Option space for future imbalance pricing in the Nordics once connected to the European balancing energy platforms

Common Nordic TSO paper written by:
Statnett, Energinet, Svenska kraftnät and Fingrid

24. April 2023

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List of abbreviations used in document

ACE	Area Control Error
aFRR	automatic Frequency Restoration Reserve
AOF	Activation Optimization Function
BRP	Balance Responsible Party
BSP	Balancing Service Provider
EB GL	Electricity Balancing Guideline
ENTSO-E	European association for the cooperation of transmission system operators (TSOs) for electricity
FRR	Frequency Restoration Reserve (refers to both aFRR and mFRR)
ISHM	Imbalance Settlement Harmonisation Methodology
ISP	Imbalance Settlement Period
MARI	Manually Activated Reserves Initiative
mFRR	manual Frequency Restoration Reserve
mFRR DA	manual Frequency Restoration Reserve Direct Activation
mFRR SA	manual Frequency Restoration Reserve Scheduled Activation
MTU	Market Time Unit
NRA	National Regulatory Authority
PICASSO	Platform for the International Coordination of Automated frequency restoration and Stable System Operation
TSO	Transmission System Operator
VoAA	Value of Avoided Activation
VWA	Volume Weighted Average

1. Purpose of the document

The Nordic TSOs Statnett, Energinet, Svenska kraftnät and Fingrid, are commonly working on defining the future imbalance pricing design to be implemented in the Nordic countries once connected to MARI and PICASSO, the European balancing energy activation platforms for the balancing energy products mFRR and aFRR.

Imbalance pricing design is a national matter (national proposal and regulatory decision), however, due to the long history of Nordic harmonisation regarding electricity markets, balancing the electricity systems and imbalance settlement, the Nordic transmission system operators (TSOs) are working together towards defining a new common design with the aim to maintain the high level of Nordic harmonisation in the future as well.

The purpose of this document is to introduce the topic to all interested stakeholders and to serve as background knowledge for stakeholders to give informal feedback or input to the Nordic TSOs regarding the future imbalance pricing design to be implemented in the Nordic countries once they are connected to MARI and PICASSO.

The document introduces the topic and sets the framework for why changes must be made to the imbalance pricing design in the near future. The document also introduces the design options and possible approaches to imbalance pricing which have to be in line with the framework set by the relevant legislation. Finally, information regarding the timeline for the further work, relevant legislation, additional examples of imbalance pricing calculations are provided, and an overview of previous stakeholder interaction is included. A simple Excel tool is published along with this document, for all interested parties to be able to test the different design approaches and to compare them with each other.

1.1 Possibility to provide informal stakeholder feedback or input

It is important to note, that the Nordic TSOs have not yet made a proposal on how the imbalance pricing design in the future should be. The design work is currently ongoing and is therefore also open for informal stakeholder feedback and input.

If you wish to provide the Nordic TSOs with informal feedback or input, please send this by e-mail to Erica Schandorff Arberg from Energinet, who will collect all incoming informal stakeholder feedback and input on behalf of the Nordic TSO working group.

Practical information:

- Send an e-mail to ear@energinet.dk with the subject: *"Informal feedback regarding future imbalance pricing design"*.
- Feedback and input must be received by **Tuesday 16. May 2023** to respect the timeline for the further work ahead.

The Nordic TSO's will not be commenting on or answering the informal stakeholder feedback or input received. It will neither be published. It will however be informally considered in the Nordic TSO's further work with making a proposal for the future imbalance pricing design.

2. Introduction

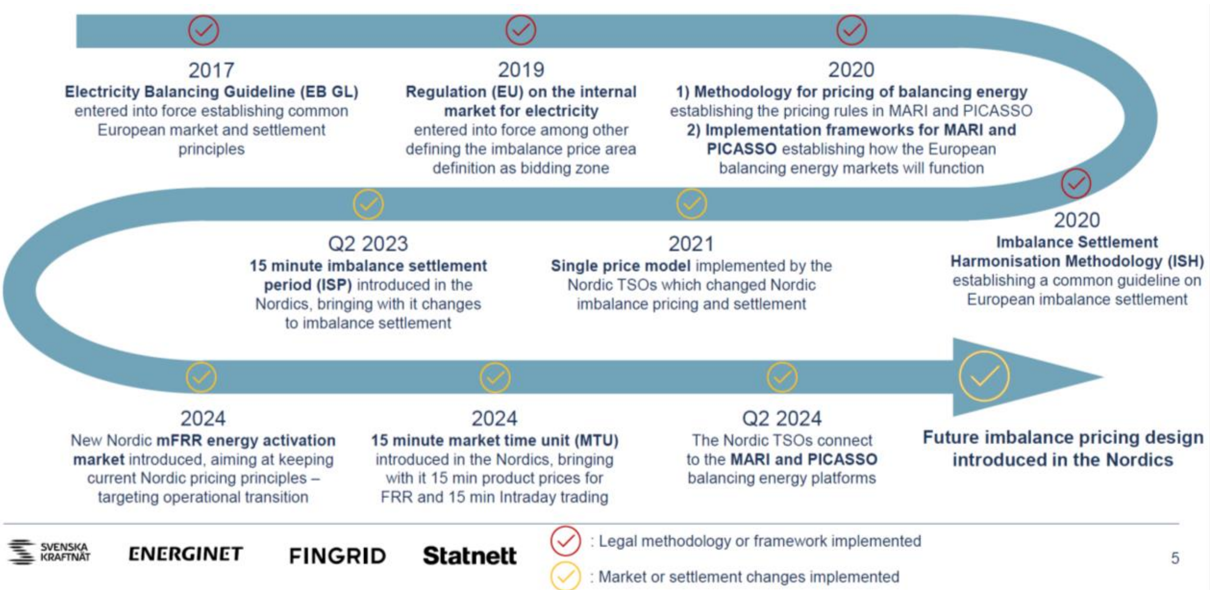
The fundamental design of the imbalance price setting in the Nordics will soon have to change due to two main reasons:

1) Connection to the common European balancing energy activation platforms, MARI and PICASSO, and introduction of area control error (ACE) based balancing in the four Nordic control areas: Norway, Denmark, Sweden, and Finland.
2) Implementation of part two of the Imbalance settlement harmonisation methodology (ISHM), which provides for further harmonisation with the connection to MARI and PICASSO. Also, the introduction of ACE-based balancing requires a change to set the dominating direction per imbalance price area, which shall equal the bidding zone.

