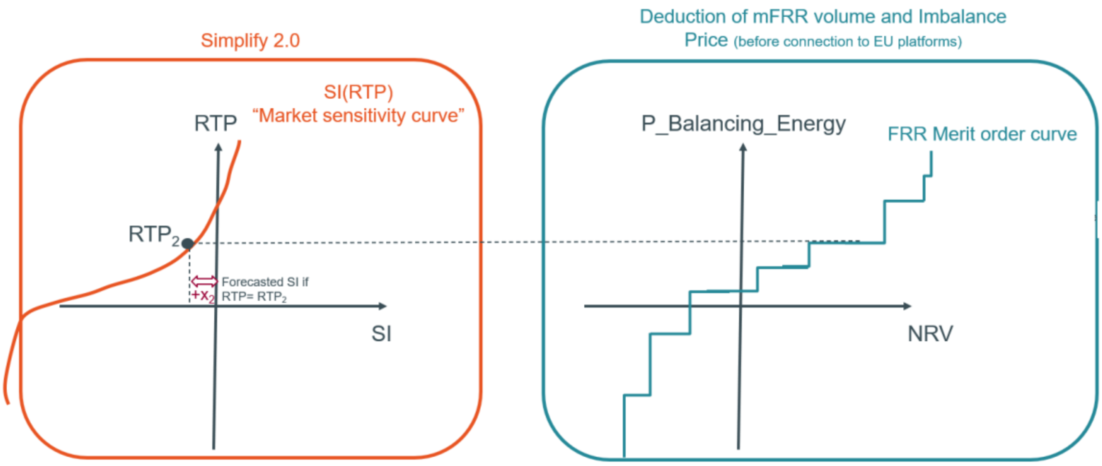
This volume 'x1' therefore needs to be entirely covered by explicit activations, resulting in a new real-time price 'RTP2' (according to the real-time price formula).



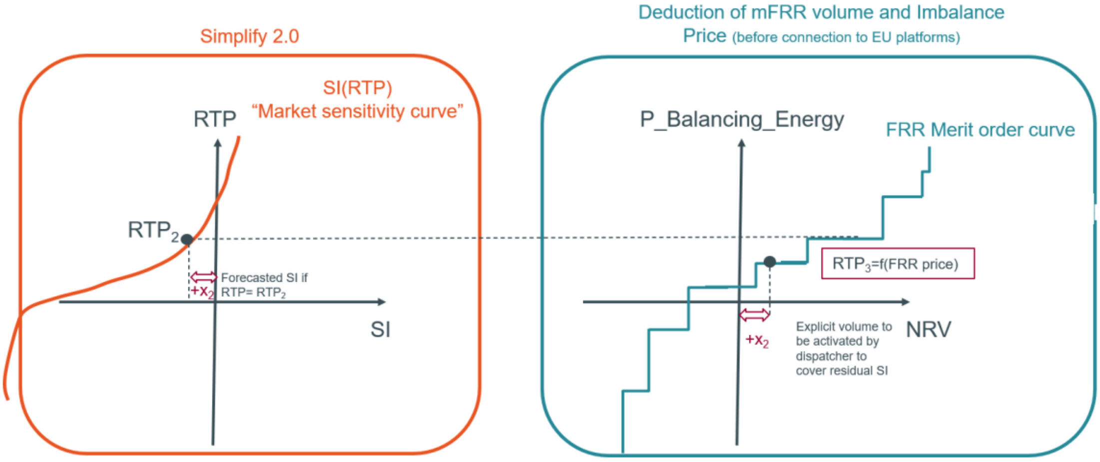
Since 'RTP2' and 'RTP1' are different, the smart balancing controller loop has not converged yet, and the loop is entered again with a new RTP value, for instance equal to 'RTP2'.



