SVENSKA KRAFTNÄT

Balancing market outlook 2030

2024-12-19

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CHAPTER 1

Introduction

Initial words

A core mission for Svenska kraftnät as Sweden's transmission system operator (TSO) is to balance the power system in a safe and cost efficient manner. We have to deliver on this mission every second, now and in the future, throughout uncertainties and changing conditions.
Well functioning markets for ancillary services are key to achieving our goals.

I believe that collaboration and learning from each other are crucial in developing new solutions to enable the electrification and the transition of the power system. Increasing market information, transparency about what we do know, as well as where there are uncertainties, will help us move forward together.

I hope this outlook will give you as a market actor more knowledge and perhaps some new insights. I'm looking forward to keep improving our stakeholder dialogue and your feedback on this new report.

Anna Jäderström
Director Balancing Markets

About this report

Welcome to Svenska kraftnät's first outlook for ancillary services!
Sweden's ambitious CO_2 emission reduction targets imply electrification of different sectors such as industry and transportation, leading to forecasted large increases of electricity demand in the future. Furthermore, the production mix in the Swedish system has significantly changed over the last decade with increasing shares of wind and solar power production, a development foreseen to continue in the coming decades. This has led to new market conditions, impacting e.g. supply and demand for ancillary services.

The purpose of this report is to provide information and insights about recent and future developments of ancillary services in Sweden, including market design reforms, historical development of demand and prices for different products, as well as projections of future demands. The aim is to further enable market actors to identify viable business cases and to make investment decisions for ancillary services provisions.

The report presents historical data up until and including September 2024 and projections for the next five years. The future is, however, by its very nature uncertain. This means that forecasts will always be associated with errors in hindsight. Svenska kraftnät strives to be transparent regarding these uncertainties in order to provide market actors with full information about possible future developments. Hence, the forecasts presented in this report should be considered the best estimates currently available, but they can all be subject to change.

Development of the ancillary services markets is crucial to ensure a reliable and secure operation of the electric power system also in the future. Creating efficient markets, open to a variety of technologies and market actors, will reduce costs for consumers as well as creating business cases for service providers. We hope that this report paves the way for further stakeholder engagement in the ancillary services markets!

Svenska kraftnät's strategy and market design

The transmission system operators are in the centre of the development of the electric power system and market. Svenska kraftnät's updated strategy towards 2030, highlights changes necessary to meet and facilitate the development of the system and Svenska kraftnät.

The future electricity market has been identified as a development area that requires extra attention in order for Svenska kraftnät to meet long-term goals and objectives. Specifically, Svenska kraftnät will develop the market design in order to use resources efficiently, contribute to strengthening long-term investment signals for adequacy and flexibility, and create incentives for abilities required to meet a more volatile energy system. Hence, development of ancillary services markets is key in order to meet the ambitions of Svenska kraftnät.

Market integration

Market integration provides efficiency by allowing trading and sharing resources between countries. Integration of the balancing markets in the Nordics and continental Europe provides the tools to use existing balancing resources efficiently.

Competition

Competition is vital for market efficiency. By removing entry barriers, providing equal access and low transaction costs for different actors, competitive markets can be promoted.

Efficient cost allocation

In order to achieve system efficient incentives for market actors, costs and benefits need to be appropriately allocated to the actors providing benefits or causing costs.

Key events

The electricity market design is continuously improved to become more efficient and to meet current and future challenges. Although all improvements contribute to the electricity market development, some have a more significant impact on balance management. Below you find some key recent and upcoming developments that have significant impact on balancing the electric power system from a market perspective.

OCTOBER 17, 2023

National capacity market mFRR

The Swedish capacity market for mFRR was successfully launched, and has since ensured capacity for the energy activation market. The national capacity market is a step towards a common Nordic mFRR capacity market.

JUNE 13, 2024

Intraday market auctions

In order to enhance the possibilities for market actors to adjust positions between the day-ahead market closure and delivery, intraday market auctions have been introduced as a complement to the continuous intraday trading.

OCTOBER 29, 2024

Flowbased capacity allocation method day-ahead

The introduction of flowbased capacity allocation facilitates a more efficient use of the transmission grid. As a first step, the flowbased method was successfully launched for the day-ahead market.

2025

Transition to 15 minutes

To facilitate a more variable electricity system, 15 minutes MTU and ISP will be introduced. The transition implies a more efficient balancing process by allowing trading that better reflects actual production and consumption. A prerequisite for this transition is the introduction of an automated mFRR energy activation market.

MTU - Market time unit
ISP – Imbalance settlement period

Key takeaways

Here are the key takeaways from Svenska kraftnät's outlook on the future of the balancing market and the demand for ancillary services.

1

The balancing market is evolving rapidly, where the overall demand for ancillary services is expected to grow over the next five years. A diversified range of technologies and an efficient market design will be crucial to meet this growing demand.

2

Increased demand for resources that are located geographically close to the imbalances. This is driven by the grid reaching full utilization, at least in one direction, particularly for frequency restoration reserves (FRR). Consequently, the need to secure day-ahead capacity for aFRR and mFRR will also increase.

3

The current balancing model is under review. This includes reassessing how we dimension our reserves (aFRR and mFRR) as well as exploring the incentives and mechanisms to help the power system to be balanced.

CHAPTER 2

Background

Why do we need ancillary services?

Grid capacity and wholesale energy market
Svenska kraftnät plays a critical role in allocating capacity for the electricity market by setting limits that ensure stability and reliability across the grid. This capacity allocation allows market participants to engage in energy transactions, to a large extent through the power exchange (via NEMOs). Svenska kraftnät's capacity allocation uses factors such as forecasted demand and production, grid constraints, and energy availability from different sources.

Power system characteristics
Depending on the outcome in the wholesale energy market, specific technologies are called upon to either produce or consume electricity, shaping the grid's characteristics during each market time unit (MTU). This results in varying system properties, such as available flexibility and inertia.

"Ancillary services have always and will always be needed"

The outcome on the wholesale energy market, where production is planned to meet demand, does not always reflect real-time conditions. Sudden shifts in weather can swiftly alter consumption or generation from wind and solar, leading to discrepancies between forecasted and actual production. Similarly, unexpected technical interruptions, such as failures in high-voltage cables (HVDC), grid infrastructure, or in large production or consumption units, can disrupt the planned energy flow. These unforeseen changes require rapid response measures to rebalance supply and demand in real time. Ancillary services will always be needed as long as consumption and production are not required to match each second. Further, the alternative would be that each market actor is required to maintain reserves for all eventualities, which would risk large volumes being withdrawn from the markets as a precaution.

"Markets for ancillary services enable cost and resource efficiency, the alternative being that each market actor is required to keep reserves of their own"

By establishing separate markets for different ancillary services, the TSO enables efficient resource allocation to meet specific demands. Each market targets a distinct service, allowing technologies with different strengths to contribute where they are most effective as well as enabling strong competition through transparent markets.

