STUDY ON PUBLICATION OF PRICE INFORMATION FOR BALANCING MARKETS CLOSE TO REAL TIME

Energiforsk

Foreword

Europe's electricity markets are undergoing rapid change, driven by new balancing rules, shorter settlement periods, and the accelerating integration of renewable energy. In Sweden, these developments have significantly increased price volatility and exposed market participants to new forms of risk.

This report examines how recent regulatory and market changes affect balance responsible parties and the incentives they face. It highlights the growing importance of predictable, interpretable price signals, sufficient intraday liquidity, and timely information for enabling market-based flexibility. Drawing on international experience and the Swedish context, the report aims to contribute to a more informed discussion on how balancing markets can evolve to support system stability without imposing disproportionate risks on market participants.

Energiforsk would like to express its appreciation to the authors of this report: Ksenia Tolstrup, Carlos Úbeda, and Bob Hebb at Magnus Energy. The report authors are responsible for the content of the report.

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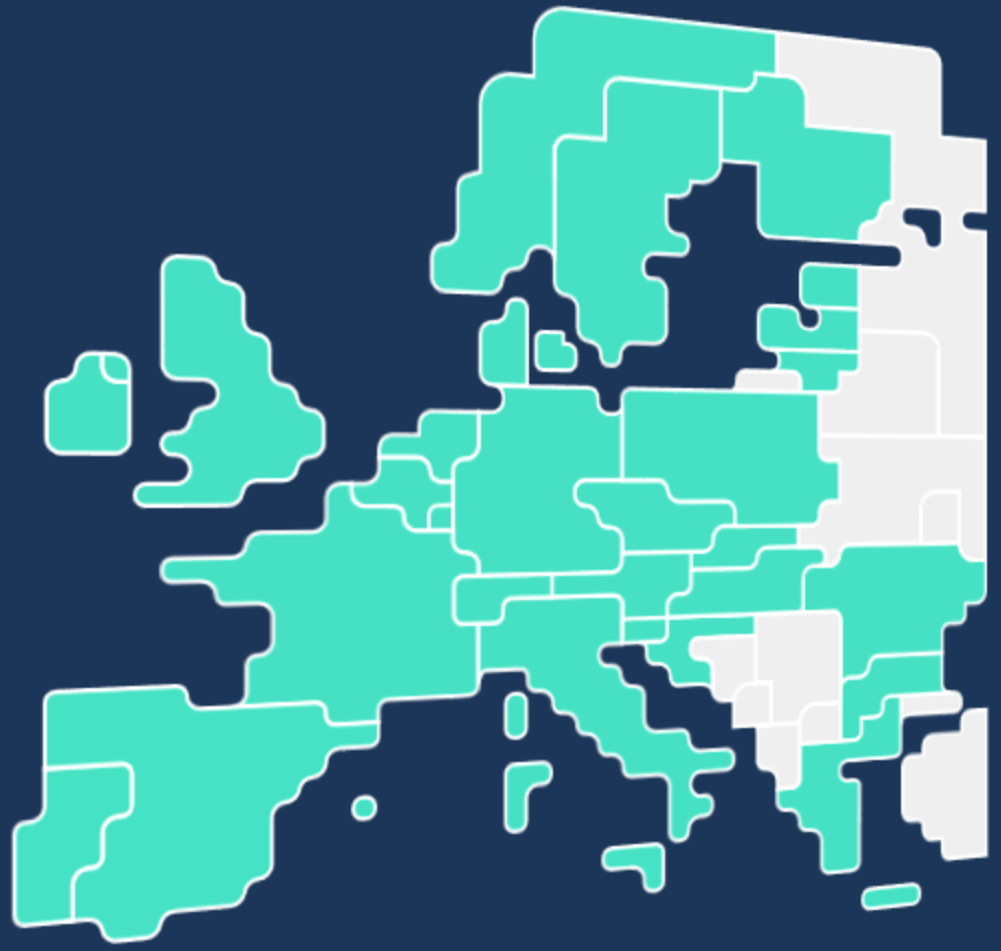
MAGNUS energy

Study on passive balancing and publication of price information close to real time

Report commissioned by Energiforsk



December, 2025

Authors: Ksenia Tolstrup, Carlos Úbeda, Bob Hebb

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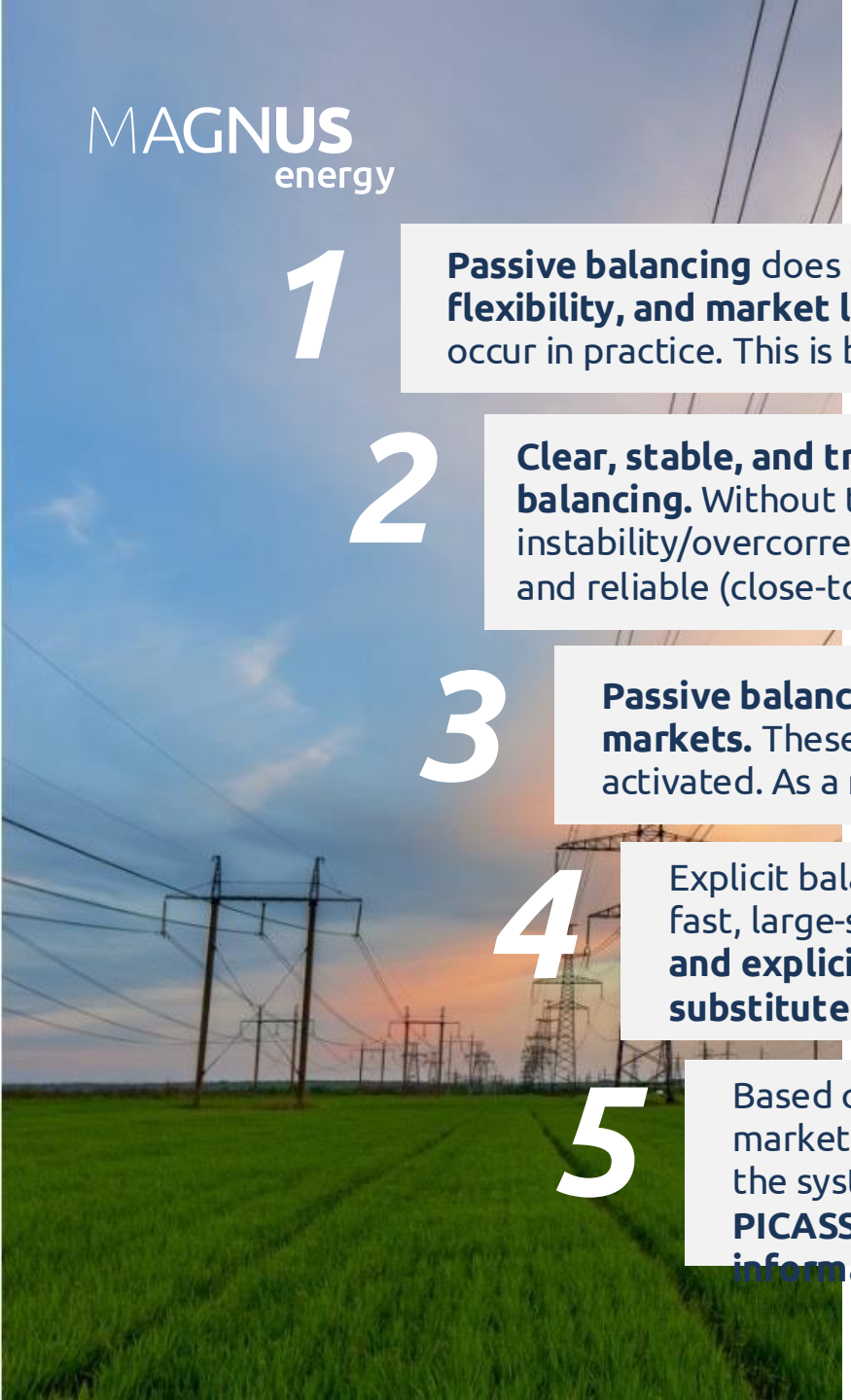

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1 **Passive balancing** does not occur on a yes/no basis, but **depends on price exposure, asset flexibility, and market liquidity**. Even when passive reactions are legally prohibited, they still occur in practice. This is because imbalance prices **inevitably create incentives for market actors.**

2 **Clear, stable, and transparent imbalance prices are a prerequisite for effective passive balancing.** Without them, price-based reactions may become inefficient or create system instability/overcorrections. Passive balancing can therefore be supported through timely and reliable (close-to-)real-time data publications – especially for smaller BRPs.

3 **Passive balancing enables flexibility from assets that cannot participate in explicit balancing markets.** These, often cheaper resources can respond before expensive balancing reserves are activated. As a result, more system flexibility is captured and total balancing costs can be reduced.

4 Explicit balancing provides reliability, predictability, and precise control for the TSO. It is essential for fast, large-scale, and security-critical balancing actions. Experience of other areas shows that **passive and explicit balancing deliver best results if deliberately designed to *complement* rather than substitute each other.**

5 Based on the experience of other analyzed countries, passive balancing can yield beneifts for both market parties and the TSO. Going forward, however, the possibility to passively balance and support the system will depend on **the upcoming balancing market evolutions (esp. accessions to PICASSO & MARI), which may limit the predictability and interpretability of local imbalance information.**

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1. Context & framework

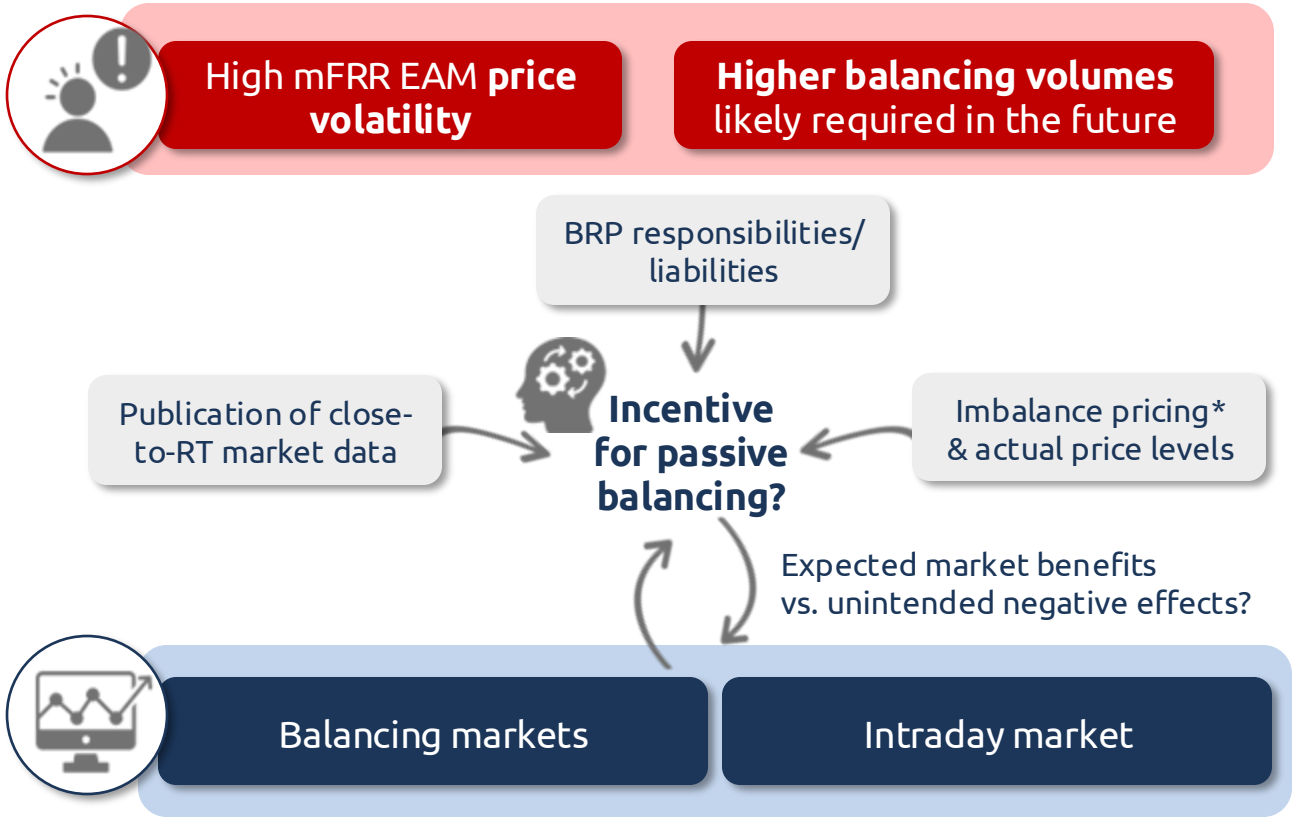
- **Foundations of imbalance settlement**
- **Regulatory context**
- **TSO balancing philosophies**

Context & framework of the study | Swedish stakeholders recently proposed that that Svenska kraftnät should consider publication of market information close to real time.

The Swedish Electricity Market Inquiry has proposed that Svenska kraftnät publish market information closer to real time, following high price volatility in the Nordic mFRR Energy Activation Market since its March 2025 launch and rising balancing needs. While full integration of resources into the balancing market is the long-term goal, this remains difficult for smaller players. Near real-time data availability and self- or passive balancing could potentially offer tangible system benefits by allowing participants to respond more effectively to system needs without being formally integrated into balancing market operations.

Key question: How current balancing market challenges in Sweden can be best addressed and could passive balancing* be part of the solution?

This study reviews how similar practices are applied in other markets, expected behavioural changes among participants, and the potential benefits of passive balancing, including more flexibility, lower costs, and higher system efficiency. It also considers downsides such as risks of overreaction in self-balancing and difficulties managing network bottlenecks, to ensure that greater transparency is introduced in an effective and secure way.



*** Passive balancing** = allowing BRPs to deviate from an own balanced portfolio position to support balancing of the system

The ultimate goal of this study is to generate a common understanding among stakeholders of the implications of real-time price publication and of passive balancing in particular.

Context & framework of the study | Balancing Responsible Party (BRP)

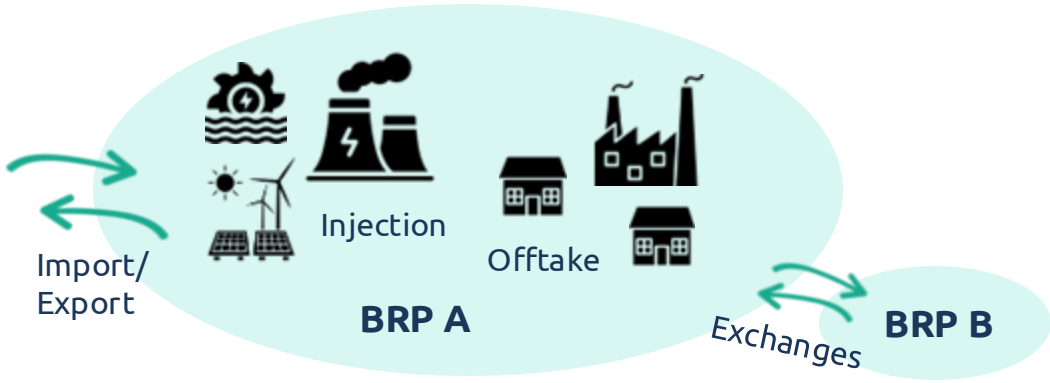
A **Balancing Responsible Party (BRP)** is an entity that is **financially responsible for the balance between the electricity it injects into the grid and the electricity it withdraws** (or consumes), for a specific area or portfolio of assets, over a given period (usually 15 minutes or 1 hour depending on the market).

The Imbalance of a given (BRP) is the quarter-hourly difference between:

- **its total injections** within its balance perimeter, namely: 1) injections at injection points, 2) imports; 3) purchases from other BRPs (HUB and Power Exchange)

&

- **its total offtakes** within its balance perimeter, namely: 1) offtakes at offtake points; 2) exports; 3) sales to other BRPs (HUB and Epex)
- Corrections of activated balancing & congestion bids
- When applicable corrections of activations of independent BSPs



Imbalances are settled **at the imbalance price** based on the cost of activated balancing energy by the TSO to resolve an imbalance in its control area.

Adequate imbalance price signals can give necessary incentives to market parties to fulfill their balancing responsibility by:

- Using DA & ID state-of-the-art forecasts
- Using DA/ID markets to trade flexibility with other BRPs
- Invest in portfolio flexibility
- Being active in the balancing market

Context & framework of the study | Foundations of imbalance pricing in the EU

Objective of imbalance pricing

1. **Incentivise BRPs** to balanced and/or help to restore the system imbalance
2. **Incentivise BSPs** to execute requested control power
3. **Recovery of balancing costs** (balancing margin = Imbalance settlement – activation costs)

Imbalance price setting

The imbalance price is mainly set by the price of activated aFRR & mFRR energy.

Many choices for the exact price setting, e.g. marginal [rice of a 4-second period, weighted average, cap, floor, price adders, …

Principles of imbalance price determination

		System imbalance		*Certain TSOs*
		Positive (system long: generation > demand) → IP >0	**Negative** (system short: generation > demand) → IP < 0	**Both** directions in the **same ISP**
Imbalance position of BRP	Positive (injection **>** scheduled)	BRP receives the downward BE activation price	BRP pays the upward BE activation price to TSO	*System long: BRP pays the **downward** BE activation price System short: TSO pays the **upward** BE activation price*
	Negative (injection **<** scheduled)	BRP pays the downward BE activation price to TSO	BRP receives the downward BE activation price	*System long: TSO pays the **downward** BE activation price System short: BRP pays the **upward** BE activation price*

BSP – balancing service provider; ISP – imbalance settlement period

Context & framework of the study | Regulatory background on imbalance settlement based on key provisions from the EU Electricity Balancing Guideline and the Harmonized Imbalance Settlement Methodology

EBGL (Electricity balancing Guideline)

Applying **single pricing** (one price for pos. & one for neg. imbalances) or *optionally* **dual pricing** (separate positive/negative prices) with clear conditions for regulatory approval and methodology (52(2)(c–d)).

Art. 12(3): Requirement to publish **"the current system balance of its scheduling area(s) as soon as possible but no later than 30 minutes after real-time".**

Art 53(1): Within three years, TSOs must harmonise to a 15-minute ISP aligned with MTU duration. → Sweden introduced 15-ISP in May 2023
Art 55(1–3): TSOs must establish rules to calculate a single imbalance price (IP) (positive, zero, or negative) per settlement period, per imbalance-price area, and per direction, incorporating the value of avoided activation of FRR or RR.

Art 55(4–5):

- The negative-imbalance price must not fall below the weighted average of activated balancing-energy prices (or, if none activated, the avoided-activation value).
- The positive-imbalance price must not exceed the weighted average of activated balancing-energy prices (or, if none, the avoided-activation value).

Art 55(6): If **both** positive and negative balancing energy are activated in one period, **TSOs may choose a bounding principle for each imbalance direction (based on paras. 4-5)**

ISHM (Harmonized Imbalance Settlement Methodology)

Art. 6 (Imbalance calculation): Defines that **imbalance = final position – allocated volume**, indicates surplus (+) or shortage (–)

Art. 7 (Single pricing): Mandates a single IP per ISP and price area, i.e. the same €/MWh applies to both positive and negative deviations.

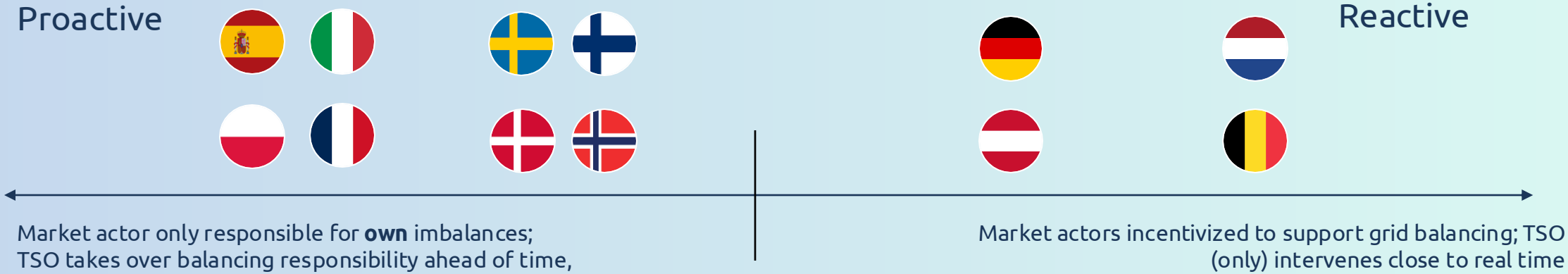
Art. 9 (Price determination): For each ISP, price area and direction, the IP is **set at the *weighted average* of activated balancing-energy prices** *(or, if none activated in that direction, at the "value of avoided activation").*
Art. 9(6) one or several of the following **additional components** may be included in the price calculation:
(a) **a scarcity component** to be used in nationally defined scarcity situations;
(b) **an incentivising component** to be used to fulfil nationally defined boundary conditions;
(c) a component related to the **financial neutrality** of the connecting TSO.

