

Impact assessment of Sweden's accession to the European balancing platform MARI

Final report

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Authors

Paul Brière (Artelys)

Jimmy Brossier (Artelys)

Michaël Gabay (Artelys)

Renaud Saltet (Artelys)

Contact person

Paul Brière (Artelys)

paul.briere@artelys.com

Abbreviations list

AC	Alternating Current
aFRR	Automatic Frequency Restoration Reserve
ATC	Available Transfer Capacity
AOF	Activation Optimisation Function
BSP	Balancing Service Provider
CBCL	Cross-Border Capacity Limit
DA	Direct Activation
EAM	Energy Activation Market
ENTSO-E	European Network of Transmission System Operators for Electricity
HVDC	High-Voltage Direct Current
IA	Impact Assessment
ISP	Imbalance Settlement Period
KPI	Key Performance Indicator
MARI	Manually Activated Reserves Initiative
mFRR	Manual Frequency Restoration Reserve
MTU	Market Time Unit
NBM	Nordic Balancing Model (Nordic balancing development program)
PICASSO	Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation
PSM	Price Spread Mitigation
TP	Technical Profiles
TSO	Transmission System Operator
URB	Unforeseeable Rejected Bid

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Introduction

The establishment of common European platforms for the activation of mFRR and aFRR was initiated following the approval of the Electricity Balancing guideline in March 2017. These European platforms are intended to enhance the coordinated exchange of cross-border balancing energy. In this context, MARI (mFRR activation platform) went live at the end of 2022, bringing together the German and Czech TSOs¹. Since then, the number of TSOs using the platform has grown. As of December 2025, the countries connected to the platform were Austria, Belgium, Czech Republic, Estonia, Germany, Latvia, Lithuania, the Netherlands, Portugal, Slovakia and Spain.

At the Nordic level, the mFRR activation markets have long been in place at national level. In addition, a common Nordic framework for mFRR balancing energy exchange has existed since 2002. To enable better integration of the national balancing markets, a common mFRR Energy Activation Market for the Nordic countries (Nordic mFRR EAM) was launched on 4 March 2025², including Denmark (DK1 and DK2), Sweden (SE1, SE2, SE3 and SE4), Norway (NO1, NO2, NO3, NO4 and NO5) and Finland (FI). Moreover, a trilateral market for the reservation of mFRR capacities between Denmark, Sweden and Finland has already been in place since the end of 2024³.

At European level, the aim is to move towards greater integration of all European TSOs to improve the economic efficiency of balancing markets. The accession of Nordic countries to MARI is thus planned for Q1 2027⁴ as specified on the figure below. This accession may have a strong impact on balancing prices, economic surplus and on exchanges between zones. In this context, the aim of this assignment is to assess the impact of different levels of balancing markets integration for Sweden with respect to the mFRR (MARI) balancing platform.

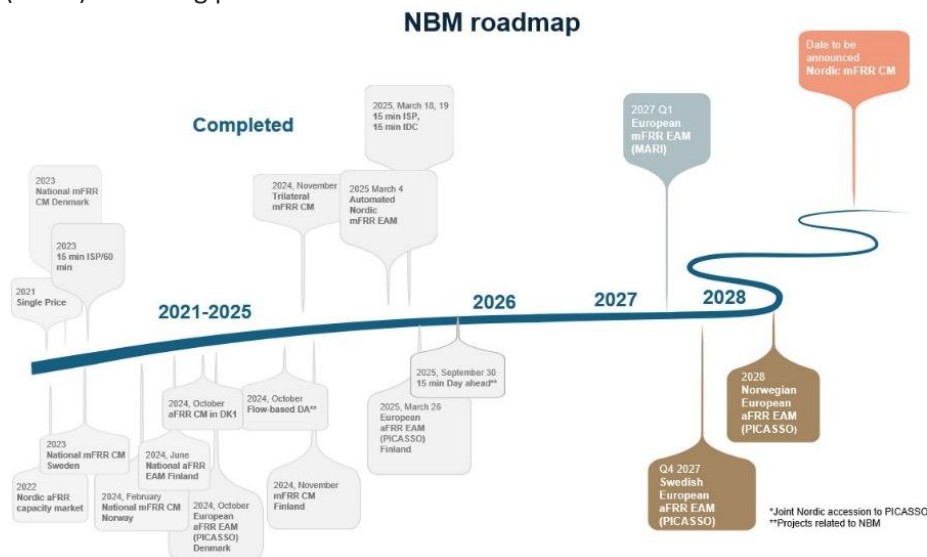


Figure 0-1: Nordic Balancing Model (NBM) roadmap⁴

¹ https://www.entsoe.eu/network_codes/eb/mari/

² <https://nordicbalancingmodel.net/roadmap-and-projects/automated-nordic-mfrr-energy-activation-market/>

³ <https://nordicbalancingmodel.net/trilateral-capacity-market-for-mfrr-is-live/>

⁴ <https://nordicbalancingmodel.net/roadmap-and-projects/>

1 Methodology

This section presents the methodological framework used to assess the impact of Sweden's accession to the European balancing platforms. It describes the modelling approach, the definition of the market configurations considered, and the data and assumptions used to simulate market outcomes. The objective is to ensure a consistent and robust comparison between the different levels of market integration.

1.1 High-level overview

To perform the Impact Assessment, three distinct market configurations are considered for Sweden:

1. **Swedish national market:** Sweden operates a stand-alone mFRR energy activation market without cross-border exchanges. This configuration does not correspond to any existing market configuration, but is simply used in the present Impact Assessment as a reference case to assess the benefits of market integration at the Nordic level.
2. **Nordic market:** Sweden participates in the Nordic mFRR energy activation market (EAM), including Denmark, Norway and Finland. This configuration reflects the market configuration in place since the go-live of the Nordic mFRR EAM on 4 March 2025.
Of the three modelled configurations, this configuration is also the closest one to the Nordic cooperation for balancing which exists since 2002.
3. **European market:** Sweden participates in the European mFRR platform (MARI), together with all Nordic countries and countries operational in the platform. This configuration represents the expected market situation after the Nordic countries' accession to MARI.

The different market situations are illustrated in Figure 1-1 and described further in the next sections.

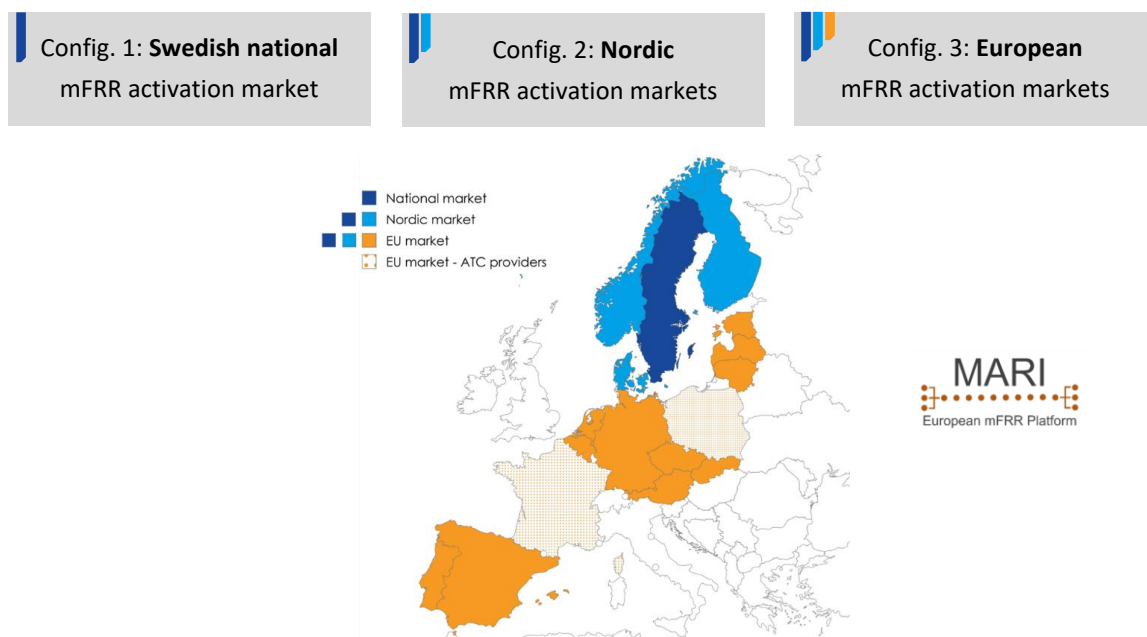


Figure 1-1: Market situations overview for mFRR

On the figure above, the countries that only participate in the European mFRR activation market are represented in orange, and the countries represented with orange dots (France and Poland) are modelled as ATC providers without submitting demand nor bids. Countries that are included in both European and Nordic mFRR activation markets configurations simulated are represented in light blue. Sweden, represented in dark blue, is included in the three market configurations simulated: Swedish national, Nordic and European mFRR activation markets.

For each configuration, mFRR activation is simulated using historical market data, including activation demands from TSOs and bids from balancing service providers (BSPs).

1.1.1 Swedish national market

This market situation considers Sweden and its associated balancing service providers (BSPs) in a stand-alone configuration. In this national market situation, Sweden has a national energy activation market for mFRR and no cross-border balancing exchange with other countries.

1.1.2 Nordic market

In this situation, the Nordic activation market is considered for the mFRR. This is the current situation for Sweden since the go-live of the Nordic mFRR EAM (4 March 2025).

The countries considered for the mFRR activation in this market situation are Sweden, Denmark, Norway and Finland.

Western Denmark (DK1) is included in the Nordic mFRR activation process⁵ and is therefore considered as part of the Nordic market for the mFRR Impact Assessment.

It should be noted that Nordic balancing cooperation did not start with the Nordic mFRR EAM. A common Nordic framework for mFRR balancing exchange has been in place since 2002. The Nordic mFRR EAM therefore represents a substantial evolution of the Nordic balancing setup rather than the creation of an entirely new cross-border balancing model.

1.1.3 European market

In this situation, the Nordic countries are considered part of the European platform MARI for mFRR activation. The countries included in the simulation are all countries having accessed MARI as of December 2025 (as well as all Nordic countries), to ensure the most realistic configuration using historical data. More details about the European market situation are described in section [1.2](#). This market does not currently exist and is therefore modelled as a prospective scenario.

⁵ Fingrid, Energinet, SVK, Statnett, "Nordic System Operation Agreement - Annex Electricity Balancing," 2020, updated 2025

1.2 Temporal and spatial scope

1.2.1 Introduction: timeline of different countries' connection to the MARI platform

Considering the successive connection time of different countries to the MARI platform is essential for determining the start and end dates of the market simulations as well as the countries to be considered, as it determines the availability of real market data.

The accession dates of the countries that were operational in MARI as of December 2025 are described in Figure 1-2.

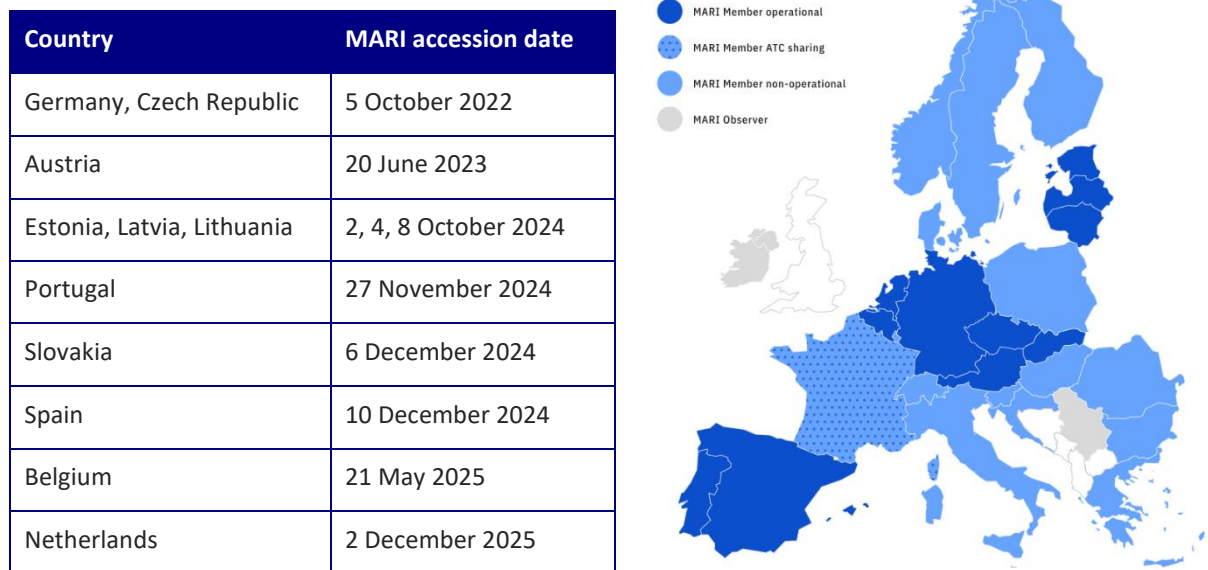


Figure 1-2: MARI accession dates (left) and MARI status as of December 2025 (right)⁶

1.2.2 Temporal and spatial scope of the simulations

The temporal scope (start and end dates) of the simulation as well as the countries included in the simulations have been determined based on three criteria:

- | **The availability of real market data** (demands from TSOs and bids from BSPs). This is mainly conditioned by the connection chronology of the different countries to MARI.
- | Similarity to the expected market situation when Sweden would connect to MARI.
- | **The representativeness of the simulated period.** To account for the impact of seasonality of production and demand dynamics on the results, it is essential to simulate a sufficiently long timeframe covering both winter and summer periods.