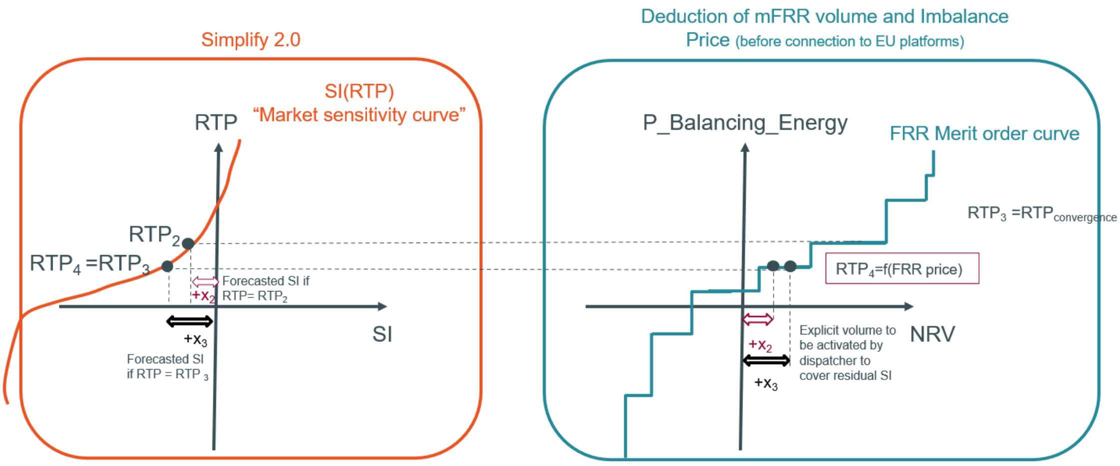
This time, 'RTP2' differs from the price of the market equilibrium reached at the end of the wholesale markets, meaning that the System Imbalance forecaster needs to account for an implicit reaction from the market to compute the residual system imbalance 'x2'. 'x2' is smaller (in absolute terms) than 'x1' because the higher 'RTP2' has stimulated a market implicit reaction that partially covers the expected disturbance.



Again, this forecasted residual system imbalance 'x2' needs to be exclusively covered by FRR activations, leading to a new RTP equal to 'RTP3'.

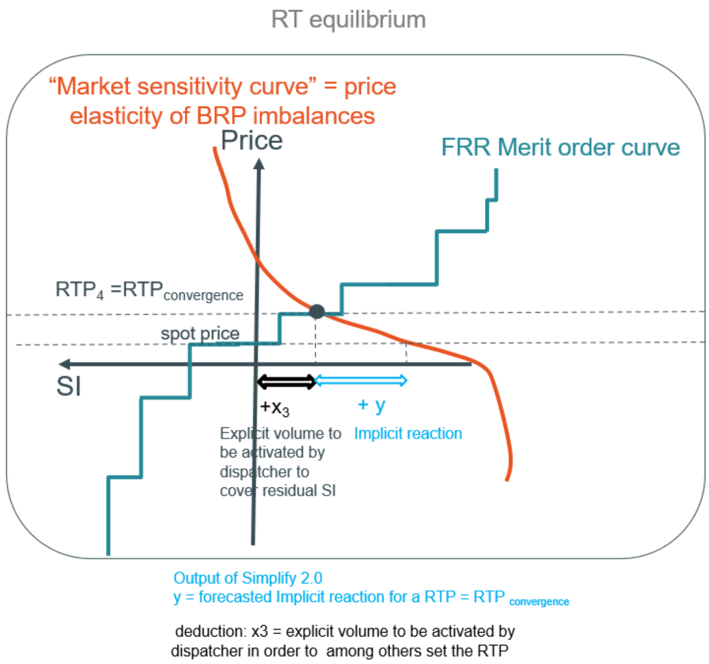


'RTP3' being different from 'RTP2' a third iteration of the loop occurs, leading to a volume 'x3' to be activated explicitly and hence to a real-time price 'RTP4' which, this time, is equal to 'RTP3'.



This means that the algorithm of the smart balancing controller converged and that :

- The volume to be activated explicitly is equal to 'x3';
- Whereas the real-time price forecast is equal to 'RTP4'.