Art. 10 (Value of Avoided Activation): VoAA is the cost that would have been incurred had FRR or RR been activated—serving as **a price bound when no actual activations occur.**

Art. 11 (Dual pricing conditions): Allows TSOs to propose, and NRAs to approve, a dual-pricing regime subject to: clear justification criteria; a published methodology; NRA approval per EBGL Art 37.

Context & framework of the study | Whether or not a BRP is allowed to deviate from a balanced position to support the system is tightly linked to the overall TSO balancing philosophy while its implications and impact on BRP incentives will largely depend on the details of design.

Overview of the balancing philosophies and TSO examples.
Ultimately, they are **distributed on a spectrum** depending on the actual design*



Control objective: minimize imbalance **price**
Imbalance price: focus on cost recovery

Typical outcome: higher TSO balancing volumes (and likely procurement cost)

More compatible with **dual** pricing

Control objective: minimize imbalance **volumes**
Imbalance price; focus on adequate imbalance price signals

Typical outcome: Strong incentives for BRPs to take deliberate imbalanced positions; likely lower imbalances and thus balancing activation volumes but risk of "overreaction"

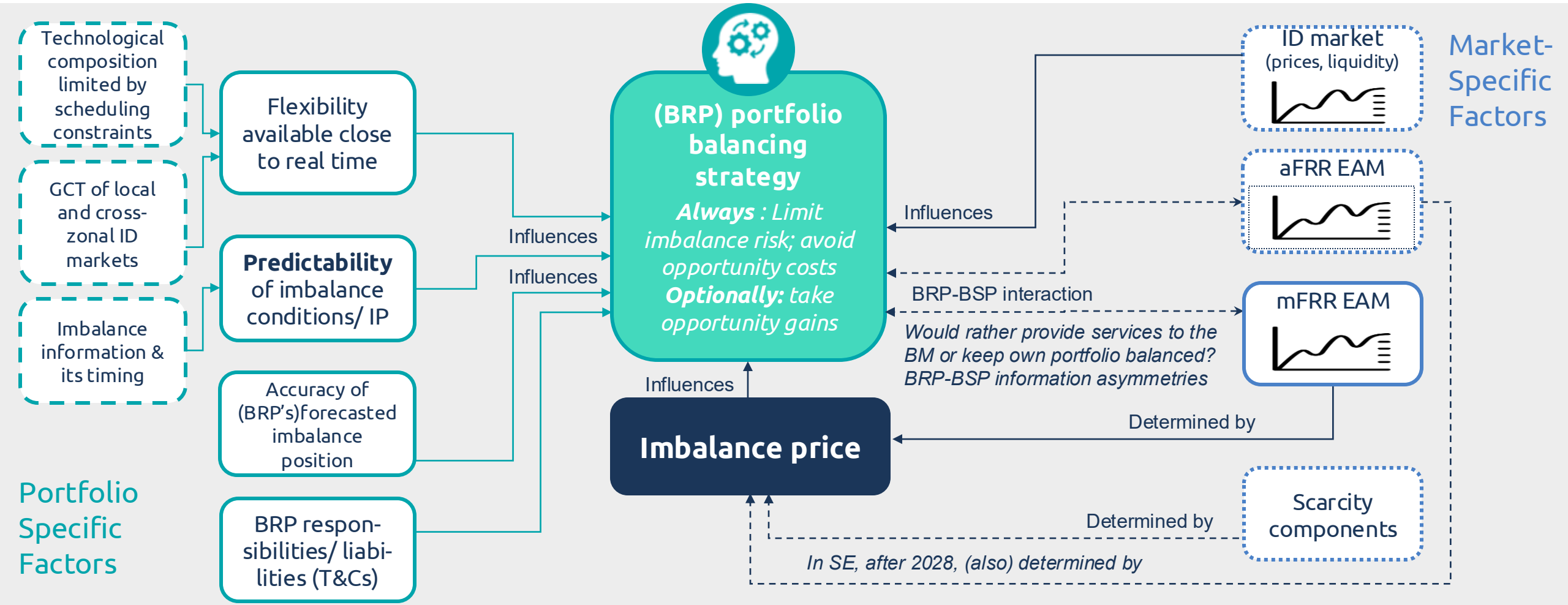
More compatible with **single** pricing

* The degree of TSO reactiveness/proactiveness is illustrative here and *not* meant to show the *exact* position on the spectrumm

2. BRP perspective

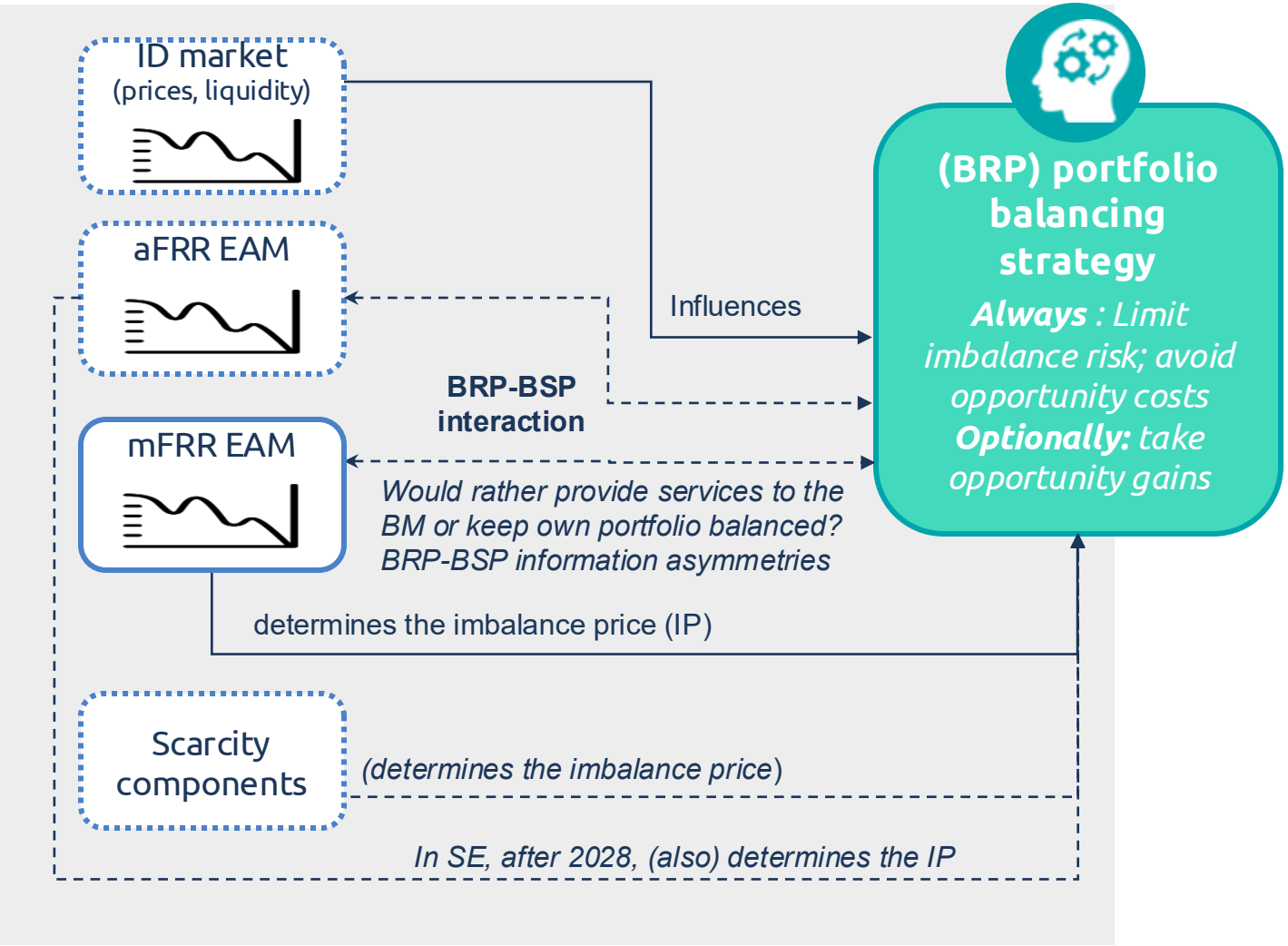
Key incentives for passive balancing

BRP incentives | Beyond the imbalance price itself, a BRP's portfolio balancing strategy is influenced by several portfolio-specific factors and a number of markets affecting imbalance price (IP) formation.



For a BRP, it may make financial sense to deliberately deviate from a balanced portfolio depending on the pricing rule, spread between the IP and trading costs, certainty about imbalance sign (if information available or forecasted)

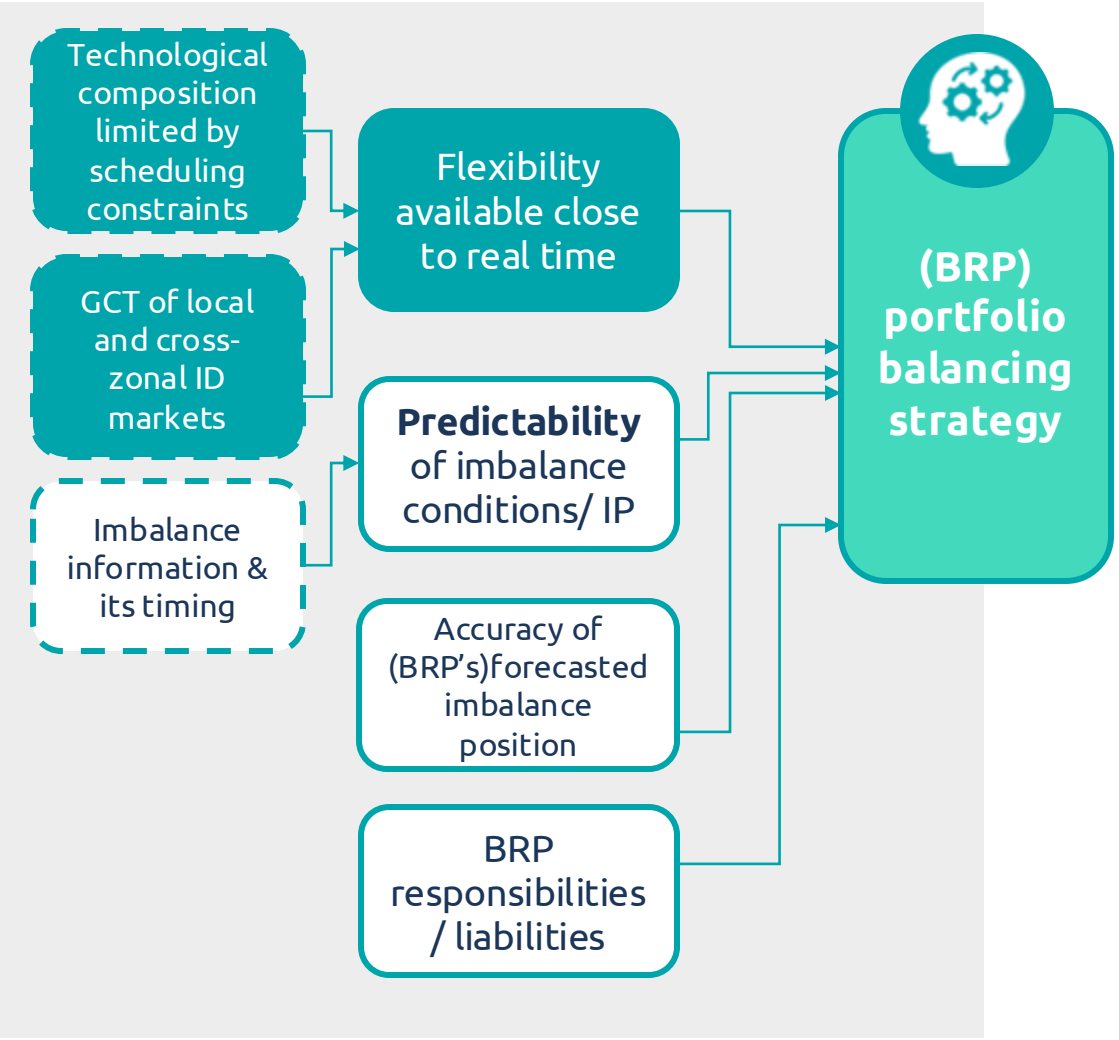
BRP incentives | Beyond the imbalance price itself, a BRP's portfolio balancing strategy is influenced by a number of markets affecting imbalance price (IP) formation.



1. **Product mix & available marketplaces drive BRP strategy optimisation.** BRPs optimise across day-ahead, intraday and multiple balancing products (FCR-N/-D, aFRR, mFRR), choosing between explicit participation in balancing markets and implicit balancing via DA/ID trades based on expected prices and risk spreads.
2. Selling capacity into balancing capacity or DA markets ties up resources; **BRPs allocate volumes where expected net return is highest (or opportunity costs is the lowest),** so market access and timing (GCTs) shape their scheduling strategy.
3. **Intraday liquidity constraints matter.** ID liquidity can be reduced by day-ahead mechanisms (e.g., ID capacity restrictions produced by DA-FBMC in the Nordics), which limits late re-balancing of portfolio position and increases the value of own portfolio flexibility.
4. **Links between BRP & BSP portfolios affect incentives.** Larger BRPs/BSPs or those with many reserve-providing units benefit from better market information and can coordinate across markets, improving optimisation. They may also influence balancing/imbalance prices, yet increasing **internationalisation, cross-zonal platforms and marginal pricing will likely raise the risk** of such strategies, strengthening incentives to minimise exposure to price risk.
5. **The way the IP is calculated (and the components it includes) affects its magnitude and thus BRP strategies.** The lower the IP, the lower the incentive to react to it.

EAM – energy activation market; BSP – balancing service provider, DA – day-ahead, ID- intraday, GCT – gate closure time; FBMC – flow-based market coupling

BRP incentives | Flexibility available close to real time



Key influences of technological portoflio composition:
BRPs with fast, controllable assets (BESS, fast gas turbines, flexible hydro generation) can use imbalance price volatility and either (i) trade proactively on intraday, or (ii) intentionally deviate from the balanced position (if allowed) if settlement favours the profitable side.
BRPs with inflexible portfolios, such as many intermittent RES, have less room to optimise and so stronger incentive to minimise imbalances via conservative scheduling.

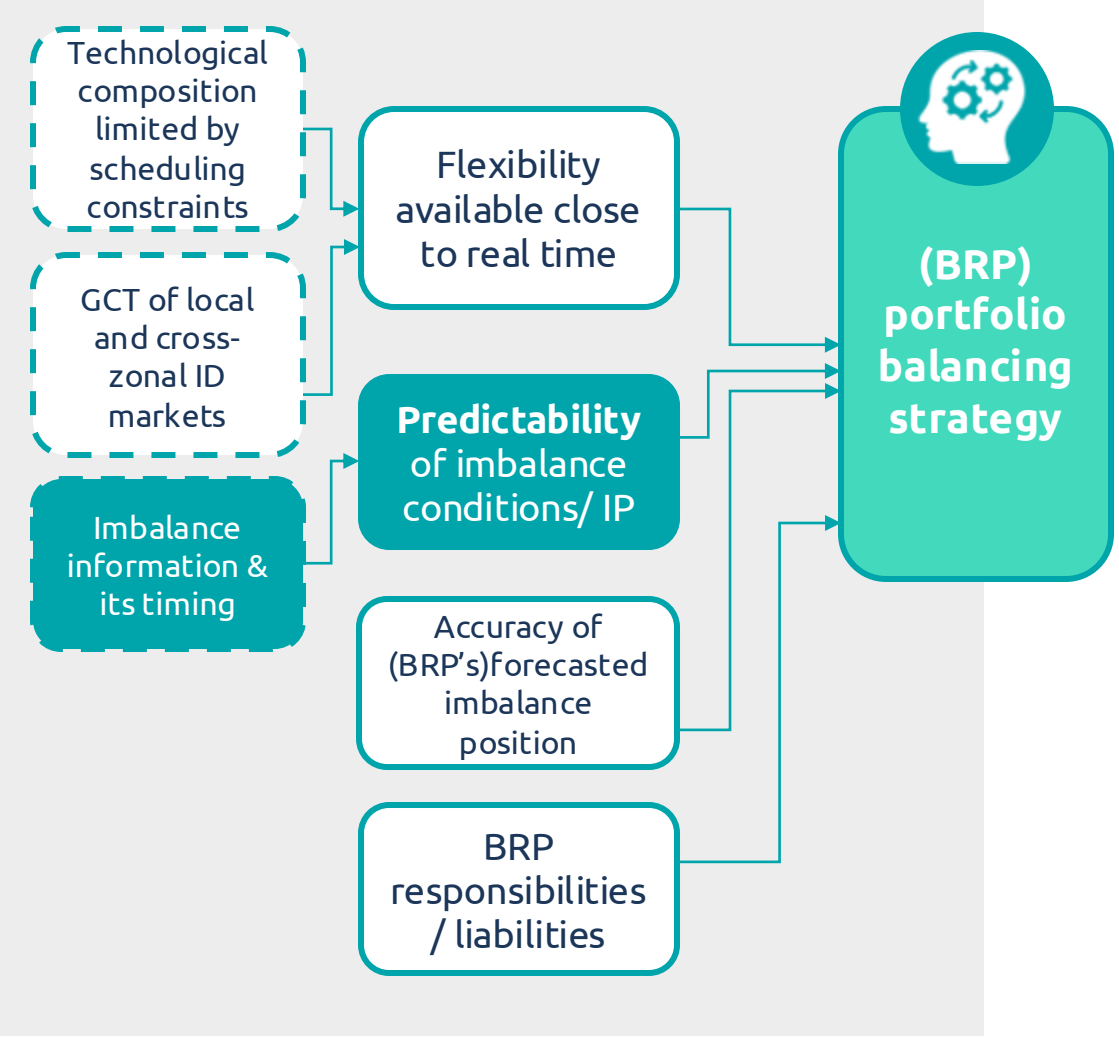
In practice:
There is a difference between physical flexibility (e.g., flexible generation) vs. contractual flexibility.

Physical: High flexibility magnifies all incentives → can rapidly adjust positions. Low portfolio flexibility → limited ability to respond, *regardless of pricing or transparency.*

Contractual: e.g. ID market access and schedule adjustments possible. Intraday markets allow participants to trade energy close to real time to correct their forecasts and positions, making them crucial for passive balancing – provided firm schedules expected not earlier than the national ID GCT.

BESS – battery energy storage; DA – day-ahead, ID- intraday, GCT – gate closure time

BRP incentives | Predictability of imbalance conditions / the imbalance price



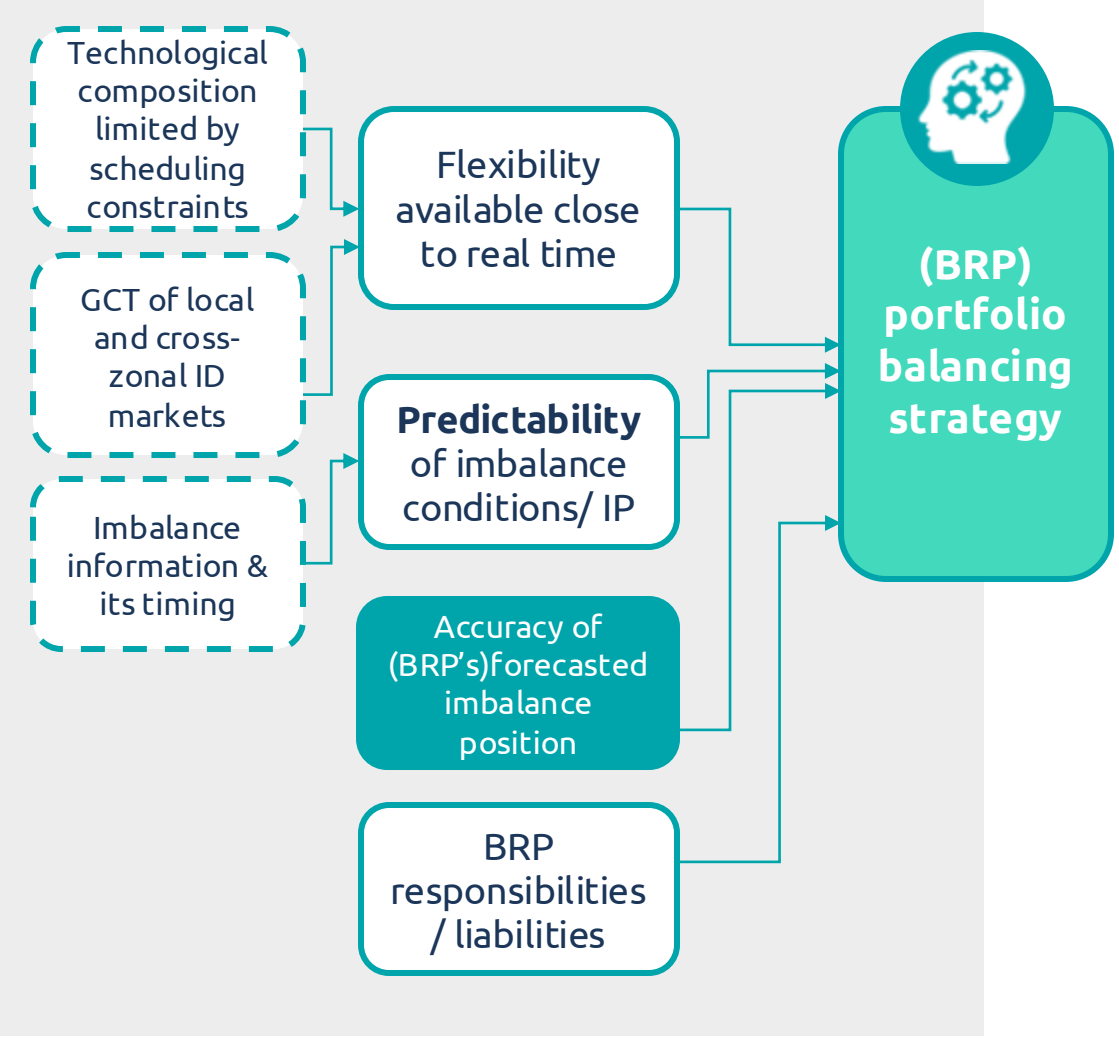
Main logic:
If TSOs publish near-real-time system imbalance signals, BRPs can act (via automated trading, flexible assets) to reduce both their own risk and to help the system. That increases incidental "implicit" balancing. Lack of transparency keeps BRPs hedged and more conservative.