⁶ ENTSOE, MARI project page, 2025, https://www.entsoe.eu/network_codes/eb/mari/

Considering these three criteria, the analysis covers the period from **4 March 2025** (go-live date of Nordic mFRR EAM) to **3 March 2026**, thus covering a full year.

The countries included in the simulations are all MARI operational members as of December 2025, together with the operational members of Nordic mFRR EAM (Denmark, Sweden, Norway and Finland). Although non-operational yet, Poland is also considered in the simulations, as an ATC-sharing member (see section [1.3.3 Case of Poland](#)).

The assessment uses a **15-minute MTU**, in line with both MARI and Nordic mFRR EAM.

1.3 Input data

The input data required to run the market clearing simulations are:

- | Activation demands from the TSOs.
- | Bids from BSPs (volumes and prices).
- | Cross-zonal capacities open to mFRR activation.

This input data is required for all simulated countries, over the whole simulation horizon, at the market granularity of 15 minutes.

For the operational members of MARI or the Nordic mFRR EAM, the historical input data has been recovered for the analysis.

However, to cover the entire spectrum of the analysis, historical data is not sufficient and assumptions are thus needed to simulate the market. For instance, no historical cross-border capacity open for balancing exists as a European market integrated with the Nordic countries does not currently exist.

The assumptions taken for this impact assessment are depicted in the following.

1.3.1 Cross-zonal capacities open to mFRR activation

1.3.1.1 Overview

Currently, two separate markets are in place for mFRR activation (MARI in continental Europe and Nordic mFRR EAM), without any coupling between them. Therefore, cross-zonal capacities open to balancing between the two regions are not part of the historical balancing market data. This input data is nonetheless needed to model the accession of Sweden (and of other Nordic countries) to MARI.

Several approaches are considered to estimate the cross-zonal capacities open to mFRR activation, depending on the type of interconnection and the data available:

- | **For interconnections already represented in MARI** (i.e. between two operational members of MARI): cross-zonal capacities are taken from MARI historical market data.
- | **Similarly, for interconnections already represented in Nordic mFRR EAM** (i.e. between two operational members of Nordic mFRR EAM): cross-zonal capacities are taken from Nordic mFRR EAM historical market data.

- | **For HVDC interconnections between the Nordic countries and the rest of Europe:** cross-zonal capacities are based on an estimation of total capacity provided by Svenska kraftnät of 400 MW, distributed along the cables. This is further described in section [1.3.1.2](#)
- | **HVDC interconnections between the Nordic countries and continental Europe.**
NB: the Baltic cable, between Sweden (SE4) and Germany is **not considered** for delivering cross-zonal balancing services, as recommended by Svenska kraftnät.
- | **For the AC interconnections between Denmark (DK1) and Germany:** the cross-zonal capacity is based on the historical ATC that has been used in the PICASSO input data, as Denmark and Germany are both operational members of PICASSO. This assumption allows the use of historical data but may be conservative as the cross-zonal capacities reserved for aFRR are often limited compared to the cross-zonal capacities reserved for mFRR.
- | **For the interconnections around Poland:** the cross-zonal capacities are based on remaining cross-zonal capacity after the intraday continuous market (see section [1.3.3 Case of Poland](#)).

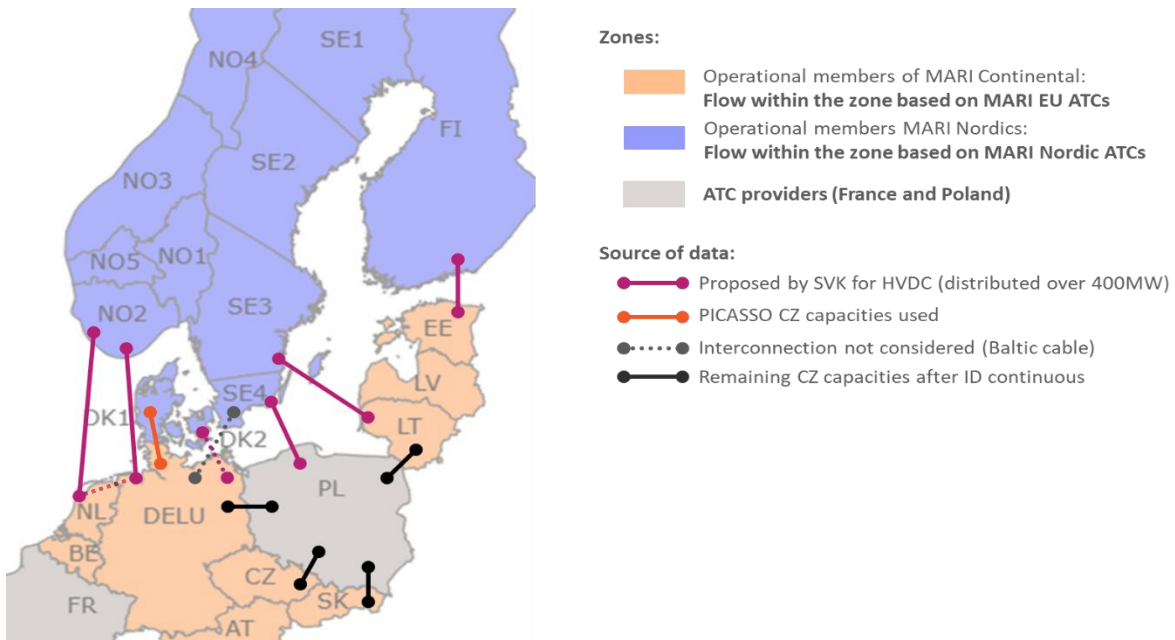


Figure 1-3: Interconnections overview for mFRR activation

1.3.1.2 HVDC interconnections between the Nordic countries and continental Europe

The Nordic countries and continental Europe are connected via multiple HVDC cables. The following table lists the operating HVDC interconnectors between the Nordic countries and continental Europe (PL, EE, DE-LU, NL, LT):

Table 1-1: List of HVDC interconnectors between the Nordic countries and continental Europe

Interconnection	Zones	Country	Power (MW)	Commissioning date
NordLink 1	NO2 ↔ DE-LU (TenneT)	NO – DE	700	2020
NordLink 2	NO2 ↔ DE-LU (TenneT)	NO – DE	700	2020
NorNed	NO2 ↔ NL	NO – NL	700	2008
Kontek	DK2 ↔ DE-LU (50Hertz)	DK – DE	600	1995
Baltic Cable	SE4 ↔ DE-LU (TenneT)	SE – DE	600	1994
SwePol Link	SE4 ↔ PL	SE – PL	600	2000
NordBalt	SE4 ↔ LT	SE – LT	700	2016
EstLink 1	FI ↔ EE	FI – EE	350	2006
EstLink 2	FI ↔ EE	FI – EE	650	2014

Svenska kraftnät is currently evaluating how much ATC between the entire Nordic region and continental Europe can be allocated to balancing. Although the assessment is not yet finalised, an indicative figure of **400 MW of cross-border transfer** between the Nordic countries and continental Europe for balancing purposes was used for the present Impact Assessment.

The 400 MW has been distributed to the different interconnectors, proportionally to their capacity. As mentioned previously, the Baltic Cable has been excluded from the analysis as this interconnection may not be available for cross-border balancing energy exchanges when the Nordic countries join MARI, following Svenska kraftnät's recommendation. Figure 1-4 summarises the capacity considered for FRR transfer between the different bidding zones.

Zones	ATC (MW)
NO2 ↔ DE-LU (TenneT)	112 (168 with the redirection of NO2-NL)
NO2 ↔ NL	56 (redirected to NO2-DELU)
DK2 ↔ DE-LU (50Hertz)	48
SE4 ↔ DE-LU (TenneT)	Excluded
SE4 ↔ PL	48
SE4 ↔ LT	56
FI ↔ EE	80
Total	400

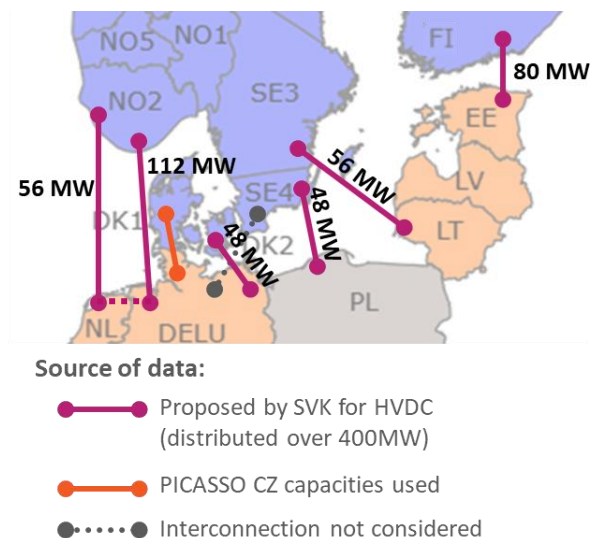


Figure 1-4: ATC for balancing between the Nordic countries and continental Europe, numerical values (left) and graphic representation (right)

These ATCs are assumed to be continuously reserved for cross-border balancing purposes by the TSOs and therefore are treated as **constant parameters** on all MTUs.

Finally, since the Netherlands connected to MARI only from 2 December 2025 (as described below), it has been decided to redirect the capacity related to the NO2-NL interconnection (56 MW) to Germany (resulting in a 168 MW capacity for NO2-DE instead of 112 MW). This ensures that the inflows and outflows from Norway to continental Europe are not restricted during the time when the Netherlands is not operational on MARI. This adjustment is considered robust for this analysis due to the proximity between the Netherlands and Germany that are highly interconnected.

The main limitations relating to the assumptions employed in calculating the available transfer capacities (ATCs) of HVDC interconnectors are outlined below:

- | No **ramping constraints** are modelled. In reality, however, HVDC cables are subject to ramping limits due to operational constraints.
- | No constraints on **flow direction changes** are included (avoiding polarity reversal). In practice, HVDC interconnectors cannot switch power flow direction continuously without operational restrictions. These operational limitations are not captured in the modelling.

1.3.2 Case of Belgium and Netherlands

Belgium and the Netherlands connected to MARI respectively on **21 May and 2 December 2025**.

The two countries are only **considered in the simulations after their MARI go-live date**. During the period from the impact assessment start date (4 March 2025) to their respective go-live date, the countries are excluded from the simulations (neither activation demands, BSP bids nor cross-zonal capacities are considered for these two countries in the clearing).

The decision to exclude Belgium and the Netherlands before the go-live dates enables the analysis to **exclusively rely on historical data**.

1.3.3 Case of Poland

Poland is not part of the MARI platform yet but is expected to **join in December 2026** according to the accession roadmap⁷. Its accession is anticipated to reshape the regional balancing market, particularly for the Baltic countries, by providing a direct connection to continental Europe. It will also add a new balancing opportunity from Sweden to continental Europe via the *SwePol* HVDC cable, connecting SE4 to Poland.

⁷ ENTSOE, "mFRR-Platform accession roadmap (14th Update), 26/02/2026:
https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/Network%20codes%20documents/NC%20EB/2026/MARI_Accession_Roadmap_FEB_2026.pdf

Due to the absence of historical participation data and the limited public availability of information on the Polish balancing market, it is **difficult to anticipate Polish demand and participants' bidding behaviour or to quantify its precise impact on price formation and exchange volumes**.

To represent a situation corresponding to the expected conditions when Sweden connects to MARI, with Poland acting as a link for the Nordic and Baltic countries to continental Europe, **Poland is assumed to be connected to MARI** in the present Impact Assessment, **but only as an ATC provider** (i.e. no mFRR bids and demands are assumed for Poland in the simulation), similarly to the role France currently plays for the Spain–Germany connection.

This approach enables the incorporation of cross-zonal flexibility and potential market coupling effects without the need for assumptions regarding Polish bidding strategies. The cross-zonal capacities assumptions for Poland are further described in the following section.