5.2 Identified design and implementation challenges

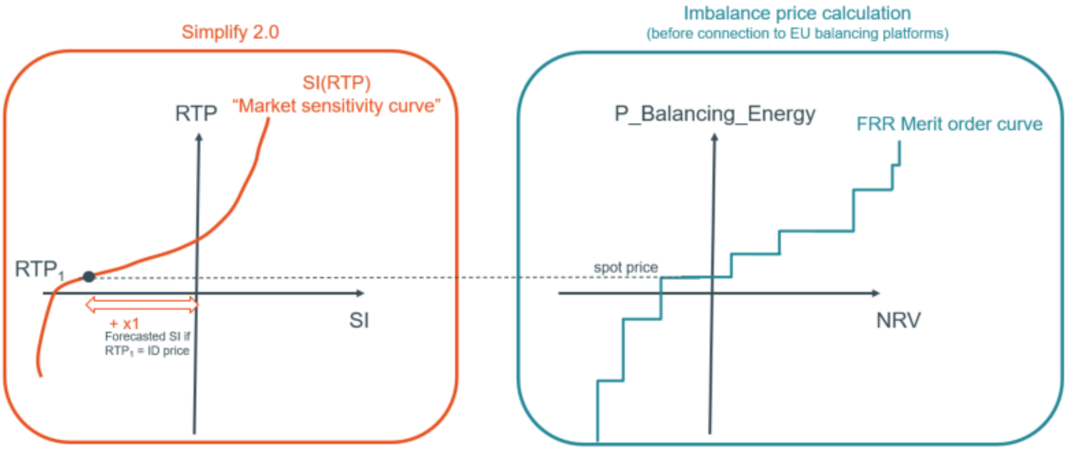
Of course, the development of such a decision-making tool is ambitious and entails many challenges. However, ELIA believes that any additional support that the dispatcher and the market receive to efficiently balance the grid will be precious (especially considering the growing complexity of the system) and that any incremental step in the direction of the 'real-time price' vision will hence be beneficial, even if forecasts will never be perfect for all the quarter-hours, and even if the journey towards the final vision takes time.

With full transparency, the list of the challenges and remaining open design questions already identified by ELIA will be explained in this chapter. These challenges and remaining open questions will serve as starting point for the next design notes of this series, so ELIA invites the market participants to raise any additional concern/question they would have identified when answering the public consultation of this first design note.

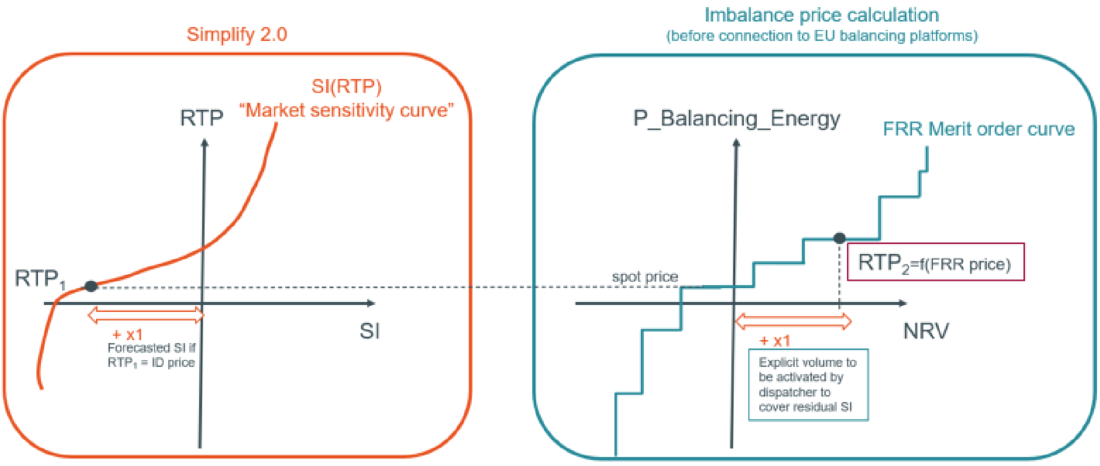
5.2.1 SBC convergence and price decorrelation

As explained in section 4.2, the fact that the 'real-life' supply and demand curve are not necessarily differentiable and entail indivisibilities have consequences on the real-time equilibrium and SBC convergence.