In practice:
System imbalance indicator (e.g. in MW and sign and/or the (forecasted imbalance price) or/and a marginal balancing energy activation price) published publicly on a TSO platform. These can be published with different degrees of frequency (e.g. every minute) to enable actionable decisions within the same ISP.

Without timely and transparent information – or at least a possibility to reliably forecast it – passive balancing **degenerates into random exposure** instead of targeted system support. Alternatively, the pool of "helpers" will be limited to larger BRPs with better forecasting capabilities.

The positive impact of the available information (close to) real time depends on broader market conditions, such as **effects of international cooperations**, NBM, in the future accession to PICASSO and MARI. Especially with the latter, the predictability of imbalance prices is bound to go down, which makes passive balancing more difficult.

BRP incentives | Accuracy of (BRP's) forecasted imbalance position



Main logic:
With the rise of decentralized generation, incl. behind the meter, and evolving consumer preferences, it is becoming more challenging for BRPs to accurately predict their portfolios positions.

Forecasting becomes increasingly complex, and prediction errors may grow, particularly during specific or unforeseen events, such as extreme weather, unexpected events, or sudden shifts in consumption patterns.

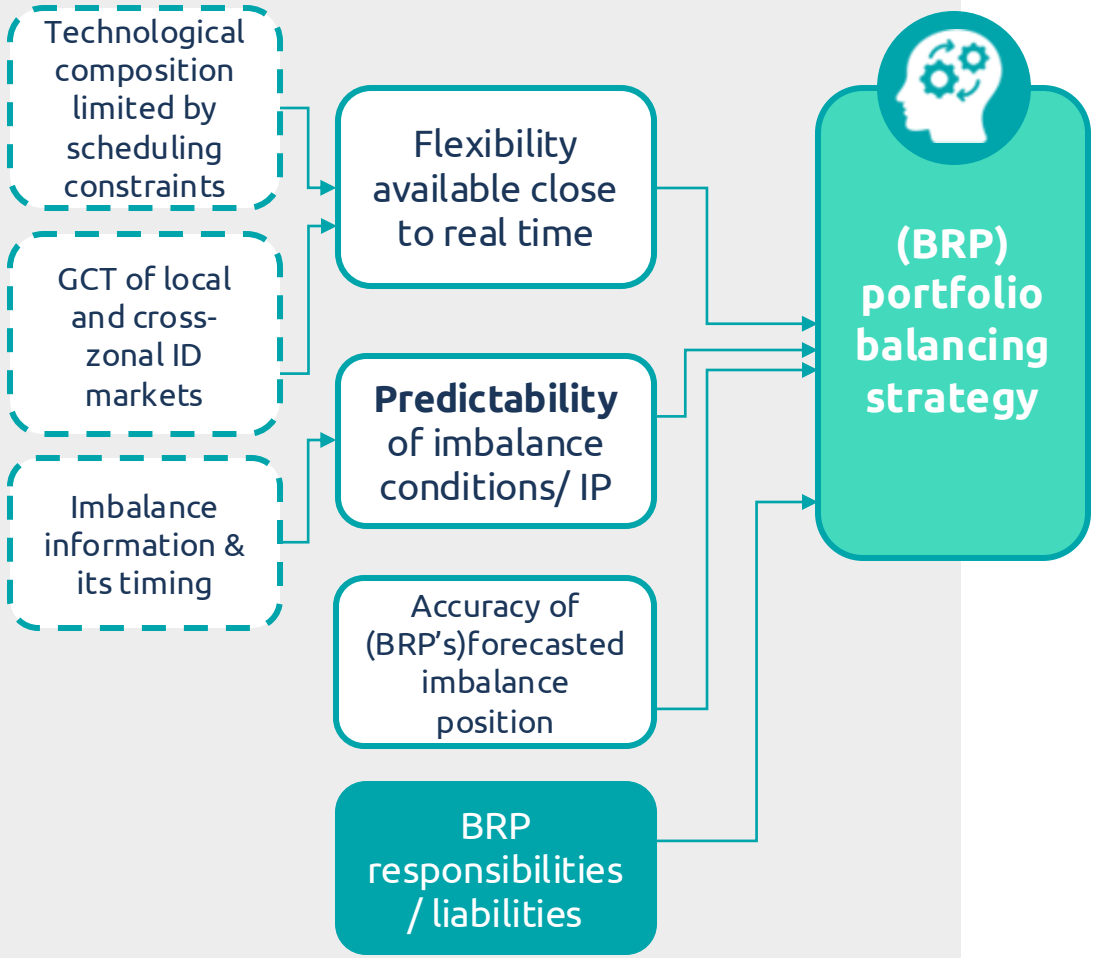
In practice:
BRPs take forecasting risk into account when balancing their portfolios. They weigh potential imbalance costs, prediction accuracy, and the costs of available balancing actions—whether through intraday trading or utilizing their own flexibility.

In situations of high prediction uncertainty, BRPs are likely to be reluctant to take balancing actions unless they are confident that these actions will meaningfully improve their portfolio balance, especially if the cost of the action could exceed the potential reduction in imbalance costs.

If the cost of a balancing action is expected to be lower than the anticipated future imbalance price, under a single pricing mechanism, BRPs will always benefit from taking the action—regardless of whether their resulting position is long or short.

As such, even in markets where BRPs have a balancing obligation but are not permitted to contribute directly to system imbalance correction, they can act as if participating in implicit balancing.

BRP incentives | Terms & conditions for BRPs



Under the EBGL, *a BRP "shall be financially responsible for the imbalances" and must "strive to be balanced in real time." TSOs must include terms & conditions specifying settlement, data, schedule changes and rules if non-compliance.*

In practical terms:
The conditions, responsibilities and financial liabilites for settling imbalances are specified in the national BRP T&Cs. These further define settlement process & formulas, data duties and the consequences of non-compliance. Examples of the latter are failure to submit schedules in the required timeframe (day-ahead, intraday); persistent or excessive imbalance (large or repeated deviations from declared position), breaches of reporting obligation or of credit/collateral requirements.

A TSO can recur to several actions depending on the issue*:
TSO issues an imbalance invoice after settlement finalisation.
→ If unpaid or collateral inadequate, TSO issues margin/collateral call
→ If the BRP does not comply, TSO can suspend nomination rights / limit access and apply administrative fees.
→ If Persistent, contract termination, netting of positions, liquidation/forfeiture of collateral, possible auctioning of shortfall and recovery of additional costs.

How liabilities & penalties change BRP incentives for passive balancing:
Liabilities and penalties primarily change the risk-reward profile of deliberate (passive) imbalances. Anything that increases downside risk, cash-flow volatility or legal uncertainty (big imbalance invoices, collateral calls, admin fees, etc) makes BRPs less willing to hold deliberate imbalances to help the system. Conversely, predictable upside (clear payment rules or high but transparent imbalance prices) makes passive balancing more attractive **if** the downside is capped, predictable, and hedgeable.

Note that **financial BRPs** (above) respond primarily to the cash-flow risk profile whereas **physical BRPs** face operational constraints when balancing (ramping, asset limits), so identical rules can have different behavioural effects depending on BRP type.

T&Cs – terms & conditions

* exact measures depend on the national T&C specifics

BRP incentives | Liabilities & their effect on BRP's willingness to passively balance (continued)

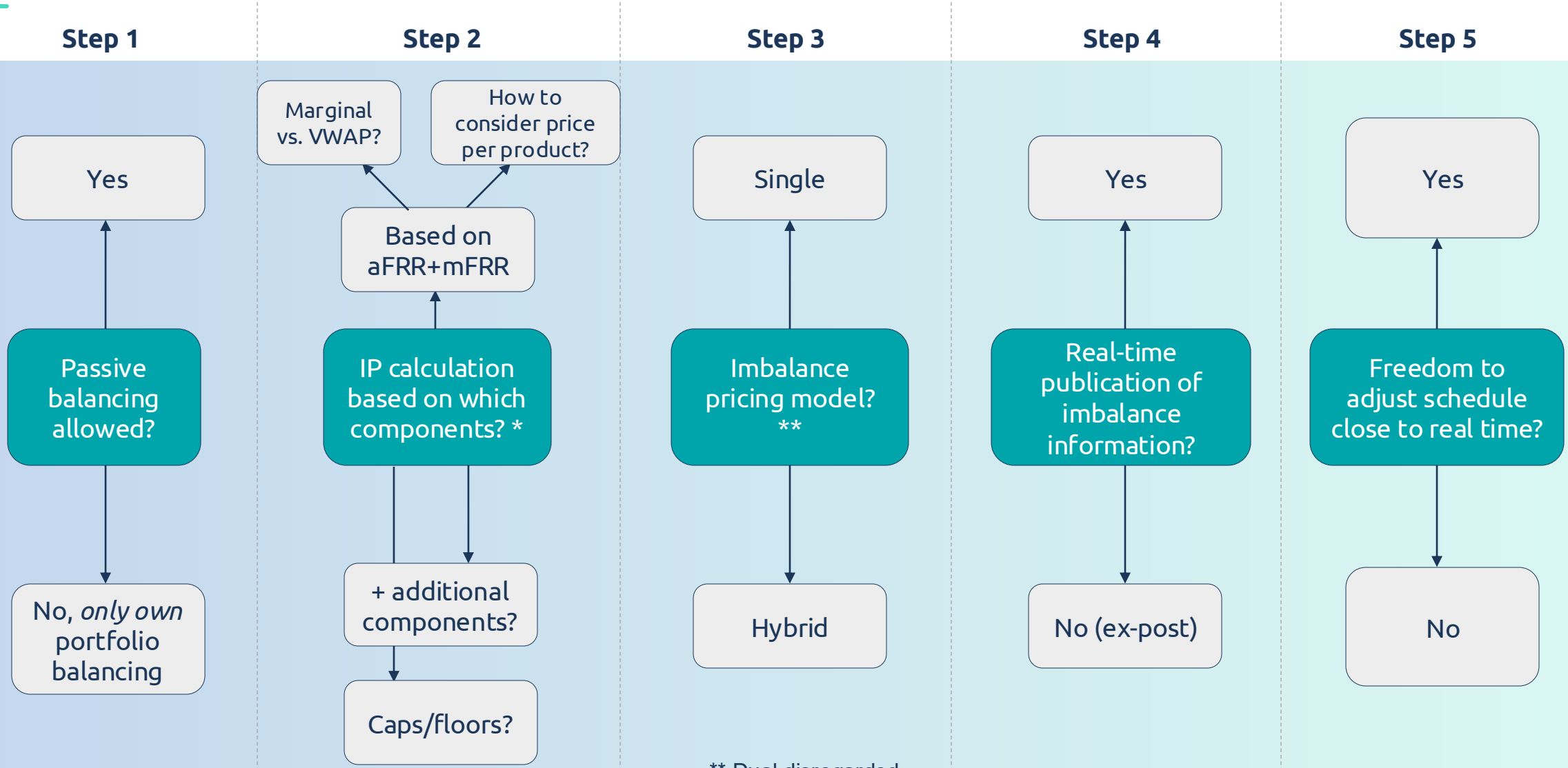
Type of risk	Effect
Imbalance settlement (volume × ISP) — the baseline financial liability	→ If the BRP expects to be paid for the sign of their deviation, passive balancing can be profitable; if they expect to be *charge*d, they will avoid it. The *variance* of IPs (spikes) also matters: higher variance → higher risk premium → fewer voluntary deviations.
Collaterals* & margin calls * Collateral is a cash/credit flow cost and can have strict deadlines.	→ collateral increases the *liquidity cost* of taking imbalances. Even if a passive position is expected to be profitable ex-post, the upfront collateral burden (and risk of swift margin calls) deters BRPs with tight liquidity. It also raises a preference for intraday hedging rather than holding an imbalance.
Suspension / limitation of market access / termination	→ threatens ongoing business. Even low-probability extreme sanctions create asymmetric downside and therefore reduce willingness to passively balance.
Regulatory fines / legal exposure (due to suspected manipulation) where regulatory enforcement can impose large fines for deliberate manipulation or fraud.	→ increases legal risk premium; BRPs will avoid strategies that could be interpreted as manipulative, even if technically profitable.
Interaction with IP design (caps, scarcity adders, VWAP vs marginal): caps/floors reduce upside or downside; VWAP reduces volatility but dilutes marginal rewards; marginal pricing amplifies upside/downside.	→ predictable, rule-based scarcity components that are transparent can encourage passive balancing (if upside is credible/expected). By contrast, unpredictable extreme spikes or tiny-volume marginal effects combined with liability exposure strongly discourage passive balancing.
Cross-border netting/IGCC treatment, i.e. if netting removes local exposures or moves costs cross-border, local BRPs may not capture the local system signal.	→ weakens the local incentive to passively balance – also since such effects are more difficult to predict or rely on.

IP – imbalance price; ISP imbalance settlement period; VWAP – volume-weighted average price; IGCC – imbalance netting cooperation

3. TSO perspective

Imbalance settlement design for passive balancing

Imbalance settlement design features for passive balancing | Key steps in determining imbalance settlement design and the role of publishing real-time imbalance information.



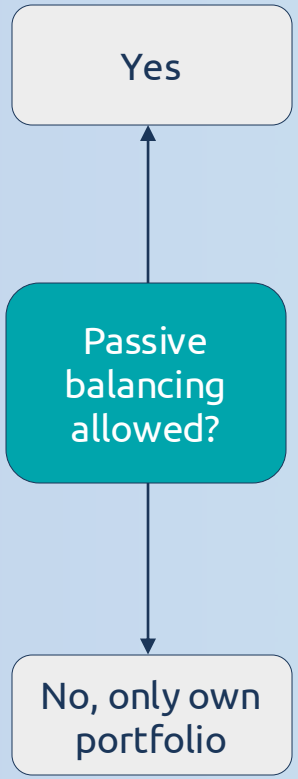
** Dual disregarded

VWAP – volume-weighted average price; VoAA – Value of Avoided Activation

* Based on aFRR or mFRR only disregarded as no longer compatible with the EBGL/ISHM

Step 1 – Imbalance settlement design features for passive balancing | Does a BRP have a legal obligation to submit balanced nominations?

Step 1



The EBGL explicitly provides for a BRP *"in real time… to strive to be balanced or help the power system to be balanced"* — so being intentionally imbalanced to support the system is not forbidden by the guideline. What matters in practice is how each TSO's BRP T&Cs (and national methodologies) implement that principle: most require you to submit nominations and to use market windows to correct, but they do **not** generally outlaw deliberate passive balancing — they treat it as a commercial choice that carries the usual financial/contractual consequences.

In practice:

BRPs must submit schedules and use (DA/ID) market windows. Intentional (voluntary) imbalance is typically allowed but is financially exposed. That is, a BRP can *choose* to hold a deliberate imbalance to "help the system" — they will simply be settled at the applicable imbalance price. This is why EBGL's wording is permissive. Several TSOs explicitly state the imbalance tariff is intended to incentivise passive balancing behaviour (e.g. Elia or TenneT NL).

Although deliberate imbalance is allowed, the TSO's collateral rules, margin calls and fees create liquidity and compliance costs that can discourage doing so except when economically rational. Also, repeated or abusive deviations can trigger escalation, which largely depends on the "proactiveness" of the NRA.

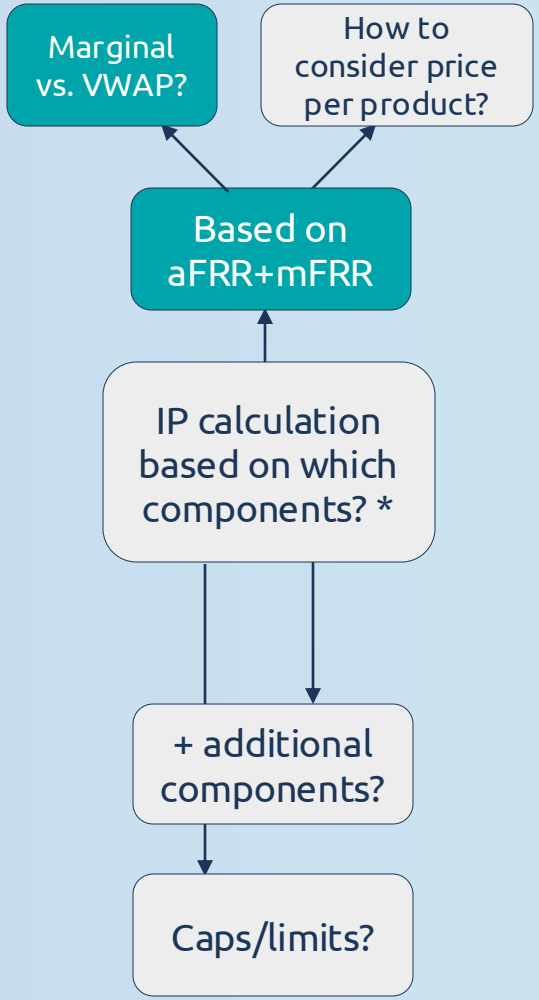
Even though the EBGL allows it, **T&Cs can and do impose limits that affect whether a BRP practically can or will support the system by being imbalanced:**

- a BRP must submit the required nominations and cannot retroactively claim "I intended to help the system" if they missed windows. Late/incorrect nominations can lead to admin fees.
- If taking an imbalance increases your exposure above collateral thresholds, the TSO can demand top-up, which can be a strong deterrent.
- Many T&Cs contain provisions against persistent large deviations; repeated "helping the system" that looks like gaming

Hence, national T&Cs rarely say "BRPs are not allowed to help the system"; they more commonly say "BRPs must submit and try to balance using market windows, and if you remain imbalanced you will be settled and subject to credit/penalty rules." The *practical* limits on voluntary imbalance therefore come from other requirements, changes and provisions rather than from an outright prohibition.

Step 2 – Components for the imbalance price calculation | Marginal vs. VWAP for aFRR – the choice of the approach determines the level of *imbalance price risk exposure.*

Step 2



Key options:

Marginal pricing sets the imbalance price equal to the price of the marginal balancing energy activated to restore balance; average pricing spreads total activated balancing costs over total imbalance volumes (weighted average). Note that is **only relevant for the aFRR** balancing energy price component of the imbalance price since it is the aFRR marginal price that is determined with a granularity higher than the length of the ISP (4 seconds). The price of mFRR is already calculated per 15-min ISP, so only the use of marginal pricing is possible.