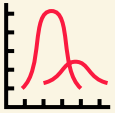
Balancing the power system requires several steps

A part of Svenska kraftnät's system responsibility as the TSO in Sweden is to ensure that the grid is stable and balanced all year round. Achieving this requires a series of steps that must function together to ensure everything runs as efficiently as possible.

Terms and conditions for balance responsibility
In addition to Svenska kraftnät's system responsibility, market participants are responsible for managing their own balance. By establishing clear terms and conditions for balance responsibility, market participants can be incentivized to align with the power system's needs and penalized when they cause imbalances according to the polluter pays principle.

Market design
Offering your flexibility to Svenska kraftnät should be easy. Continuous improvements in market design and functionality aim to lower barriers for entry to ancillary service markets.

Technical requirements
Developing and establishing clear technical requirements will enable more technologies to participate in the market. This approach also enhances the quality of reserve delivery and ensures that resources meet the power system's needs effectively when activated.



Dimensioning reserves & forecasting imbalances
Svenska kraftnät plays a crucial role in determining reserve requirements for capacity products and forecasting imbalances for energy products in each bidding zone. By providing accurate projections, Svenska kraftnät ensures that the power system receives the necessary resources to maintain balance while keeping the market informed of current demand, enabling actors to supply their resources accordingly.

Roles and new possibilities

Separation of responsibilities
On the 1st of May 2024, a significant organizational change was implemented by separating the functionality and responsibility of providing ancillary services from the previous BRP role and transferring it to a new role – BSP. By removing the obligation for a BSP to take on the role of a BRP, many responsibilities have been reduced, allowing the BSP to focus solely on providing ancillary services.

Implementing a fully independent BSP
Looking ahead, the newly established BSP role will be allowed to operate independently of any BRP no later than 2028. Until then, it will temporarily need to take on the responsibilities of both roles of BSP and BRP to ensure continuity and to fulfill its obligations during the transition period.

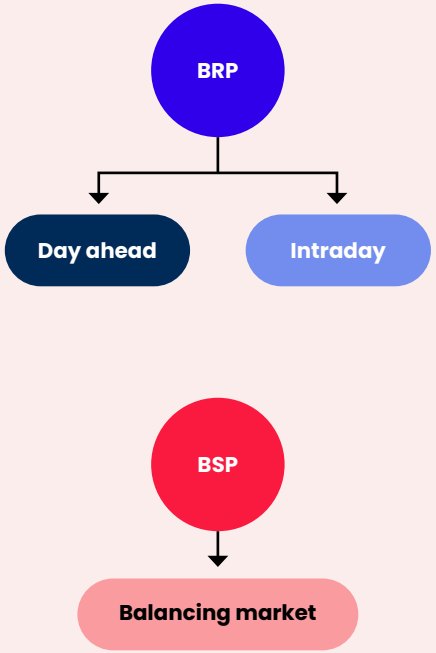
Separation of roles also means separation of market access
The original BRP role provided access to both the wholesale energy market and the balancing market, but with the separation of roles, market access is also divided — with the flexibility for any market participant to assume both roles if participation in both markets is desired.

This change eliminates the need for the BSP to manage energy trading for its customers, enabling them to specialize in their core expertise: providing ancillary services in a reliable and efficient way.

Improved possibilities for contribution
The division of roles introduces a new approach to providing resources for balancing. Svenska kraftnät firmly believes that these key changes will improve the possibilities to contributing to the balancing of the system:

- In real time, each BRP shall strive to be balanced or help the power system to be balanced. Svenska kraftnät is currently exploring requirements concerning this obligation.

- The BSP will be allowed to aggregate resources for ancillary services across multiple BRPs without needing bilateral agreements with them. This change will simplify how BSPs acquire customers and resources, optimize portfolio structuring, and increase the availability of resources in the balancing markets.



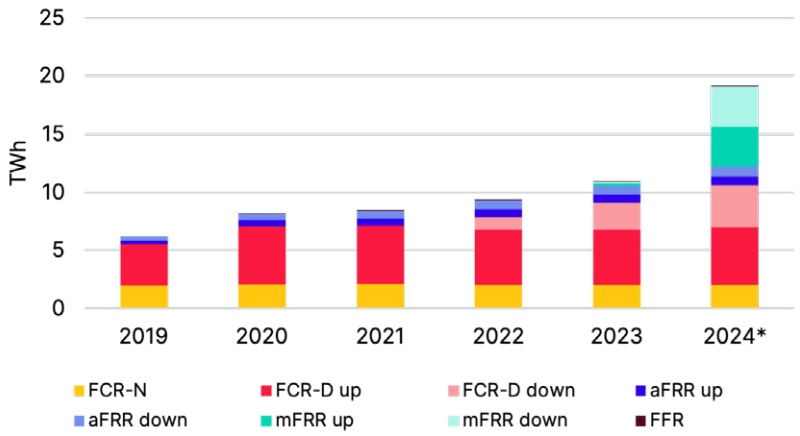
Development of volumes and prices up to now

Since 2019, the cost of balancing has risen. The explanation is a combination of rising prices and rising procured volumes of balancing capacity.

Rising volumes – why?
Rising volumes depends on a number of things. Most important are:

- **Introduction of the mFRR capacity market.** Until October 2023, mFRR was only an energy activation market – and therefore not included in the capacity volumes procured for ancillary services.
- **Larger share for Sweden as part of Nordic FCR requirements.** The way each country's share is calculated has changed during the years, resulting in a larger share for Sweden.
- **New HVDC cables.** Affects the size of actual reference incident in Nordic area, and thereby increases the need for volume in some products.
- **Focus on improved frequency quality.** There has been a trend in worsening frequency quality, especially in hourly transition, which needs to be handled.