Implementation of ACE-based balancing in the Nordic system and connection to MARI and PICASSO will impact substantially on how the Nordic TSOs will balance the Nordic system, also bringing with it a change of focus from the Nordic synchronous area to bidding zone level for each TSO.

Once the Nordic TSOs are connected to the MARI and PICASSO platforms, balancing energy prices will be set for standard products and potentially national specific products for mFRR and aFRR according to the European pricing methodology. These balancing energy prices will be part of the future imbalance price design, as described in the ISHM.

A roadmap showing the road leading to the needed changes for future imbalance settlement and design is illustrated in Figure 1.



The roadmap includes the above mentioned reasons that will affect a future design of the Nordic imbalance design, along with an overview of relevant legislation and legal framework, which sets the rules and framework for imbalance settlement in Europe (illustrated by the red markings on the figure), together with market or settlement changes that either has or will be implemented in the near future in the Nordics (illustrated by the yellow markings on the figure).

Scope
In this document, we will focus on the changes related to balancing energy prices and change to dominating direction. We will not discuss other design elements such as additional components, fees or mitigation measures (as implemented by the common Nordic Single Price project, see design document). We will neither explicitly discuss how to include potential specific products in the imbalance price.

3. Framework

This chapter briefly explains the framework for changes leading to a new future imbalance price design. A short introduction to the European balancing energy activation platforms MARI and PICASSO is given, along with an explanation of how they will affect the imbalance price setting in the future. Finally, the changes to imbalance price design in the future are explained in short, before more details are explained in the following chapters.

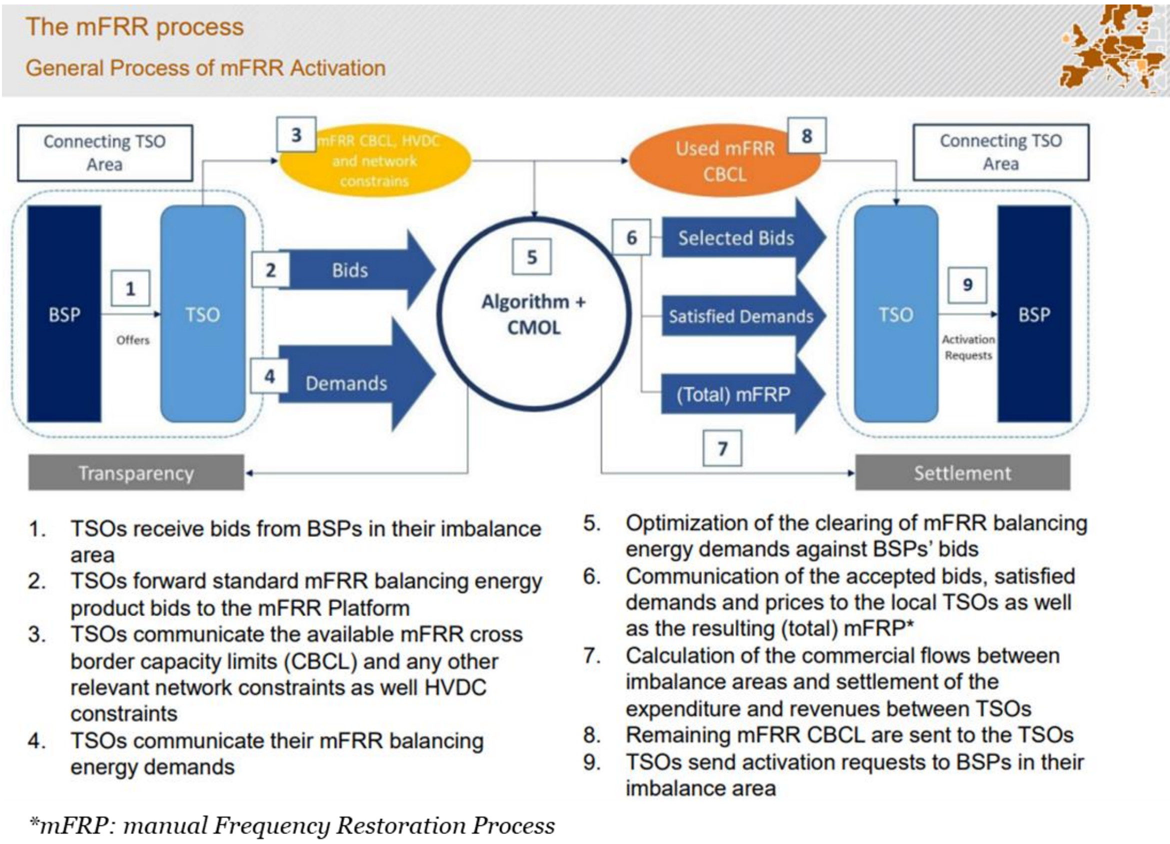
3.1 Short introduction to MARI and PICASSO

MARI is the European balancing energy activation platform for the standard product for mFRR. The standard product can be activated in two ways: As scheduled activation (SA) of mFRR or direct activation (DA) of mFRR. The MARI platform was brought successfully into operation on 5 October 2022. It is currently CEPS and the German TSOs which have connected to the platform.

PICASSO is the European balancing energy activation platform for the standard product for aFRR. The PICASSO platform was brought successfully into operation on 1 June 2022. It is currently the Austrian and the German TSOs which have connected to the platform.

All four Nordic TSOs have requested to connect to both MARI and PICASSO at a later point in time than the legal connection date set by the Electricity Balancing Guideline (EB GL). All four Nordic TSOs have also gotten their requests granted, and therefore now have a new legal date of 24 July 2024 to connect to MARI and PICASSO.

To provide a basic understanding of how MARI and PICASSO work, the general process for mFRR activation in MARI is illustrated in Figure 2. The technical process of PICASSO is a bit different than in MARI, but the underlying concept is the same.



From the processes of mFRR and aFRR activation through the MARI and PICASSO platforms, it is important to highlight the following:

- With MARI and PICASSO, each Nordic TSO will set the balancing energy demand for mFRR and aFRR per bidding zone (step 4 in Figure 2). The bidding zones in the Nordic countries consists of NO1-NO5 in Norway, DK1 and DK2 in Denmark, SE1-SE4 for Sweden and FI in Finland.

- The algorithms of MARI and PICASSO, which consists of two different activation optimization functions (AOF), resolves how to optimize the total demand of the connected countries (step 5 in Figure 2).
  - The AOF in MARI nets the demands for scheduled activation if it's economically profitable to do so, based on a socio-economic perspective. For direct activation there is not netting of demand, as the AOF solves the demand for one bidding zone at a time.
  - The AOF in PICASSO always nets the demands if there is available transmission capacity.