- *Marginal* gives a stronger, directional scarcity signals and thus incentive to stay balanced but can also produce volatile/extreme prices which can create a financially disastrous exposure for some BRPs, especially those having high shares of intermittent RES in their portfolios.
- *Average* reduces extreme volatility but dilutes real-time scarcity signals and can blunt incentives to respond

EU context:

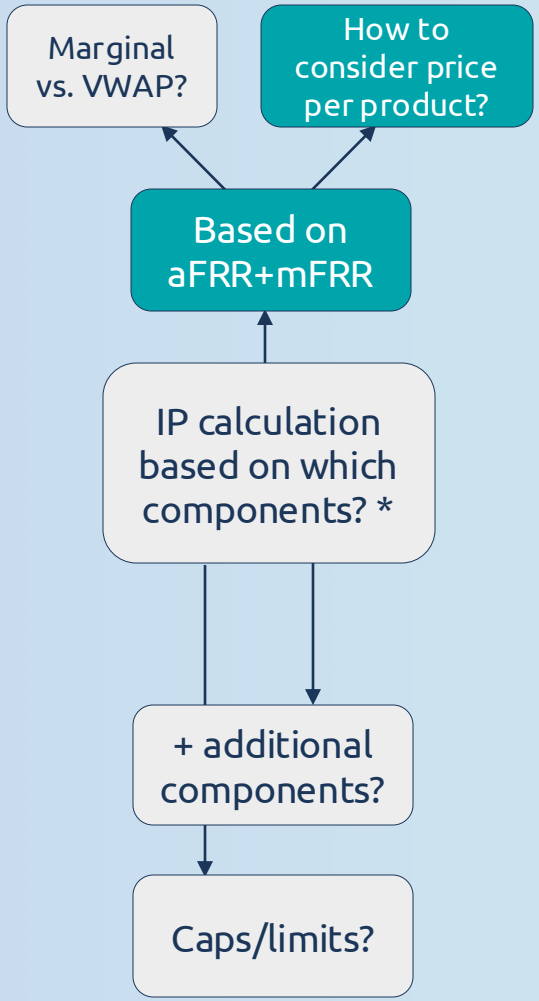
EBGL / ISHM provide for imbalance calculations potentially using several components and thecalculation of a VWAP of all balancing energy prices (see page 8) but do *not* mandate the choice of either marginal or weighted average pricing for aFRR.

Marginal pricing can be applied to prioritise efficient real-time signals and strong incentives for staying balanced whereas the weighted average pricing can be used to prioritise stability and limiting BRPs' financial exposure. Additional components could also be alternatively used to limit extreme cases, e.g. through caps or additional incentivizing components.

ISP – imbalance settlement period; VWAP – volume-weighted average pricel EBGL – Electricity Balancing Guideline; ISHM – Harmonized Imbalance Settlement Methodology

Step 2 – Components for the imbalance price calculation | Per-product price consideration (mFRR / aFRR)

Step 2



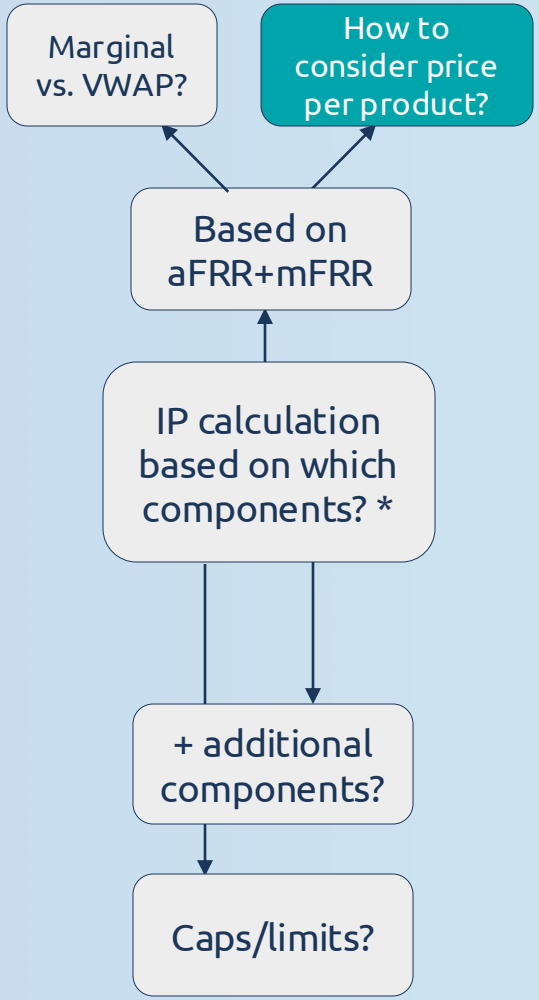
Key options:
(a) use a single BE price based on a dominant-product rule or
(b) keep per-product prices and weight them with actual activation volumes or other weigting factors

EU context:
The EBGL and the ISHM treat balancing energy prices from platforms as the primary inputs and the ISHM currently requires a "weighted" approach. The expectation is that activation for each product is priced on the platform (marginal) and then weighted coherently in imbalance price formulas (ISHM, Art. 55). Yet the ISHM does not specify the weighting rule and only narrows the design space and prescribes options and constraints but leaves a number of operational choices to the TSOs (to be approved by the regulators). In addition, no specific rules are provided with regard to the IP calculation in ISPs where activations were carried out in both directions. Thus, the implementation details (how to aggregate across products and timeframes) are left to TSO imbalance-settlement methodologies and BRP T&Cs.

Metric / Option	Dominant-product rule	Volume-weighted per-product average
Price volatility	High — single marginal event (even small volume) can produce large spikes.	Low–medium — averaging smooths out spikes across products.
Incentive strength	Strong — marginal payoff rewards reactions highly.	Weak — helper earnings diluted
BRP exposure (financial risk)	High — volatile ISP, high collateral/hedge needs.	Low — more predictable, easier to manage.
Perceived fairness	Moderate — simple but some BRPs may feel penalised by single marginal events they didn't cause.	High — spreads costs according to all products used.
Operational complexity	Low — one price input from market (easy to implement).	Medium — need per-product price & volume reporting and weighting.
IT / data requirements	Low — publish marginal price and activated net volume.	Medium — publish activated volumes & prices per product timely.
Gaming risk	High	Lower
Implementation cost & timeframe	Low cost, fast to deploy.	Medium cost, moderate lead time.

Step 2 – Components for the imbalance price calculation | Per-product price consideration *(continued)*

Step 2



Price aggregation using volume-weighted average of product prices
Example: aFRR activated 10 MW at €100/MWh, mFRR activated 40 MW at €200/MWh →
IP = (10*100 + 40*200)/(10+40) = (1000 + 8000)/50 = €180/MWh
Note that total actiation volumes can be substituted by other "weighting factors", e.g. to prioritize one product over the other. Then the division would by the sum of those weighing factors.

Advantages

- Smooths volatility which also means that large spikes in one product are diluted by other products' volumes.
- Reflects well the blend of actual procurement costs when several products were used.
- Reduces the short-term shock to BRPs caused by small-volume marginal events (lessens outlier impacts).
- Perceived as fairer based on actual product contribution to restoring balance.

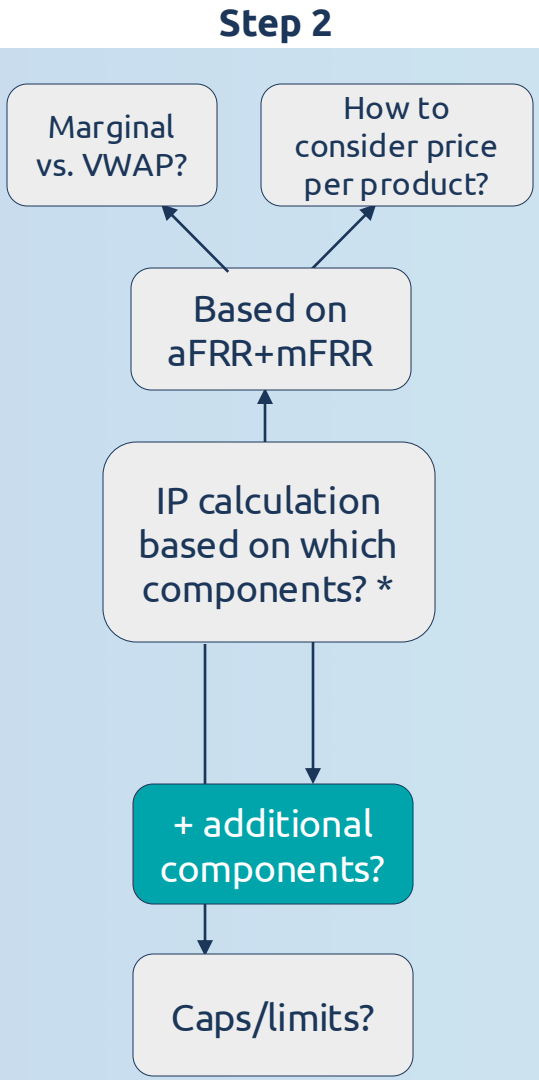
Disadvantages / risks

- Diminished scarcity signal: averaging reduces the marginal price signal that should drive efficient real-time behaviour and investment.
- Complex: requires accurate and timely reporting of activated volumes and prices per product.
- Can hide the true marginal cost
- Can potentially distort the incentives in the balancing energy markets with a lower (expected) price, in this case aFRR, reducing their incentives to offer capacity in that market.

BRP price exposure is lower and more predictable as it is easier to manage cashflow and collateral needs.Yet strong effects of per-product activation volumes (or other weighting factors) and prices on the final IP can be expected. By extension, this affects imbalance price predictability, esp. if balancing energy prices are not punctually published.

Most systems converge to hybrid solutions to balance the trade-offs e.g. by adding safeguards to the **marginal dominant price (**dynamic caps, or minimum volume thresholds that limit extreme small-volume marginal spikes: Small-volume spike protection (e.g. minimum volume for marginal price application or short smoothing over the last minute); using a weighted average but with a marginal adder (grows with system stress so scarcity signals are preserved).

Step 2 – Components for the imbalance price calculation | Additional components



Key options:

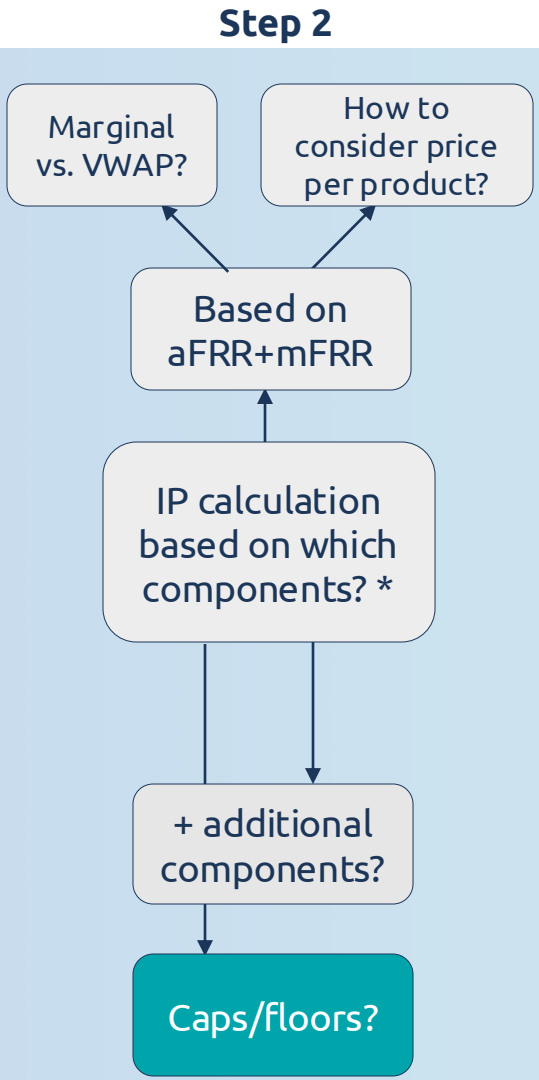
Pursuant to the ISHM, Art.9(6), 3 options are possible:

1) **Scarcity component** raises the imbalance price during low-reserve / scarcity situations. It increases the upside for BRPs who stay on the paid side → can encourage voluntary/passive balancing in scarcity, but it also raises BRP downside risk if the accuracy of BRP's forecast is low.
2) **Incentivising component** is designed to nudge parties to use earlier markets (day-ahead / intraday) rather than rely on imbalance settlement. It tends to discourage simple "gambling" on IP and encourage BRPs to close positions earlier → it can reduce passive balancing that relies on opportunistic timing, while encouraging constructive voluntary support when explicitly signalled.
3) **Financial-neutrality component** compensates or corrects flows so the connecting TSO remains revenue-neutral (e.g., IGCC settlements, cross-border offsets). Its effect on passive balancing depends on whether it preserves the local price signal or dilutes it → weakened local passive-balancing incentives in case of the latter.

Their deisgns in practice (combinations also possible):

Scarcity component	Incentivizing component	Neutrality component
• **Adder approach** where the final IP equals the base IP plus the scarcity adder in a given ISP. This one normally equals zero as long as a given margin (scarcity trigger or function) is not exceeded. • **Multiplicative uplift:** $IP_{final} = IP_{base} * (1 + \alpha)$ in reserve scarcity periods. • **Step adder:** fixed € amount once a given reserve band is exceded.	**Penalty/discount** on IP for imbalances that persist despite available intraday windows **Positive incentive, i.e.** reduced charge or uplift for those who close positions earlier. **Coefficient multiplier** $IP_{final,\,i} = IP_{base} * (1 + \beta_j)$, where β_j could be positive (penalty) or negative (discount for compliance).	**IGCC-based settlement**: the IGCC process calculates settlement prices for exchanged netting volumes; TSO neutrality can be guaranteed by TSO-TSO settlement adjustments rather than by changing BRP ISP directly. **TSO neutrality offset:** $IP_{final} = IP_{base} + Adjustment_{ISP,}$ where the latter may be positive or negative and is computed from TSO net position (IGCC settlement amounts).

Step 2 – Components for the imbalance price calculation | Price caps



Key considerations:
Caps/floors (price limits) refer to a hard upper (cap) and lower (floor) bound on the imbalance price could generally be used to dampen the effect of ruinous imbalance price spikes, ultimately limiting BRPs' downside/financial risk.

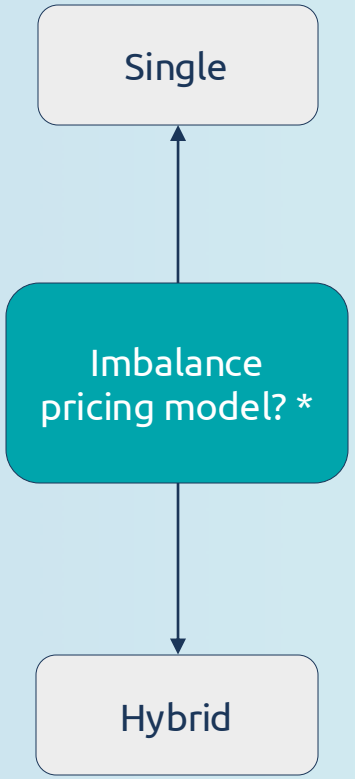
Floors limit extreme negative imbalance prices, protecting BRPs from large downside exposure in surplus events and reducing cash-flow/collateral stress. But if set too high they mute the negative scarcity signal that incentivises downward flexibility and curtailment, can encourage over-production or gaming, and distort short-term dispatch and intraday incentives. Consequently, floors should be calibrated (or dynamic, e.g. linked to surplus magnitude or reserve levels), paired with complementary safeguards, and aligned across borders to avoid arbitrage.

Decision considerations:
Cap setting at the level high enough to preserve an incentive for passible balancing either a fixed bound or a function, e.g. dependent on the magnitude of imbalance or scarcity of balancing resources. The effect if a mirror of the additional-component logic.

These set hard bounds on the imbalance price used to curb ruinous spikes, limit BRP risk exposure. Caps should be high/Floors should be low (or dynamic, e.g. linked to imbalance magnitude or reserve scarcity) to preserve useful incentives while protecting against tail risk. (Cf. if set too low they blunt scarcity signals and distort incentives).

Step 3 – Imbalance pricing model | Single vs. dual/hybrid pricing

Step 3



Under single pricing, the TSO settles *all* imbalances at the system's balancing energy (BE) price or that period:
If the system is short, the imbalance price is equal to the upward balancing price.
If the system is long, the imbalance price is the downward balancing price.
If BRP imbalance is:
- same direction as the system imbalance → the BRP pays the balancing price (more punitive than DA/ID price).
- opposite direction (helping) → the BRP ***receives* the balancing price, which can be higher** (if system short) or **lower** (if system long), meaning you can make money by having an imbalance that reduces the system imbalance.
→ There's a direct financial incentive to align BRP's imbalance with what helps the system — if they can predict the system imbalance direction and respond quickly, you can profit from "helpful imbalances."

Under dual pricing, the TSO applies one price for **short positions** (BRP consumed/ undersupplied **more than scheduled**) and *different* price for **long positions** (BRP consumed/undersupplied **less than scheduled).**
Main caveat: what a helper receives is likely LOWER than what the causer pays:
- If BRP imbalance is **in the opposite direction** to the system imbalance ("helper"), the BRP doesn't necessarily get paid as much for that help, so the monetary benefit can be much smaller.
- If BRP imbalance is **in the same direction** as the system imbalance ("causer"), BRP gets charged a penalty price.
→ The *profitable* strategy is almost always to have zero imbalance (self-balance), because the upside from helping the system is small or zero, while the downside from hurting it is big.

Feature	Dual Pricing	Single Pricing
Reward for helping system?	Weak/ none	Strong
Penalty for hurting system?	Strong	Strong
Incentive focus	Keep own portfolio balanced	Help system (if profitable & predictable)
Risk of deliberate imbalances	Low	Higher

Main message:
For helping solve imblances, the reward is different → (much) lower in dual pricing model. Incentive is focused on own portfolio balancing in case of dual pricing and on helping the system in case of the single imbalancing pricing model.

Step 4 – Publication of imbalance information | … can strengthen the incentive for passive balancing but on its own insufficient to enable it.

Step 4

When BRPs can reliably see the system imbalance (direction and magnitude) or a short-term IP signal, they are better positioned to react to reduce their exposure and/or to take a profitable "helping" position. This **can strengthen the incentive for passive balancing** (cf. Ex-post publication leaves BRPs to rely on their own forecasting capabilities and on intraday markets).

What information to publish:

1. **System imbalance (direction + volume) — forecast vs actual**
   - **Near-real-time actual (MW + sign, e.g. every minute)** is the strongest enabler for targeted passive balancing. Encourages helpers across many BRPs including small players with limited forecasting capabilities.
   - **Short-horizon forecast (nowcast/5–15 min ahead)** is even more valuable because it gives a prediction window for action; it increases proactive corrective trades but brings certain forecast error risk.
   - **Ex-post only** reduces incentive for passive balancing – unless under certain conditions (e.g. systematically occuring events) or using advanced forecasting (e.g. in DE).
2. **Imbalance price (IP) — forecast vs indicative vs final**
   - **Indicative/short-term forecast of IP (with uncertainty band):** Provides price signal to weigh action costs vs expected reward and increases economically rational passive balancing even by smaller parties.
   - **Final IP ex-post only** would generally discourage passive balancing - unless under certain conditions (e.g. systematically occuring events) or using advanced forecasting (e.g. in DE).
3. **Activated balancing volumes & per-product prices (aFRR, mFRR, FCR)**
   - **Near-real-time per-product activation volumes + marginal prices:** Enables BRPs (and BSPs) to estimate the IP if it's not readily available but raises complexity due to a likely "translation step" between aFRR/mFRR prices and the final IP.
   - **Aggregated / delayed publication** preserves some transparency for ex-post analysis and market monitoring but limits use for short-term position adjustment.

Concerning the frequency of publication, high frequency can help maximize opportunities for passive balancing but also requires automation on the BRP side to make use of it and can contribute to "overshoots".

Availability of ex-ante/close-to-real time information can certainly benefit BRPs. However, information alone is insufficient. General predictability of imbalances (underlying factors), liquid intraday markets, the ability to adjust positions close to real time and reliable own-portfolio forecasts are needed, otherwise greater transparency can risk raising price volatility, collateral needs and hurt inflexible RES-heavy BRPs.

Step 5 – How flexibly can BRPs adjust nominations | Freedom to re-nominate positions close to real time (or even ex post) enables passive balancing

Step 5

- Option to re-nominate positions coupled with late intraday (ID) gate closures (e.g. 15 min) give BRPs room to adjust and therefore boost passive balancing whereas early position lock-ins remove that option.
- Generous compensation or weak enforcement lowers downside risk and encourages "helpers" through passive balancing whereas strict/no compensation deters voluntary deviation.
- Tight nomination-accuracy rules and strong penalties suppress strategic deviations whereas real-time visibility of system direction enables targeted, constructive passive actions.