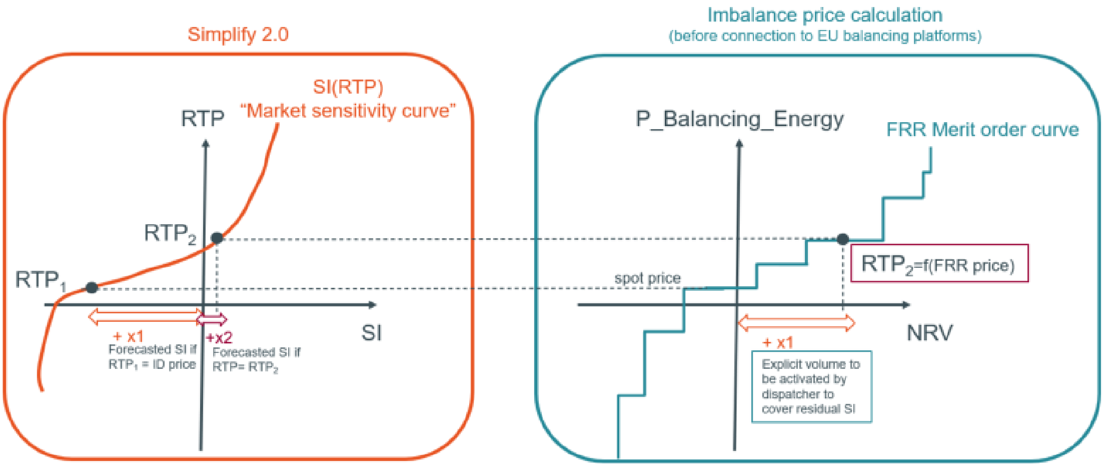
A simple example considering a 'stepped' supply curve illustrates these consequences. Again, the SBC is entered with 'RTP1' equal to the price of the last market equilibrium. Under this assumption, Simplify forecasts a system imbalance equal to 'x1'.



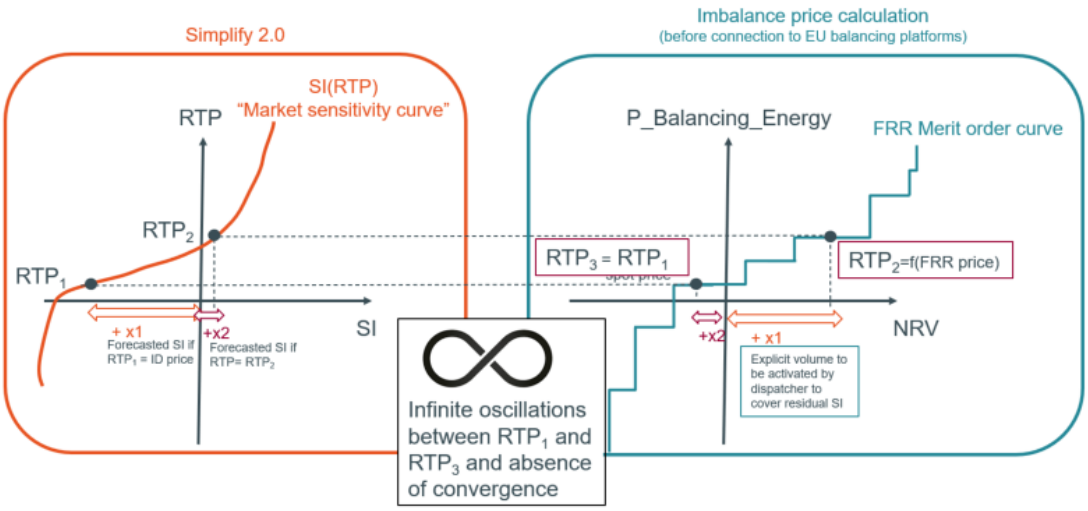
This system imbalance needs to be entirely covered by explicit activations, leading to a new RTP equal to 'RTP2'.



This new RTP being higher than the price of the last market equilibrium, it stimulates an implicit reaction that makes the system slightly switch in the other direction, leading to a positive residual system imbalance 'x2'.