- The TSOs will receive back the satisfied demand per bidding zone (step 6 in Figure 2), which can differ from the original bidding zone demand (step 4 in Figure 2) in case of insufficient available bids.
  - Satisfied demand is a key concept in the ISHM, and important element to understand.

- Activation volumes in a bidding zone may also differ from the satisfied demand of the bidding zone due to exchange with other bidding zones.

The balancing process is also sequential, as the "final demand" of a bidding zone is solved stepwise (first with mFRR SA, then aFRR and potentially mFRR DA), and taking into account that activated bids for mFRR are not deactivated if the balancing demand changes during the imbalance settlement period (ISP).

On standard versus specific products
EB GL introduces the concept of *standard products* together with the MARI and PICASSO platforms. The establishment of the standard products is necessary to enable exchange in the common European platforms. With the introduction of the standard products also comes the introduction of *specific products*. Specific products are national products, which a TSO can design themselves and use in addition to standard products, if the national regulating authority (NRA) approves this. Specific products can be used if it is demonstrated that a) standard products are not sufficient to ensure operational security and to maintain the system balance efficiently or b) that some balancing resources cannot participate in the balancing market through standard products. Bids for specific products can be converted by the TSO into the standard product and thereby activated through MARI and PICASSO platforms, or they can be activated nationally only. Specific products which are not converted to standard products can only impact the imbalance price nationally.

For further details regarding standard and specific products Article 25 and 26 of the EB GL.

3.2 How MARI and PICASSO affect imbalance price setting

Today, we only have the mFRR balancing energy prices for up and down direction that are used when setting the imbalance price in the Nordics. When connected to the MARI and PICASSO platforms, there will be several mFRR and aFRR energy activation prices from standard products and potentially then national specific products activated for balancing purposes during the 15 min ISP, which must be considered in the imbalance price setting. This is specified in the ISHM.

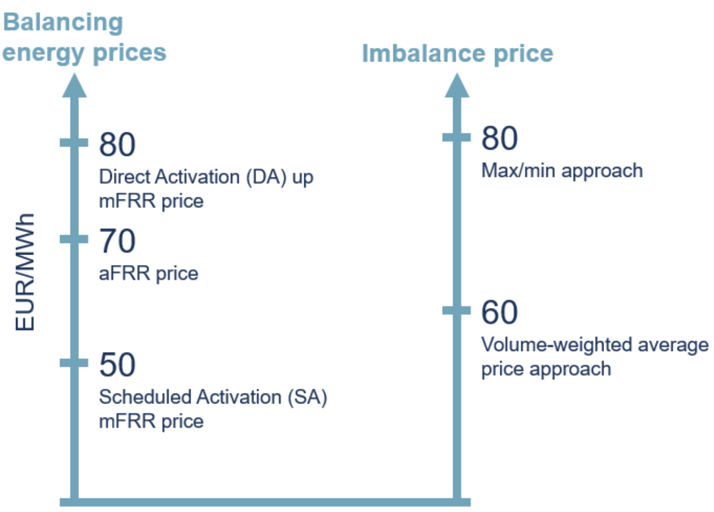
From MARI, it is possible to have one mFRR price for scheduled activation and up to four mFRR prices for direct activation for the same ISP. From PICASSO it is possible to have up to 225 prices for the 15 min ISP. These balancing energy prices are used to settle the Balancing Service Providers (BSPs), and are also input for calculating the imbalance price for the Balance Responsible Parties (BRPs) for each ISP. The introduction of several balancing energy prices is a large change for the Nordic countries compared to the current practice.

Overview of the relevant products to consider when setting a future imbalance price:

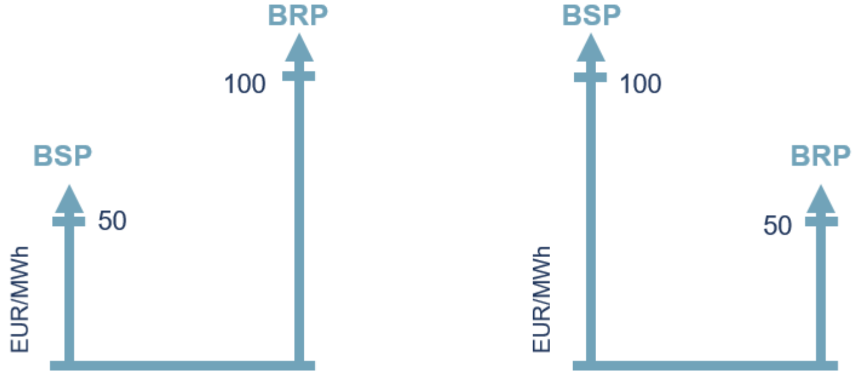
Platform	**Product**	**Possible activation directions within the uncongested area**	**Prices per 15 min ISP**
MARI	Scheduled Activation (mFRR SA)	• Up • Down • Both Up and Down • None	1 price
MARI	Direct Activation (mFRR DA)	• Up • Down	Up to 4 prices
PICASSO	aFRR	• Up • Down • None	Up to 225 prices
No common platform	Possibility for specific product(s) which are nationally defined and activated for balancing purposes	Unknown	Unknown

Bidding zones that belong to the same uncongested area in the market clearing of the MARI and PICASSO platforms, will have the same balancing energy prices for the given product/activation process per market time unit (MTU).

An important aspect with several balancing energy prices, is that there will be a misalignment by design of the financial incentives between BSPs and BRPs. In the current Nordic market design, all balancing energy is priced with the mFRR prices, and the imbalance price is set as the mFRR price in the dominating direction. This gives the same value of the balancing energy in the dominating direction, whether delivered as a BSP or BRP (noting that a BRP is not allowed on purpose to have an imbalance in the direction of the system imbalance). With several balancing energy prices, there will always be a difference between at least one balancing energy price in the dominating direction and the imbalance price, as illustrated in the figure below.



This can be further elaborated. If the balancing energy price to the BSP for delivering a given product, is systematically *lower* than the imbalance price seen by the BRP, this may give the incentive to keep flexibility available as a BRP and use flexibility to manage own imbalances instead of delivering energy as a BSP to the TSO. If the balancing energy price to the BSP for delivering a given product, is systematically *higher* than the imbalance price seen by the BRP, it may lead to less discipline in delivering the balancing energy as a BSP, given that a BSP in some way or another will face the imbalance price as a price for non-delivery (as a BRP or through financial agreement with a BRP). This may also imply that other measures may be necessary from the TSO to follow up on delivery of balancing energy from BSPs.