Example: *with a late GCT and TSO compensation, a small BRP is willing to inject 1 MWh to help a short system because of expected ISP minus costs is predictable and downside is limited. Cf. under a strict/no-compensation regime the same BRP avoids the action because potential extreme imbalance costs and margin calls create very costly risk.*

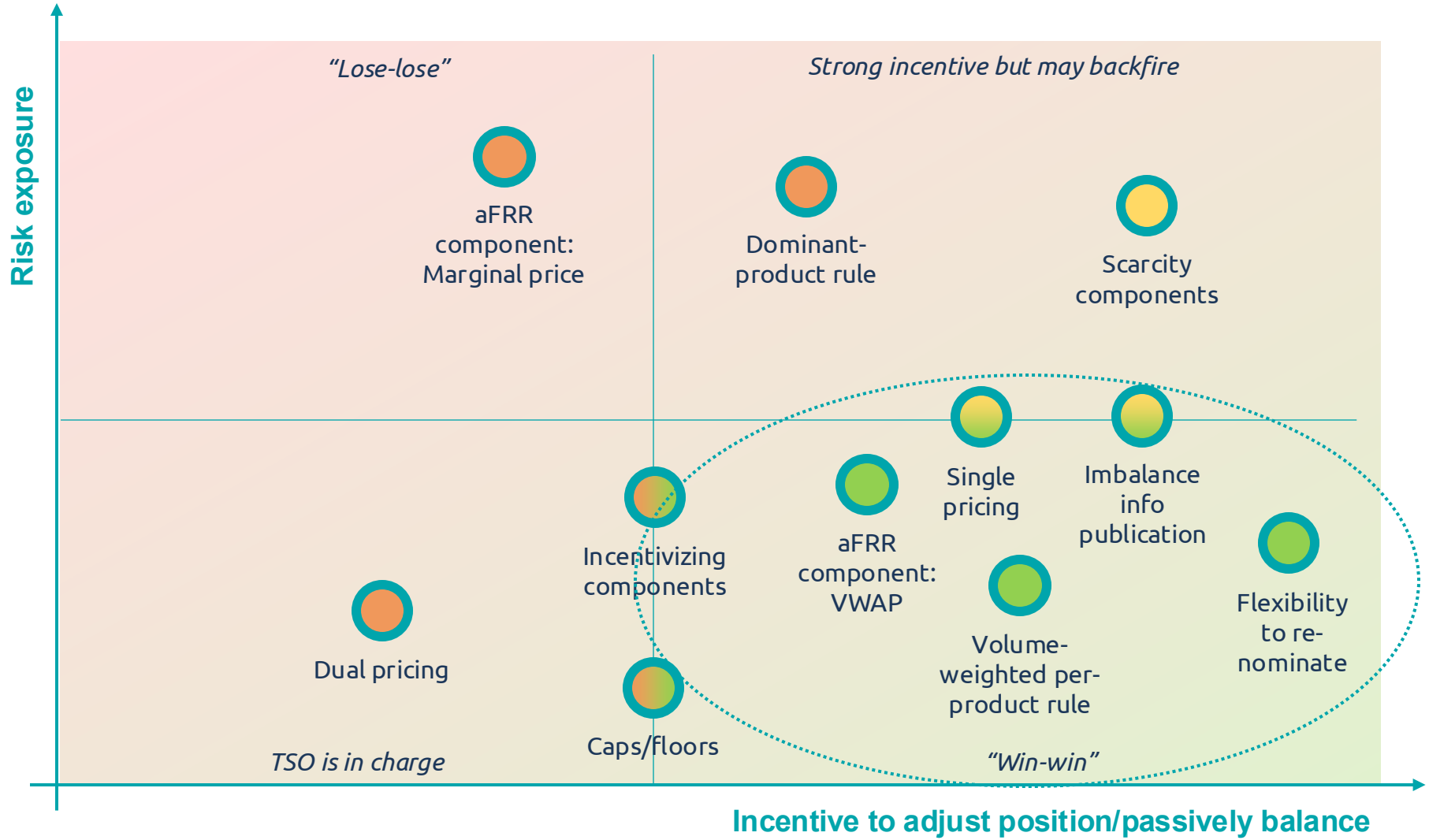
Permissive nomination requirements/compensated firmness + late GCTs encourage BRPs to help the system in real time, while early lock-in and strict accuracy /penalties channel balancing to TSOs and suppress voluntary deviations.

Firmness = the extent to which a BRP's submitted schedule (generation, consumption, cross-zonal trade) is binding, and who bears the cost if the schedule is altered or not fulfilled.

Permissive nomination requirements = the rules allow a BRP to deviate from its nominated schedule close to real time (i.e. nominations are not so rigid that any deviation is immediately penalised).

Compensated firmness = BRPs may legally deviate close to real time and, if later a TSO curtails trades due to system constraints, receive compensation.

Summary of the key effects on the incentive for passive balancing– It's all about minimizing tradeoffs. A "win-win" for BRPs and the TSO is likely to be achieved through design elements that create a strong incentive for BRPs to adjust positions while mitigating their excessive risk exposure.



Note: This matrix does not cover other dimensions such as complexity of implementation or interdependencies with other markets (e.g. effects of intraday market liquidity or impact on balancing markets)

Summary of key advantages and disadvantages of passive balancing

Advantages

- TSO may reduce both **imbalance volumes and balancing costs**
- Reducing TSO interventions through passive balancing decreases the operational costs of balancing services. **These savings can be passed on to consumers** via lower system charges.
- Participants have **stronger incentives to improve their forecasting accuracy and operational planning .**
- For BRPs, **no separate balancing service contract or complex prequalification** needed as passive balancing is an inherent option under the BRP role
- **A new revenue stream** for BRPs as part of value stacking.
- Encourages **active portfolio management** and frequent position adjustments in intraday markets, enhancing liquidity and price discovery.
- May help **unlock distributed energy resources and flexibility,** which might otherwise not support system balancing explicitly.

Disadvantages

- **TSOs cede some control over real-time balancing**, which can complicate grid stability management, especially under unexpected conditions or grid stress.
- BRPs may face a higher **financial risk** due to exposure to volatile imbalance prices. Smaller or less sophisticated players might find it difficult to manage these risks effectively.
- **Strategically influencing** of prices by some of the larger players may be possible without appropriate oversight and data availability.
- Risk of **overcorrection.**
- Passive balancing depends on **voluntary** market participant actions and **may not guarantee sufficient balancing resources** in critical situations → crucial role of aligning passive balancing design with BRP incentives.

4. Cross-country overview & lessons learned

- Cross-country overview for Belgium, Germany and Netherlands
- Quantitative Belgian case study
- Lessons learned from Belgium and Germany

Cross-country overview | Overview of the key design elements* of imbalance settlement in Belgium, the Netherlands, Germany and Sweden.

	Belgium	Netherlands	Germany	Sweden
BR enforcement	Legal + financial Should return to balanced position on request by Elia	Legal + financial	Legal + financial	Legal + financial
ISP	15 min	15 min	15 min	15 Min (since May 2023)
Number of prices	Single imbalance pricing	Dual pricing possible during some ISPs	Single imbalance pricing	Single imbalance pricing
Main IP component for aggravating imbalances	Marginal control energy price	Marginal control energy price	Average control energy price	Marginal price of mFRR energy
Main IP component for reducing imbalances	Marginal control energy price	Marginal control energy price	Average control energy price	Marginal control energy price
Additional IP components	Variable component	n/a	Variable component	Variable component
Prices used in IP calculation	aFRR and mFRR	aFRR and mFRR	aFRR and mFRR	mFRR only
Publication of the final IP	*Ex ante* estimation Real time pubication Validated *ex post*	An hour or less after delivery	More than a week after delivery	An hour or less after delivery
GCT for notification of internal trade schedules	Ex-post notification allowed	Ex-post notification allowed	15 min before delivery	45 min before delivery

** based on ENTSO-E survey of July 2025 (status end of 2024)*

Further details on the main and additional imbalance-price components are provided on the next page.

Cross-country overview | Overview of the key design elements* of imbalance settlement in Belgium, the Netherlands, Germany and Sweden (continued)

IP component		Belgium	Netherlands	Germany	Sweden
Main component for aggravating/ reducing imbalance		**Direction:** - Up-reg: MIP* sets the price - Down-reg: MDP* sets the price **Main Component:** - IP (MIP/MDP) = extreme of {aFRR VWA, mFRR marginal}, bounded by the VoAA floor/cap. - If only one product was activated, IP = that component, subject to the VoAA bound. **No activation:** If SI stays inside Elia's dead-band (± 25MW), IP is a neutral value: average of VoAA up and VoAA down	**Direction:** - Up-reg: up aFRR sets the price - Down-reg: down aFRR sets the price **Main Component:** Per ISP, the IP is set by the most extreme aFRR activation price observed across the 4-s cycles in that direction **Dual pricing** (both up & down activated in the ISP): two prices apply: short BRPs pay the up-reg price; long BRPs settle at the down-reg price. **No activation:** a single settlement price applies for the ISP (average afrr up and down)	**Direction:** No separate up/down IP. Germany settles with a uniform price (reBAP) **Main Component:** The base component (Module 1) is the volume-weighted average price of activated aFRR and mFRR across the German control areas for each 15-min ISP. The final imbalance price (reBAP) is then the max/min of Modules 1–3 depending on the sign and size of the GCC balance. **No activation:** When there is no net FRR activation and the GCC balance is close to zero, reBAP is set by an intraday-based AEP. As the system moves into scarcity, additional price components steepen prices in the short/long direction.	**Direction:** - Up-reg: up mFRR sets the price - Down-reg: down mFRR sets the price **Main Component:** Per ISP, the IP is set by the marginal CBMO of mFRR in the regulation direction **No activation:** When there is no relevant mFRR activation for the bidding zone (or no dominating direction), the TSO calculates a VoAA and adds an Incentivising Component (IC) so that the resulting imbalance price equals the day-ahead price for that bidding zone.
Additional component	Used	**Incentivising component (alpha):** meant to strengthen the incentives when the SI is large. It is added to the MIP/MDP	-	**Incentivising component (Module 2):** links the imbalance price to an intraday market index to nudge BRPs to balance in the market rather than rely on balancing energy **Scarcity component (Module 3):** raises the price when the system is under stress	**Incentivising component:** added to match the DA price
	Proposed	-	**Scarcity component**	-	-

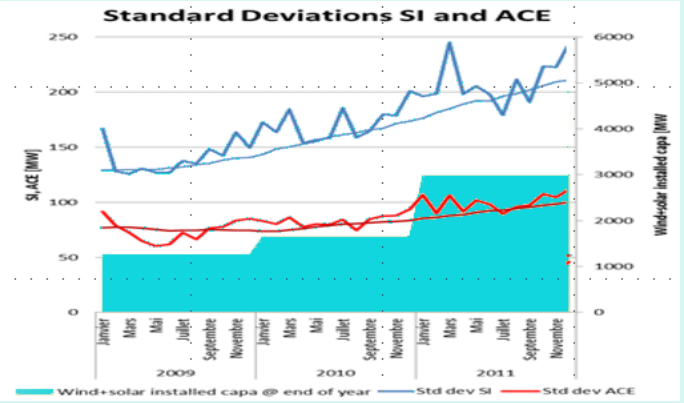
Note: VoAA is computed differently in each country
MIP = marginal increase price; MDP = marginal decrease price; IP = imbalance price; SI = system imbalance

Belgian case study | Start of the Passive balancing model

1 Until the end of 2012 Elia applied a double average imbalance pricing mechanism

		Net regulation Volume	
		Net Downward regulation	**Net Upward regulation**
BRP Imbalance	**Positive**	Weighted Avg cost downwards regulation	92% Market price
	Negative	109% market price	Weighted Avg cost of upwards regulation

- **Increase in structural imbalances** (lengt, magnitude, frequency) with small increase in RES
- **Bad FRCE quality**, increasing reserve needs, increasing frequency interTSO emergency support
- **Increasing costs** for small BRPs



Source Bob Hebb (Elia) Symposium Luzern 2017

In the past, Elia applied a double imbalance pricing mechanism, which led to several issues.

- First, the mechanism failed to provide adequate incentives for BRPs during extreme imbalance events. In such situations, BRPs that were initially helping to restore the system balance often reverted to their individual balanced position making the situation even worse. This created significant operational challenges for the Belgian TSO, Elia.
- Second, BRPs that did not contribute to the system imbalance ended up paying more than those BRPs whose portfolios were highly correlated with the system imbalance. This outcome was perceived as unfair and inefficient by the market parties.

This situation led to further adverse outcomes. Structural imbalances often persisted throughout the day without any corrective reaction from market parties, resulting in very frequent activation of inter-TSO assistance contracts. At the same time, ACE regulation quality deteriorated and failed to meet the targets agreed within ENTSO-E. These issues triggered discussions on increasing reserve volumes, even though the Belgian balancing market was already tight. As the top right graph shows, end 2011, the standard deviation of the ACE exceeded the 100-MW threshold, whereas the standard deviation of the system imbalance keeps on creasing. In the meantime, only 3000 MW of solar PV and wind were integrated in the Belgian system.

To address these shortcomings, a new imbalance pricing mechanism was introduced with the objective of providing stronger incentives for BRPs that are more aligned with system needs.

Belgian case study | Start of the passive balancing model *(continued)*

The introduction of single pricing ended up creating stronger incentives for BRPs, particularly during extreme imbalance events. This is not surprising since the single imbalance pricing approach encourages BRPs to continue supporting system balance even in stressed situations and ensures a fair remuneration for doing so. In addition, it ensures that BRPs that are, on average, balanced with limited correlation to the system imbalance are exposed to lower imbalance costs. **Following the introduction of single marginal pricing, several actors began to behave differently within the balancing time frame.** For instance, DSO-connected CHPs started monitoring Elia's real-time balancing publications and actively modulate their CHP output as a function of the imbalance price. This resulted in real-time support of up to 200 MW. Similar behavior was also observed among smaller BRPs.

Given the clear (at that time unintended) benefits of this behavior, the TSO initiated discussions with stakeholders to explore how this supportive response could be further facilitated. Following a modification of the BRP contract, larger BRPs also began to actively support the system imbalance. Until then, they had refrained from doing so due to concerns about potential liability in the event of grid-related incidents.

Ultimately, the TSO decided to allow **only passive balancing support from BRPs with physical assets**, while retaining the possibility for Elia to request BRPs to move back to balanced physical position. This approach ensures that purely financial traders cannot take deliberate positions, which is meant to avoid situation where simultaneous erroneous actions by multiple financial players would occur and no longer be correctable in real time during system operation.

2 January 1st 2012 start of single marginal imbalance pricing

		Net regulation Volume	
		Net Downward regulation	Net Upward regulation
BRP Imbalance	Positive	Marginal decremental price	Marginal incremental price
	Negative		

To achieve **more effective balancing incentives** for BRPs
- Improve RES forecasting
- Participation on the intraday markets
- Use of own flexibility when possible

Lower balancing costs for "Balanced ARPs"

incentivise market participants in keeping to support the system balance
- ➢ Give an incentive to favor imbalances which are helping to resolve the system imbalance. (own imbalance position is not relevant anymore)

→

3 As of mid-2012 spontaneous start of passive balancing market in Belgium

- 500 MW of DSOs connected CHP (Greenhouses) starting to **react in real time to imbalance prices** (exposure via passed through contracts)
- **Smaller BRPs** start supporting system imbalance
- Mid 2013 after changing rules in BRPs contract* (liability); **Large BRPs** start supporting system imbalance

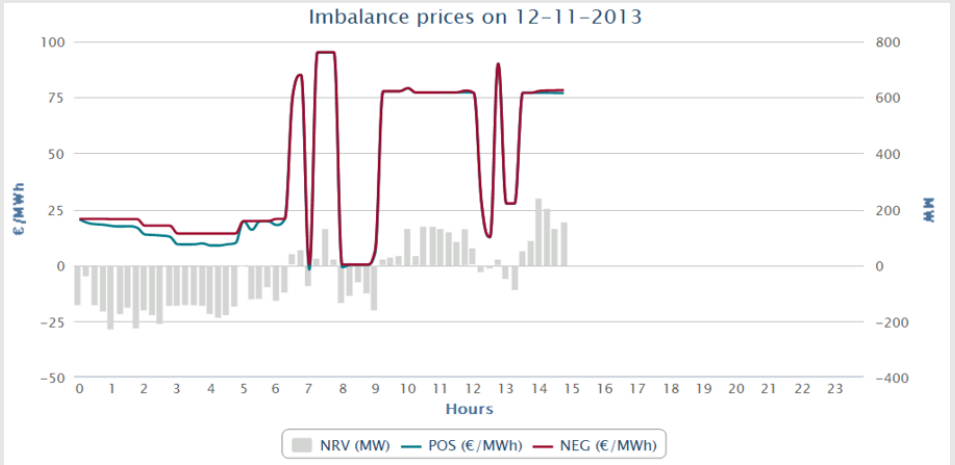
⇒ **Residual balancing timeframe becomes a real time market**

**Allowed to help to restore the system imbalance, but should be always possible to return to a balanced position (exclude Financial traders)*

Belgian case study | Data publications on January 1st 2012 (example website Elia 12/11/2013)

(Close to real time) Imbalance price

Publication (non validated) right after ISP



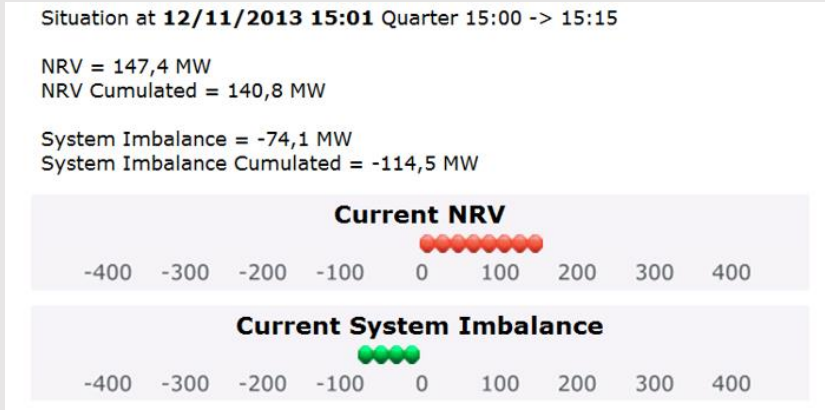
In 2012, Elia did several publications related to the imbalance price. The following are the most relevant for the purposes of this study:

Close-to-real-time imbalance price publication
At the start of each quarter-hour, Elia published the imbalance price of the previous quarter-hour along with the activated balancing volume on its website. This price was indicative and not yet validated.

Real-time publication of NRV and system imbalance
Elia published in real-time the Net Regulated Volume (NRV), which represents the net volume of all balancing actions activated by Elia in real time. In addition, the actual system imbalance of the Belgian control area was published. The publication of both indicators is necessary because balancing actions—whether automated or manually activated—lag behind the actual system imbalance.

Current system imbalance & regulation

Real time publication updated each 5 sec.

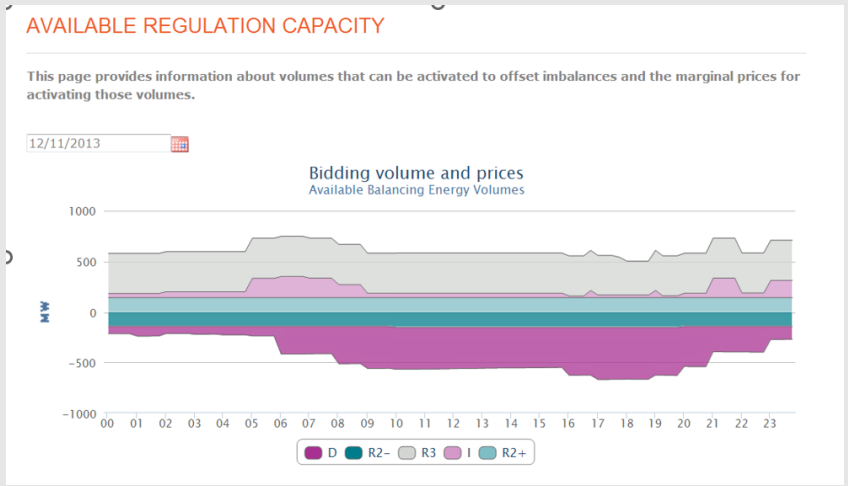


Source: Elia publication website

Belgian case study | Data publications on January 1st 2012 (example website Elia 12/11/2013) *(continued)*

Offered volume and prices

Ex ante Based on submitted aFRR & mFRR bids



Merit order (offer) volumes and prices
Based on bids submitted by market parties, Elia published the available volumes per type of balancing reserve. In addition, an estimated cost of balancing energy was provided as a function of the activated volume.

Activated balancing volumes and prices
At the beginning of each quarter-hour, Elia published the volumes and prices of activated balancing energy in the previous quarter-hour on its website. These prices were also indicative and non-validated at the time of publication.