1.3.3.1 Methodology to estimate Poland's cross-zonal capacities open to mFRR activation

PROPOSED APPROACH: USE THE REMAINING CAPACITY AFTER THE INTRADAY CONTINUOUS MARKET

In general, cross-zonal capacities open to balancing are strongly correlated to remaining ATC capacities after the intraday, logically following the electricity market sequence. Therefore, the approach adopted in the present assessment to estimate the cross-zonal capacities open to balancing for Poland is to use these **remaining cross-zonal capacities after the Intraday continuous**⁸.

VALIDATION OF THE APPROACH: COMPARISON WITH MARI HISTORICAL DATA

To validate the proposed approach, **the remaining cross-zonal capacity after the intraday continuous** (downloaded from ENTSO-E's Transparency Platform) has been compared with **historical ATCs** open to cross-zonal mFRR activation (taken from Nordic mFRR EAM historical data), for several borders of countries participating in mFRR cross-zonal activation market (Nordic mFRR EAM in our case).

The analysis validates that historical ATCs open to mFRR follow in general the **same pattern** as the remaining cross-zonal capacities after the Intraday Continuous auction from ENTSO-E's Transparency Platform. Differences **are visible in some specific periods** (e.g. on-off behaviour for historical ATCs in MARI), or on some borders. But overall, it validates that remaining cross-zonal capacity after the intraday continuous is a relevant proxy for cross-zonal capacities open to mFRR.

The results from the statistical analysis undertaken as part of this assignment are subject to confidentiality and can be shared upon request.

⁸ See parameter *Offered Transfer Capacity Implicit [11.1] – Intraday (Continuous)*, published on ENSTO-E's Transparency Platform: <https://transparency.entsoe.eu/market/allocation/continuous/offeredCapacity>

1.4 Simulation tool

Currently, the market clearing algorithm used for mFRR energy activation at the European level is **MARI Activation Optimisation Function (AOF)**, and a specific version of the algorithm (called **Nordic mFRR AOF** in the following) is used for the Nordic countries. Artelys is the **developer of both MARI AOF and Nordic mFRR AOF**.

1.4.1 Introduction: differences between current versions of MARI AOF and Nordic mFRR AOF

The features that are specific to one version of MARI and that are not included in the other are described below. The way these differences have been handled in the present Impact Assessment is described in the section [1.4.2 Algorithm used for the simulations](#) below.

FEATURES AVAILABLE IN MARI AOF AND NOT IN NORDIC MFRR AOF

| Aggregated areas

An aggregated area is a set of scheduling areas⁹ that can have specific mFRR demand requirements. They include at least two scheduling areas. Aggregated areas differ from control areas in the sense that they do not necessarily represent an area controlled by a single transmission system operator (one aggregated area can include several scheduling areas from different control areas).

In MARI, demands can be submitted at the aggregated area level and are called aggregated demands. In Nordic mFRR AOF, demands must be submitted at the scheduling area level.

| Net technical profiles

Technical profiles (TPs) enable limiting the flow of balancing energy on a set of interconnectors, per direction. There are two types of TP: gross technical profiles (limit on the sum of the interconnectors flows in the direction of the TP) and net technical profiles (limit on the net sum of all interconnectors flows under the TP). Although gross TPs are present in both MARI AOF and Nordic mFRR AOF, net TPs are only implemented in MARI AOF.

| Net position limits

In MARI AOF, net position limits make it possible to configure limits on the import and/or export of energy in a given scheduling area or aggregated area. There are two types of net position limits: net position limit on import and net position limit on export.

Net position limit constraints are not available in Nordic mFRR AOF.

| Direct activation

⁹ The full definitions of scheduling, control and aggregated areas can be found in the MARI AOF public documentation (November 2023), Section 4.1. Market Areas – https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/Network%20codes%20documents/NC%20EB/2023/MARI_AOF_PublicDocumentation_v1.2.pdf

In addition to Scheduled Activations, Direct Activations (DA) are required to perform further activations when imbalances occur between two scheduled activations. DA allows bids to be activated at any point in time when an unexpected imbalance occurs.

Direct activations are present in MARI AOF but not in Nordic mFRR AOF.

FEATURES AVAILABLE IN NORDIC mFRR AOF AND NOT IN MARI AOF

| **Price spread mitigation**

Improvements have recently been implemented in Nordic mFRR AOF to address situations where prices unexpectedly spread from one area to another. For this purpose, a specific subproblem is solved and used to determine uncongested areas. This approach has a number of benefits but can sometimes lead to negative congestion rent.

The improvements are currently not integrated into MARI AOF but might be included in the future.

| **Tolerance band**

In MARI AOF, the volume of accepted bids cannot exceed the inelastic demand in the same direction, except in the presence of bids of the opposite direction (counter-activation).

On the contrary, in Nordic mFRR AOF, the volume of accepted bids can exceed the inelastic demand if this helps to improve social welfare (e.g. to accept block orders). This flexibility in the clearing is called "tolerance band". Currently, 10 MW of tolerance band is added to all inelastic demands submitted in Nordic mFRR AOF, and the tolerance-bids matching quantity is minimised.

| **Elastic demand**

Even though Elastic Demand was supported by the algorithm since go live, it was not used by TSOs before June 2026. As a consequence, elastic demand is not modelled in this analysis.

1.4.2 Algorithm used for the simulations

The impact of Sweden's accession to the European energy activation platforms for mFRR (MARI) has been quantified **using MARI AOF algorithm**. Then, a **sensitivity analysis** has been carried out to assess the **impact of the Price Spread Mitigation feature** currently implemented in the Nordic mFRR EAM on the market clearing outcomes.

This approach is justified by the uncertainties on the future state of MARI AOF when Svenska kraftnät will join the European mFRR EAM, and potential features currently implemented in Nordic mFRR AOF and not in MARI AOF (like the price spread mitigation), but which might be implemented in MARI AOF before Sweden joins the European mFRR EAM.

To ensure consistency in the analysis and to reflect the expected evolution of the algorithms, the following simplifications have also been implemented in the clearing algorithms used for the current impact assessment compared to the algorithms currently used in operation:

- | **Tolerance bands** have been disabled in Nordic mFRR AOF (including in the Sweden-only and Nordics-only runs using Nordic mFRR AOF).

This choice is motivated by the fact that tolerance band is not supported by MARI AOF. Hence, the feature is not available and there is no good assumption to configure tolerance bands in non-Nordic countries. In order to be able to compare all results, the modelling assumptions (data and optimisation model) should not change when extending the geographical perimeter.

Even though the feature is implemented on Nordic mFRR EAM, it has not been activated either in Nordic or Sweden-only studies in order to enhance the comparability of the results of the Impact Assessment.

- | **Direct activation** has not been considered in MARI AOF.

This modelling choice is motivated by the absence of assumptions to configure direct activation in Nordic countries (because the feature is currently not available in Nordic mFRR AOF), and the necessity to treat equally Nordic and non-Nordic countries in the assessment (to avoid biases). This currently represents a limited volume of activations and is therefore not a significant assumption.

- | **Aggregated areas, net technical profiles and net position limits** have not been considered in MARI AOF.

This modelling choice improves the compatibility between the two algorithms (as long as these features are anyway not supported by Nordic mFRR AOF).

The input data from MARI had to be slightly pre-treated accordingly. In particular, Germany has been treated as one single scheduling area (instead of several scheduling areas with aggregated demands). Net technical profiles and net position limits have been removed from the input files. Given that the German model has an infinite CBCL assumption, merging all data in a single scheduling area does not affect the results.

Finally, for both algorithms, cross-zonal capacities are represented using an ATC approach (and not flow-based), to reflect the current operational reality.

1.5 Limitations

The proposed methodology is the outcome of discussions between Svenska kraftnät and Artelys and represents a robust approach to assess the potential impact for Sweden of accession to the MARI platform. However, several limitations should be acknowledged to ensure transparency in the evaluation of the proposed approach:

- | **Use of historical data:** The analysis relies on historical market outcomes to reproduce realistic market behaviour and price formation. While this ensures consistency with observed conditions, it also implies that the results remain dependent on past system states (generation mix, interconnection capacities, demand patterns). Future structural changes (e.g. additional renewable integration, evolving bidding strategies) are therefore not fully captured.
- | **Simplified assumption on the cross-zonal capacities between the Nordic countries and the rest of Europe:** based on Svenska kraftnät's recommendation, this Impact Assessment assumes that the total cross-zonal capacity over all HVDC between the Nordic countries and the rest of Europe, open to mFRR cross-zonal activation, is equal to 400 MW. This assumption limits the mFRR activation exchanges between the Nordic countries and the rest of Europe, and therefore the benefits of coupling the mFRR activation markets.
- | **Exclusion of Belgium and the Netherlands prior to their go-live:** Belgium is excluded from the simulations between 4 March and 21 May 2025, and the Netherlands between 4 March and 2 December 2025. This decision ensures the use of realistic data but slightly reduces the completeness of the analysis. Consequently, any cross-border effects involving Belgium and the Netherlands before their respective accessions are not represented, which may underestimate mFRR exchanges in Central Western Europe during that time window.
- | **Consideration of Poland as an ATC provider:** Poland is modelled as an ATC provider enabling potential balancing transfers between the Baltics and continental Europe. This assumption introduces a simplified representation of Poland's role, as it does not explicitly model bidding behaviour, activation and demand profiles that could occur after its accession date. The resulting outcomes should therefore be interpreted as indicative rather than predictive of Poland's actual future participation.
- | **Non-consideration of the tolerance band:** Currently, in Nordic mFRR AOF, the volume of accepted bids can exceed the inelastic demand if this helps to improve social welfare (e.g. to accept block orders). This flexibility in the clearing, called "tolerance band", is not allowed in MARI AOF, and was not considered at all in the present impact assessment.
- | **Other methodological limitations:** Regulatory or market design evolutions that may occur after the study horizon are not considered. Market practices which have been changed after the considered period (such as usage of elastic demand by TSOs) are also out of scope.

Overall, it is considered that while these simplifications may affect the quantitative precision of some results, they do not alter the qualitative conclusions regarding the expected operational and market impacts of Sweden's accession to MARI.

2 Results

This section presents the results of the simulations assessing the impact of Sweden's participation in the MARI platform. It analyses how market integration affects economic efficiency, cross-border exchanges, and price formation, and compares outcomes across national, Nordic, and European configurations. To conclude the section, a sensitivity analysis is described to assess the impact of the Price Spread Mitigation feature on the market clearing outcomes.

2.1 Economic surplus

This section evaluates the impact of market integration on economic surplus and its components. It analyses how welfare is redistributed between the system operator, balancing service providers, and cross-border exchanges, and quantifies the overall efficiency gains associated with larger market integration.

Explanation notes on Social Welfare and Surplus:

The economic surplus of a market (also called social welfare) is the benefit brought by the market (in comparison to a situation where no market would exist, i.e. where buyers would not be able to buy and sellers would not be able to sell). The economic surplus is made of three components, defined as follows:

- | **Demand-side surplus:** Svenska kraftnät's welfare for its participation in the energy activation market. Demand-side surplus is computed as the difference between the TSO willingness to pay to activate mFRR (fixed at price cap/floor of +15,000 €/MWh for upward inelastic demand and -15,000 €/MWh for downward inelastic demand in MARI) and the price paid on the activation market, multiplied by the activated volume. *This parameter is referred to as 'Demand surplus' in the graphs.*
- | **Offer surplus:** The surplus captured by Swedish Balancing Service Providers (BSPs) through energy activations. Offer surplus is computed as the difference between the price paid to the BSPs and the price requested in the bids, multiplied by the activated volume. *This parameter is referred to as 'Surplus bids' in the graphs.*
- | **Congestion rents:** Revenues stemming from congestions between different bidding zones. Congestion rents are computed as the price difference between pairs of interconnected bidding zones multiplied by the flow on the interconnection.

In the following, we distinguish **congestion rents between Swedish bidding zones** (also called internal congestion rents) and **congestion rents between Sweden and other countries** (also called external congestion rents).

NB: for the external congestion rents, only 50% of the rent is attributed to Sweden (and therefore represented on the following graphs), under the assumption that the congestion rent of each interconnection is divided equally between the two countries connected.

In this study, the purpose is not to evaluate the absolute economic surplus of the markets considered (in comparison to a situation where markets would not exist at all), but to compare the economic surplus under different market configurations (Swedish national EAM, Nordic EAM and European EAM). Therefore, the focus is on differences of economic surplus between two situations rather than total valuation of surplus.

2.1.1 The implementation of a Nordic cooperation for mFRR activation has had a significant positive impact on Sweden

A comparison between the Swedish national mFRR energy activation market (EAM) and the Nordic mFRR EAM indicates a substantial improvement in social welfare for Sweden. When comparing the Swedish national mFRR EAM situation to the Nordic situation, a difference in social welfare of 459 M€ is calculated. The decomposition of this surplus difference is depicted considering several components: demand-side surplus, offer surplus and congestion rents (defined in the clarification note that follows). The breakdown of surplus differences is depicted in Figure 2-1, which presents the difference in economic surplus for Sweden between the two configurations over the analysis period (March 2025 to March 2026).