To which extent these structural differences may impact on the strategies of BSPs and BRPs, depend on the actual balancing energy price formation for mFRR and aFRR and whether differences in prices are large and/or systematic.

3.3 How the ISHM part 2 impacts on the imbalance price setting

How to calculate the imbalance price is regulated in the Imbalance Settlement Harmonisation Methodology (ISHM) under EB GL, which provides the main framework on how to set the dominating direction and imbalance price in the future.

The dominating direction ("direction of the total system imbalances" in ISHM terminology) is used to define if the imbalance price is set for a negative (deficit) or positive (surplus) imbalance in the ISP. Dominating direction shall as a minimum be set based on the satisfied demand of frequency restoration reserves (FRR), so both mFRR and aFRR, in the bidding zone (see article 8 of the ISHM). The setting of the dominating direction based on satisfied demand per bidding zone is also a large change to the current design in the Nordics. We are currently applying an exception rule in the ISHM, which allows us to set the dominating direction across a set of imbalance price areas as we do frequency-based balancing (see article 8(3) of the ISHM). With ACE-based balancing, the dominating direction shall be set per imbalance price area, where the imbalance price area is defined to be equal to the bidding zone in the Market Regulation 2019/943 (see article 6(6)).

If there is a relevant balancing energy price for the dominating direction for the bidding zone, it shall be used to set the imbalance price. With many balancing energy prices, there is a higher likelihood of relevant balancing energy prices for both directions per ISP, so that an imbalance price shall be based on the balancing energy prices of its direction. In case of no relevant-balancing energy prices, the imbalance price will be set to the so-called Value of Avoided Activation (VoAA). VoAA shall be set based on the bid price or prices from FRR balancing energy. Today in the Nordics, the VoAA is used together with the incentivizing component to set the imbalance price equal to the day-ahead price, which is also used as a reference price in the mFRR market, when there is no dominating direction.

So, what do we mean by a *relevant* balancing energy price? This is to distinguish that there can be a balancing energy price in a bidding zone, but it does not have to be taken into account if the bidding zone does not have "explicit demand" for it. By "explicit demand" is meant that a bidding zone has a satisfied demand which is unequal to zero for the balancing energy product/activation process which the balancing energy price is valid for.

Further explained: If a bidding zone has zero demand for a balancing energy product, but is activating for delivery to another bidding zone, there will be a balancing energy price for this product in the bidding zone. However, the bidding zone performing the delivery does not have to take this balancing energy price into account, but it can choose to do so. This is due to the boundary condition described below. When setting the imbalance price for the bidding zone, it is therefore a design option whether to take into account only the balancing energy prices that the bidding zone has had an "explicit demand" for or to take into account all the balancing energy prices from the uncongested areas.

When calculating the imbalance price, it is specified by the ISHM that the TSOs must use certain approaches. The relevant approaches which are allowed are the volume weighted average (VWA) approach, the maximum/minimum price approach, or a combination of these approaches. The imbalance price will be based on the balancing energy prices for FRR (also possible to adjust with additional components) and respective satisfied demand volumes.

The imbalance price needs to be set so that the imbalance price at least respects the boundary condition of the volume weighted average value of the balancing energy prices. The imbalance price for a negative imbalance (deficit) cannot be lower than the weighted average price from the relevant balancing energy prices for upward activation. The imbalance price for a positive imbalance (surplus) cannot be higher than the weighted average value calculated from the relevant balancing energy prices for downward activation. The ISHM specifies that this calculation shall use the bidding zone's satisfied demand as the volume-weight, so that any balancing energy price without a satisfied demand can be ignored.

4. Different approaches for imbalance price calculation

The imbalance price setting approaches given by the ISHM (Article 9) are described here in detail by the Nordic TSOs, along with two possible combined approaches, which in exact form are design ideas created by the Nordic TSOs. With respect to the combined approaches, the Nordic TSOs have developed an additional alternative compared to what was shown in the Nordic webinar on 8. February 2022.

An overview of the different design approaches, which are introduced and explained in more detail in this chapter, is illustrated in Figure 3.

We have also developed some examples which are included as an annex to this document, in addition to an Excel tool published together with this document, which can be used to further explore and understand the different approaches.

We will return to the details of VoAA in the next chapter.

Design approach 1

- **Volume weighted average (VWA) approach**
- **Local* prices** (only take into account prices for which you have an explicit demand)
- **VoAA design** could either be based on mFRR SA or first available up and down bids

Design approach 2

- **Combined approach 1**
  Max/min price of:
  - VWA of aFRR
  - mFRR SA
  - mFRR DA
- **Local* or uncongested area** prices** from demands to take into account in imbalance price setting
- **VoAA design** could either be based on mFRR SA or first available up and down bids

Design approach 3

- **Combined approach 2**
  Max/min price of:
  - VWA of aFRR, mFRR SA and mFRR DA
  - mFRR SA
  - mFRR DA
- **Local* or uncongested area** prices** from demands to take into account in imbalance price setting
- **VoAA design** could either be based on mFRR SA or first available up and down bids

Design approach 4

- **Max/min approach**
  Max/min price of mFRR SA, mFRR DA or aFRR
- **Local* or uncongested area** prices** from demands to take into account in imbalance price setting
- **VoAA design** could either be based on mFRR SA or first available up and down bids

* Local prices: only take prices into account for which the bidding zone has an explicit demand (demand > 0)
** Uncongested area prices: take into account all prices available for the bidding zone (demand ≥ 0)

4.1 Design approach 1: Volume weighted average approach

The volume weighted average approach calculates the imbalance price as the volume weighted average of the bidding zone's satisfied demand of FRR energy prices in the 15 min ISP in the relevant direction.

With the volume weighted average approach, only balancing energy prices that the bidding zone has an explicit demand for, will be taken into an account. All balancing energy prices with a satisfied demand equal to zero will "disappear" in the calculation of the volume-weighted price as satisfied demand is the volume-weight.

The volume weighted average approach gives the cheapest and likely most stable imbalance prices of the possible different design approaches. This also means that the imbalance price signals to the market will also be the softest with this approach compared to the other possible design approaches. The financial incentive to deliver balancing energy for the BSP through the cost of an imbalance may be weakened, since the imbalance price will most likely be lower than the price of some balancing energy products. This can give market participants who operates as both BSP and BRP an unwanted incentive to avoid delivering balancing energy if settled as requested volumes.