Activated volume and prices

Publication (non validated) right after ISP

12/11/2013

		Upward regulation Volume					Downward regulation Volume				
Quarter	NRV (MW)	GUV (MW)	IGCC+ (MW)	R2+ (MW)	Bids+ (MW)	R3+ (MW)	GDV (MW)	IGCC- (MW)	R2- (MW)	Bids- (MW)	R3- (MW)
00:00 > 00:15	-139,847						139,847	33,633	106,214		
00:15 > 00:30	-39,915						39,915		39,915		
00:30 > 00:45	-136,128						136,128	5,711	130,417		
00:45 > 01:00	-165,148						165,148	29,022	136,126		
01:00 > 01:15	-228,062						228,062	122,944	105,118		
01:15 > 01:30	-174,555						174,555	68,411	106,144		
01:30 > 01:45	-150,598						150,598	30,156	120,442		
01:45 > 02:00	-226,449										
02:00 > 02:15	-161,639										
02:15 > 02:30	-177,782										
02:30 > 02:45	-208,898										
02:45 > 03:00	-140,450										
03:00 > 03:15	-140,442										
03:15 > 03:30	-138,924										

		Incremental Prices					Decremental Prices				
Quarter	NRV (MW)	MIP (€/MWh)	IGCC+ (€/MWh)	R2+ (€/MWh)	Bids+ (€/MWh)	R3+ (€/MWh)	MDP (€/MWh)	IGCC- (€/MWh)	R2- (€/MWh)	Bids- (€/MWh)	R3- (€/MWh)
00:00 > 00:15	-139,847						20,48	20,48	20,48		
00:15 > 00:30	-39,915						20,48		20,48		
00:30 > 00:45	-136,128						20,48	20,48	20,48		
00:45 > 01:00	-165,148						20,48	20,48	20,48		
01:00 > 01:15	-228,062						20,46	20,46	20,46		
01:15 > 01:30	-174,555						20,46	20,46	20,46		

The combination of these four publications enabled market parties to estimate better the imbalance price for the upcoming quarter-hour and to actively manage their balancing groups based on relevant real-time information.

Source: Elia publication website

Belgian case study | NEW Data publications since January 1st 2012 (example website Elia 9/11/2025)
Elia strives to provide equal access to information to all market parties but it is still ultimately their own responsibility

1 min Imbalance Price
Non-validated imbalance price based on latest info

This page provides information about the cumulative imbalance price and its components for every minute of the prev

Time interval for publication of data

At the specified time, the most recent available data are collected and displayed as quickly as technically possible. The
of the Current System Imbalance, as the latter values are instantaneous values.
All published values are **non-validated values** and can therefore only be used for information purposes.

Situation at 09/11/2025 from 12:12 to 13:11

Quarter	Minute	Quality status	ACE (MW)	SI (MW)	α (€/MWh)	α' (€/MWh)	MIP (€/MWh)	MDP (€/MWh)	Price (€/MWh)
13:00 > 13:15	13:11	Data issue	0,077	144,162	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:10	Non validated	-1,736	149,928	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:09	Non validated	-4,498	150,913	0,82	0,00	82,42	**70,00**	69,18
13:00 > 13:15	13:08	Non validated	-7,553	153,720	0,84	0,00	82,42	**70,00**	69,16
13:00 > 13:15	13:07	Non validated	-9,531	149,877	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:06	Non validated	-2,493	143,051	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:05	Non validated	1,842	131,777	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:04	Non validated	1,224	121,097	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:03	Non validated	2,606	95,404	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:02	Non validated	0,138	89,486	0,00	0,00	82,42	**70,00**	70,00
13:00 > 13:15	13:01	Non validated	13,297	108,834	0,00	0,00	82,42	**70,00**	70,00

Since 2013 and up to the present day, Elia has further enhanced its balancing-related publications in order to better support BRPs in the real-time management of their balancing groups.

One-minute imbalance price
Elia introduced the real-time publication of a one-minute imbalance price, calculated based on the balancing actions activated so far within the ongoing quarter-hour. This provided BRPs with a much more granular and timely indication of imbalance conditions.

Support estimation of allocation of profiled clients
Updated each 5 min, metering at DSO connection points

Last values displayed: 09/11/2025 13:19

EAN code	Injection Station	Location	Voltage Level	DSO	Region	Value
541453161252993345	AALNO 15	AALST	15	FluviusMidden-Vlaanderen	Flanders	-10,889
541453198270815618	AALST 15	AALST	15	FluviusMidden-Vlaanderen	Flanders	-22,143
541453118726748222	AALTE 12	AALTER	12	FluviusImewo	Flanders	-5,246
541453153283327817	AARSC 10	AARSCHOT	10	FluviusZenne-Dijle	Flanders	-1,030
541453100400942569	AARTS 15	AARTSELAAR	15	FluviusAntwerpen	Flanders	0,002
541453190902346378	ADEGE 12	ADEGEM	12	FluviusImewo	Flanders	3,274
541453142791384450	ALKEN 10	ALKEN	10	FluviusLimburg	Flanders	1,755
541453172167605162	AMEL 15	AMEL	15	ORES(Est)	Wallonia	4,397
541453120061892270	AMERI 11	IXELLES	11	SIBELGA	Brussels	-16,315
541453194170778985	AMPSI 15	AMPSIN	15	RESA	Wallonia	0,089
541453155502566094	ANGLE 15	ANGLEUR	15	RESA	Wallonia	-17,010
541453123467002533	ANS 15	ANS	15	RESA	Wallonia	-7,564
541453151601809267	ANTOI 15	ANTOING	15	ORES(HainautElectricité)	Wallonia	-18,122
541453147829836604	ARLON 15	ARLON	15	ORES(Luxembourg)	Wallonia	-2,020
541453114541262387	ATHUS 6	ATHUS	6	ORES(Luxembourg)	Wallonia	-2,518
541453187722414738	AUBAN 15	AUBANGE	15	ORES(Luxembourg)	Wallonia	-3,409
541453191883486503	AUVEL 11	AUVELAIS	11	ORES(Namur)	Wallonia	-6,302
541453182743471869	BAASR 15	BUGGENHOUT	15	FluviusMidden-Vlaanderen/FluviusZenne-Dijle	Flanders	-5,740

Real-time publication of offtakes and injections at DSO connection points
While real-time metering data for TSO-connected clients was already available to BRPs, they faced challenges in managing in real time the DSO-connected part of their portfolios. By publishing real-time offtake and injection data at DSO connection points and, given that BRPs know which DSO clients belong to their portfolio, this publication enabled them to also monitor their DSO-connected assets in real time.

Source: Elia publication website

Belgian case study | NEW Data publications since January 1st 2012 (example website Elia 9/11/2025) *(continued)*

Elia strives to provide equal access to information to all market parties but it is still ultimately their own responsibility

Day ahead imbalance forecast

Based on nominations provided by BRPs on D-1

***Disclaimer**: In case of delays in the SDAC process the publication of the Day-Ahead Imbalances for the next day can be incomplete until 16h00.*

09/11/2025

Time Slot	Day-Ahead positive imbalance	Day-Ahead negative imbalance	Day-Ahead global imbalance
00:00 > 00:15	236,90	-242,70	-5,80
00:15 > 00:30	66,10	-267,20	-201,10
00:30 > 00:45	52,00	-368,90	-316,90
00:45 > 01:00	50,50	-380,00	-329,50
01:00 > 01:15	64,00	-177,60	-113,60
01:15 > 01:30	53,90	-175,20	-121,30
01:30 > 01:45	50,40	-173,70	-123,30
01:45 > 02:00	49,90	-176,90	-127,00
02:00 > 02:15	62,70	-181,80	-119,10
02:15 > 02:30	61,30	-178,60	-117,30
02:30 > 02:45	50,80	-176,40	-125,60
02:45 > 03:00	50,70	-170,50	-119,80
03:00 > 03:15	80,20	-123,90	-43,70
03:15 > 03:30	80,90	-122,60	-41,70

System imbalance forecast for current Qh and net Qh

publication updated each minute with probability % for accuracy

System imbalance forecast current quarter hour (near real-time)

Information | Table | Analyze | Forecasted SI vs Current SI | Export | API

	Prediction Datetime	Quarter hour	Resolution code	Input data availability	System imbalance forecast	Probability in [-inf,-400]
192	8 November 2025 05:37	8 November 2025 05:30	PT1M	0	2.73 MW	0
193	8 November 2025 05:36	8 November 2025 05:30	PT1M	0	-20.54 MW	0
194	8 November 2025 05:35	8 November 2025 05:30	PT1M	0	-28.85 MW	0

Probability in [-400,-200]	Probability in [-200,0]	Probability in [0,200]
0	0.521	0.478
0.002	0.691	0.307
0.004	0.724	0.272
0.005	0.68	0.314

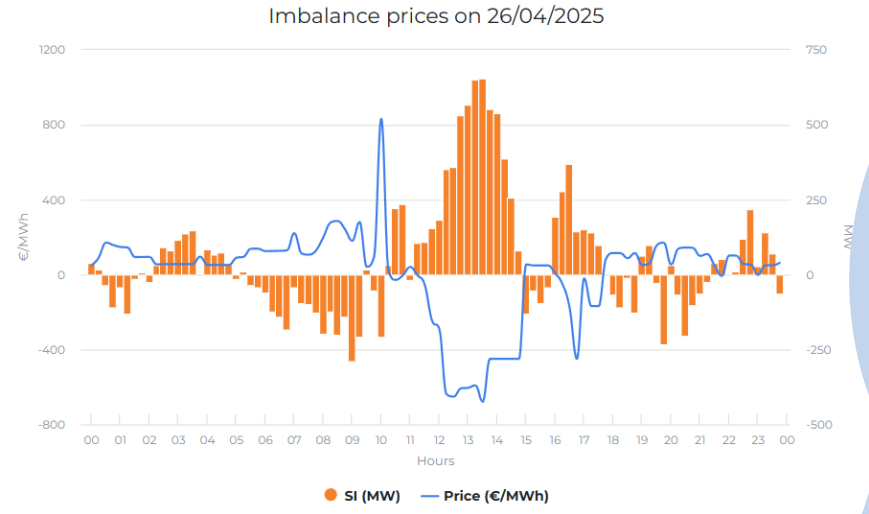
Day-ahead and real-time system imbalance forecasts
Elia developed forecasts of the system imbalance position from the day-ahead stage up to real time, providing BRPs with improved insight into expected system conditions and evolving grid status.

The combination of these publications further enhanced the ability of market parties to actively manage their balancing groups in real time and to respond more effectively to system needs.

Source: Elia publication website

Belgian case study | Examples of days with large System Imbalances — Imbalance prices Incentivizing BRPs to be balanced and help restore system imbalance

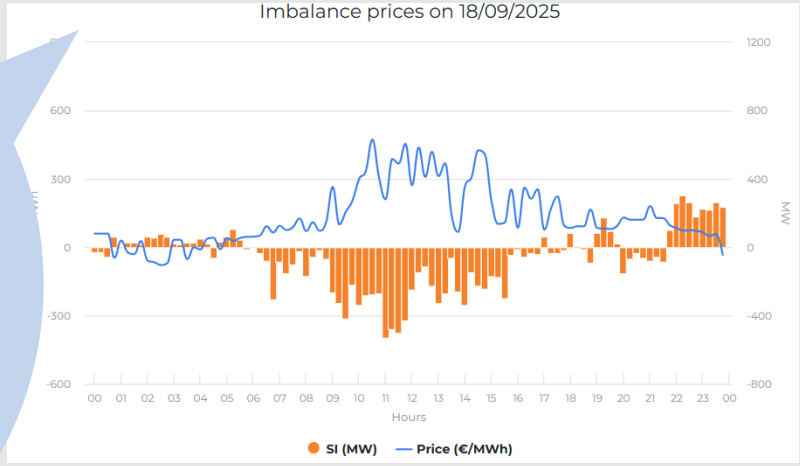
26/04/2025 - Belgium faced a **strong positive imbalance** because of a **solar prediction error of 1GW**



Quarter	SI (MW)	ACE (MW)	Incremental Prices MIP (€/MWh)	Floor (€/MWh)	aFRR+ (€/MWh)	mFRR+ (€/MWh)	Reserve Sharing+ (€/MWh)	Decremental Prices MDP (€/MWh)	Cap (€/MWh)	aFRR- (€/MWh)	mFRR- (€/MWh)	Reserve Sharing- (€/MWh)
15:15 > 15:30	-52,283	-0,363	**49,00**	49,00	12,26			-4,40	-4,40	12,26		
15:00 > 15:15	-129,123	9,807	**54,00**	54,00	29,29			-450,00	-4,90	29,29	-450,00	
14:45 > 15:00	81,354	-160,935	600,00	54,00	600,00			**-450,00**	-25,00	600,00	-450,00	-316,79
14:30 > 14:45	258,784	-56,501	184,59	54,00	184,59			**-450,00**	-25,00	184,59	-450,00	-316,79
14:15 > 14:30	387,950	-1,726	54,00	54,00	2,42			**-450,00**	-25,00	2,42	-450,00	-316,79
14:00 > 14:15	539,596	6,815	54,00	54,00	-20,67			**-450,00**	-25,00	-20,67	-450,00	-316,79
13:45 > 14:00	551,301	-7,233	55,00	55,00	-282,03			**-450,00**	-25,00	-282,03	-450,00	-326,20
13:30 > 13:45	654,204	158,969	55,00	55,00	-679,12			**-679,12**	-25,00	-679,12	-450,00	-326,20
13:15 > 13:30	650,786	175,061	55,00	55,00	-591,31			**-591,31**	-25,00	-591,31	-450,00	-303,00
13:00 > 13:15	567,821	106,348	55,00	55,00	-604,45			**-604,45**	-25,00	-604,45	-450,00	-303,00
12:45 > 13:00	531,158	53,565	60,00	60,00	-607,33			**-607,33**	-14,00	-607,33	-450,00	-303,00
12:30 > 12:45	360,901	98,484	60,00	60,00	-651,79			**-651,79**	-14,00	-651,79	-450,00	
12:15 > 12:30	351,983	117,611	60,00	60,00	-638,70			**-638,70**	-14,00	-638,70	-174,40	
12:00 > 12:15	183,503	60,698	60,00	60,00	-288,31			**-288,31**	-20,00	-288,31		

In Belgium, the most extreme activated price in the relevant balancing direction determines the imbalance price.
During extreme system events, imbalance prices can to reach levels of up to €400/MWh when the control area is short, and down to -€200/MWh when it's long.

18/09/2025 - Belgium faced a **strong negative imbalance**



Quarter	SI (MW)	ACE (MW)	Incremental Prices MIP (€/MWh)	Floor (€/MWh)	aFRR+ (€/MWh)	mFRR+ (€/MWh)	Reserve Sharing+ (€/MWh)	Decremental Prices MDP (€/MWh)	Cap (€/MWh)	aFRR- (€/MWh)	mFRR- (€/MWh)	Reserve Sharing- (€/MWh)
14:00 > 14:15	-357,192	-41,608	**254,25**	86,70	254,25			71,00	71,00	254,25		
13:45 > 14:00	-256,704	-18,558	**66,00**	66,00	38,87			38,87	64,50	38,87		
13:30 > 13:45	-63,835	-35,307	**137,20**	66,00	137,20	-1,01		64,50	64,50	137,20		
13:15 > 13:30	-269,882	-29,617	**366,58**	66,00	366,58	-2,96		63,00	63,00	366,58		
13:00 > 13:15	-326,000	-42,776	**306,04**	62,20	306,04			62,00	62,00	306,04		
12:45 > 13:00	-226,969	-116,826	**418,83**	61,00	418,83			60,00	60,00	418,83		
12:30 > 12:45	-115,334	-79,774	**308,57**	61,00	308,57			60,00	60,00	308,57		
12:15 > 12:30	-147,155	9,212	**438,00**	61,00	53,14	438,00		53,14	60,00	53,14		
12:00 > 12:15	-245,204	-2,073	**250,00**	61,00	54,41	250,00		54,41	60,00	54,41		
11:45 > 12:00	-429,020	-48,828	**454,70**	60,00	454,70	293,16		57,00	57,00	454,70		
11:30 > 11:45	-502,838	-20,832	**307,26**	60,00	288,69	307,26		56,00	56,00	288,69		
11:15 > 11:30	-477,451	-70,147	**358,27**	60,00	358,27	334,00		56,00	56,00	358,27		
11:00 > 11:15	-530,196	-98,025	**147,08**	60,00	147,08			56,00	56,00	147,08		
10:45 > 11:00	-270,563	-51,140	**300,00**	60,00	109,51	300,00		55,00	55,00	109,51		
10:30 > 10:45	-277,875	-37,444	**472,87**	60,00	153,91	472,87		55,00	55,00	153,91		
10:15 > 10:30	-280,050	-100,935	**326,36**	60,00	219,12	326,36		55,00	55,00	219,12		
10:00 > 10:15	-337,249	-112,583	**293,58**	60,00	213,08	293,58		55,00	55,00	213,08		
09:45 > 10:00	-217,997	-23,708	**182,02**	63,60	113,44	182,02		55,00	55,00	113,44		
09:30 > 09:45	-419,432	-44,744	**109,61**	64,10	109,61	33,10		54,00	54,00	109,61		
09:15 > 09:30	-328,580	-14,191	**82,70**	65,70	82,70			54,00	54,00	82,70		
09:00 > 09:15	-263,768	-63,705	**263,19**	66,20	263,19			54,00	54,00	263,19		

Source: Elia publication website

Belgian case study | Future challenges

Cross border balancing markets

- Access to cheaper balancing energy from neighboring countries is reducing the business case for BRPs/BSPs under the passive balancing concept, though opportunities remain.
- Cross- border marginal pricing influences imbalance price formation in the Belgian market. Hence a misaligned market design could encourage passive balancing, even when the overall system is balanced.

Elia applies weighted average pricing for aFRR to set the imbalance price

Battery integration

- Battery can react very fast to imbalance opportunities. They can wait until the final minutes of the quarter-hour, when the imbalance price signal is more reliable.
- Batteries can inject high power (MW) in short bursts to maximize average energy (MWh), but simultaneous reactions from multiple units can cause significant MW deviations within the quarter-hour

Elia is considering ramping restrictions to batteries

Passive vs Active Balancing: future evolution in Belgium

HARNESSING FLEXIBILITY IN THE ENERGY TRANSITION: A COMPARATIVE STUDY OF DIFFERENT MODELS TO BALANCE THE ELECTRICAL GRID (Elia, May 2025)

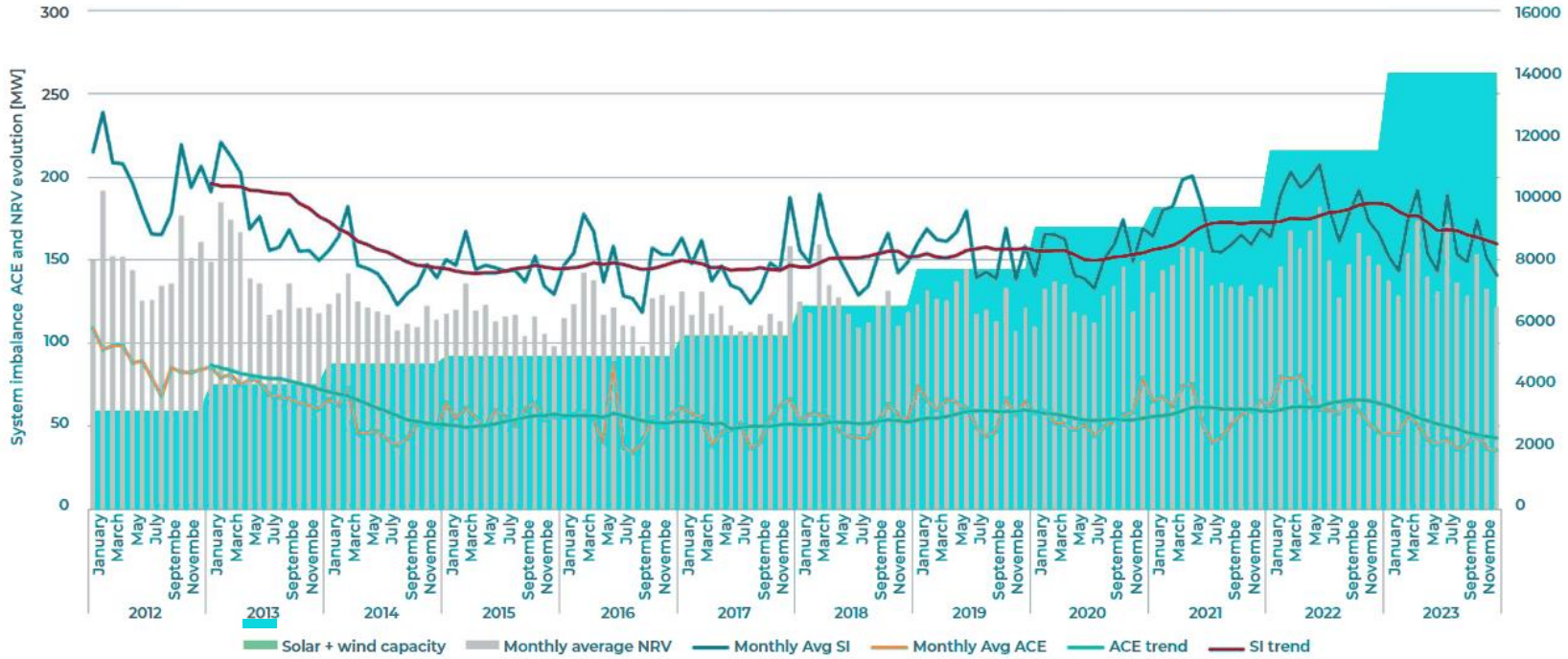
Elia continues to combine active (explicit) and passive (implicit) balancing mechanisms. Participation rules:
- large plants (>25 MW) must bid all flexibility;
- small assets can choose explicit or implicit participation.