Procured volumes – Capacity markets, TWh



* Forecast from October 2024

PROCURED VOLUME:
+300 % since 2019

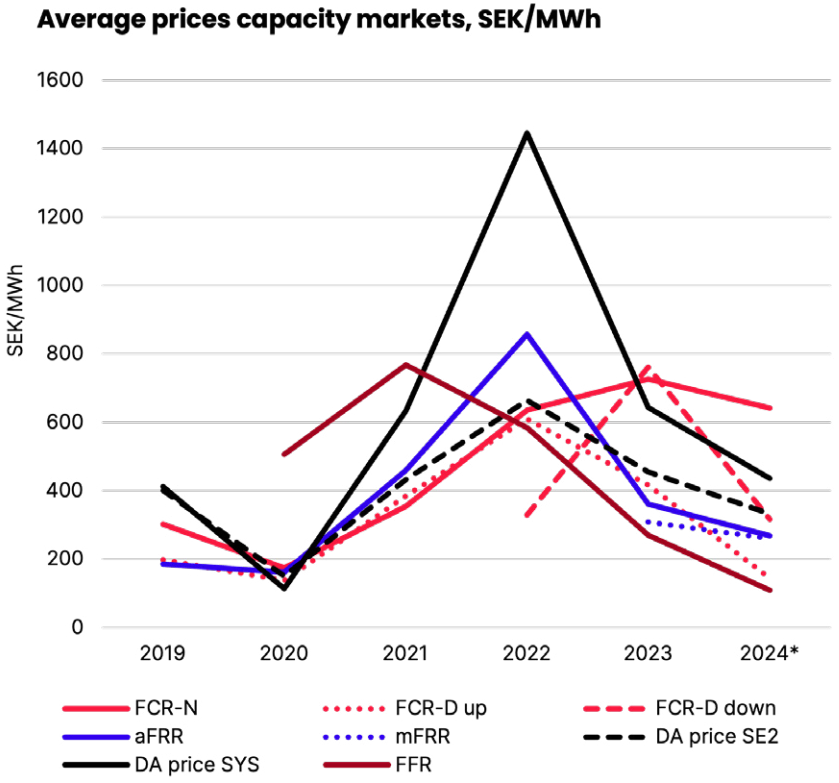
Procured volume of balancing capacity is calculated in **TWh** since each MW procured has to be available for one hour. Actual activation time, in case of activation, varies from seconds up to 15 minutes. Only a small share of the procured volume is activated.

Development of volumes and prices up to now

Rising prices 2019 – 2022. Why?
Important factors – among other things:

- **Rising spot prices.** Affects price on up-regulation since spot prices is the opportunity cost for plannable up-regulation/production.
- **More volatile prices.** Hours with low prices can give a tight supply in down-regulation since the plannable production reduces production.
- **Increased demand – lack of competition.** Some of the markets for ancillary services suffer from high market concentration with few actors and low liquidity. Higher demand in those market leads to higher prices compared to markets with better competition.

PRICES:
Correlation with rising spot prices



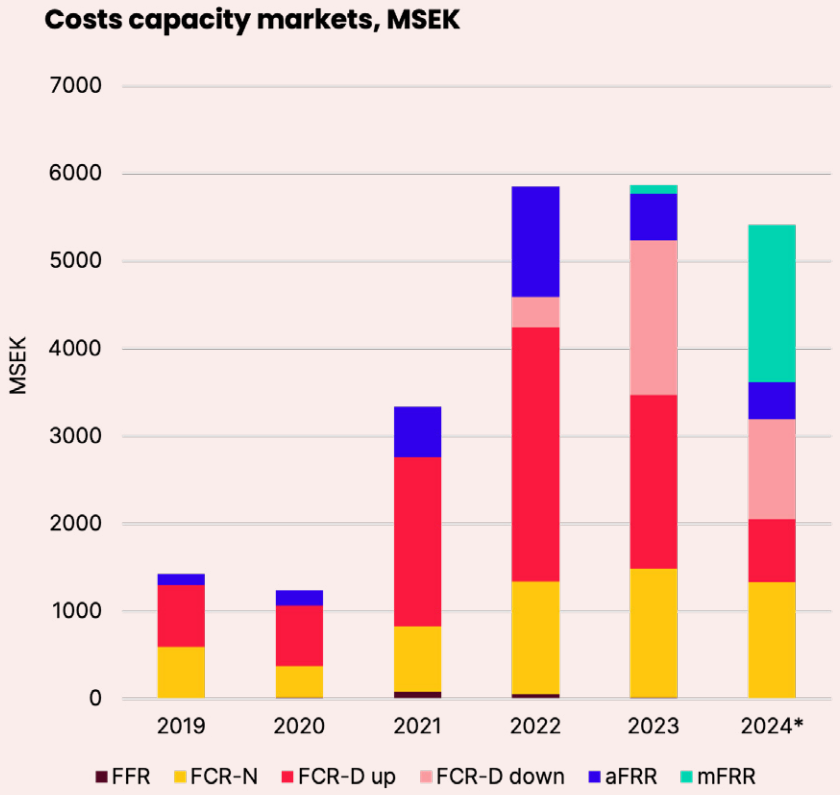
* Forecast from October 2024

Development of costs for ancillary services

RECALL:

PROCURED VOLUME:
+300 % since 2019

PRICES:
Correlation with rising spot prices



* Forecast from October 2024

CHAPTER 3

Outlook 2030

Market development and integration

Electrification is identified as key in order to meet climate goals, and the electricity demand is foreseen to increase significantly as a result. In Sweden, this is reflected by the planned goal of a system accommodating an annual demand of 300 TWh by 2045. Simultaneously, the generation mix is changing with larger shares of wind power and solar power production.

Electricity markets are central in facilitating this development, creating conditions for investments and dispatch while maintaining a robust and reliable system. In order to achieve efficient markets, an enhanced representation of the technical characteristics of the electricity system is required. Implementation of *flowbased capacity allocation method and 15 minute MTU and ISP* are changes leading to more detailed reflections of the technical system and conditions, facilitating an efficient use of resources also in the future.

From a welfare perspective, there are gains in sharing resources between regions and countries. This also applies to balancing markets, where an integration within the Nordics as well as on a European scale leads to a more efficient use of existing resources. The common efforts in the Nordic Balancing Model program lead to an increased Nordic integration of balancing markets and sharing of balancing resources between the Nordic countries. From the market participants' perspective, market integration provides possibilities to access a larger market.

Efficient future balancing is not only dependent on an efficient use of existing resources, but also relying on investments addressing current and future balancing demands. The introduction of area balancing will lead to increased transparency concerning the need of balancing resources in different geographical locations of the electricity system. Area pricing for balancing markets implies incentives to allocate investments to those parts of the system where the need is the greatest.

Ancillary service market overview and outlook

Svenska kraftnät procures different ancillary services through separate markets. The table below provides an overview of existing products and the corresponding capacity and energy activation markets.

Fast frequency Reserve	Frequency Containment Reserves			Frequency Restoration Reserves		
FFR Annual procurement	FCR-D up CM	FCR-D down CM	FCR-N CM	aFRR up CM	mFRR up CM	mFRR up EAM
				aFRR down CM	mFRR down CM	mFRR down EAM

The coming sections provide an outlook for each ancillary service that is structured into three parts. The first part introduces the product and the market, the second offers a highlight view of current trends in the market, and the third presents an outlook of estimated future changes.

INTRODUCTION

- Introduction of the product
- Dimensioning process
- Market setup

KEY HIGHLIGHTS

- Historical volumes and prices
- Prequalified capacity
- Number of BSPs

OUTLOOK 2030

- Estimated future volumes
- Description of uncertainties
- Market development

CM – Capacity market
EAM – Energy activation market

FAST FREQUENCY RESERVE

FFR

What is FFR?