With the volume weighted average approach, the balancing energy prices of both aFRR and mFRR for the dominating direction, will be weighted based on the satisfied demand of the bidding zone.

$$Imbalance\ price = \frac{\sum(Satisfied\ demand\ per\ product * Balancing\ energy\ price\ per\ product)}{Total\ satisfied\ demand} \quad (1)$$

In the volume weighted average approach the price signal of small volume activations will smooth away. For example, in case where a few MWh of mFRR DA would be needed to be activated the affect for the imbalance price will remain insignificant if volumes of mFRR SA and aFRR will be noticeable. With this smoothing effect a noticeable part of the balancing energy will have a higher price than the imbalance price. Also, a bidding zone with a large imbalance, may get a lower imbalance price than a bidding zone with a smaller imbalance, if the bidding zone with the larger imbalance has been able to mitigate the imbalance with a higher share of cheaper balancing energy products that the other bidding zone.

4.2 Design approach 2: Combined approach 1

The combined approach 1 sets the imbalance price based on the max/min price of either the mFRR SA price, the mFRR DA price or the volume weighted average aFRR price.

The volume weighted average aFRR price will be calculated for the 15 min ISP, based on the satisfied demand of aFRR in the bidding zone. It will then only include aFRR prices for which the bidding zone has an explicit demand in the dominating direction.

When selecting the max/min mFRR SA and mFRR DA prices for imbalance price calculation, it is possible to either take into account only balancing energy prices for which the bidding zone has an explicit demand for or use all the available mFRR prices from the uncongested areas.

With the combined approach 1 it is possible to avoid effects from overly high aFRR spike prices which might occur due the 4 second optimisation cycles in PICASSO, but still give a stronger marginal price-based signal to the market and to give a price signal that is based on uncongested area mFRR prices.

When the dominating direction is up (need for up regulation):

$$Imbalance\ price = Max(VWA_{aFRR,up}, mFRR\ SA_{up}, mFRR\ DA_{up}) \quad (2)$$

When the dominating direction is down (need for down regulation):

$$Imbalance\ price = Min(VWA_{aFRR,down}, mFRR\ SA_{down}, mFRR\ DA_{down}) \quad (3)$$

4.3 Design approach 3: Combined approach 2

The combined approach 2 sets the imbalance price based on the max/min price of either the mFRR SA price, the mFRR DA price or the volume weighted average price of all mFRR and aFRR prices with an explicit demand for the bidding zone.

The volume weighted average price will be calculated for the 15 min ISP, based on the satisfied demand of mFRR and aFRR in the bidding zone. It will then only include aFRR and mFRR prices for which the bidding zone has an explicit demand in the dominating direction.

When selecting the max/min mFRR SA and mFRR DA prices for imbalance price calculation, it is possible to either take into account only mFRR balancing energy prices for which the bidding zone has an explicit demand or use all the available mFRR prices from the uncongested area in the dominating direction.

With the combined approach 2, the idea is to give a marginal mFRR price-based signal to the market while always ensuring to comply with the boundary condition for the imbalance price. Thereby, aFRR contribution will be softened and imbalance pricing may else target similar results as today. In the combined approach 2, mFRR (either mFRR SA or mFRR DA) will be price setting for the imbalance price if one of the mFRR prices are greater than the volume weighted average price for the 15 min ISP.

When the dominating direction is up (need for up regulation):

$$Imbalance\ price = Max(VWA_{up}, mFRR\ SA_{up}, mFRR\ DA_{up}) \quad (4)$$

When the dominating direction is down (need for down regulation):

$$Imbalance\ price = Min(VWA_{down}, mFRR\ SA_{down}, mFRR\ DA_{down}) \quad (5)$$

4.4 Design approach 4: Max/min approach

The max/min approach selects the imbalance price as the max/min price depending on direction, of all aFRR and mFRR prices relevant in the 15 min ISP.

When selecting the FRR prices for imbalance price calculation, it's possible to take into account only balancing energy prices for which the bidding zone has an explicit demand for in the dominating direction or use all the available FRR prices from the uncongested areas.

In this option, in addition to the mFRR prices, all the possible aFRR prices in the dominating direction (maximum 225 prices) from the 15 min ISP would be taken into account when setting the imbalance price. Including all the individual aFRR prices may result in extreme imbalance prices and high volatility. There is also the highest risk of misalignment between balancing energy prices for FRR products and the imbalance price due to possible spikes in the aFRR prices.

When the dominating direction is up (need for up regulation):

$$Imbalance\ price = Max(aFRR_{up}, mFRR\ SA_{up}, mFRR\ DA_{up}) \quad (6)$$

When the dominating direction is down (need for down regulation):

$$Imbalance\ price = Min(aFRR_{down}, mFRR\ SA_{down}, mFRR\ DA_{down}) \quad (7)$$

4.5 What imbalance price to expect?

The outcome from the different imbalance price approaches is highly dependent on the demand for different balancing energy products and the balancing energy price levels and spreads.

We do not know well how the future balancing energy prices will relate to each other: Whether mFRR prices or aFRR prices will be the highest/lowest, and how large any spread between these prices will be, except that mFRR DA will at least be the same or higher/lower (depending on direction) than the SA price due to the product pricing rules. Else, it is difficult to foresee how the mFRR and aFRR prices will form, and we do not have any historical experience with separate mFRR and aFRR balancing energy prices.

The imbalance price will probably most often be defined by aFRR or mFRR DA in both the combined 1 and max/min approaches if mFRR SA is expected to be cheapest product and used as the base balancing energy product. However, in the volume weighted average approach and most often in combined 2, mFRR SA will have the greatest affect if it most often constitutes the largest volume.

The aFRR product will most likely have smaller volumes of activations but greater volatility and price spikes might occur due to the frequent optimisation/amount of control cycles. Therefore, in the max/min approach aFRR might be the price setting product most often.

5. Value of Avoided Activation

The value of avoided activation is needed when an imbalance price area has no demand or no balancing energy activated for its direction.

Today, such situations are defined when there are no activations of mFRR for balancing in the uncongested area (subset of imbalance price areas). The situations with no dominating direction are today frequent. The imbalance price in these situations is today set to the day-ahead price by adjusting the value given by the VoAA, based on bid prices, with the incentivizing component. This design choice is because of the use of the day-ahead price as a reference price in the Nordic mFRR market today. The day-ahead price forms the floor and roof for the mFRR price in up and down direction and is the mFRR price in case of no activation.