Implicit bidding and market reactions
- Are considered as a key enabler to unlock decentralised flexibility due to transactional costs and operational constraints in explicit bidding process
- Even in an exclusive explicit bidding market, BRPs will have price elastic behaviour and any legal prohibition for passive balancing is difficult to enforce
- Not facilitating and considering implicit reactions is creating an inefficient balancing market

Next planned evolutions
- *Publish imbalance price forecasts to guide the market's implicit reactions and to avoid oscillations*
- *Lower participation barriers for explicit balancing products while preserving their value.*
- *Stabilize the imbalance price by reviewing the formula to reflect true 15-minute energy value.*
- *Develop a TSO decision tool to optimize explicit activation volumes considering implicit market responses.*

Lessons learned from the Belgian case | Introduction of single imbalance pricing in 2012 and later explicit facilitation of passive/implicit balancing has generated benefits for BRPs/BSPs and the system as a whole.

Evolution of system imbalances (SI*) and area control areas (ACE**) against the trend in RES penetration in 2012-2024 (monthly averages)



→ **+14 GW RES** added since 2009 (vs ~10 GW peak load)

→ Shift to passive balancing brought system imbalances **back to 2009 levels** – and kept it stable

→ **Contracted reserve volumes remains stable,** reflecting consistent regulation quality

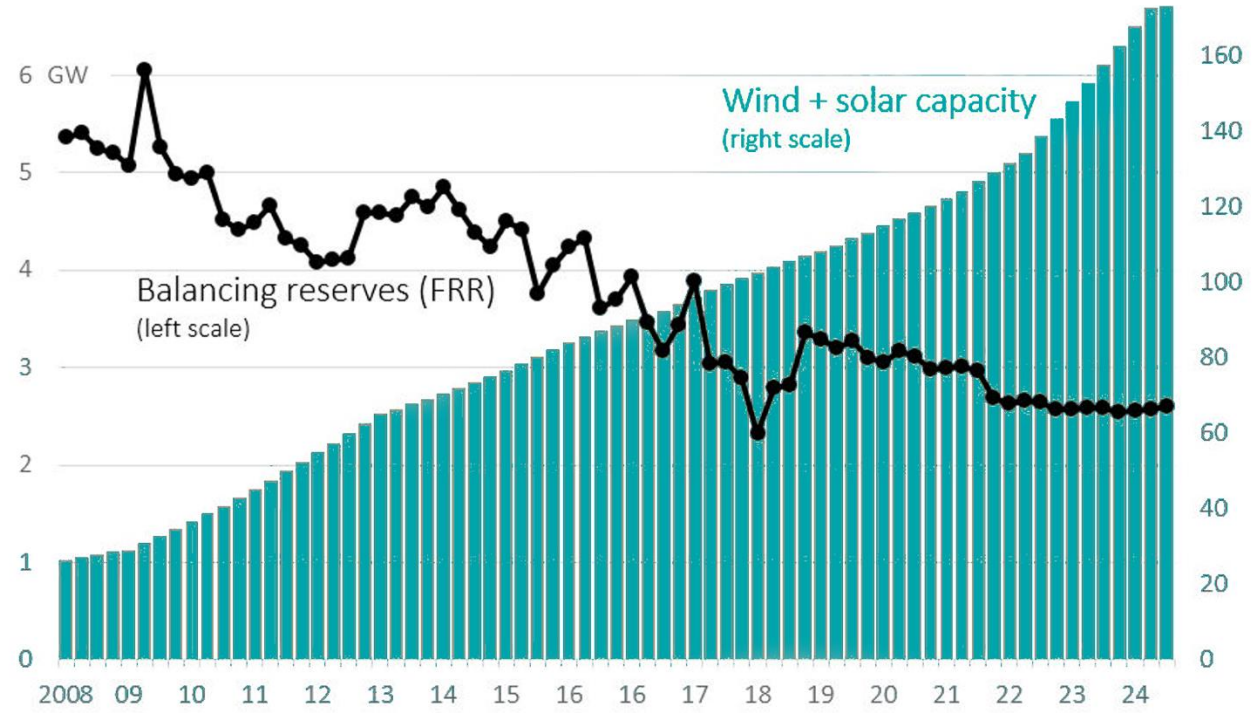
Key lessons learned from the Belgian model

1. Passive balancing has contributed to keeping contracted reserve volumes stable despite 4,5 times higher installed shares of volatile RES in 2024 as compared to 2012.
2. Since the introduction of single pricing in Belgium in 2012, the real-time market became a key element in value stacking for BSPs and BRPs.
3. System value is seen in a "healthy" combination of implicit *and* explicit balancing
4. Passive balancing is seen as a key enabler to unlock decentralized flexibility while explicit bidding process is linked high transactional costs and operational constraints.

Source: Harnessing flexibility in the energy transition: a comparative study of different models to balance the electrical grid (Elia, May 2025)
* SI is the aggregated imbalance of all BRPs in a given control area.
** ACE represents the final, metered imbalance of a control area, after implicit and explicit balancing activations. It is a key indicator of the control area's contribution to the quality of the synchronous frequency.

Lessons learned from the German case | The growing share of variable RES is not necessarily associated with more resources needed for short-term balancing. The German case, in fact, demonstrates the opposite.

Evolution of balancing reserve requirements in Germany against the trend in RES penetration in 2008-2024



Source of the graph: adapted from Hertie School, 2025

→ **Even in an exclusively explicit balancing market, BRPs may have an incentive for price elastic behavior and any legal prohibition for passive balancing is difficult to enforce in reality.**

Key lessons learned from the German model

1. Although not formally allowed, there is a strong indication that German market parties are engaging in passive balancing due to the applied imbalance settlement design (e.g. single pricing, scarcity & incentivizing components).
2. Germany demonstrated a trend similar to Belgium *(previous slide)*. Since 2008, wind and solar installed capacity increased 6-fold whereas the volume of reserved aFRR+mFRR balancing capacity halved.
3. Research largely attributes this to a very liquid intraday market with internal ID GCT of only 5 minutes, 4-TSO coordination as well as improved weather models and forecasting both on the TSOs' and market parties' sides.
4. Passive balancing may have further contributed to this positive trend.

5. Imbalance settlement in Sweden

Current situation, implications of passive balancing & outlook

Current situation in Sweden | The applied model and price formation in the Swedish imbalance settlement

Balancing Philosophy

Sweden's balancing setup leans proactive. Under the Nordic single-price/single-position model (since 1 Nov 2021), imbalance current system balance and estimated imbalance prices are published ex-post (estimate ≤30 min after delivery, preliminary on D+2 10:00, final on D+13) so BRPs don't see live prices within the delivery hour. With the 15-minute ISP (from 22 May 2023) and an imbalance price set by the marginal activated mFRR bid when there is activation. The design rewards getting balanced ahead of time rather than reacting mid-hour.

In addition, Sweden's within-zone **continuous intraday trading closes one hour before the delivery hour**, while Belgium and the Netherlands trade until T-5 and even open an After-Market at delivery, giving their BRPs far more last-minute flexibility, whereas in Sweden BRPs are incentivized to proactively keep a balanced portfolio position.

Contractually, a BRP in Sweden must continuously plan and (if needed) trade to **keep its portfolio balanced per 15-min ISP**, and submit their final schedules before gate closure (around 45–60 minutes before delivery).

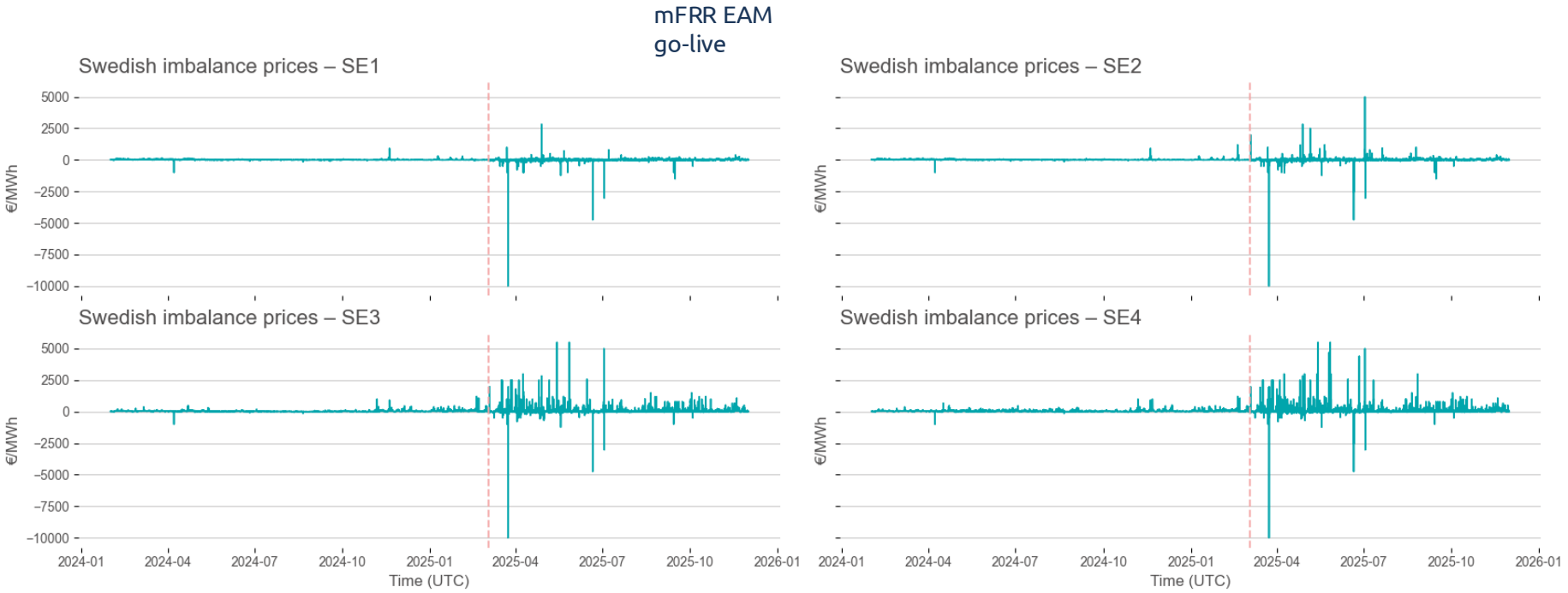
Current model & recent changes

- **Single-price** imbalance settlement, i.e. same price for positive/negative imbalances.
- Calculated **per 15 min ISP** and per **Market Balancing Area** (MBA – SE1, SE2, SE3, SE4). eSett runs the settlement.
- Reference market: **mFRR energy**. The Nordic mFRR Energy Activation Market went live 4 Mar 2025, going from 60 minutes manual balancing to 15 minutes automated balancing. **aFRR is not used** in the imbalance price calculation in SE yet.

Price formation

- Dominating direction of regulation in the MBA:
  - If the MBA is **up-regulated** (system short)-> imbalance price **= mFRR up marginal price**
  - If the MBA is **down-regulated** (system long) -> imbalance price = **mFRR down marginal price**
- No activation: use Value of avoided activation (VoAA) + Incentivising Component (IC):
  - VoAA = average of the lowest bid up and highest down bid (mFRR)
  - IC adjusts VoAA to the DA price of the ISP in the MBA
- In addition, BRPs in Sweden pay **an imbalance fee**, covering administrative costs and procurement of reserves dimensioned for forecast errors
- Following the recent volatility and price spikes on the balance market, Svenska kraftnät is consulting on **lowering the cap applied to mFRR** prices (and thus imbalance prices)

Current situation in Sweden | Imbalance prices 2024-2025 – Volatility and extreme prices have increased since the mFRR EAM go-live on March 4th, 2025.



Metric	Before mFRR EAM	After EAM (03/2024 -)
Mean (EUR)	23.58	30.28
Std. Dev. (EUR)	54.00	147.39
Min/Max (EUR)	-1,005 / 1,203	-10,000 / 5,500

A rather sudden shift in Swedish imbalance prices since March 2025 is driven by a combination of balancing market design changes and market conditions:

- **Go-live of mFRR EAM:** automated 15-min clearing made mFRR activations much more frequent and turned the EAM into the main driver of imbalance-price formation.
- **ACE-based, local balancing**: imbalances are now corrected per area, with flow-based only in DA and tighter ATC in ID/balancing, SE3–SE4 often have to resolve imbalances locally, so almost all ISPs have a dominant direction and prices typically follow balancing energy instead of DA.
- **Thin mFRR liquidity in southern Sweden:** limited local mFRR volumes and a shallow bid depth mean that, when cross-border flows are constrained, even small needs in SE3–SE4 quickly arrive to very expensive bids.
- **15-minute ISPs and BRP transition effects**: 15-min settlement increased sensitivity to short-term forecast errors; BRPs needed time to adapt forecasting and trading, so part of the volatility spike is a new effect and improved over time.

Possible implications for market actors and the TSO in Sweden | What could be expected if passive balancing were introduced in Sweden under *current* circumstances?

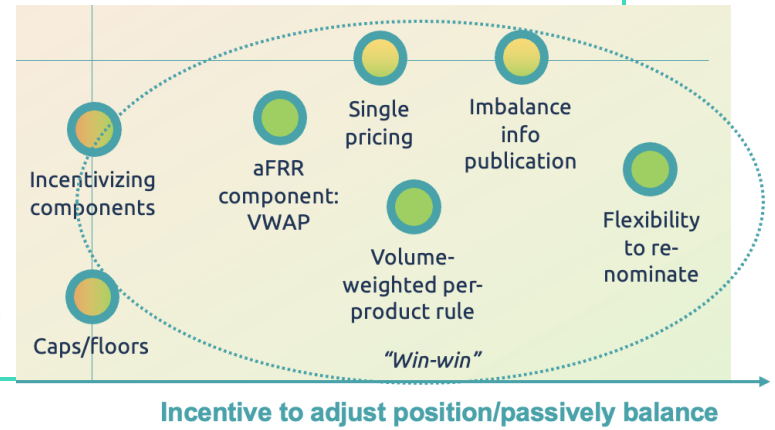
Market parties

If passive balancing is allowed/encouraged:

- It is worth investing in **improved forecasting capabilities and in flexible assets**, especially if imbalance exposure is costly (or if imbalance prices are volatile as is currently the case)
- If done right, **passive balancing can turn into an extra source of revenue** – especially for makret parties otherwise not participating in the balancing markets.
- **deliberate imbalance strategies** can be profitable under some designs but these **carry** legal, financial and reputational **risk.**
- Experience of Germany and Belgium, among others, shows **that successful passive balancing generally requires a liquid, close-to-real-time intraday market** to enable making use of fast position correction opportunities and intraday vs. imbalance price differentials.

TSO

- Some elements of the current imbalance settlement design are already conducive to passive balancing. **The incentive is likely to be further strengthened by:**
  - integrating the aFRR price component in line with the ISHM *(see next slides)*
  - shortening the lead time of final schedule notification and
  - *ex ante* as well as real-time publication of imbalance information to engage a broader range of market parties and technologies.
- If BRPs are sufficiently incentivized to passively balance, **the balancing volume can be likely reduced,** yet also stronger market monitoring likely needed to avoid exploitation of price spikes or overreactions.
- **Intraday liquidity** and cross-border intraday access matters a lot BRPs to enable them to correct positions (adjust schedules) close to real time.
- If the TSO's position is neutral (not excessively pushing for passive balancing and not actively discouraging it), several design elements can enable BRPs to make their own choice based on the imbalance price signal.



Expected future developments in Sweden | Several upcoming changes of the imbalance settlement design are driven by the EU regulatory requirements. These then have implications for the effect of passive balancing.

European regulatory context – key relevant elements

Electricity Balancing Guideline (EBGL)

Art. 12(3): Requirement to publish **"the current system balance of its scheduling area(s) as soon as possible but no later than 30 minutes after real-time".**

Art 53(1): … TSOs must harmonise to a 15-minute ISP aligned with MTU duration. → Sweden introduced 15-ISP in May 2023

Art 55(1–5): TSOs must establish rules to calculate a single imbalance price (IP) per settlement period, per imbalance-price area, and per direction, incorporating the value of avoided activation of FRR or RR.

Further requirements/changes can be expected as a result of the process of the EBGL revision (expected end of 2027).

Harmonized Imbalance Settlement Methodology (ISHM)

Art. 9 (Price determination): For each ISP, price area and direction, the IP is **set at the *weighted average* of activated balancing-energy prices.**

Art. 9(6) one or several of the following **additional components** may be included in the price calculation:
(a) **a scarcity component** to be used in nationally defined scarcity situations;
(b) **an incentivising component** to be used to fulfil nationally defined boundary conditions;
(c) a component related to the **financial neutrality** of the connecting TSO.

Art. 12(3) TSOs need to **assess further harmonisation needs** for imbalance settlement in line with the objectives of the EBGL.

Swedish context

Svenska kraftnät is expected to **join PICASSO during 2027/2028.** The Nordic TSOs are planning to connect to MARI during a similar timeframe.

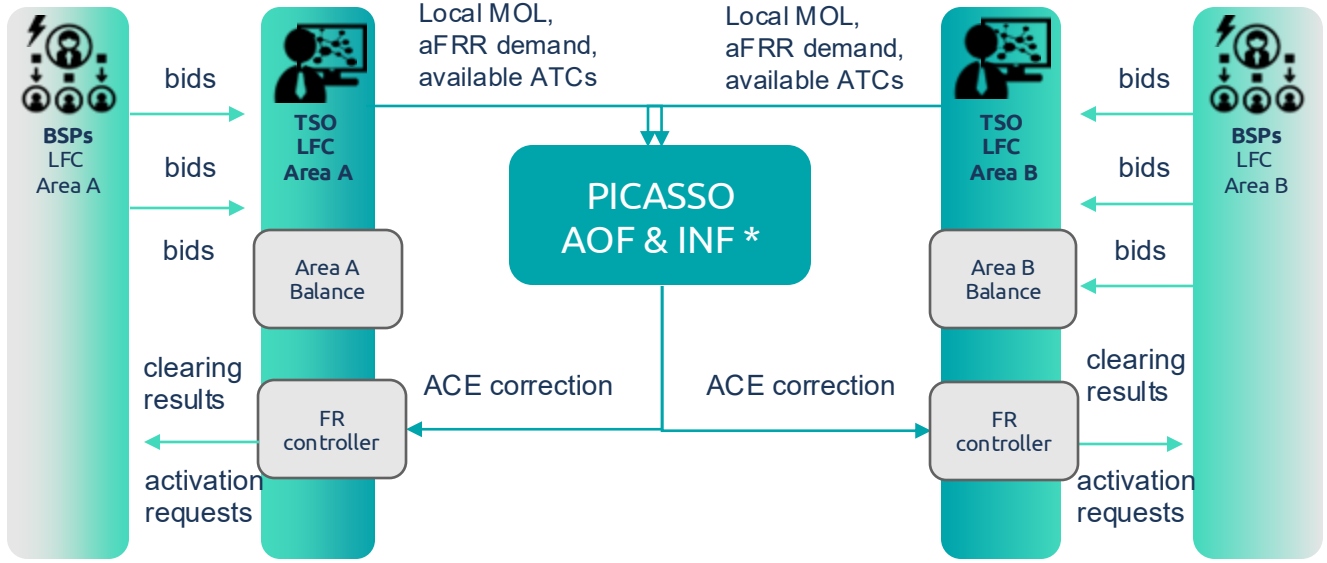
→ Cross-border marginal prices from MARI and PICASSO will then become the inputs to imbalance pricing under the ISHM. [Svenska kraftnät, Q&A 2025].

→ This would further align Nordic imbalance pricing with EU rules, **increase exposure of Swedish BRPs to cross-border balancing dynamics and propagate price spikes from PICASSO to national imbalance prices** – as already seen in other balancing areas.