The fast frequency reserve (FFR) is designed to stabilize the frequency in the event of a disturbance in the Nordic synchronous area at low levels of system inertia. FFR has the fastest response time of all ancillary services at 0.7 to 1.3 seconds for full activation, for a duration of 5 to 30 seconds. The response time varies depending on the frequency deviation, where the larger the deviation the faster the response.

FFR is a product that only provides upwards regulation and ensures that FCR is capable of frequency regulation at low levels of system inertia.

Planning

Dimensioning process

The FFR volume is dimensioned based on the total Nordic system inertia and its forecasted levels as well as the reference incident in the Nordic synchronous area.

Distribution of the Nordic FFR need is determined by a key factor based on the yearly total generation (TWh) and consumption (TWh) in each control area. The key factor is also based on each TSOs contribution to system inertia and size of reference incident. In 2024 the Swedish FFR need amounts to up to 105 MW.

TSO	Share 2025
Svenska kraftnät	35%
Energinet (DK2)	8%
Fingrid	18%
Statnett	39%

Securing capacity

FFR annual procurement

FFR is a Nordic product with common technical requirements. Procurement of FFR is made on a national level.

There is an annual procurement of FFR, where contracts are signed for a period from April to April. The supplier provides a contractual price for a given volume. The capacity remuneration depends on the call-off volume using the marginal price.

Activating energy

Weekly call-offs

During the delivery period, hourly capacity call-offs are made twice a week. On Mondays for Tuesday to Friday, and on Fridays for Saturday to Monday.

The hourly call-off volume is dependent on the forecasted system inertia in the Nordic synchronous area and can therefore vary throughout the year.

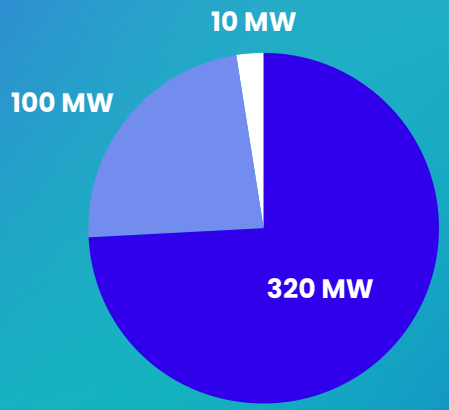
During activation, all bids that are called off are activated. There is no remuneration for FFR energy activation.

FFR – KEY HIGHLIGHTS

Prequalified capacity Q4 2024

430 MW

+270 MW added since 2023 which is an increase of 170 %



With a fixed annual demand, prequalified capacities compete during the procurement phase

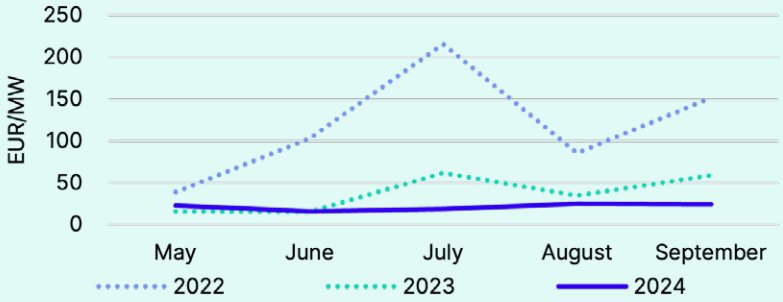
2024
Annual procurement – 250 MW
Total prequalified capacity – 410 MW

HOW MANY PROVIDERS ARE QUALIFIED?

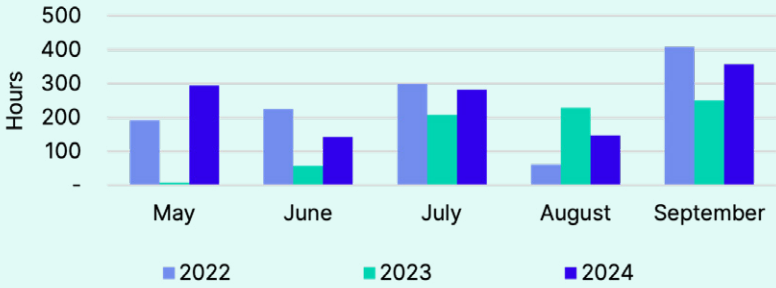
18 Providers

+4 added 2024
+7 added 2023

Historical prices



Number of call-off hours



Falling prices due to improved competition

New actors: Increased number of providers and a maturing market has led to increased liquidity and lower marginal prices as a result.

FFR – OUTLOOK 2030

The dimensioning of FFR is based on the fore-casted levels of system inertia and the reference incident in the Nordic synchronous area.

As the transition to a higher proportion of renewable energy sources continues, the number of hours with low levels of system inertia is forecasted to increase. Consequently, the forecasted hours with a need for FFR in the Nordic synchronous area is projected to increase.

The forecasted FFR need varies greatly depending on the future production mix of the Nordic power system.

The most significant change in FFR need is seen between the 2035 EP and SF scenarios, ranging from close to 0 to 2.5 times of today's FFR need. This highlights the uncertainties in forecasting the FFR need during the ongoing technology shift as a result of the energy transition.

Investigation of dynamic FFR

The forecasted number of hours below 150 GWs each year in the Nordic synchronous area, which is indicative for the procured FFR volume, will most likely put more stringent requirements on the design of the FFR product moving forward.

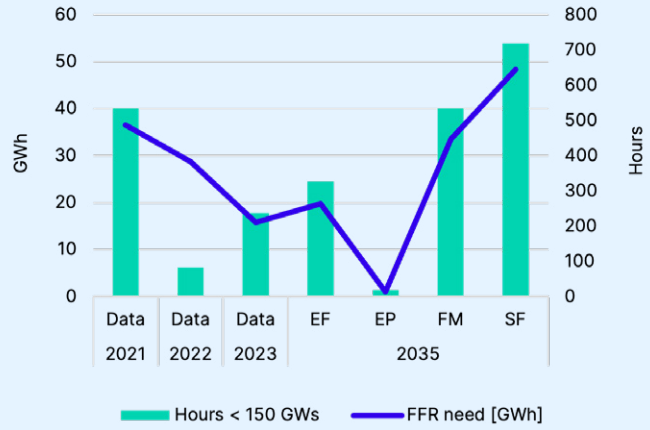
The integration of advanced technologies, such as battery storage and demand-side response mechanisms, will play a crucial role in meeting these forecasted needs. These technologies can provide rapid response capabilities, effectively supplementing the FFR requirements.

A possibility is to introduce a new type of FFR product, dynamic FFR. Technical pre-conditions for dynamic FFR are currently under investigation in a Nordic joint project.

Transition to D-1 market

The current FFR market is intended to transition from annual procurement with weekly capacity call-offs to a capacity market with hourly trade the day before delivery (D-1). A new IT platform for procurement of FFR on the new D-1 market is preliminarily planned for 2027.