When we enter MARI, the reference to the day-ahead market price for the mFRR price will be taken away as the mFRR prices in MARI will only be based on bid prices. The current rationale for using the day-ahead price as a reference for the imbalance price therefore disappears.

5.1 Cases when VoAA is needed in the future

The cases where we need to use the VoAA in the future are more complex than today, as the dominating direction is set based on the satisfied demand or imbalance of the bidding zone. The cases can be summarized as follows:

1. The total demand in a bidding zone is netted
2. The total demand in an uncongested area is netted
3. No FRR demand in the bidding zone
4. The net satisfied demand for a bidding zone is exactly zero

We will now go through each of these cases.

The total demand in a bidding zone is netted
In this situation, the demand of a bidding zone in a specific ISP has been netted in all balancing energy platform runs, and the resulting balancing energy prices are based on the opposite direction of the bidding zone's demand.

These cases when a bidding zone is fully netted might occur relatively often compared to other situations when we need to define the VoAA, but not as frequent as indirectly today.

The total demand in an uncongested area is netted
In this situation, the demand from all bidding zones in an uncongested area has been netted in a run in MARI or PICASSO, so no activation has been needed. In this case, the balancing energy platforms will set a balancing energy price based on first available up and down balancing energy bid price in the uncongested area for the run.

This is an unrealistic scenario, as demand is set independently per bidding zone and are unlikely to exactly match, but can at least theoretically happen.

No FRR demand in the bidding zone
In this situation, the bidding zone has no demand in either MARI or PICASSO in the ISP.

An ISP with no demand of mFRR for a bidding zone might occur in the future. But an ISP with no aFRR demand for a bidding zone is unrealistic when the demand is automatically calculated by an ACE-control without a dead-band (there will always be a rest imbalance in real-time which forms the basis for the aFRR demand).

The net satisfied demand for a bidding zone is exactly zero
In this situation, the satisfied demand for up regulation and down regulation for FRR products in a bidding zone for a specific ISP is summed up to zero. In case the dominating direction is calculated only on satisfised demand, and it summaries to zero, the dominating direction is set to none.

This is relatively unlikely situation, but theoretically possible.

5.2 How to set the VoAA

According to the ISHM, the VoAA shall be based on bid price or bid prices. Other options as previous market prices (for example day-ahead) were explored when the ISHM was established, but the final choice was to use bid price(s) from FRR as these are closer to real-time.

Therefore, VoAA could be formed as a mid-price of first up and first down balancing energy bids from local or common bid list for FRR either pre auction or after auction. It is also possible to use an actual FRR balancing energy price, which by definition in itself is based on a bid price(s).

Based on the above, a non-exhaustive list of options is provided here to give an overview:

- Mid-price first up/first down local bid list for mFRR (set pre auction)
- Mid-price first up/first down common bid list for mFRR (set pre auction)
- Mid-price first up/first down local bid list for mFRR (set after auction)
- Mid-price first up/first down common bid list for mFRR (set after auction)
- Use the mFRR SA price from MARI

On the latter: MARI will provide a price for the mFRR SA product even if there is no demand or activation in a bidding zone; If the bidding zone is used as transit for activation in one bidding zone to cover demand in another bidding zone, the transit bidding zone will also have a price available. In a situation where all demand in the bidding zones in an uncongested area are fully netted, MARI will calculate a price based on first up- and down bid prices in the uncongested area. We therefore expect that there in almost all imbalance settlement periods will be a balancing energy price for SA. It is possible to think about the mFRR SA price as a sort of "reference price" for balancing energy in case of no demand or no activation in the right direction. At least if mFRR SA is seen as the key balancing energy product used to balance.

There are several design options, but a pragmatic and simple approach on how to set the VoAA may be desirable and also acceptable due to limited application. Furthermore, for the sake of simplicity, it may be preferable to handle the different cases in the same way.

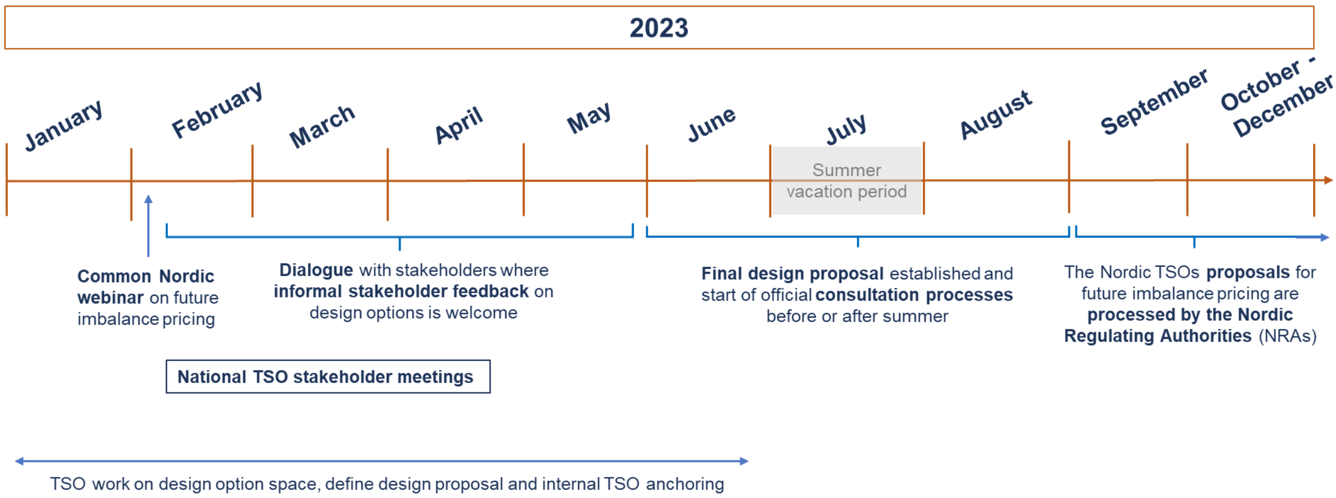
6. Timeline and further work

The Nordic TSOs are currently working on defining the future imbalance price design which will be implemented when connections to the MARI and PICASSO platforms are established. The legal deadline in the four Nordic countries for connecting to MARI and PICASSO is 24 July 2024.

In the current phase, the different design options are presented to stakeholders to set the framework for possibilities regarding a new imbalance pricing design. Informal feedback and input from stakeholders are welcome, see Chapter 2.1 regarding details of how to provide written feedback to the TSOs.