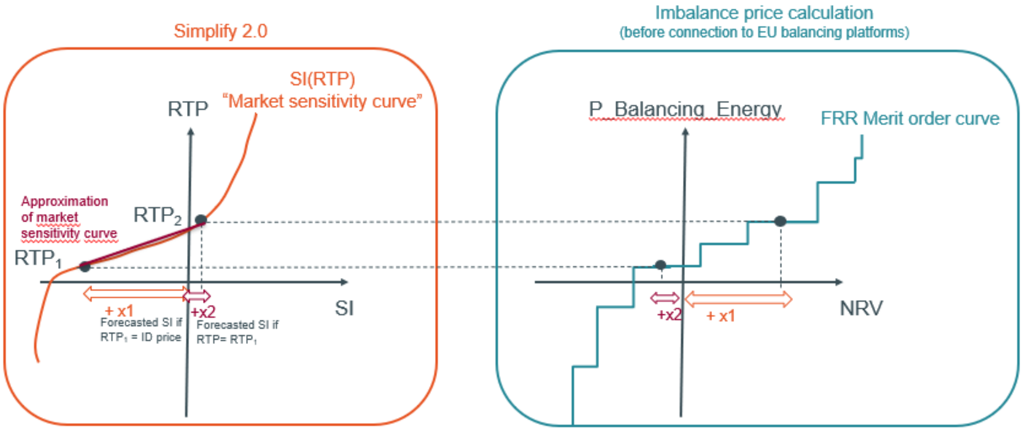


This residual system imbalance is covered by explicit activations of downward bids offered at the price of the last market equilibrium ('spot price'), resulting in a new RTP which is again equal to 'RTP1'.

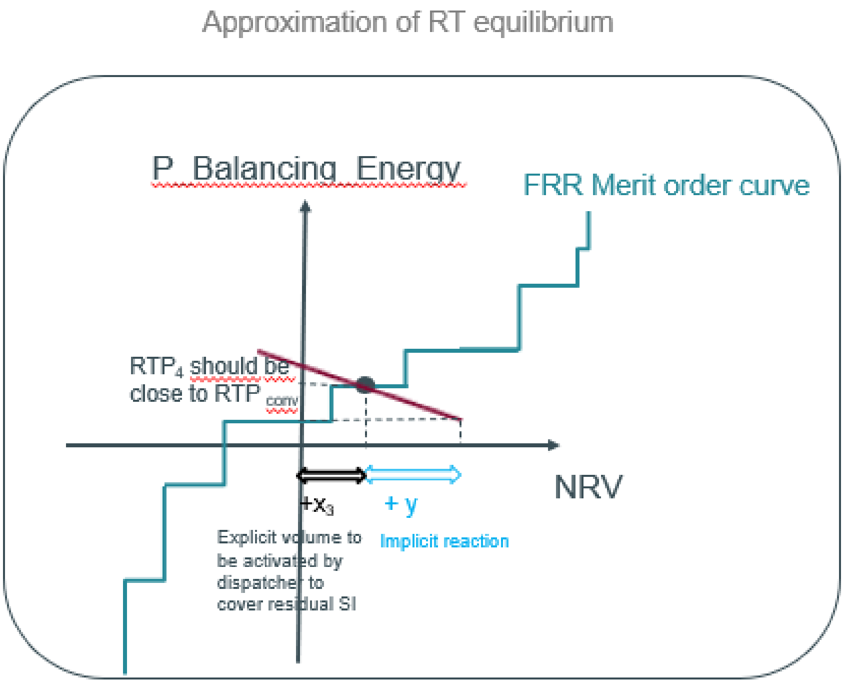


If the loop was not broken with additional conditions (for instance based on the maximum number of iterations), this situation would create infinite oscillations between 'RTP1' and 'RTP3' and no convergence would be reached.

To solve this convergence issue, different solutions exist. One of them consists in approximating the 'demand curve' with a linear interpolation between the two points (x1, RTP1) and (x2, RTP2) of the oscillations.