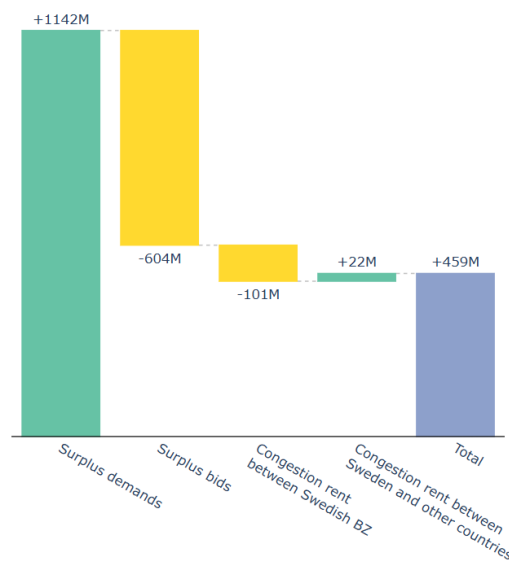


Figure 2-1: Comparison of economic surplus between Nordic EAM and Swedish national mFRR EAM

From this breakdown, several key findings underline the critical importance of the accession to the Nordic mFRR EAM compared to a Swedish national mFRR EAM for Svenska kraftnät:

- | **Increase in demand-side surplus** (*“surplus demands”*): Svenska kraftnät benefits from access to larger volumes, which leads to a reduction in unsatisfied demand, as well as from access to more competitive and diversified mFRR bids, which leads to lower balancing activation costs. These two aspects will be covered in the subsequent analyses, in section [2.3 Market prices](#) and in section [Q](#) for the rejected demand analysis.
- | **Reduction in offer surplus** (*“surplus bids”*): Offer surplus decreases as scarcity events (during which BSPs capture high prices) are less frequent, and as competition intensifies among BSPs operating in a larger market, reflecting more efficient price formation.
- | **Reallocation of congestion rents**: congestion rent between Swedish bidding zones decreases, while external congestion rent increases, confirming the growing role of cross-border exchanges and the shift of binding constraints from domestic to cross-border interfaces.
- | **Significant welfare improvement**: Total economic surplus increases by **459 M€** compared to the Swedish national mFRR EAM, demonstrating the strong benefits of market coupling and access to a larger pool of balancing resources.

Clarification note regarding the comparison of Swedish national EAM and Nordic mFRR EAM:

As described in section [1. Methodology](#), the Swedish national mFRR EAM modelled in the present Impact Assessment is a counterfactual reference scenario and does not correspond to a historical market arrangement.

In particular, the comparison between the Swedish national and Nordic configurations modelled in the present Impact Assessment should not be interpreted as the value of the Nordic mFRR EAM set up in 2025. Indeed, since Sweden has participated in Nordic balancing cooperation since 2002, a significant share of the market integration benefits, compared with a hypothetical stand-alone Swedish market, were already realised prior to the go-live of the Nordic mFRR EAM in 2025.

2.1.2 Accession to MARI will also have a positive impact on Sweden, but more moderate than the Nordic cooperation on mFRR activation

Extending the scope of the mFRR activation market from the Nordic region to the European level through MARI generates **additional welfare gains for Sweden**. However, these benefits (under the modelling assumptions retained) **are more moderate** than those observed when comparing the Nordic mFRR EAM to a counterfactual Swedish national EAM.

The modelling assumption which has the largest impact on this result is the interconnections cross-border capacities open for mFRR between the Nordic countries and continental Europe (see section [1.3.1 Cross-zonal capacities open to mFRR activation](#)).

Figure 2-2 extends the previous analysis by adding the impact on the economic surplus of the accession to the European mFRR EAM (MARI) compared to the accession to the Nordic EAM from a Swedish national mFRR EAM (when adding up the benefits associated with reducing scarcity events and the benefits associated with an increase in exchanges in non-scarcity situations). The progressive accession to a larger market is analysed in two steps, first the accession from the Swedish national mFRR EAM to the Nordic EAM is represented again and completed with the accession from the Nordic EAM to the European EAM.

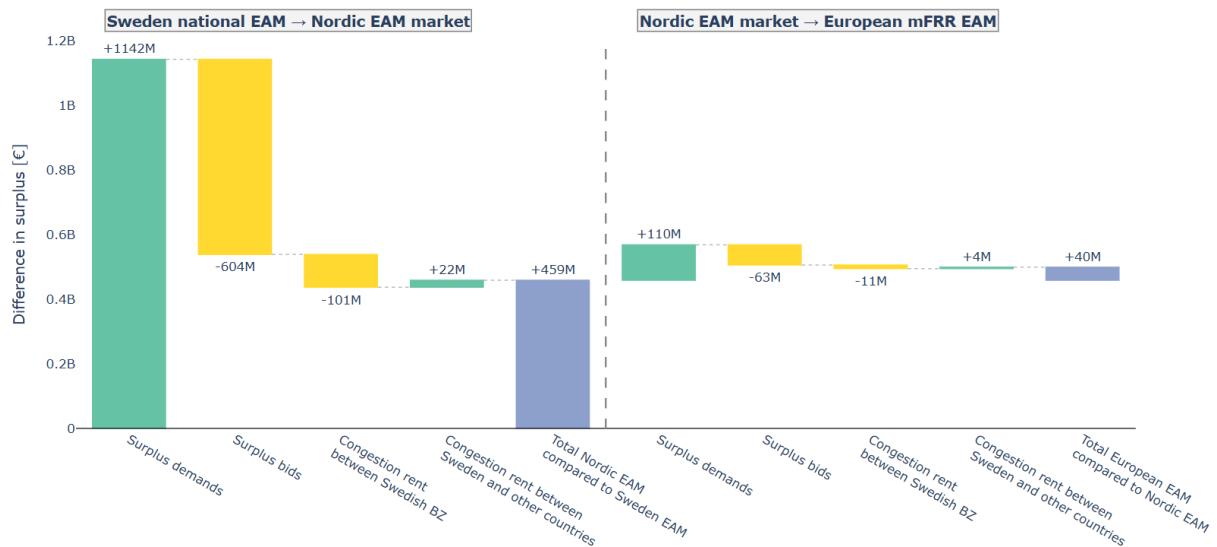


Figure 2-2: Comparison of economic surplus between Nordic EAM and Swedish national mFRR EAM (left part) and between European EAM and Nordic EAM (right part)

The following considerations can be extracted from this comparison:

- | **A 40 M€ benefit in surplus** is observed when comparing the European EAM (MARI) to the Nordic EAM. This limited difference in surplus for the access to the European EAM (MARI) highlights the fact that a large share of the market efficiency improvements is already captured at Nordic EAM level, where geographical proximity, strong interconnections, and complementary resource mixes allow for efficient balancing exchanges. The European extension nevertheless provides incremental benefits by **enabling additional cross-border optimisation opportunities**.
- | The benefits for Sweden when moving from the Nordic mFRR EAM to the European mFRR EAM (when adding up the benefits associated with reducing scarcity events and the benefits associated with an increase in exchanges in non-scarcity situations) follow the same pattern observed for the transition from national to Nordic mFRR EAM: it leads to a decrease in offer surplus and an increase in demand-side surplus, characterised with lower costs for purchasing balancing energy due to greater competitiveness. The distinction between the benefits associated with reducing scarcity events and the benefits associated with an increase in trade in non-scarcity situations is analysed in the section below.

2.1.3 A significant share of the benefits comes from scarcity situations

The simulations show that scarcity situations (i.e. situations with **rejected demand**) occur in several MTUs. These situations of scarcity arise when part of the mFRR demand cannot be satisfied due to insufficient bids from BSPs compared to the demand, and to network limitations (e.g. congestion restricting cross-zonal exchanges). Although these situations occur relatively rarely (compared to the whole year), they have a significant impact on economic surplus, due to unsatisfied demand and resulting extreme market prices.

This effect is particularly pronounced for **upward balancing**, revealing a structural scarcity of upward mFRR resources in southern Sweden and insufficient transmission capacity to meet the mFRR activation demand only with Swedish BSPs. This reflects the characteristics of the Swedish BSP portfolio and the underlying generation mix participating in balancing markets.

The figure below highlights the frequency of scarcity events and the associated volume of rejected demand observed across the three market configurations, Swedish national mFRR EAM, Nordic EAM and European EAM. As shown in the figure, the progressive connection to larger market pools has led to a reduction in volumes of unsatisfied demand and scarcity events. A **large reduction in scarcity events occurred between the Swedish national mFRR EAM and the Nordic EAM**, and **accession to the European EAM further contributed to this trend**.

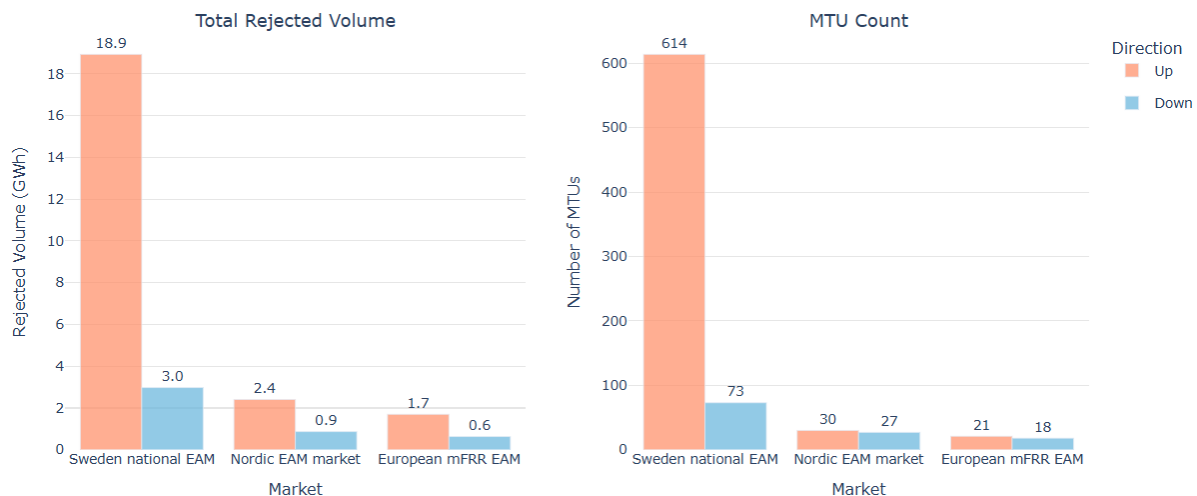


Figure 2-3: Overview of the rejected demand per market and direction for Sweden, with aggregated rejected volumes (left) and the associated number of MTUs with rejected demand (right)

In the upward direction, scarcity events are reduced from 614 MTUs in the Swedish national EAM configuration (1.8% of the total simulated MTUs¹⁰) to 30 MTUs in the Nordic EAM configuration (less than 0.1% of the total MTUs). The volume of upward rejected demand is also divided by almost 8 from the Swedish national to the Nordic EAM configuration.

It should be noted that the volume of rejected demand observed in the simulations might be impacted by the non-consideration of any tolerance band in the simulations. The “tolerance band” is the fact

¹⁰ 34,708 MTUs were simulated in total (365 days at a 15-minute granularity, with approx. 300 MTUs with missing data).

that the volume of accepted bids can exceed the inelastic demand if this helps to improve social welfare (e.g. to accept block orders). This flexibility in the clearing is currently implemented in Nordic mFRR AOF, but is not in MARI AOF, and was not considered at all in the present impact assessment (see section [1.4 Simulation tool](#) for further details).

By design, the unsatisfied demand is priced at a high level ($\pm 15\text{k€}/\text{MWh}$). Consequently, although relatively rare, MTUs with unsatisfied demand have a significant impact on the economic surplus. Figure 2-4 illustrates the benefits of the Nordic EAM and European EAM compared to the Swedish national mFRR EAM and Nordic EAM, as displayed in Figure 2-2 and discussed previously, but specifically separating the market time units (MTUs) corresponding to scarcity events to the cases where no demand is rejected.