After the summer vacation period, the Nordic TSO's expect to have a final proposal for the future imbalance price design ready for formal national stakeholder consultations. The formal national stakeholder consultations must be held by each TSO before the Nordic TSO's can send updated national BRP terms and conditions to the relevant NRA for approval.

An overview of the expected timeline for current and future work can be seen here:



Annex 1: Relevant legislation

An overview of the relevant legislation and legal frameworks that stipulates or sets the fame for imbalance design in Europe is listed here, together with a link to the formal documents.

Electricity Balancing Guideline (EB GL)

Official title: Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Found here, from 23 November 2017.

Art. 44 stipulates general settlement principles.

Imbalance Settlement Harmonisation Methodology (ISHM)

Official title: Methodology for the harmonisation of the main features of imbalance settlement in accordance with Article 52(2) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Found here, from 15 July 2020.

Title III (Art. 7, 8, 9, 10 and 11) sets the framework for specification and harmonisation of imbalance price calculation.

European Electricity Regulation

Official title: REGULATION (EU) 2019/943 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 5 June 2019 on the internal market for electricity

Found here, from 5 June 2019.

Art. 6(6) states that each imbalance price area shall be equal to a bidding zone.

Methodology for Pricing of Balancing Energy

Official title: Methodology for pricing balancing energy and cross-zonal capacity used for the exchange of balancing energy or operating the imbalance netting process in accordance with Article 30(1) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Found here, from 24 January 2020.

Implementation Framework for PICASSO

Official title: Implementation framework for the European platform for the exchange of balancing energy from frequency restoration reserves with automatic activation in accordance with Article 21 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Found here, from 24 January 2020.

Implementation Framework for MARI

Official title: Implementation framework for the European platform for the exchange of balancing energy from frequency restoration reserves with manual activation in accordance with Article 20 of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing

Found here, from 24 January 2020.

Annex 2: Additional examples

Case 1: Area A and B are uncongested and both are upregulating

Satisfied balancing energy demand for the areas in 15 minutes will be:

	Area A	Area B
mFRR SA	20 MWh	10 MWh
mFRR DA	10 MWh	0 MWh
aFRR for runs 1-75 (75*4s=5min)	0,5 MWh	0 MWh
aFRR for runs 76-150 (75*4s =5min)	3 MWh	5 MWh
aFRR for runs 151- 225 (75*4s=5min)	0 MWh	10 MWh

And the prices from activated bids are for example

mFRR SA	30 €/MWh
mFRR DA up	60 €/MWh
aFRR for runs 1-75 (75*4s=5min)	300 €/MWh
aFRR for runs 76-150 (75*4s =5min)	50 €/MWh
aFRR for runs 151- 225 (75*4s=5min)	40 €/MWh

Design 1 - Volume weighted average

Imbalance price will be in area A volume weighted average of all FRR products which has satisfied demand for dominating direction.

$$Imbalance\ price = \frac{20MWh * 30\frac{€}{MWh} + 10MWh * 60\frac{€}{MWh} + 0,5MWh * 300\frac{€}{MWh} + 3MWh * 50\frac{€}{MWh}}{20MWh + 10MWh + 0,5MWh + 3MWh}$$
$$= 44,78\frac{€}{MWh}$$

Imbalance price will be in area B

$$Imbalance\ price = \frac{10MWh * 30\frac{€}{MWh} + 5MWh * 50\frac{€}{MWh} + 10MWh * 40\frac{€}{MWh}}{10MWh + 5MWh + 10MWh}$$
$$= 38\frac{€}{MWh}$$

Design 2A – Combined local with VWA of aFRR

Imbalance price will be in area A maximum of mFRR prices and volume weighted average of aFRR

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 60\frac{€}{MWh}; \frac{0,5MWh * 300\frac{€}{MWh} + 3MWh * 50\frac{€}{MWh}}{0,5MWh + 3MWh}\right)$$
$$= 85,71\frac{€}{MWh}$$

Imbalance price will be in area B

$$Imbalance\ price = Max\left(30\frac{€}{MWh};\frac{5MWh * 50\frac{€}{MWh}10MWh * 40\frac{€}{MWh}}{5MWh + 10MWh}\right) = 43{,}33\frac{€}{MWh}$$

Design 2B – Combined uncongested area with VWA of aFRR

Imbalance price in area A will be the same as in the earlier 2A local example since all mFRR prices were already considered in the local solution and uncongested design doesn't offer additional mFRR prices

$$Imbalance\ price = 85{,}71\frac{€}{MWh}$$

Imbalance price in area B when also mFRR DA price from area A is considered.

$$Imbalance\ price = Max\left(30\frac{€}{MWh};60\frac{€}{MWh};\frac{5MWh * 50\frac{€}{MWh}10MWh * 40\frac{€}{MWh}}{5MWh + 10MWh}\right) = 60\frac{€}{MWh}$$

Design 3A – Combined local with VWA of all FRR

Imbalance price will be in area A maximum of mFRR prices and volume weighted average of FRRs

$$Imbalance\ price = Max\left(30\frac{€}{MWh};60\frac{€}{MWh};\frac{20MWh * 30\frac{€}{MWh} + 10MWh * 60\frac{€}{MWh} + 0{,}5MWh * 300\frac{€}{MWh} + 3MWh * 50\frac{€}{MWh}}{20MWh + 10MWh + 0{,}5MWh + 3MWh}\right) = 60\frac{€}{MWh}$$

Imbalance price will be in area B

$$Imbalance\ price = Max\left(30\frac{€}{MWh};\frac{10MWh * 30\frac{€}{MWh} + 5MWh * 50\frac{€}{MWh} + 10MWh * 40\frac{€}{MWh}}{10MWh + 5MWh + 10MWh}\right) = 38\frac{€}{MWh}$$

Design 3B – Combined uncongested area with VWA of all FRR

Imbalance price in area A will be the same as in the earlier 3A local example since all mFRR prices were already considered in the local solution and uncongested design doesn't offer additional mFRR prices

$$Imbalance\ price = 60\frac{€}{MWh}$$

Imbalance price in area B when also mFRR DA price from area A is considered.