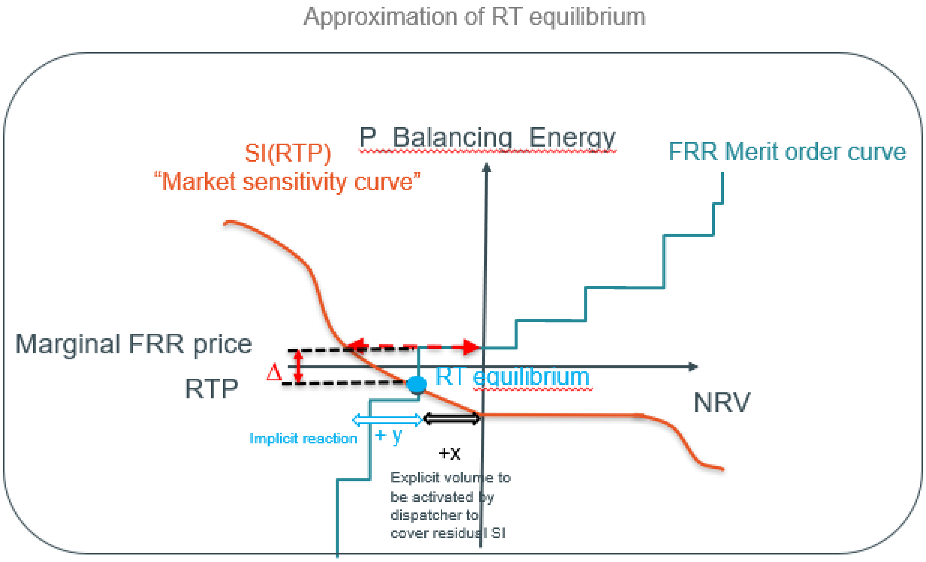
The intersection between this linear interpolation of the 'demand curve' and the supply curve, defined by (x3, RTP4), should then be close to the real-time equilibrium.



And the loop of the SBC can then be re-entered with 'RTP4' as initial input to make the algorithm converge.

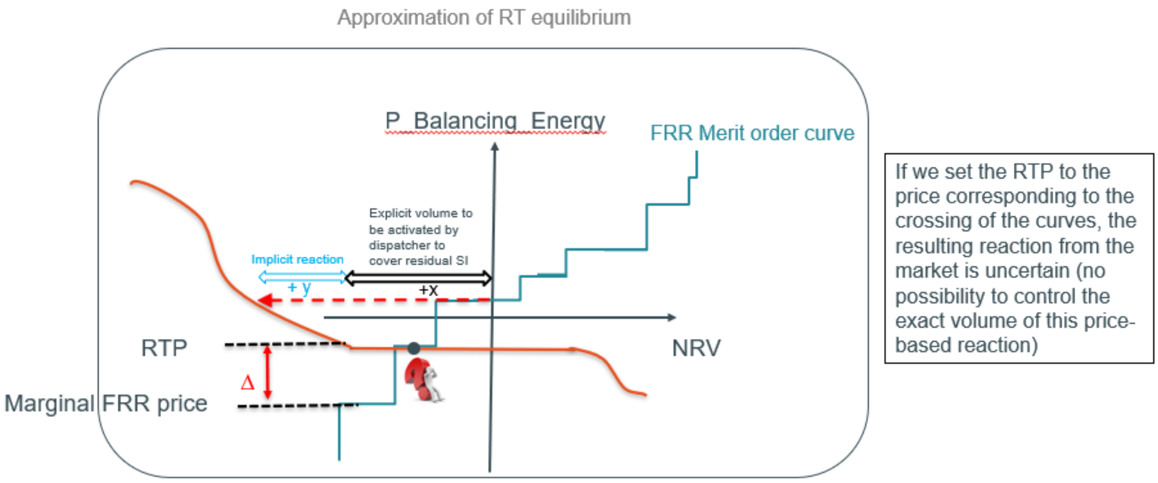
Other situations can make the convergence of the SBC challenging:

- When the 'supply' and 'demand' curves cross each other in a vertical step of the supply curve:



At that moment, the most efficient way to balance the system consists in fully activating the explicit bids up to (and including) the one just before the vertical step of the intersection, and to set the real-time price to the price of the intersection. This creates a slight deviation of the real-time price from the marginal price of the activated FRR bids. This possible decorrelation between the RTP and the marginal FRR price needs to be taken into account in the convergence criteria, and in the algorithm of the SBC.