Estimated yearly FFR need



Scenarios

- SF – Small-scale renewables: Decommissioning of existing nuclear power and construction of renewable power sources
- FM – Mixed: Operational extension of existing nuclear power
- EP – Electrification plannable: Operational extension of existing and construction of new nuclear power
- EF – Electrification renewables: Decommissioning of existing nuclear power and construction of renewable power sources

FREQUENCY CONTAINMENT RESERVE
– DISTURBANCE UPWARD

FCR-D upward

INTRODUCTION AND SUMMARY

What is FCR-D upward?

Frequency containment reserve for disturbance is designed to stabilize the frequency in the event of a disturbance in the Nordic synchronous area. FCR-D responds automatically if the measured frequency deviates from the normal band (49.9 – 50.1 Hz). It has the second fastest response time of all ancillary services, treading closely behind FFR.

FCR-D upward is automatically activated upwards if the frequency drops below 49.9 Hz. Full activation is reached at 49.5 Hz, which protects the Nordic synchronous area against disturbances such as the loss of a large power producing plant.

Planning

Dimensioning process

The dimensioning of FCR-D upward is based on the actual reference incident in the Nordic synchronous area and may therefore vary throughout the year. The maximal Nordic demand is dimensioned for Oskarshamn 3, 1450 MW.

Svenska kraftnät's share of the Nordic volume requirement is determined by a key factor based on the yearly total generation (TWh) and consumption (TWh) in each control area.

TSO	Share 2025
Svenska kraftnät	37%
Energinet (DK2)	3%
Fingrid	21%
Statnett	39%

Securing capacity

FCR-D upward capacity market

FCR-D upward is a Nordic product with common technical requirements. Svenska kraftnät procures capacity according to the Swedish volume requirement on the common Swedish-Danish (DK2) FCR capacity market. Procurement is performed with hourly trade on two complementary auctions the day before delivery (D-1).

Since February 2024 accepted capacity bids are remunerated according to the marginal price (pay-as-cleared).

Activating energy

Pro-rata activation

During activation, all accepted capacity bids are activated proportionally (pro-rata) according to the frequency deviation.

There is no remuneration for FCR-D energy activation.

TSO-TSO TRADE

Some FCR can be exchanged between the Swedish-Danish market and the other TSOs in the Nordic synchronous area, Statnett and Fingrid. This trade is performed on the second auction. If the offered export from Statnett/Fingrid is competitive in relation to bids on the Swedish-Danish market, capacity can be imported to fulfill the national requirement. Similarly, additional capacity can be procured on the Swedish/Danish market to be exported.

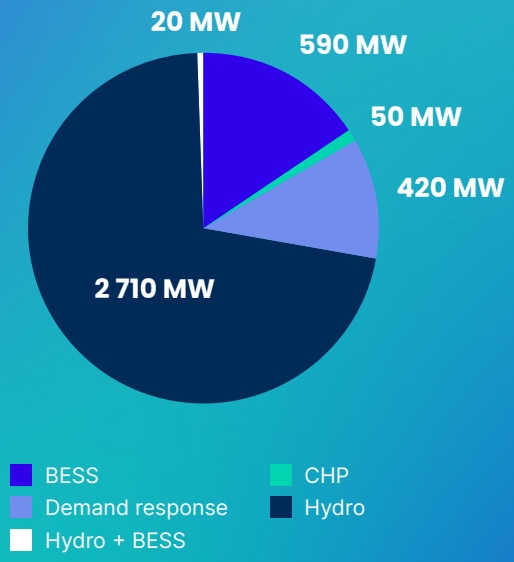
For operation safety reasons a minimum of 2/3 of the total Swedish FCR requirement must always be procured within Svenska kraftnät's control area.

FCR-D UPWARD – KEY HIGHLIGHTS

Prequalified capacity Q4 2024

3 710 MW

Trending technologies are BESS & Demand response

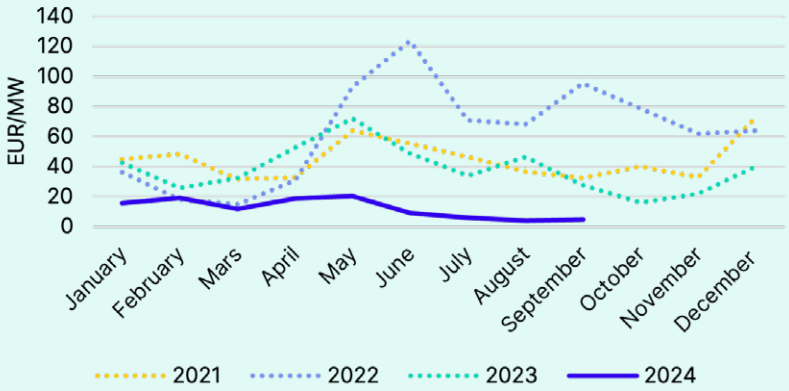


HOW MANY BSPs ARE QUALIFIED?

22 BSPs

+8 added 2024
+2 added 2023

Historical prices



Pay-as-Cleared. The way the market prices are calculated changed from pay-as-bid to the more efficient price setting strategy pay-as-cleared, or marginal pricing, in February 2024.

New actors (e.g. BESS) lead to improved liquidity, stronger competition and thereby lower prices.

Spot price is the opportunity cost for plannable power-producing actors (e.g. hydro power) when it comes to up-regulation. A lower spot price leads to lower opportunity cost, and thereby a lower price of up-regulation.

Falling prices due to lower spot prices and improved competition

FCR-D UPWARD – OUTLOOK 2030

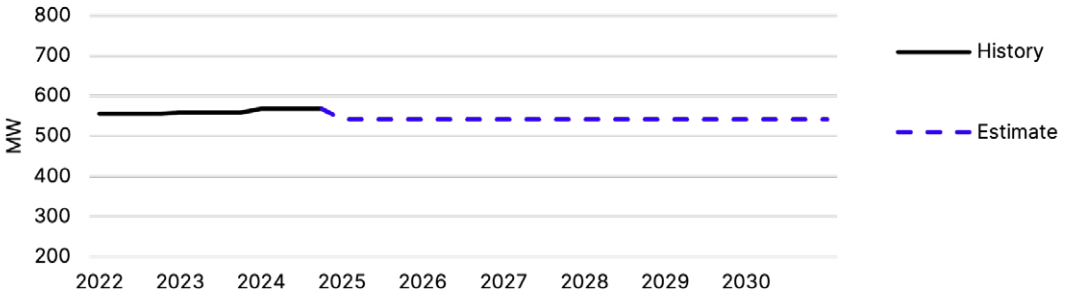
Dimensioning of FCR-D upward is based on the actual reference incident in the Nordic synchronous area and may therefore vary throughout the year. The chart below shows the estimated maximum hourly need of FCR-D upward in Sweden.