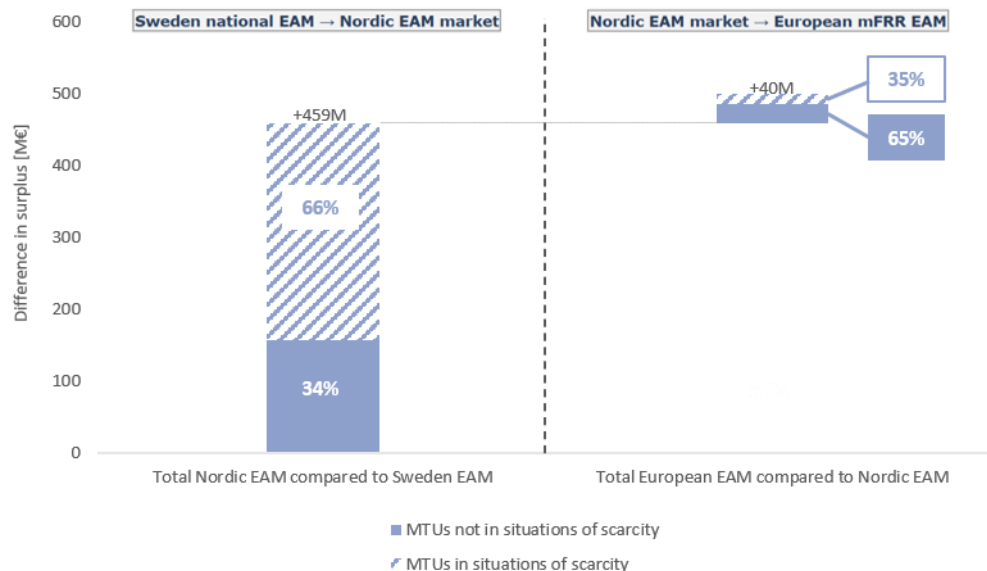


Figure 2-4: Surplus difference and distribution between MTUs with and without unsatisfied demand

This figure indicates that **over 65% of the benefits** of switching from a Swedish national mFRR EAM to a Nordic or European EAM happen on situations of scarcity. In other words, the 687 MTUs with rejected demand in Sweden in the Sweden EAM configuration (614 MTUs in the upward and 73 MTUs in the downward direction, as depicted on Figure 2-3) account for more than 65% of the benefits, while representing only 2% of the MTUs simulated.

For the transition from the Nordic EAM to the European EAM, the situations of scarcity are responsible for **35% of the benefits' increase observed**. In other words, the 57 MTUs with rejected demand in Sweden in the Nordic EAM configuration (30 MTUs in the upward and 27 MTUs in the downward direction, as depicted on Figure 2-3) account for 35% of the benefits, while representing less than 0.2% of the MTUs simulated.

The graphs below illustrate the surplus evolution, similarly to Figure 2-2 but without considering the MTUs corresponding to scarcity events.

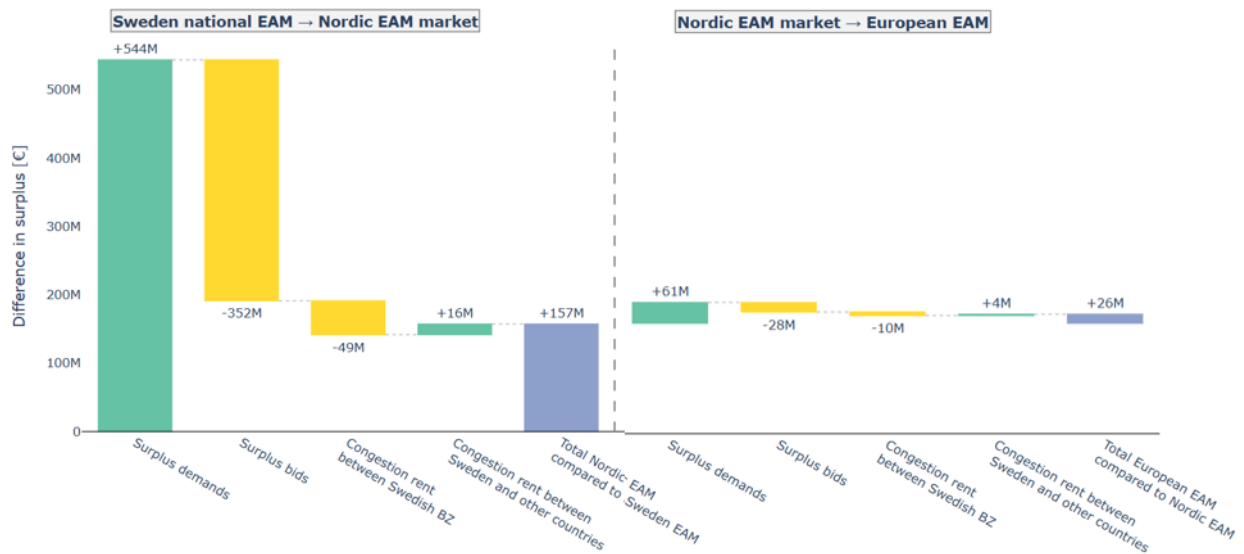


Figure 2-5: Comparison of economic surplus between Nordic EAM and Swedish national mFRR EAM (left part) and between European EAM and Nordic EAM (right part) without considering the MTUs corresponding to scarcity events

This comparison indicates that even under normal operating conditions, there is still a substantial benefit in connecting to a larger market for Sweden with benefits reaching 157 M€ between the Swedish national mFRR EAM and the Nordic EAM, and an additional increase of 26 M€ observed when acceding to the European platform.

2.2 Cross-border activation and interconnection usage

This section examines how market integration influences cross-border balancing exchanges and the utilisation of interconnections. It provides insights into the role of neighbouring countries in meeting Swedish balancing needs and the extent to which interconnection capacities constrain market outcomes.

2.2.1 Sweden's cooperation with other Nordic enables Svenska kraftnät to activate a significant share of its mFRR demand from abroad

With a larger pool of available balancing resources, market integration enables Svenska kraftnät to source a significant share of its mFRR activation demand from abroad, **reducing reliance on domestic resources**.

Moreover, in some situations, it can also **allow the activation of larger and cheaper domestic indivisible bids** (which would not be accepted without Nordic mFRR EAM, as their volume exceeds the demand in Sweden).

The figure below displays the share of Swedish balancing demand met by demand netting within Sweden (i.e. between Swedish bidding zones), by Swedish BSPs and by foreign BSPs through interconnections with neighbouring countries. These cross-border flows and the contributions of the different countries are illustrated using country flags, allowing for a direct identification of the geographical origin of activated balancing resources. As a reminder, Poland being considered as an "ATC provider", the flows related to this country are the flows going to or coming from continental Europe through Poland.

Explanation notes on activations terminology:

In the figure below:

- | **Demand** represents total balancing energy needs from Svenska kraftnät in upward and downward balancing direction.
- | **Activation** represents upward and downward activation volumes activated, result of the market clearing.
- | **Imports/exports** represent cross-border energy inflows from and outflows to neighbouring countries through the interconnections.

Market Time Units (MTUs) have been classified as up or down depending on the direction of the aggregated demand at the national level (i.e. the sum of the activation demand across all four Swedish bidding zones). In cases where opposing imbalances occur simultaneously across bidding zones, for example, when one zone requires upward activation while the aggregate Swedish system experiences a negative (downward) imbalance, the MTU is displayed on the graph of the predominant direction. In this case, both upward and downward demands are displayed on the graph (this explains why downward demand appears on the graph of the up direction and vice-versa).

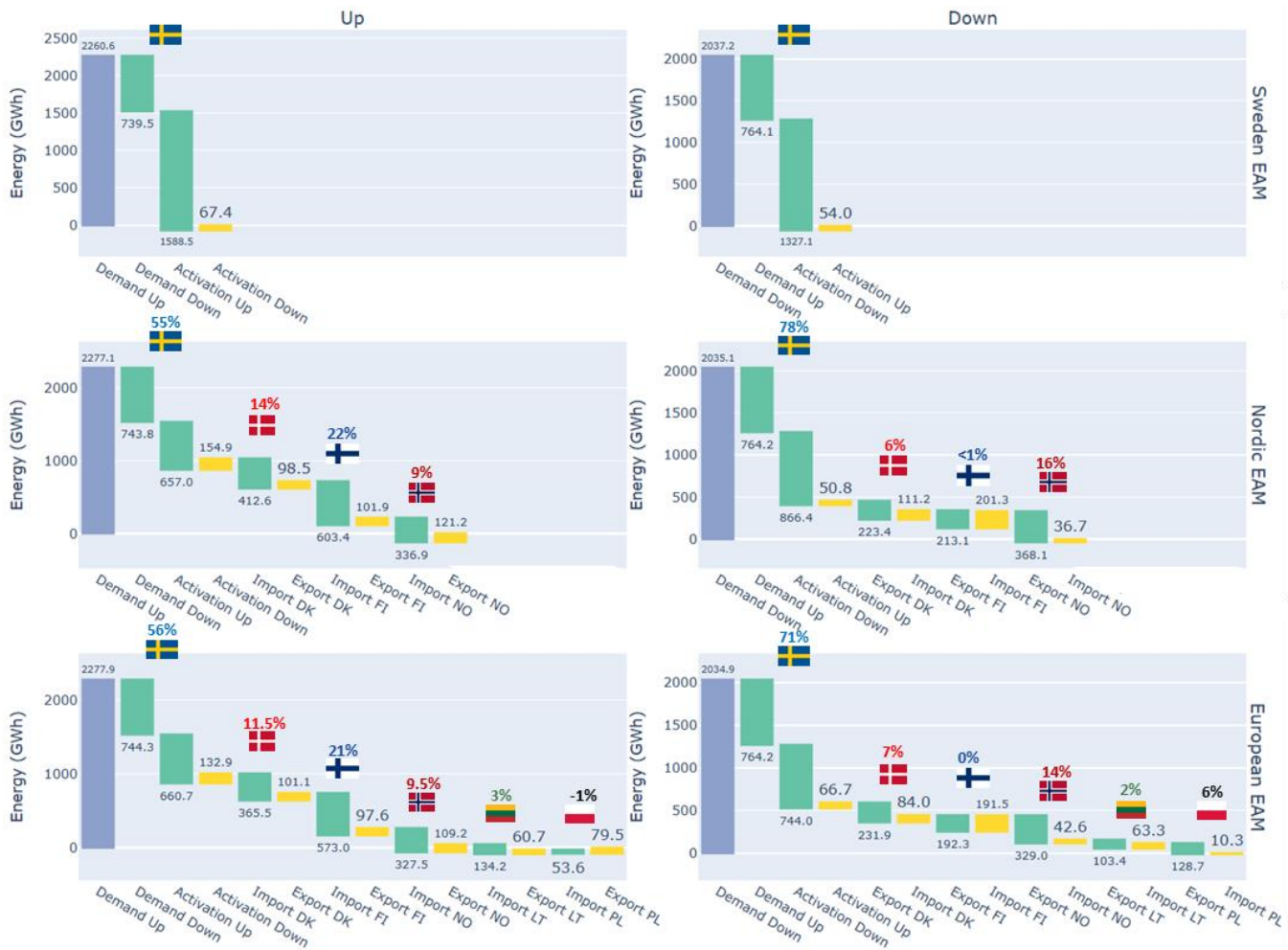


Figure 2-6: mFRR demand in Sweden, domestic activation in Sweden and imports and exports from neighbouring countries on the MTUs on where the demand is predominantly up (left) and down (right)

The graph above reveals the following key findings:

- In the two directions (up and down) and in the three market configurations (Swedish national mFRR EAM, Nordic EAM and European EAM), **30% of the needs are met with domestic (i.e. intra-Swedish) demand netting**. On MTUs when the imbalance is predominantly upward (left), netting is visible with the 'demand down' indicator, whereas on MTUs when the imbalance is predominantly downward (right), netting is characterised by the 'demand up' indicator. This netting highlights an avoidance of energy activation which results in a saving of costs.
- In the upward direction, in the Nordic EAM and European EAM configurations, **Sweden relies more on the imports from the neighbouring countries (especially from other Nordic countries) than on its local BSPs**: activation in Sweden represents 22% of the demand, while imports from all other countries represent 45% of the demand (44% for the European EAM), reflecting the **structural position of Sweden as net importer when the country faces upward imbalance**. The **shift from a Nordic EAM to a European EAM has little impact** on this result: in the European EAM, Sweden still mostly relies on the imports from the other Nordic countries. The imports from Lithuania and Poland only represent 2% of the Swedish demand.

- | **In the downward direction, Sweden relies less on its neighbouring countries than in the upward direction:** contributions from neighbouring countries amount to only 22% of the Swedish demand in the Nordic EAM, and 29% of the Swedish demand in the European EAM (which is lower than the 44% of the upward direction). Moreover, unlike the upward direction, the shift from Nordic to European EAM has an impact on the origin of the BSPs activated to meet the Swedish demand.

To complete this analysis, the focus is placed on the Swedish bidding zones with limited balancing resources and close to continental Europe: SE3 and SE4. Similarly to the figure above, Figure 2-7 displays how the balancing demand is met (between local activations and imports and exports) but focusing only on SE3 and SE4.