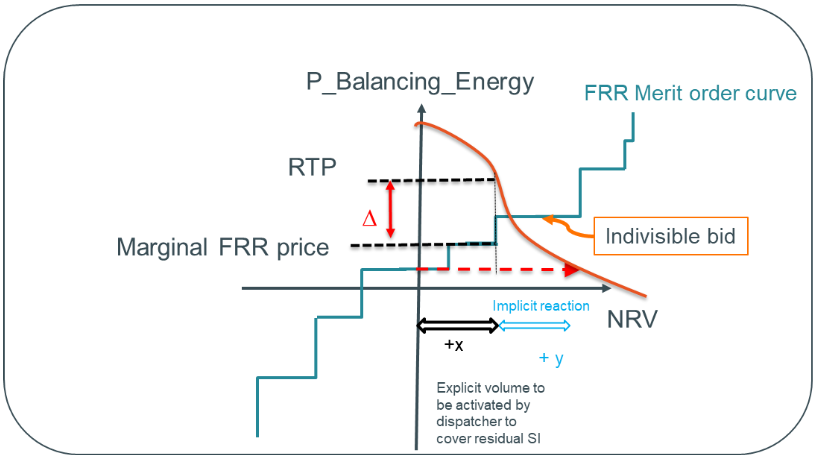
- When the 'supply' and 'demand' curves cross each other in a large horizontal step of the 'demand curve' (for instance due to lots of assets from a same technology presenting similar reactions to the price signal):



At that moment, an efficient way to balance the system could (for instance) consist in limiting the RTP to a price that does not stimulate the large amount of flexibility reacting to the same price signal, and to cover the residual imbalance by activating more explicit flexibility for which the operator has perfect control on the volume. This, again, creates a slight deviation of the real-time price from the marginal price of the activated FRR bids. This possible decorrelation between the RTP and the marginal FRR price needs to be taken into account in the convergence criteria, and in the algorithm of the SBC.

- In case of explicit bid indivisibility

Approximation of RT equilibrium



At that moment, an efficient way to balance the system could (for instance) consist in not activating the indivisible bid in which the two curves cross each other, and to stimulate more implicit reaction to the RTP. This, again, creates a slight deviation of the real-time price from the marginal price of the activated FRR bids. This possible decorrelation between the RTP and the marginal FRR price needs to be taken into account in the convergence criteria, and in the algorithm of the SBC.

Note that all these situations justify a slight decorrelation between the real-time price and the marginal price of the activated FRR, in order to allow a finer regulation of the system balance (and avoid possibly large over- or undershoots).

5.2.2 System Imbalance sensitivity to the RTP

In order for the smart balancing controller to converge, a System Imbalance forecaster that accounts for the expected implicit reaction of the market until the end or the quarter-hour needs to be developed. ELIA identifies a challenge in the development of this building block of the SBC. Indeed, we need to express the System Imbalance as a function of the RTP, but the RTP in turn depends on the activated balancing energy which is directly linked to the System Imbalance. The system imbalance and the real-time price are hence strongly dependent, which can lead to endogeneity bias.

Another way to look at this problem is from a 'data' perspective. Since the measured system imbalance is the result of both balancing events (e.g. forecast errors, forced outage, etc. that cause the problem) and market implicit reactions (that help solving the problem), it means that we only have one metric available in our model that mixes two opposing effects (i.e. the cause and the solution to imbalances). This makes it challenging for the model to learn the right causal effect: a higher RTP is the consequence of a 'higher problem', but at the same time it is the trigger of a 'larger implicit reaction' (part of the solution to the problem). So in the end, how can the model identify and learn the exact impact of price on implicit reactions?