In the estimated need of FCR-D upward it is assumed that there will be no changes in the Nordic reference incident, Oskarshamn 3 of 1450 MW, until 2030. This could possibly change in the future if new large generation units are built. However, Svenska kraftnät does not forecast any changes until 2030. In the coming five years potential minor changes in the Swedish FCR-D upward need will rather depend on the sharing key between the TSOs in the Nordic synchronous area.

Based on 2023 data of generation and consumption, the Swedish sharing key will decrease from 39.1% to 37.4% in 2025. There are no available predictions of what the TSO shares will be in the future.

A future possible introduction of dynamic FFR will most likely have an impact on the need of dynamic FCR-D. Hence, a higher share of static FCR-D could be allowed. It is however too early to draw any conclusions.

Estimated FCR-D upward need 2025–2030



Market development

- Two different types of FCR-D, static and dynamic were introduced in 2024 in the Nordic harmonized technical requirements for FCR. For system stability reasons only a limited amount of FCR-D volumes can be secured from static resources. Therefore, the Nordic TSOs intend to implement a quota for the maximum share of static FCR-D in the Nordic power system. The Nordic TSOs are analyzing the maximum level and will thereafter implement the quota.
- A new IT platform for procurement of FCR is under development. During 2025 the market will transition to the new platform, Fifty Nordic MMS, which will enable new bid types and attributes for static and dynamic FCR-D.
- The long term ambition is to increase the market integration within the Nordics and the final goal is a common Nordic market for FCR. However, there will still be a requirement on securing the majority of the needed volume in each country.

Static and dynamic FCR-D
Entities that have difficulties in complying with the dynamic requirements, for example activation and deactivation performance and dynamic stability, can provide a type of FCR-D called Static FCR-D. The main difference from dynamic (regular) FCR-D is a grace period of 15 minutes where the entities are not required to deactivate and/or be able to perform a second activation.

FREQUENCY CONTAINMENT RESERVE
– DISTURBANCE DOWNWARD

FCR-D downward

INTRODUCTION AND SUMMARY

What is FCR-D downward?

Frequency containment reserve for disturbance is designed to stabilize the frequency in the event of a disturbance in the Nordic synchronous area. FCR-D responds automatically if the measured frequency deviates from the normal band (49.9 – 50.1 Hz). It has the second fastest response time of all ancillary services, treading closely behind FFR.

FCR-D downward is automatically activated downwards if the frequency exceeds 50.1 Hz. Full activation is reached at 50.5 Hz, which protects the Nordic synchronous area against disturbances caused by for example a fault on an exporting HVDC interconnection.

Planning

Dimensioning process

The dimensioning of FCR-D downward is based on the actual reference incident in Nordic synchronous area and may therefore vary throughout the year. The maximal Nordic demand is dimensioned for full export on any of the two subsea interconnectors Nordlink and North Sea Link.

Svenska kraftnät's share of the Nordic volume requirement is determined by a key factor based on the yearly total generation (TWh) and consumption (TWh) in each control area.

TSO	Share 2025
Svenska kraftnät	37%
Energinet (DK2)	3%
Fingrid	21%
Statnett	39%

Securing capacity

FCR-D downward capacity market

FCR-D downward is a Nordic product with common technical requirements. Svenska kraftnät procures capacity according to the Swedish volume requirement on the common Swedish-Danish (DK2) FCR capacity market. Procurement is performed with hourly trade on two complementary auctions the day before delivery (D-1).

Since February 2024 accepted capacity bids are remunerated according to the marginal price (pay-as-cleared).

Activating energy

Pro-rata activation

During activation, all accepted capacity bids are activated proportionally (pro-rata) according to the frequency deviation.

There is no remuneration for FCR-D energy activation.

TSO-TSO TRADE

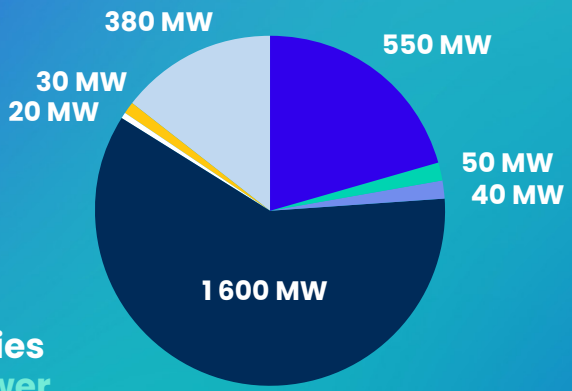
Some FCR can be exchanged between the Swedish-Danish market and the other TSOs in the Nordic synchronous area, Statnett and Fingrid. This trade is performed on the second auction. If the offered export from Statnett/Fingrid is competitive in relation to bids on the Swedish-Danish market, capacity can be imported to fulfill the national requirement. Similarly, additional capacity can be procured on the Swedish/Danish market to be exported.

For operation safety reasons a minimum of 2/3 of the total Swedish FCR requirement must always be procured within Svenska kraftnät's control area.

FCR-D DOWNWARD – KEY HIGHLIGHTS

Prequalified capacity Q4 2024

2 670 MW



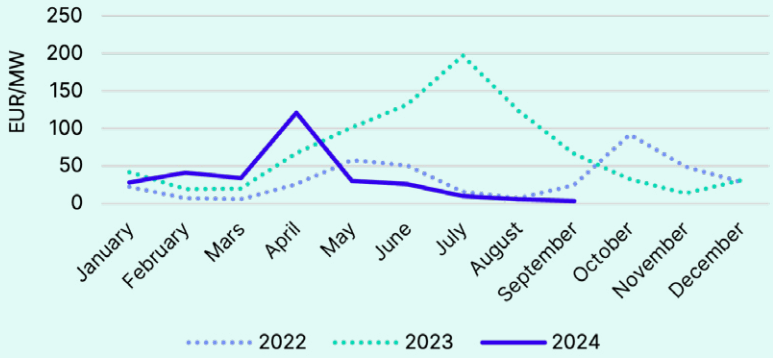
Trending technologies are BESS & Wind power

HOW MANY BSPs ARE QUALIFIED?

22 BSPs

+8 added 2024
+3 added 2022

Historical prices



Market ramp-up
The FCR-D down market started in 2022 to handle over-frequencies in the Nordic power system, for example in the event of a fault on an exporting HVDC interconnection.

Since the market started the procured volume has been ramped up quarterly. In 2025 Svenska kraftnät will procure the full volume corresponding to the Swedish share of the Nordic dimensioning.

Falling prices due to improved competition and marginal pricing

Pay-as-Cleared. The way the market prices are calculated changed from pay-as-bid to the more efficient price setting strategy pay-as-cleared, or marginal pricing, in February 2024.

New actors (e.g. BESS and Wind Power) lead to improved liquidity, stronger competition and thereby lower prices.