As expected, this figure illustrates that, in all the situations, SE3 and SE4 mostly rely on imports (and to a broader extent than at the national scale):

- | In the upward direction, activations in SE3 and SE4 represent 25-28% of the activation demand of SE3 and SE4. The remaining is met with imports from Denmark (39% of the demand in the Nordic EAM and 35% in the European EAM), Norway (17% in the Nordic EAM and 14% in the European EAM) and SE2 (9% in both the Nordic and the European EAM).
- | In the downward direction, activations in SE3 and SE4 only represent 16-18% of the activation demand of SE3 and SE4. The remaining is met with contributions from SE2 (71% in the Nordic EAM and 61% in the European EAM) and Poland (9% in the European EAM).
- | The more significant impact of Sweden's accession to European EAM, in the downward direction, is to substitute exports from SE2 with exports from Poland.

This figure also illustrates that **the connection to Lithuania and Poland has a positive impact on SE3 and SE4**. In particular, while the interconnection to Poland is more exporting than importing on the MTUs where Sweden demand is overall upward (at a national scale), thus playing in the opposite direction to the Swedish needs (-1% on the national mFRR upward demand – see figure above), on the MTUs where SE3 and SE4 demand is upward, the interconnection is more importing than exporting, thus supporting the SE3 and SE4 balancing needs (+1% of the upward demand for SE3 and SE4 – see figure below).

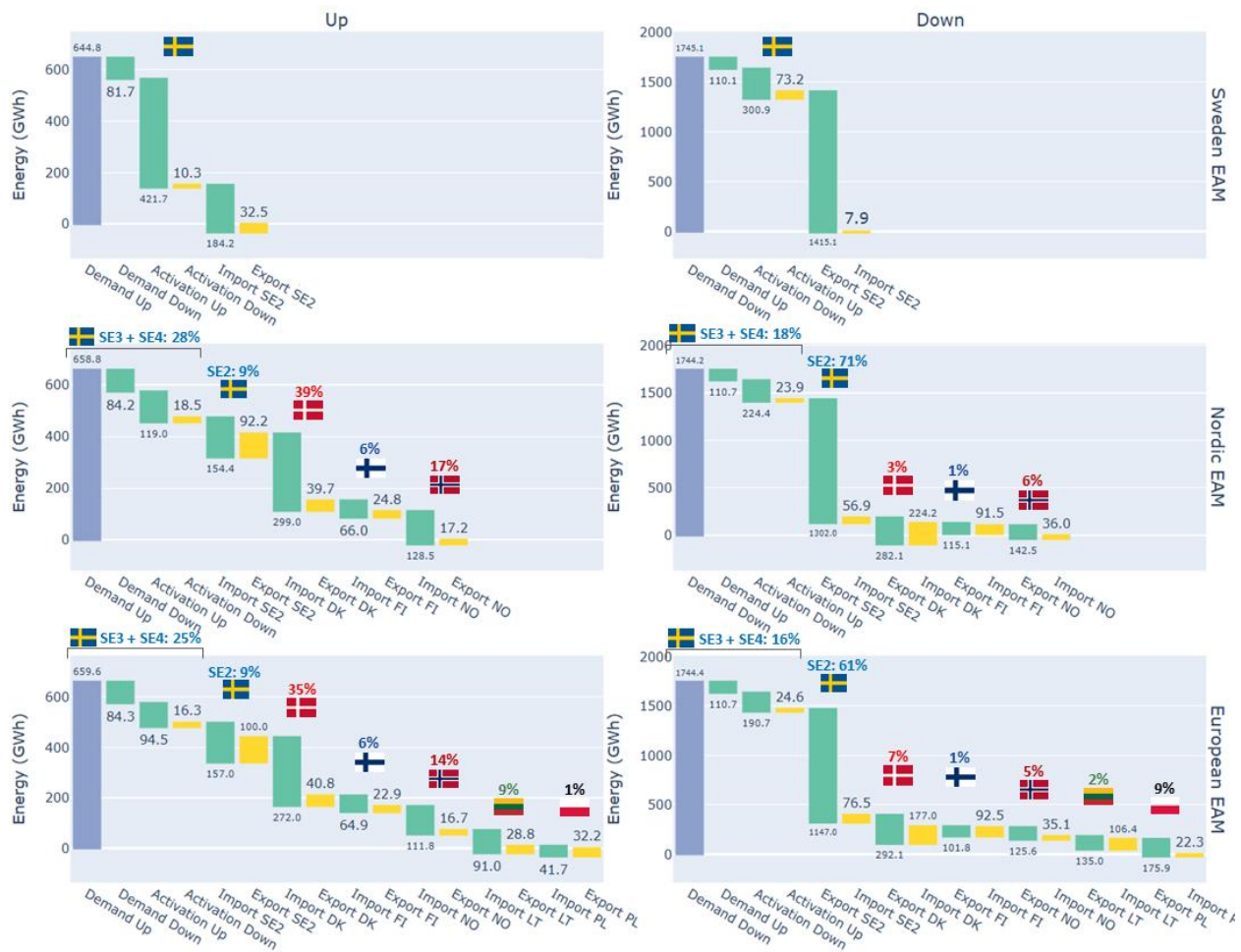


Figure 2-7: mFRR demand in bidding zones SE3 and SE4, activation in SE3 and SE4 and imports and exports from SE2 and neighbouring countries on the MTUs on where the demand is predominantly up (left) and down (right)

2.2.2 In the European EAM, the Swedish interconnections to continental Europe are heavily used but lead to a limited impact on the global picture due to their limited capacities

Various interconnections are linking the Nordic countries to continental Europe in the simulated European EAM, as described in section [1.3.1 Cross-zonal capacities open to mFRR activation](#). This section focuses on the two direct interconnections between Sweden and continental Europe, i.e. HVDC cables linking SE4 to Poland and Lithuania, to further understand the influence of these interconnections for this bidding zone with a limited available pool of balancing resources.

These interconnections enable Sweden to exchange balancing capacity with both countries. Figure 2-8 illustrates the simulated balancing flows and utilisation rates for balancing for the SE4-PL and SE4-LT interconnectors.

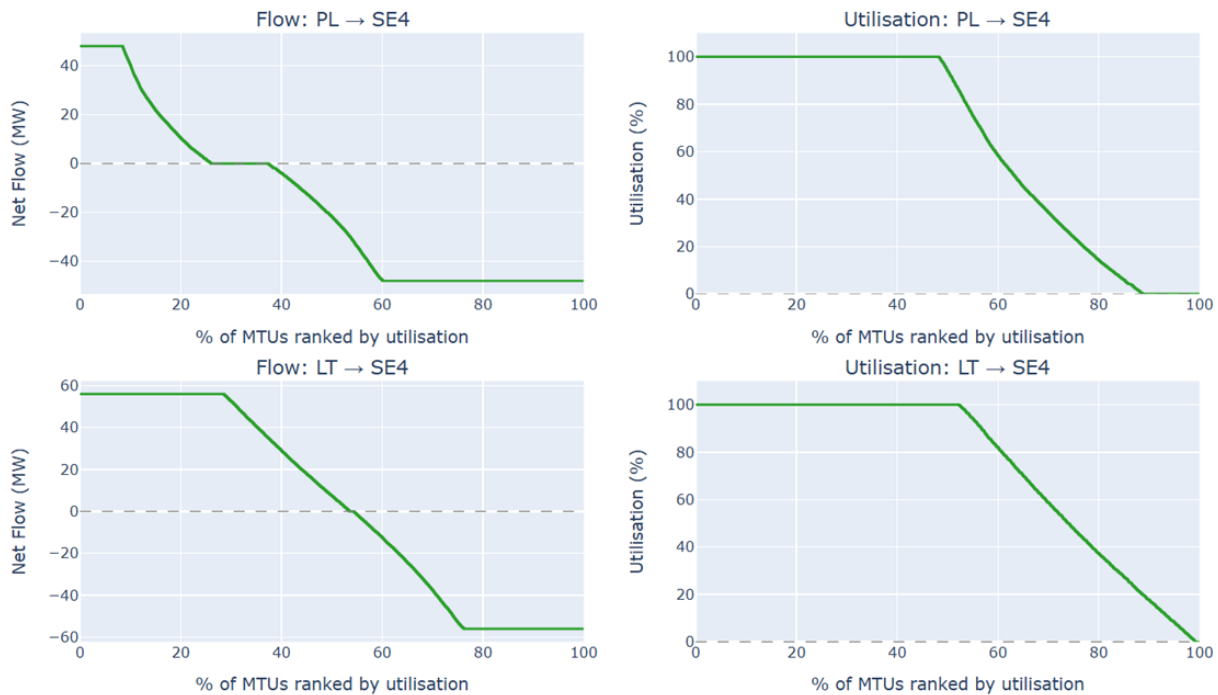


Figure 2-8: Utilisation of the Swedish interconnections to Poland and Lithuania in the European EAM (MARI) situation

This figure illustrates that the interconnection capacities between Sweden and continental Europe open to mFRR cross-border activation are used at their maximum capacity during **more than 50%** of the simulated period, as illustrated in the right-hand side of Figure 2-8. This saturation highlights a structural bottleneck on these borders, related to the limited HVDC balancing transfer capabilities. This **significantly limits the potential benefits of cross-border balancing through these interconnections**.

The duration curves highlight that the **interconnections from Sweden to Lithuania and Poland are used in both directions**, though with a **clear directional asymmetry: flows from SE4 towards PL dominate**, reflecting a persistent net export of balancing energy from Sweden to Poland. In contrast, **utilisation in the SE4-LT direction appears more evenly distributed**.

However, despite their high utilisation rate, the **role that these interconnections play in Sweden's overall balancing process** in the European EAM configuration remains **relatively minor**. As illustrated on [Figure 2-6](#), imports from Poland and Lithuania account for only 8% (6% for Poland and 2% for Lithuania) of Sweden's balancing activation in the downward direction and less than 2% in the upward direction. In other words, while the interconnections between Sweden and continental Europe are used extensively, they have a **limited influence on the overall balancing situation in Sweden**, due to their small capacities.

To provide further detail, the following figure presents the same interconnection flows as above but orders them according to their impact on the overall SE4 situation. The objective is to assess whether cross-border flows support or constrain the balancing need in SE4 with the following definition:

- Flows are considered **positive** when they are in the same direction as the main activation direction of SE4: upward main activation direction combined with imports, or downward main activation direction combined with exports.
- Flows are considered **negative** when they worsen the situation: upward main activation direction combined with exports, or downward main activation direction combined with imports.

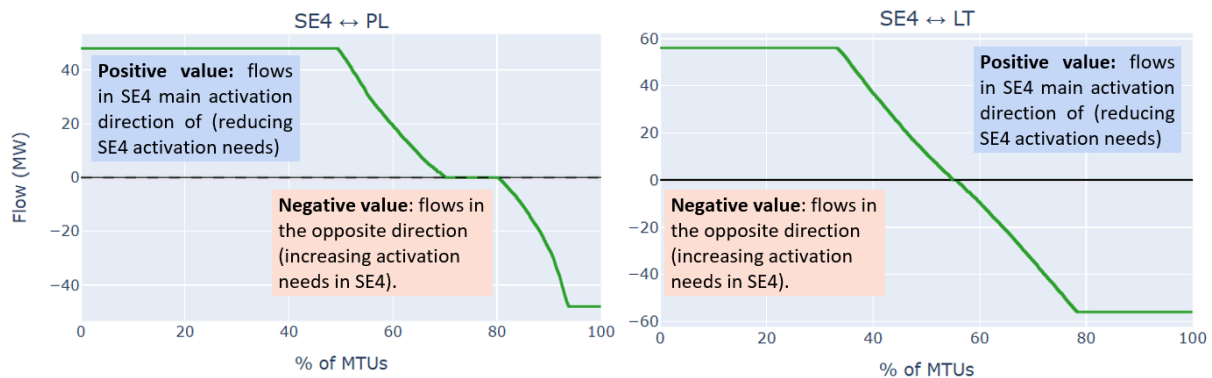


Figure 2-9: Utilisation of the Swedish interconnections to Poland and Lithuania in the European EAM (MARI) situation, compared to the main activation direction of SE4

The figure illustrates that:

- The SE4-PL interconnection is supporting SE4 and more generally the Nordic system for 70% of the MTUs (including 50% at its maximum capacity) and opposing SE4 for around 20% of the MTUs (including a bit less than 10% at its maximum capacity).
- The SE4-LT interconnection is supporting SE4 and more generally the Nordic system for 55% of the MTUs (including 35% at its maximum capacity) and opposing SE4 for around 45% of the MTUs (including 20% at its maximum capacity).

Overall, the **interconnections to the continental Europe through Poland and Lithuania tend to support balancing in SE4.**

2.3 Market prices

This section analyses the impact of market integration on marginal price levels and their variability. It highlights the effects of increased market coupling on activation price, price volatility and price convergence across bidding zones.

2.3.1 Sweden's accession to larger markets brings activation prices closer to zero (i.e. reduces upward prices and increases downward prices)

The figures below present the monthly average mFRR marginal prices across the market configurations considered, segmented by main activation direction for each Swedish bidding zone.