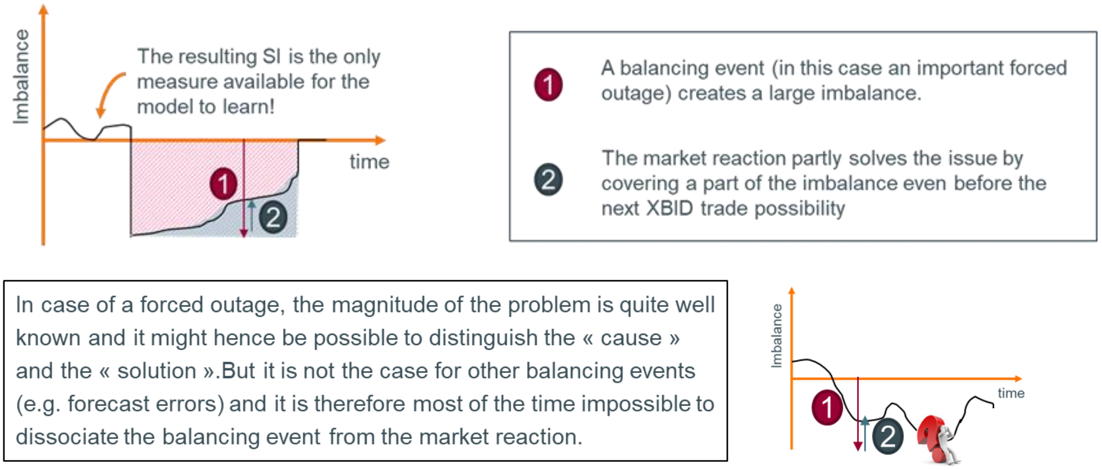


Figure 22 – illustration that the SI results from two opposing effects that are difficult or even impossible to distinguish

ELIA is currently investigating several options to address this endogeneity problem.

5.2.3 System Imbalance forecast accuracy

The accuracy of the System Imbalance forecaster will of course play a key role in the performance of the Smart Balancing Controller. As explained previously, forecast errors will always remain unavoidable and they should certainly not prevent the go-live and use of the smart balancing controller. However, a minimum level of reliability of the SI forecaster is of course required for the smart balancing controller to prove value. ELIA has been continuously (and will continue) working on the improvement of Simplify's accuracy, with promising results.

5.2.4 Open design questions

On top of these challenges related to the implementation of the smart balancing controller, some design questions still need to be addressed in the next design notes. ELIA has already identified some of these questions below and the market participants are of course very welcome to raise additional questions in their answers to the public consultation.

- The impact of the connection to the EU Balancing platforms on both the RTP formula and the working of the smart balancing controller needs to be assessed, and the design should be adapted where needed;

- The way the real-time price equilibrium will/should be impacted by congestion management schemes or reserve dimensioning methodology should be assessed;

- The impact of the proposed design on the BRP costs and balancing margin should be examined;

- The 're-runs' of the smart balancing controller after the first run (at T-13) that aims at defining the mFRR volume to be activated in SA should be further analyzed. In particular:
    - the link between the System Imbalance forecast and the dynamic of the implicit reaction should be assessed: when running the smart balancing controller at T+10, we cannot expect the same 15-minutes based average implicit reaction as in T-13

- the link between FRR activations and RTP should be further developed in the discussion around the RTP formula

- A legal assessment of the design proposal should occur, possibly identifying legal adjustments that would be required to make the proposal legally compliant;

- Etc.

6 Conclusion & next steps

This first RTP design note summarizes the key design features presented to market parties in 2023 in Working Groups CCMD. It focuses on the rationale for imbalance price evolutions and provides first insights regarding the concrete improvements that ELIA has in mind. The document is now proposed for public consultation with market parties, with the deadline to answer set to 9th February 2023.

ELIA intends to present an overview of received reactions and alternative design proposals (whenever relevant) during one next Working Group CCMD in 2024. In parallel, bilateral discussions may be organized with stakeholders to further clarify received feedback and/or approach specific design problematic.

Besides, presentations and discussions will also go on regarding the challenges and open design questions listed in section 5. This document will then be followed by other design notes that, together, will provide the complete view of the design envisaged by ELIA for the future real-time price and its related publication.