FCR-D DOWNWARD – OUTLOOK 2030

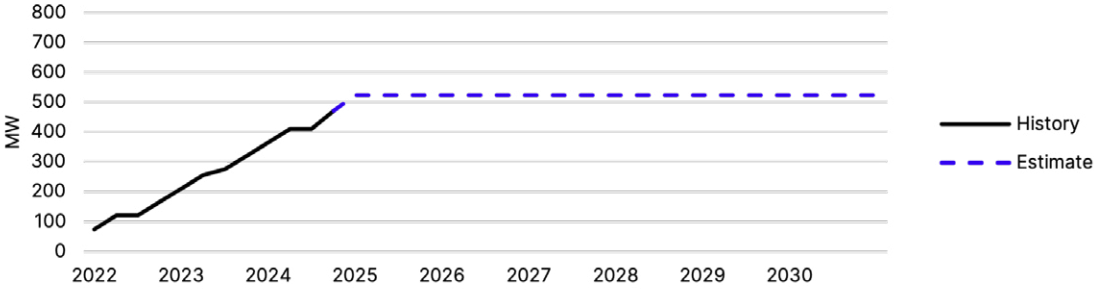
Dimensioning of FCR-D downward is based on the actual reference incident in the Nordic synchronous area and may therefore vary throughout the year. The chart below shows the estimated maximum hourly need for FCR-D downward in Sweden.

In the forecasted need for FCR-D downward it is assumed that there will be no changes in the Nordic reference incident of 1400 MW, full export on any of Nordlink or North Sea Link, until 2030. It is possible that this will change in the future if new large interconnections are built. In the coming five years, potential minor changes in the Swedish FCR-D downward need will rather depend on the sharing key between the TSOs in the Nordic synchronous area.

Based on 2023 data on generation and consumption, the Swedish sharing key will decrease from 39.1% to 37.4% in 2025. There are no available predictions of what the TSO shares will be in the future.

A future possible introduction of dynamic FFR will most likely have an impact on the need of dynamic FCR-D. Hence, a higher share of static FCR-D could be allowed. It is however too early to draw any conclusions.

Estimated FCR-D downward need 2025-2030



Market development

- Two different types of FCR-D, *static* and *dynamic*, were introduced in 2024 in the Nordic harmonized technical requirements for FCR. For system stability reasons only a limited amount of FCR-D volumes can be secured from static resources. Therefore, the Nordic TSOs intend to implement a quota for the maximum share of static FCR-D in the Nordic power system. The Nordic TSOs are analyzing the maximum level and will thereafter implement the quota.
- A new IT platform for procurement of FCR is under development. During 2025 the market will transition to the new platform, Fifty Nordic MMS, which will enable new bid types and attributes for static and dynamic FCR-D.
- The long term ambition is to increase the market integration within the Nordics where the final goal is a common Nordic market for FCR. However, there will still be a requirement on securing the majority of the needed volume in each country.

Static and dynamic FCR-D
Entities that have difficulties to comply with the dynamic requirements, for example activation and deactivation performance and dynamic stability, can provide a type of FCR-D called Static FCR-D. The main difference from dynamic (regular) FCR-D is a grace period of 15 minutes where the entities are not required to deactivate and/or be able to perform a second activation.

FREQUENCY CONTAINMENT RESERVE – NORMAL

FCR-N

INTRODUCTION AND SUMMARY

What is FCR-N?

Frequency containment reserve for normal operation is designed to stabilize the frequency within the normal frequency band (49.9-50.1 Hz). FCR-N should respond automatically if the measured frequency deviates from 50.0 Hz, with full activation.

FCR-N is a symmetric product including both upward and downward regulation. FCR-N is designed to be fully activated upwards when the frequency is 49.9 Hz or below and fully activated downwards when the frequency is 50.1 Hz or below.

Nordic Requirement
600 MW

Planning

Dimensioning process

The dimensioning of FCR-N is based on historical imbalances in the Nordic synchronous area. The dimensioning is yearly re-evaluated by the Nordic TSOs.

Svenska kraftnät's share of the Nordic volume requirement is determined by a key factor based on the yearly total generation (TWh) and consumption (TWh) in each control area.

TSO	Share 2025
Svenska kraftnät	37%
Energinet (DK2)	3%
Fingrid	21%
Statnett	39%

Securing capacity

FCR-N capacity market

FCR-N is a Nordic product with common technical requirements. Svenska kraftnät procures capacity according to the Swedish volume requirement on the common Swedish-Danish (DK2) FCR capacity market. Procurement is performed with hourly trade on two complementary auctions the day before delivery (D-1).

Since February 2024 accepted capacity bids are remunerated according to the marginal price (pay-as-cleared).

Activating energy

Pro-rata activation

During activation, all accepted capacity bids are activated proportionally (pro-rata) according to the frequency deviation.

Activated FCR-N energy is remunerated according to the imbalance price, which is based on activated mFRR energy.

TSO-TSO TRADE

Some FCR can be exchanged between the Swedish-Danish market and the other TSOs in the Nordic synchronous area, Statnett and Fingrid. This trade is performed on the second auction. If the offered export from Statnett/Fingrid is competitive in relation to bids on the Swedish-Danish market, capacity can be imported to fullfil the national requirement. Similarly, additional capacity can be procured on the Swedish/Danish market to be exported.

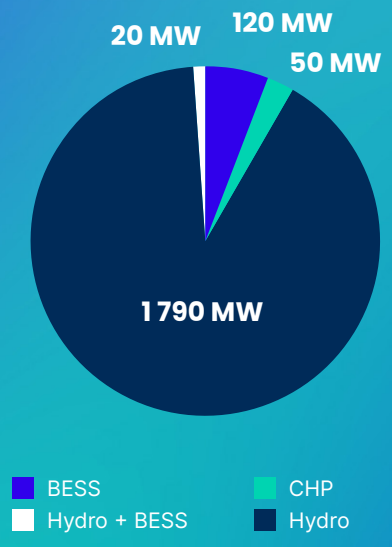
For operation safety reasons a minimum of 2/3 of the total Swedish FCR requirement must always be procured within Svenska kraftnät's control area.

FCR-N – KEY HIGHLIGHTS

Prequalified capacity Q4 2024

1 980 MW

Trending technology is BESS

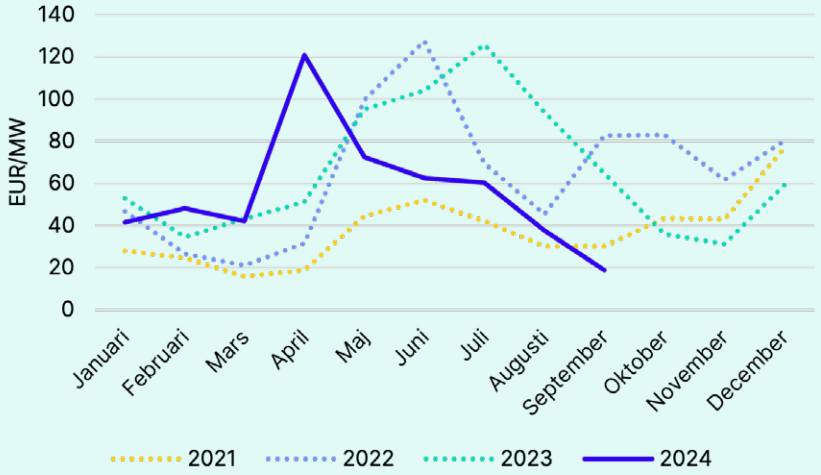


HOW MANY BSPs ARE QUALIFIED?