Figure 2-10: Monthly average¹¹ marginal price for mFRR per market situation, bidding zone and direction
Dashed lines correspond to yearly averages.

¹¹ The simulations cover the period from 4 March 2025 (go-live date of Nordic mFRR EAM) to 3 March 2026. Thus, the values displayed on the graph above for the months of March 2025 and March 2026 do not represent the full months.

The figure above indicates how market integration affects **average marginal price levels**. For the **upward direction**, the key findings are:

- | **Nordic EAM integration delivers substantial marginal price reductions.** Transition from a Swedish national mFRR EAM to Nordic EAM consistently lowers average prices across all bidding zones and directions (except in SE1 and SE2 in the downward direction, where accession to Nordic EAM slightly increases the average prices). The price reduction is more pronounced for upward balancing where Sweden faces structural constraints as discussed previously in section [2.1 Economic surplus](#).

Explanation notes:

In the present report, the conventions followed for price directions (consistently with the conventions of MARI) are:

- | In the upward direction, positive price means that the TSO pays the Balancing Service Provider (BSP), and negative prices mean that the BSP pays the TSO
- | In the downward direction, positive prices mean that the BSP pays the TSO and negative price means that the TSO pays the BSP.

Therefore, in the downward direction, increasing the prices means reducing the cost for the TSO and the remuneration for the BSPs (i.e. similar effects as increasing the prices in the upward direction).

- | **European EAM integration shows limited impact on the average marginal mFRR price.** The extension from Nordic EAM to European EAM (MARI) produces minimal additional price changes, with mixed effects across months. In the upward direction, the results show that for several months, slight reductions in marginal prices between the Nordic EAM and the European EAM are observed whereas for others, slight increases are observed.
- | **SE3 and SE4 capture the largest benefits in the upward direction.** Southern zones (SE3 and SE4) experience upward price reductions exceeding 390 €/MWh when transitioning from national to Nordic/European markets, while northern zones (SE1 and SE2) show reductions below 65 €/MWh. This aligns with the structural scarcity patterns, where southern zones of Sweden face tighter balancing constraints.
- | **Upward price reductions are largely due to scarcity event reduction.** For instance, the number of MTUs with rejected demand upward in SE4 reduces from 511 in the Swedish national mFRR EAM to 21 in the Nordic mFRR EAM. During scarcity events, the market price is equal to the bid price cap of MARI (+/- 10 000 €/MWh). Therefore:
 - **When considering all the MTUs (with activation upward),** the average market price reduces from 731 €/MWh in the Swedish national mFRR EAM to 226 €/MWh in the Nordic mFRR EAM.
 - For MTUs **with activation upward** and **without rejected demand** in SE4, the average market price changes from 561 €/MWh in the Swedish national EAM to 183 €/MWh in the Nordic EAM.

- This means that 1.4% of the MTUs (where rejected demand is reduced) are responsible for 25% of the 505 €/MWh price reduction.

Overall, the significant price reduction in the upward direction indicates that upward capacity is more locally constrained (than the downward direction) and gains more from geographic resource pooling.

In the **downward direction, the effects of market integration on market prices are less clear**. In most cases, market integration tends to **slightly increase average downward prices in Sweden** (i.e. to bring prices closer to zero). The effects are however limited compared to the upward direction. To complete this assessment, further analyses are presented in the section below.

2.3.2 Sweden's accession to larger markets helps reduce market price volatility in the upward direction

Another key consideration regarding mFRR prices is the associated price volatility. Price volatility across bidding zones is displayed in the box plots Figure 2-11, which present key statistical parameters of the marginal price distribution per Market Time Unit (MTU).

Explanation notes:

Unlike the other figures in this report, for this figure, the MTUs are separated between upward and downward direction following two logics:

- | Following the direction of the demand on the bidding zone
- | Following the main activation direction on the bidding zone.

Both logics do not necessarily coincide, since it is possible to have the demand in one direction and activations in the other direction (if the demand is netted with demand from neighbouring bidding zones in the opposite direction, and that on the top of that, balancing services is exported to the neighbouring bidding zones).

For instance, if SE1 has a demand up of +50 MW, that SE2 has a demand down of -70 MW, and that a bid down of -20 MW is activated in SE1 (to meet the demand down of SE2), then SE1 has a demand up but a main activation direction down.

In particular, all negative prices that occur on MTUs where the demand in the bidding zone is upward explained by similar logics (up demand netted with neighbouring bidding zones, and downward bids activated in the area to meet the downward demand of neighbouring bidding zones). This explains why negative prices occur in the upward direction from the demand perspective, but not in the upward direction from the activation perspective.

NB: on this graph, the direction (up or down) is systematically evaluated individually for each bidding zone (and is never computed at a national aggregated level).

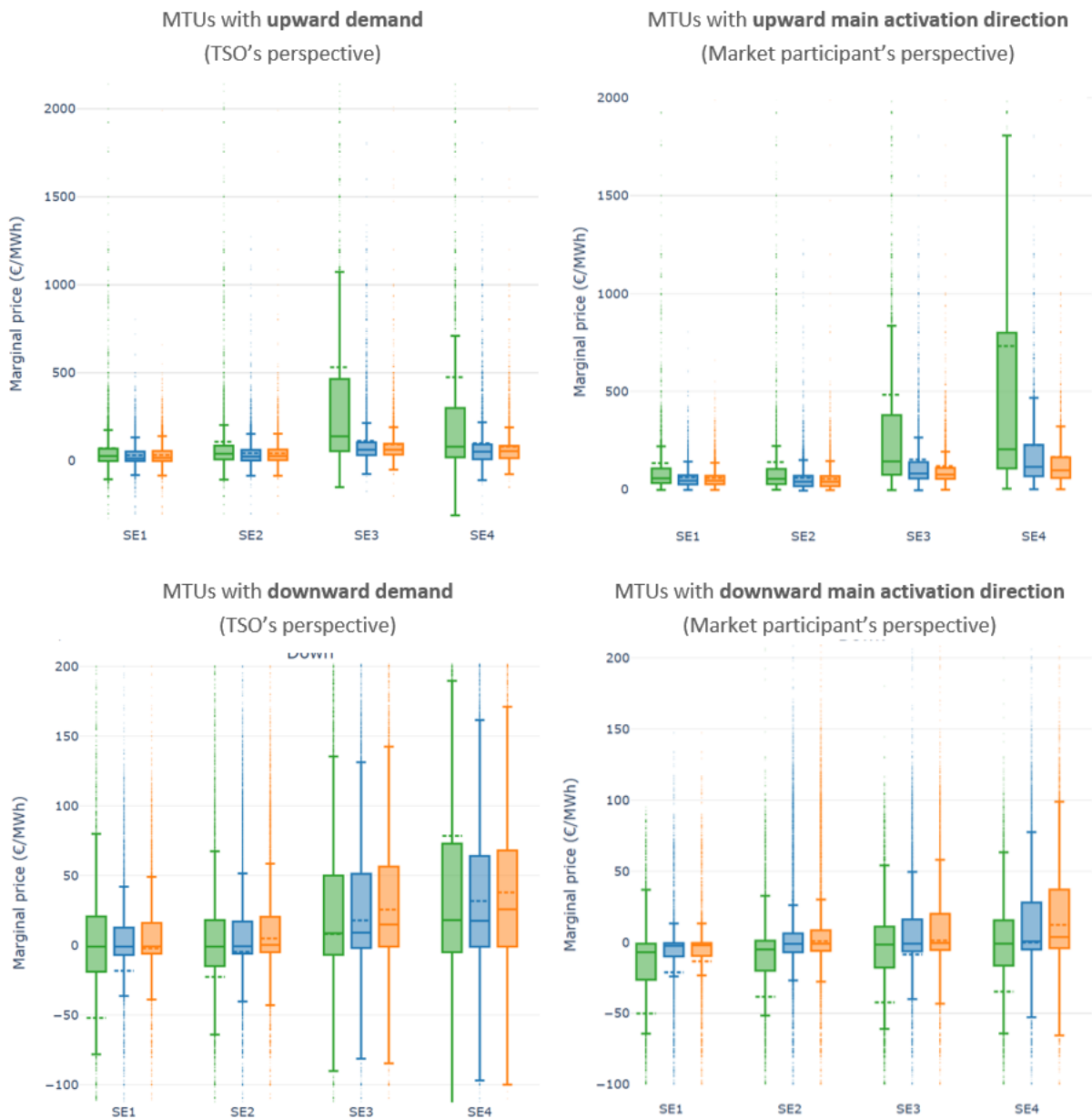


Figure 2-11: Box plot of the marginal price observed per MTU. The direction is defined according to the imbalance in the top figure, and to the activation in the bottom figure

Note: dashed lines correspond to mean price, solid lines correspond to median price. For visual representation, the graph is focused on the boxes and does not display the extreme values (maximum and minimum value are $\pm 10,000$ €/MWh).

In the upward direction, market integration shows a compression of price dispersion:

- | This is particularly visible **when moving from a Swedish national mFRR EAM to the Nordic EAM, in SE3 and SE4**, with narrower interquartile ranges and fewer extreme price realisations. This indicates a more stable price formation process supported by improved liquidity and enhanced cross-zonal balancing possibilities associated with the accession to the Nordic EAM. The median and mean prices also converge closer to zero, and extreme outliers are reduced.
- | **The transition from Nordic EAM to European EAM shows minimal additional impact on price volatility**, with interquartile ranges, medians, and means remaining relatively stable. While

there is slight variation in box positioning across the bidding zones, the overall distribution characteristics are largely preserved, suggesting that the incremental benefits of European market integration on price stability are limited compared to the substantial improvements already achieved through Nordic market coupling.

In the downward direction, the effect of market integration on price dispersion is less clear than in the upward direction:

- | The transition from a Swedish national mFRR EAM to a Nordic EAM tends to **slightly reduce price volatility** but to a lesser extent than in the upward direction.
- | On the contrary, Sweden's accession to a European EAM leads to a **slight increase in price volatility** in Sweden.

2.4 Sensitivity analysis – Impact of the Price Spread Mitigation (PSM) feature

This section assesses the influence of the Price Spread Mitigation (PSM) mechanism on market outcomes. It compares results obtained with and without this feature to evaluate its effect on economic surplus, price dynamics, and market efficiency.

The market clearing algorithm currently used for mFRR energy activation in the Nordic countries (Nordic mFRR **Activation Optimisation Function (AOF)**) presents a few differences with the algorithm used in continental Europe (MARI AOF) (see section [1.4 Simulation tool](#) for further details). In the current state of implementation, the **Nordic mFRR EAM includes a price spread mitigation mechanism**, designed to limit situations where marginal prices diverge significantly between neighbouring areas due to indivisibilities or local constraints. By contrast, the **MARI algorithm does not incorporate such a mitigation mechanism**, and prices are determined directly from the market clearing outcome, potentially leading to larger spatial price differentials under certain system conditions.

The impacts of Sweden's accession to MARI presented above were computed with MARI AOF (i.e. as if MARI AOF was the algorithm currently used in the Nordic, and the algorithm to be used after Sweden's accession to MARI).

This section discusses the extent to which the results presented above are valid when using Nordic mFRR AOF (with the price spread mitigation feature) instead of MARI AOF¹². The comparison presented in this section therefore focuses on quantifying the consequences of these design differences on three dimensions:

- | **Economic surplus**, analysed through changes in total social welfare and its main components (demand-side surplus, offer surplus, and congestion rents), to assess whether price spread

¹² Nordic mFRR AOF and MARI AOF present other differences than the price spread mitigations. The other differences were however not assessed. See section [1.4 Simulation tool](#) for further details.

mitigation materially affects overall efficiency or redistributes welfare between market participants and areas.

- | **Marginal prices**, examined by looking at the occurrences of difference between clearing prices obtained with price spread mitigation and without price spread mitigation.
- | **Unforeseeable rejected bids (URBs)**, corresponding to in-the-money bids that are not selected by the clearing algorithm, despite having a bid price strictly below the clearing price (for upward bids). The analysis assesses how the presence or absence of the price spread mitigation feature affects the frequency of URBs for the market considered.

2.4.1 The PSM has a minor impact on economic surplus

This section compares **the economic outcomes of simulations with and without Price Spread Mitigation (PSM)**, with a specific focus on the Swedish level.