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 60\frac{€}{MWh}; \frac{10MWh * 30\frac{€}{MWh} + 5MWh * 50\frac{€}{MWh} + 10MWh * 40\frac{€}{MWh}}{10MWh + 5MWh + 10MWh}\right)$$
$$= 60\frac{€}{MWh}$$

Design 4 – Max/min price

Imbalance price will be in area A both in local design is maximum of FRRs

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 60\frac{€}{MWh}; 300\frac{€}{MWh}; 50\frac{€}{MWh}\right) = 300\frac{€}{MWh}$$

Imbalance price will be in area A in uncongested design is maximum of FRRs

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 60\frac{€}{MWh}; 300\frac{€}{MWh}; 50\frac{€}{MWh}; 40\frac{€}{MWh}\right) = 300\frac{€}{MWh}$$

Imbalance price will be in area B in local design

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 50\frac{€}{MWh}; 40\frac{€}{MWh}\right) = 50\frac{€}{MWh}$$

and imbalance price will be in area B, in uncongested design, equal to imbalance price in area A

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 60\frac{€}{MWh}; 300\frac{€}{MWh}; 50\frac{€}{MWh}; 40\frac{€}{MWh}\right) = 300\frac{€}{MWh}$$

Case 2: Area A and B are uncongested, the dominating direction for area A is up and for area B down

Satisfied balancing energy demand for the areas in 15 minutes will be:

	Area A	Area B
mFRR SA	20 MWh	10 MWh
mFRR DA	10 MWh	-15 MWh
aFRR for runs 1-75 (75*4s=5min)	0,5 MWh	0 MWh
aFRR for runs 76-150 (75*4s =5min)	3 MWh	0 MWh
aFRR for runs 151- 225 (75*4s=5min)	0 MWh	-5 MWh

And the prices from activated bids are for example.

mFRR SA	30 €/MWh
mFRR DA up	60 €/MWh
mFRR DA down	15 €/MWh
aFRR up for runs 1-75 (75*4s=5min)	300 €/MWh
aFRR up for runs 76-150 (75*4s =5min)	50 €/MWh
aFRR down for runs 151- 225 (75*4s=5min)	10 €/MWh

Design 1 - Volume weighted average:

Imbalance price will be in area A

$$Imbalance\ price = \frac{20MWh * 30\frac{€}{MWh} + 10MWh * 60\frac{€}{MWh} + 0,5MWh * 300\frac{€}{MWh} + 3MWh * 50\frac{€}{MWh}}{20MWh + 10MWh + 0,5MWh + 3MWh}$$
$$= 44,78\frac{€}{MWh}$$

Imbalance price will be in area B

$$Imbalance\ price = \frac{15MWh * 15\frac{€}{MWh} + 5MWh * 10\frac{€}{MWh}}{15MWh + 5MWh}$$
$$= 13,75\frac{€}{MWh}$$

Design 2A – Combined local with VWA of aFRR

Imbalance price will be in area A maximum of mFRR prices and volume weighted average of aFRR

$$Imbalance\ price = Max\left(30\frac{€}{MWh}; 60\frac{€}{MWh}; \frac{0,5MWh * 300\frac{€}{MWh} + 3MWh * 50\frac{€}{MWh}}{0,5MWh + 3MWh}\right)$$
$$= 85,71\frac{€}{MWh}$$

Imbalance price will be in area B minimum of mFRR prices and volume weighted average of aFRR

$$Imbalance\ price = Min\left(15\frac{€}{MWh};\frac{5MWh * 10\frac{€}{MWh}}{5MWh}\right) = 10\frac{€}{MWh}$$

Design 2B – Combined uncongested area with VWA of aFRR

Imbalance price in area A will be the same as in the earlier 2A local example since all mFRR prices for upregulation were already considered in the local solution and uncongested design doesn't offer additional mFRR prices

$$Imbalance\ price = 85{,}71\frac{€}{MWh}$$

Imbalance price in area B will be the same as in the earlier 2A local example since all mFRR prices for down regulation were already considered in the local solution and uncongested design doesn't offer additional mFRR prices

$$Imbalance\ price = 10\frac{€}{MWh}$$

Design 3A – Combined local with VWA of all FRR

Imbalance price will be in area A maximum of mFRR prices and volume weighted average of FRRs

$$Imbalance\ price = Max\left(30\frac{€}{MWh};60\frac{€}{MWh};\frac{20MWh * 30\frac{€}{MWh} + 10MWh * 60\frac{€}{MWh} + 0{,}5MWh * 300\frac{€}{MWh} + 3MWh * 50\frac{€}{MWh}}{20MWh + 10MWh + 0{,}5MWh + 3MWh}\right) = 60\frac{€}{MWh}$$

Imbalance price will be in area B minimum of mFRR prices and volume weighted average of FRRs

$$Imbalance\ price = Min\left(15\frac{€}{MWh};\frac{15MWh * 15\frac{€}{MWh} + 5MWh * 10\frac{€}{MWh}}{15MWh + 5MWh}\right) = 13{,}75\frac{€}{MWh}$$

Design 3B – Combined uncongested area with VWA of all FRR

Imbalance price in area A will be the same as in the earlier 3A local example since all mFRR prices for upregulation were already considered in the local solution and uncongested design doesn't offer additional mFRR prices

$$Imbalance\ price = 60 \frac{€}{MWh}$$

Imbalance price in area B will not change in this case since all mFRR prices for down regulation are already considered in local solution and volume weighted average of all FRR prices defines imbalance price

$$Imbalance\ price = 13{,}75 \frac{€}{MWh}$$

Design 4 – Max/min price

Imbalance price will be in area A both local and uncongested design maximum of FRRs

$$Imbalance\ price = Max\left(30 \frac{€}{MWh}; 60 \frac{€}{MWh}; 300 \frac{€}{MWh}; 50 \frac{€}{MWh}\right) = 300 \frac{€}{MWh}$$

Imbalance price will be in area B both local and uncongested design minimum of FRRs for down regulation

$$Imbalance\ price = Min\left(15 \frac{€}{MWh}; 10 \frac{€}{MWh}\right) = 10 \frac{€}{MWh}$$

Annex 3: Earlier arranged stakeholder engagement

- 2. June 2022: NBM Stakeholder Reference Group meeting - Presentations at Stakeholder Reference Group Meeting 2 June 2022 in Copenhagen
- 5. July 2022: Imbalance pricing and settlement in the Nordics going forward – introduction to the steps ahead (updated)
- 21. September 2022: NBM Stakeholder Reference Group meeting –Presentations and summary from NBM stakeholder reference group meeting 21 September 2022
- 14. December 2022: NBM stakeholder reference group - Presentations and summary from NBM stakeholder reference group meeting 14 December 2022
- 8. February 2023: Common Nordic webinar: Webinar invitation to stakeholders on future imbalance pricing
- 17. March 2023: Q&A follow up from Nordic webinar on future imbalance pricing

In addition to these common Nordic events, national events have also been organised.