The TSO must select and implement one of the design approaches, justify it to NRAs under EBGL Art 52–55, integrate it into IT/settlement systems, and prepare fallback/penalty rules to maintain delivery incentives.

BRPs will face new price signals every 15 min based on combined mFRR/aFRR activations; they must adapt their risk-management and scheduling strategies accordingly.

Expected future developments in Sweden | Further implications are expected to be triggered by Sweden's accession to PICASSO platform for the exchange of aFRR balancing energy.



Key features:

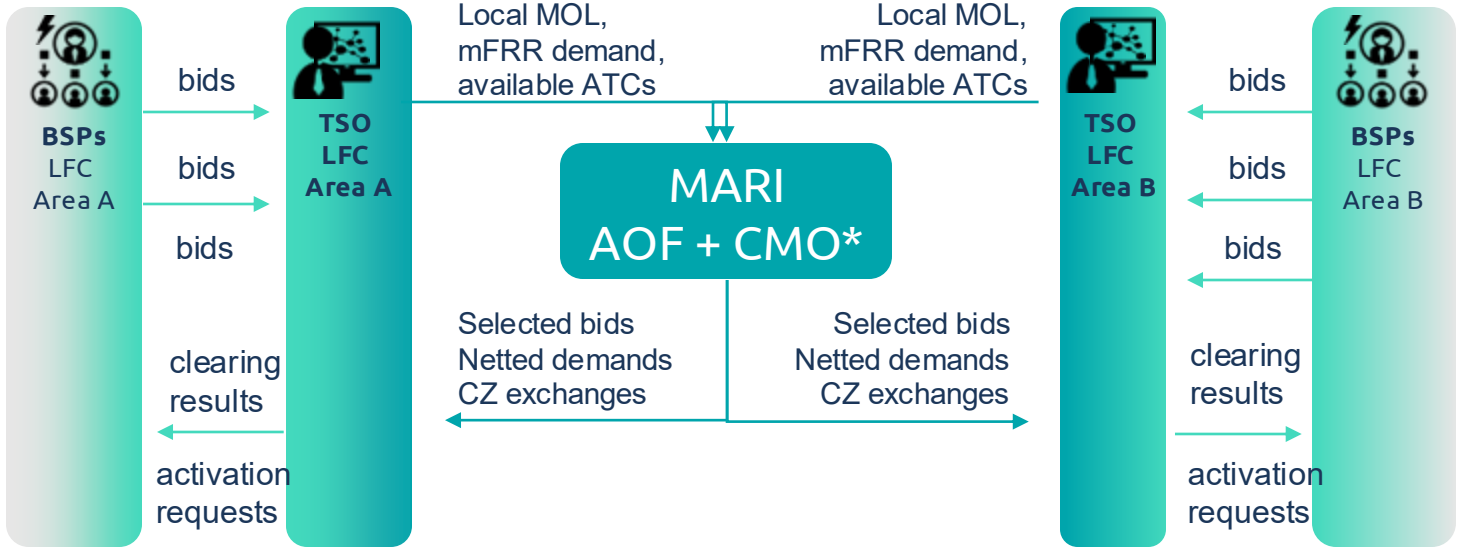
- aFRR procurement is based on a common merit order list (CMOL) of bids from all participating LFC Areas
- PICASSO does not return selected bids from the CMOL but rather an ACE correction
- CMOL and imbalance netting (IN) are considered jointly in a single optimization cycle
- **4s** optimization cycle (=MTU) with marginal prices per 4s MTU **per LFC Area**
- Local aFRR demand can be satisfied through IN **and/or** through bid volume activation
- TSO-TSO model (i.e. BSPs do **not** bid into PICASSO)
- Single (marginal) price for aFRR across several LFC Areas if no congestion

Expected impacts:

- The finally selected balancing energy bids are based on the outcome of "ACE redistribution" as a result of a global optimization, whichacts as a "polluting factor" and ultimately affects the interpretability of local results.
- Cross- border marginal pricing influences imbalance price formation but the exact influence depends on the design factors *(see previous slides)*
- BSPs and BRPs see *different* prices
- Access to cheaper balancing energy from neighboring countries is reducing the business case for BSPs potentially reducing the incentive for explicit balancing (in favor of implicit/passive balancing)
- At the same time, a misaligned market design could encourage passive balancing even when the overall system is balanced: Imbalance price spikes may become counterintuitive, as they may no longer directly reflect the actual local imbalance situation. Acting on these signals can be risky or counterproductive.

* AOF - Activation Optimization Function; INF – Imbalance Netting Function; ACE – area control error
ATC – available transfer capacities (per aFRR balancing border); MTU – market time unit

Expected future developments in Sweden | Further implications are expected to be triggered by Sweden's accession to MARI platform for the exchange of mFRR balancing energy and the resulting mFRR prices – albeit to a lesser extent compared to the PICASSO accession



Key features:

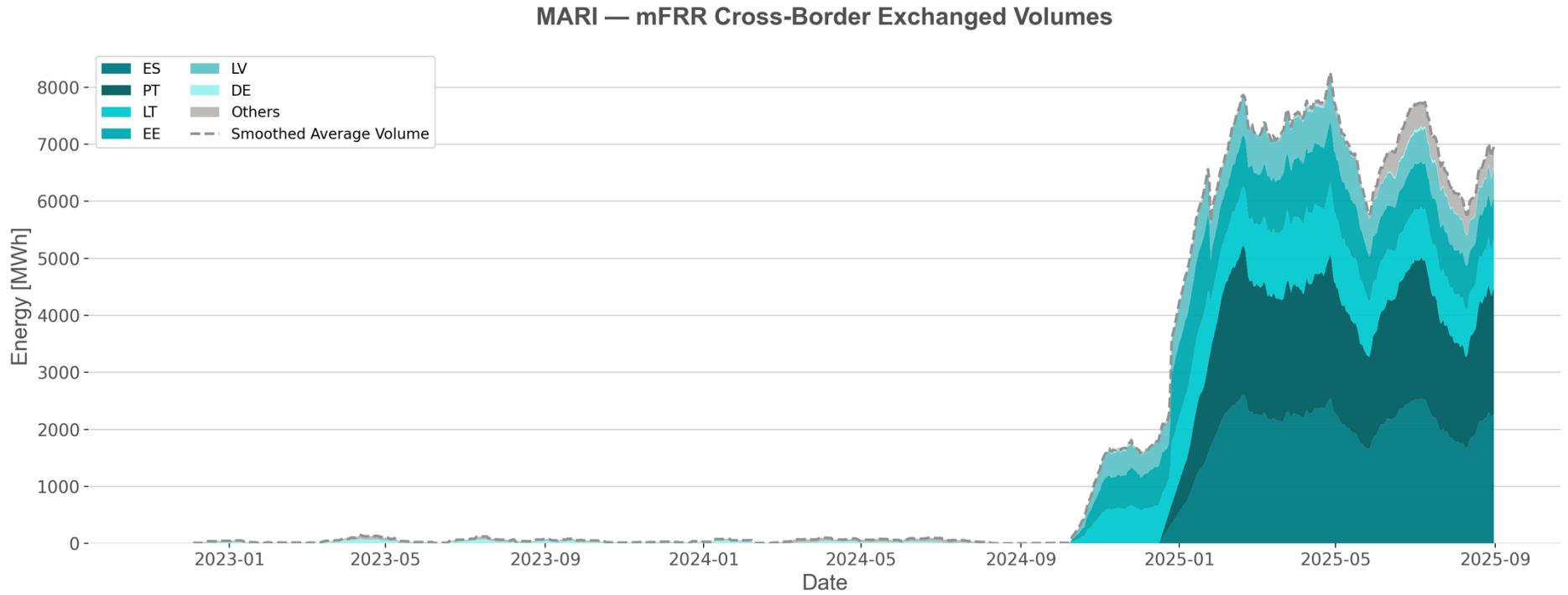
- mFRR procurement is based on a common merit order list (CMOL) of bids from all participating LFC Areas
- **15min** optimization cycle (=MTU) with **marginal prices per MTU per LFC Area**
- Scheduled or direct activation allowed
- TSO-TSO model (i.e. BSPs do **not** bid into PICASSO)
- GCT for BSPs –t-25', publication of results t-12 '
- Single (marginal) price for mFRR across several LFC Areas if no congestion

Expected impacts:

- ACE-based balancing is already used in the present-day mFRR EAM in the Nordics. From this perspective, accession to MARI is not expected to create new dynamics but would potentially affect their magnitude.
- Cross- border marginal pricing influences imbalance price formation but the exact influence depends on the design factors *(see previous slides)*
- Access to cheaper balancing energy from a broader geographical area with different local dynamics *(see next slide)* will likely diversify the pool of BSPs and increase liquidity reducing the business case for BSPs, as compared to the present mFRR EAM.
- Considering the setup of the MARI optimization algorithm *(see left),* MARI accession is likely to affect the incentive for passive balancing. The final impact, however, will also depend on the activation strategy of the TSO.

* AOF - Activation Optimization Function; CMO – common merit order; ATC – available transfer capacities (per mFRR balancing border); MTU – market time unit

Expected future developments in Sweden | Further implications are expected to be triggered by Sweden's accession to MARI platform for the exchange of mFRR balancing energy.



The graph above shows that cross-border mFRR volume exchanges remained very limited up until the latest accession waves between end of 2024 and end of 2025. Previously limited volumes to an extent had to do with larger volumes being exchanged over TERRE, a cross-border cooperation platform for the exchange of RR (replacement reserves). Due to the shortening of the intraday GCT, however, TERRE became progressively obsolete and is planned to be fully phased out by the end of this year.

Interestingly, by far the largest volumes exchanged over MARI are coming from the Iberian peninsula. The Baltic states jointly have the second highest share. Before Sweden's accession to MARI, almost all remaining TSOs will likely join the platform as well. If we would imagine, however, that Sweden joined the platform today, its market liquidity, price levels and access to balancing energy resources would likely be determined by the control areas located the farthest from the Nordics and showing very different system and market fundamentals.

MAGNUS energy

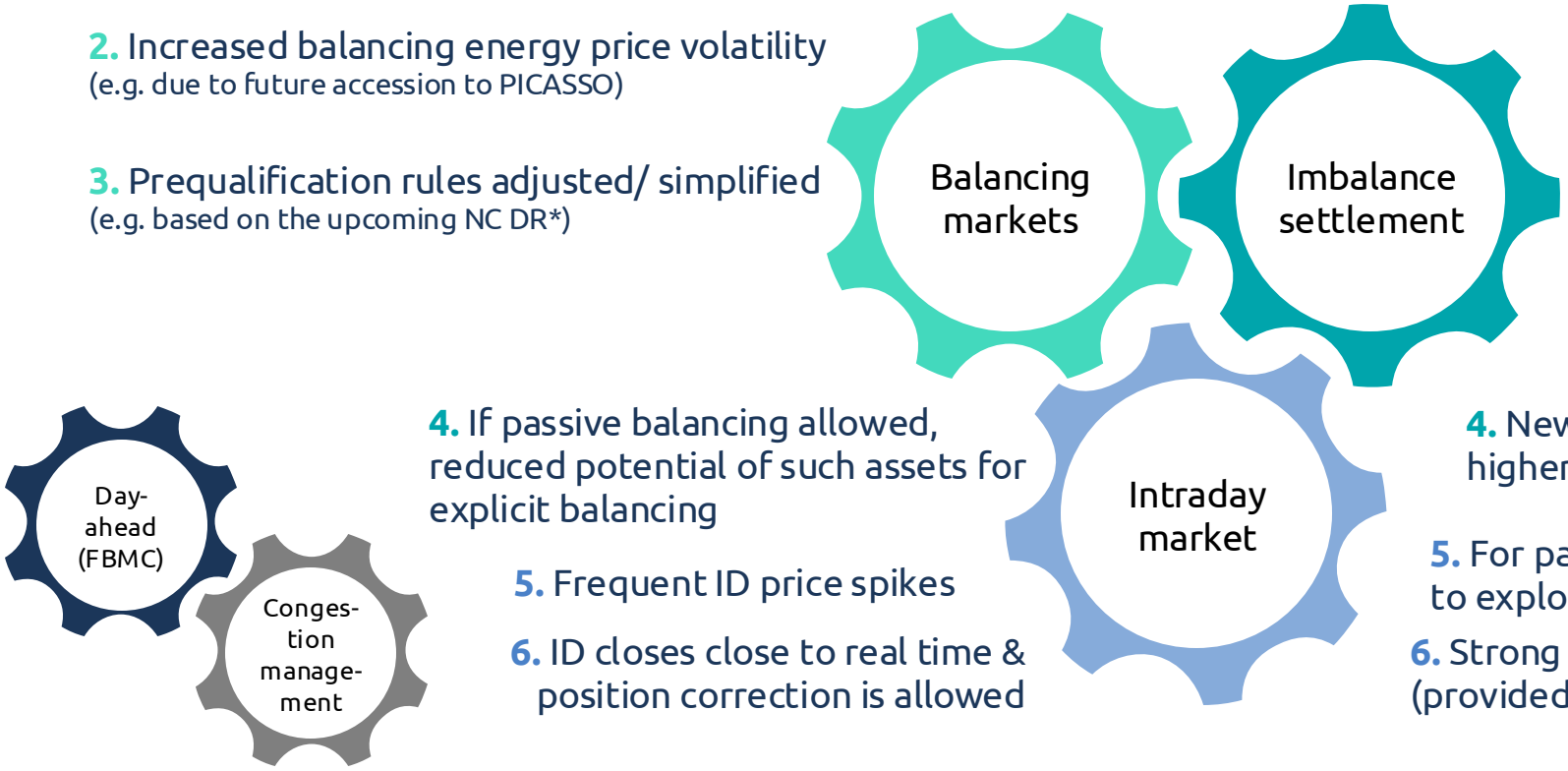
6. Conclusions

A strong link between balancing markets, imbalance settlement and the intraday market creates a strong interaction between BRP, BSP and TSO incentives. Changes in the balancing and intraday markets tend to have an impact on imbalance prices and, by extension, on the incentive to passively balance.

1. Balancing market design change
(e.g. based on the ISHM and future EBGL 2.0 revision)

2. Increased balancing energy price volatility
(e.g. due to future accession to PICASSO)

3. Prequalification rules adjusted/ simplified
(e.g. based on the upcoming NC DR*)



1. Strong propagation effects towards imbalance settlement (as e.g. seen after mFRR EAM go-live)

2. Lower incentive for passive balancing, esp. if volatility not underpinned by fundamentals (low interpretability)

3. More assets participating in explicit balancing, less incentive for passive balancing. Potentially a stronger alignment between BSP and BRP incentives.

4. If passive balancing allowed, reduced potential of such assets for explicit balancing

5. Frequent ID price spikes

6. ID closes close to real time & position correction is allowed

4. New decentralized assets in the system have a higher chance of offering implicit balancing

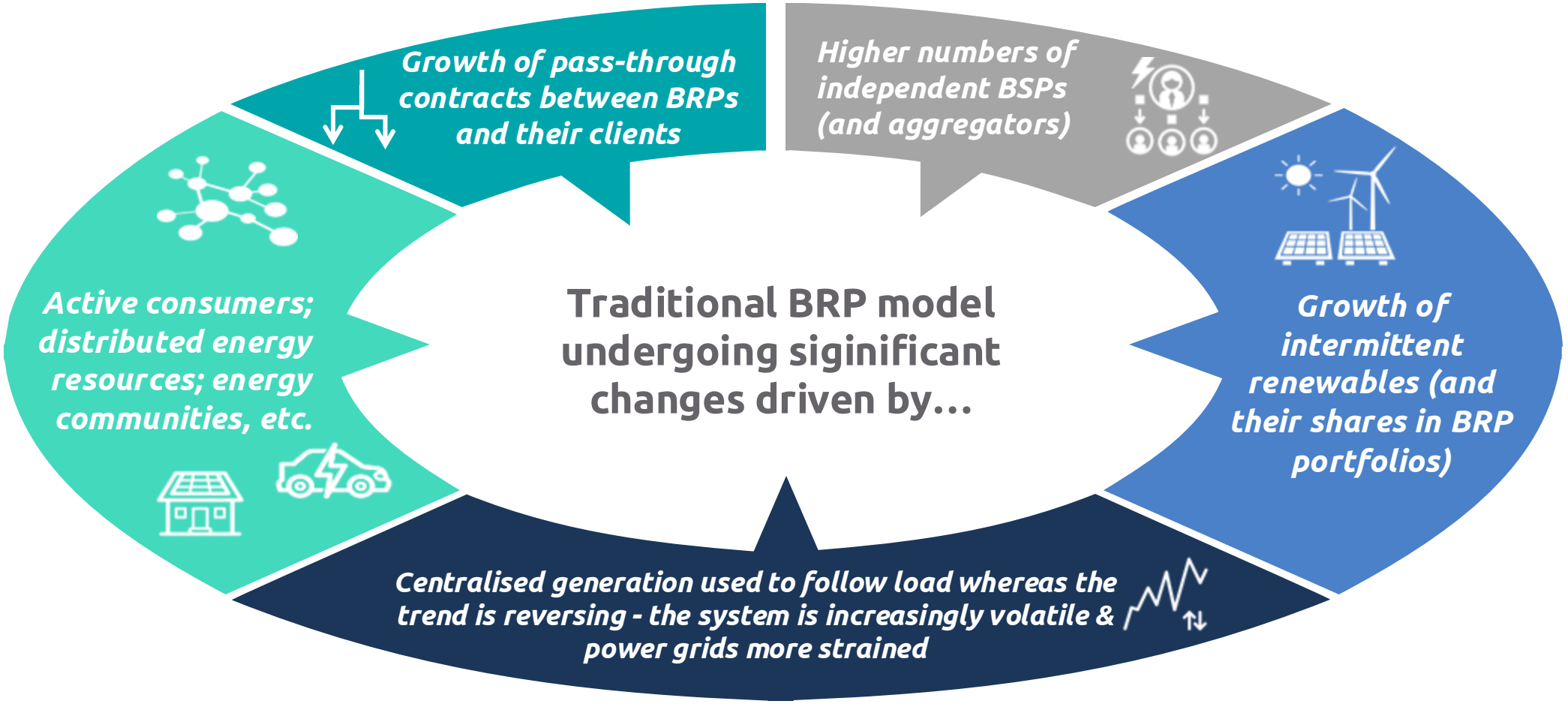
5. For passive balancing, potentially an incentive to exploit ID price – IP price differentials

6. Strong incentive to passively balance (provided IPs are high)

Striking a balance between explicit and implicit balancing as well as "connecting the dots" across different market timeframes and services likely needed in a future more volatile and interdependent system.

* **Upcoming Network Code Demand Response** leads to a reopening of the EBGL to streamline the content; strong links in terms of (simplified) prequalification criteria in draft NC DR as well as introduction of aggregation models in the EBGL.

Global future trend: The overall nature of BRP business and its role is changing due to the technological effects of the energy transition and changing regulatory requirements. BRPs have less and less control of and insight into what is happening inside their portfolios in any given time or predicting it.



The 'centralised physical balancing role' of the BRP is becoming less prominent more complex role with less predictabilty and controllability of its own portfolio. In addition, these incentives can be increasingly observed at the client level rather than BRP-level only.

Conclusions

BRP-TSO "win-win" to maximize the positive impact of passive balancing = **minimized trade-off** between incentive for passive balancing & BRP risk exposure.

Imbalance pricing formula + available information + TSO operational choices + scheduling requirements + market liquidity + asset flexibility jointly determine whether BRPs will prefer keeping a strictly balanced portfolio or assist the system through passive balancing. This may also change over time.

Publication of imbalance information may or may not be conducive to passive balancing. Publication of information alone – regardless of whether in real time or *ex post* will not create the right reaction if the other factors don't fit. **Predictability of market conditions – based on published data or not – likely has a stronger impact.** Even if a lot of imbalance information is available but the imbalance prices is very volatile and not correlated with the system conditions, BRPs are unlikely to react due to excessive risk.

A rational BRP will passively balance if their expected marginal benefit > expected cost + risk premium + expected penalties. Penalties, collateral requirements, uncertainty and strict regulatory oversight increase the costs or the risk premium, thereby reducing the incentive for passive balancing. Even modest administrative costs and an elevated (perceived) market and/or regulatory risk can flip the decision from profitable to unprofitable.

EBGL Art. 12. 3. obliges each TSO to publish "information on the current system balance of its scheduling area or scheduling areas, as soon as possible but no later than 30 minutes after real-time" → **a combination of single pricing and publication requirements makes (overt/covert) passive balancing essentially unavoidable.**

Outlook: Decreasing visibility of own (distributed portfolio) + "internationalization effects" (PICASSO/MARI) will act as "polluting factors" for local imbalances thus limiting opportunities to meaningfully adjust positions to help the system. Close-to-real-time balancing/imbalance publications can help in such situations.

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