The Price Spread Mitigation has an impact of up to 2 M€ on the market economic surplus in Sweden. Compared to the impact of the accession of Sweden to Nordic and European mFRR EAM (respectively +459 M€ and +40 M€, as already presented in section [2.1 Economic surplus](#)), the impact of the Price Spread Mitigation on the total economic surplus is relatively minor, as illustrated in Figure 2-12:

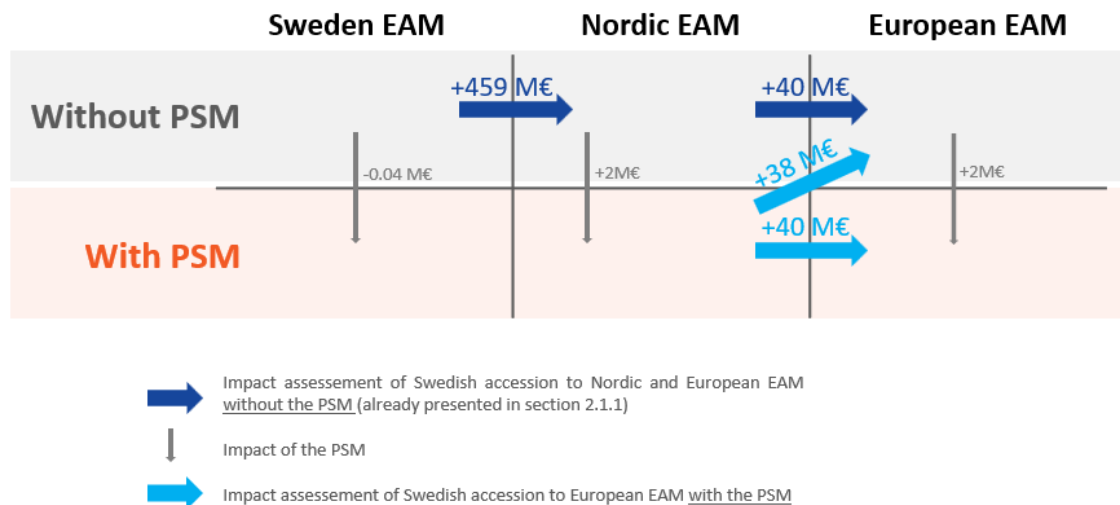


Figure 2-12: Approach for economic surplus analysis with and without PSM

Considering the current situation for Sweden is the Nordic EAM with the PSM, the impact of accession to the European EAM would therefore be +40 M€ if the PSM is adopted in the European EAM, and +38 M€ otherwise. Accessing the European EAM has therefore a positive impact on the Swedish economic surplus, even if the PSM is not adopted by the European EAM.

The figure below illustrates the impact of the PSM on the different components of the economic surplus (demand-side surplus, offer surplus and congestion rents), to assess whether the introduction of price spread mitigation materially affects overall welfare or redistributes surplus across market participants.



Figure 2-13: Comparison of the surplus gain from switching to a larger mFRR market to the surplus gain of including price spread mitigation at the Nordic and the European level

This comparison illustrates the following results:

- The difference in surplus between the Nordic and European market configurations is substantially larger than the surplus difference introduced by PSM.** In other words, the main driver of economic surplus changes is the accession to a larger market, rather than the inclusion or exclusion of price spread mitigation.
- Overall, the results indicate that **price spread mitigation has no substantial effect on total economic surplus** in the analysed configurations. While it may affect marginal prices and the distribution of surplus in specific MTUs, its impact on aggregated welfare remains limited compared to the effect of market enlargement.

2.4.2 Sweden's accession to European mFRR EAM is more efficient than the PSM to reduce extreme mFRR price events

Beyond the impact of surplus, differences between the clearing algorithms are further analysed through market price outcomes. This section focuses on the occurrences of high marginal prices to reflect the impact of the Price Spread Mitigation, which has been introduced to reduce these extreme price events.

Price levels are analysed by bidding zone and imbalance direction, focusing on the occurrence of extreme price events. For each MTU, the marginal price obtained with and without the price spread mitigation (PSM) is evaluated against a threshold in absolute terms.

Figure 2-14 presents, for each Swedish bidding zone and imbalance direction, the number of occurrences where the absolute value of the balancing price exceeds the **threshold of 500 €/MWh** (i.e. where prices exceed the range [-500, +500]).

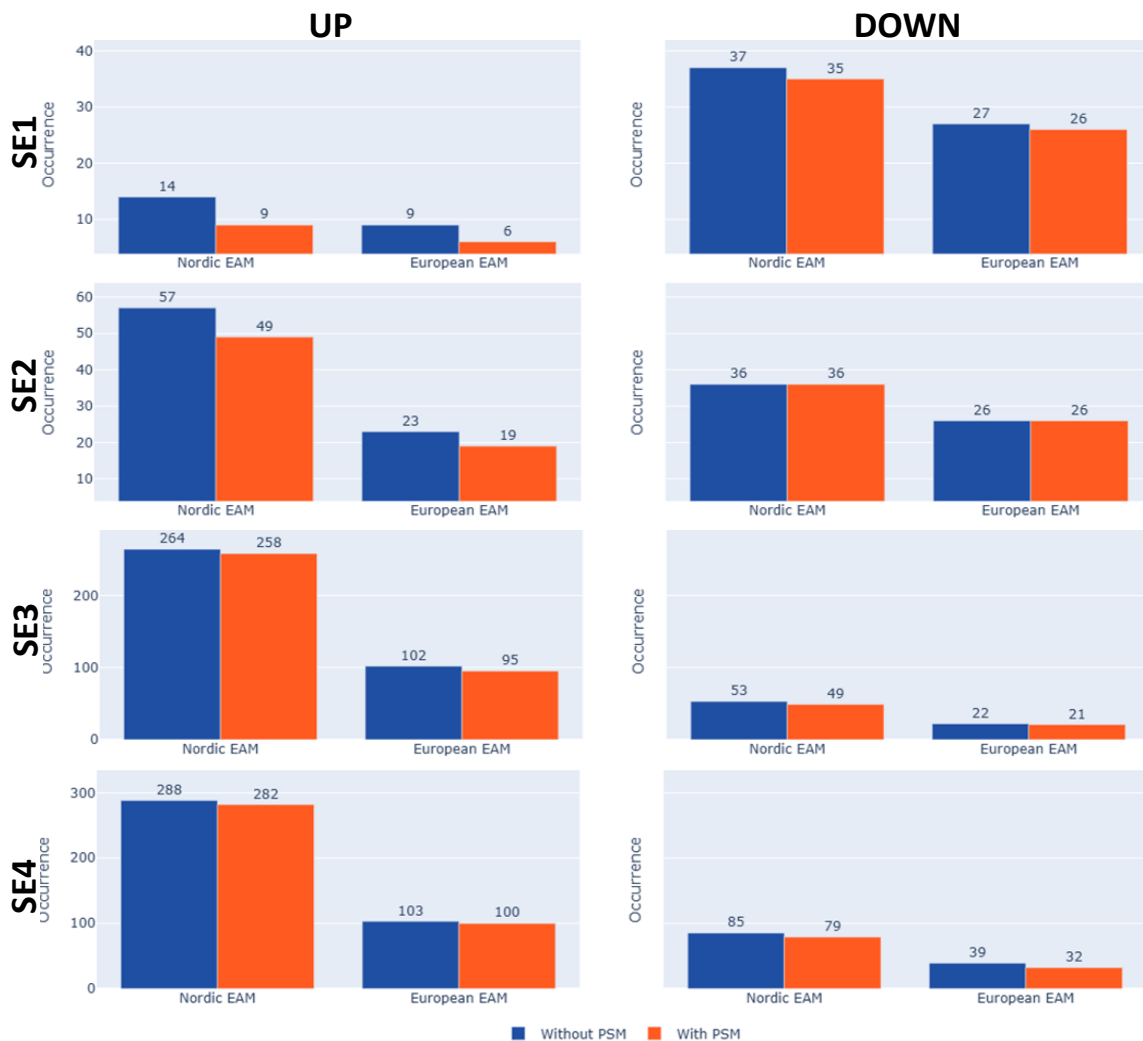


Figure 2-14: Number of occurrences of prices above 500 €/MWh (in number of MTUs) with and without price spread mitigation

The results show that the **implementation of PSM generally reduces the number of extreme price occurrences across bidding zones and imbalance directions**. However, the largest impact remains associated with the expansion of the market scope itself: the transition from Nordic to a European EAM leads to a much more significant reduction in extreme price events than the implementation of PSM alone. This highlights that **market integration plays a primary role in improving balancing outcomes** (as already highlighted in section [2.3 Market prices](#)), **while PSM provides an additional, albeit more moderate, refinement**.

2.4.3 Unforeseeable Rejected Bids

To complete this analysis, unforeseeable rejected bids (**URBs**) are used as a **key indicator to compare market designs with and without price spread mitigation (PSM)**. Differences in URB volumes highlight how design choices can influence the activation of reserves across bidding zones, market coupling scopes (national, Nordic, European), and activation directions (upward and downward).

The following results quantify differences in URB bid volumes (in GWh) between the two setups, without and with PSM, disaggregated by market configuration for Sweden.

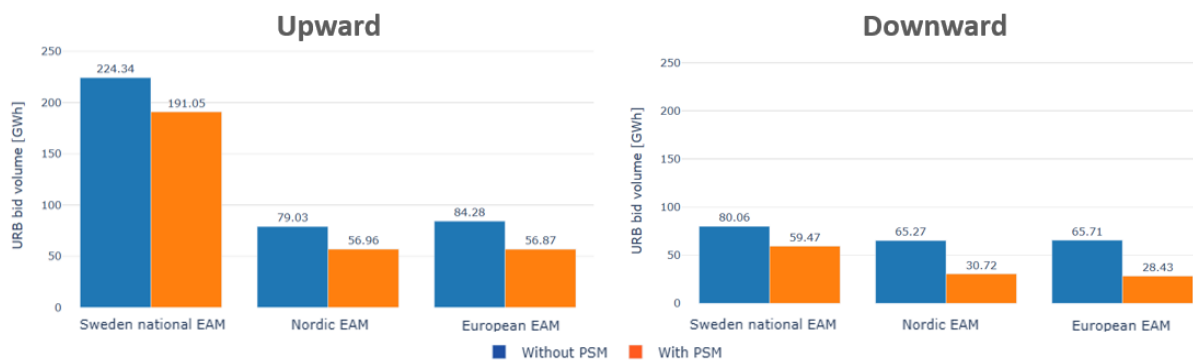


Figure 2-15: Simulated URB volumes with and without price spread mitigation

Upward direction of imbalance is represented on the left, and downward direction of imbalance is represented on the right

The following findings can be extracted from this analysis:

- The main finding of the comparison in Figure 2-15 is that **price spread mitigation significantly affects the volume of URBs**. In all simulated cases, **PSM leads to lower URB volumes compared to the MARI design without PSM**, indicating that price spread constraints can increase the efficiency of activation of available bids. **Differences of up to 37 GWh in URB volume are observed at the Swedish level for the European market** between the simulations with and without PSM.
- As expected, **URBs are also reduced when accessing a larger market pool, when moving from the Swedish national mFRR EAM to the Nordic or European EAM**. This reflects the increased availability of balancing resources and greater flexibility offered by wider market coupling. However, **no large difference is visible between the Nordic EAM and the European EAM**.

Conclusion

This assessment examined the **impact of Sweden's accession to the Nordic and European mFRR Energy Activation Market (EAM)**. Through the analysis of simulated market situations, the study evaluated the **effects of progressive market integration** on **economic surplus, price dynamics** and **cross-border resource utilisation** for Svenska kraftnät and Swedish balancing service providers.

The analyses are based on market simulations, which use the same clearing algorithm as the one used in production for MARI, as well as on historical market data (covering the period from 4 March 2025 to 3 March 2026). Additional assumptions and some simplifications also had to be made. Consequently, the results should be interpreted considering these underlying assumptions and the potential limitations they may entail¹³.

The results indicate that **broader market integration** delivers higher benefits for Sweden. **Nordic cooperation** (initiated in 2002 and finalised in 2025 with the go-live of the Nordic mFRR EAM) **achieves the most significant step** and significantly improves the economic surplus for Sweden compared to the counterfactual "Sweden-only" scenario. Cooperation provides access to a wider, more competitive pool of balancing resources. **Switching from the Nordic EAM to the European EAM further reinforces these benefits, but to a more limited extent.**

The benefits arise both from **the reduction of scarcity situations** and **social welfare increase in normal operations**. This demonstrates that market integration brings both increased reliability and cost efficiency.

Marginal price analyses across bidding zones and market configurations confirm that **broader coupling reduces price volatility**, supporting more stable and competitive marginal prices across all Swedish bidding zones.

The analysis of interconnection utilisation shows that the **physical capacity of cross-border links is a limiting factor in the balancing energy transfers with continental Europe** potentially preventing the full realisation of integration benefits.

Finally, a sensitivity analysis illustrated the relatively minor impact of the Price Spread Mitigation when considering all MTUs. In other words, accessing MARI seems to remain beneficial for Sweden in every respect (increase of social welfare, reduction of extreme prices), even if Sweden (and the Nordic countries) had to renounce to the Price Spread Mitigation feature. Nevertheless, price spread mitigation may still provide other benefits (notably in terms of the interpretability and comprehensibility of market prices), which have not been assessed in this study.

¹³ See section [1.5 Limitations](#) for further details.