17 BSPs

+8 added 2024
+2 added 2023

Historical prices



Less correlation with FCR-D

Pay-as-Cleared. The way the market prices are calculated changed from pay-as-bid to the more efficient price setting strategy pay-as-cleared, or marginal pricing, in February 2024.

Hydro Power still dominates FCR-N.

Less correlation with FCR-D. Historically FCR-N, which requires the ability of regulation both up and down, has correlated with the market showing the highest price of FCR-D up and FCR-D down. Introduction of new actors in FCR-D has made this correlation less obvious.

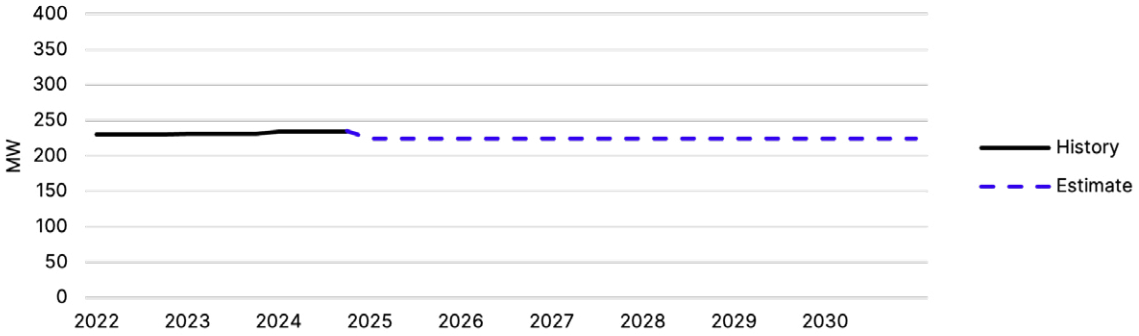
FCR-N – OUTLOOK 2030

Dimensioning of FCR-N downward is based on historical imbalances in the Nordic synchronous area and the Nordic volume requirement of 600 MW has been stable for the last years.

The chart below shows the estimated hourly need of FCR-N in Sweden. In the estimation it is assumed that the dimensioned Nordic FCR-N need will not change until 2030. However, there are some uncertainties to this estimation. There is an on-going Nordic re-evaluation of the future FCR-N dimensioning. The future FCR-N need will depend on the dimensioning and activation of the FRR products. It is too early to draw any conclusions of the impact on the future FCR-N need. Therefore this uncertainty is not included in the estimation.

Based on 2023 data on generation and consumption, the Swedish sharing key will decrease from 39.1% to 37.4% in 2025. There are no available predictions of what the TSO shares will be in the future.

Estimated FCR-N need 2025-2030



Market development

- A new IT platform for procurement of FCR is under development. During 2025 the market will transition to the new platform, Fifty Nordic MMS, which will enable new bid types and attributes for static and dynamic FCR-D.
- The long term ambition is to increase the market integration within the Nordics and the final goal is a common Nordic market for FCR. However, there will still be a requirement on securing the majority of the needed volume in each country.

AUTOMATIC FREQUENCY RESTORATION RESERVE

aFRR

What is aFRR?

Automatic frequency restoration reserve is designed to restore the frequency after a disruption. aFRR is activated automatically if the frequency deviates from 50.0 Hz. It is the faster reserve of the two frequency restoration reserve types with a required full activation time of 5 minutes.

aFRR is activated through a central control signal from Svenska kraftnät to the BSP when the frequency deviates from 50.0 Hz. aFRR upwards and downwards are procured as separate products.

Nordic Requirement
300/400 MW

Planning

Dimensioning process

The dimensioning of aFRR is based on historical frequency quality in the Nordic synchronous area. The dimensioning is currently done on a monthly basis.

Svenska kraftnät's share of the Nordic requirement is determined by a key factor that is based on our share of short-term imbalances, which may be subject to changes in the future.

TSO	Up	Down
Svenska kraftnät	26%	28%
Energinet (DK2)	13%	13%
Fingrid	15%	15%
Statnett	45%	45%

Securing capacity

aFRR Capacity Market

Since December 2022, aFRR is procured hourly through a Nordic capacity market the day before the delivery period (D-1), with bids submitted by bidding zone and hour. Svenska kraftnät procures capacity according to the Swedish volume requirement.

Accepted capacity bids are remunerated based on marginal price (pay-as-cleared). The entire volume requirement on the capacity market is remunerated, regardless of how much energy is actually activated during real-time operations.

Activating energy

Pro-rata activation

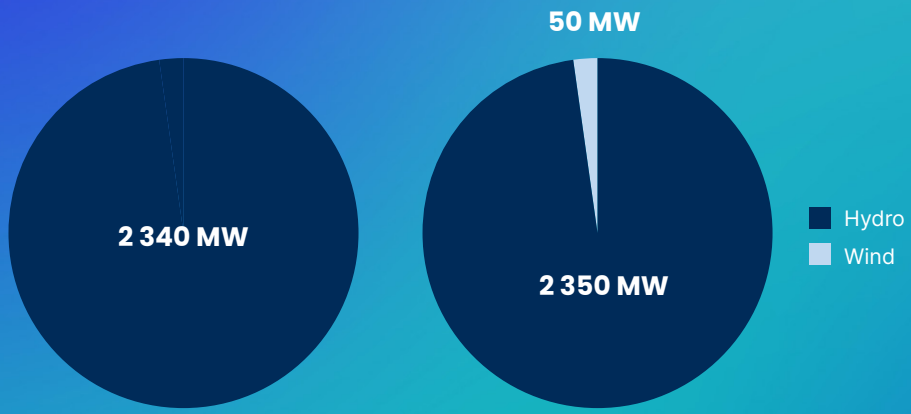
There is not yet an energy activation market (EAM) for aFRR. Instead, all accepted bids from the capacity market are activated proportionally (pro-rata) to cover the need for aFRR energy in real-time.

Activated aFRR energy is remunerated according to the imbalance price, which is based on activated mFRR energy.

The introduction of an aFRR EAM will take place when Svenska kraftnät connects to the European aFRR balancing platform PICASSO.

aFRR – KEY HIGHLIGHTS

Prequalified capacity Q4 2024



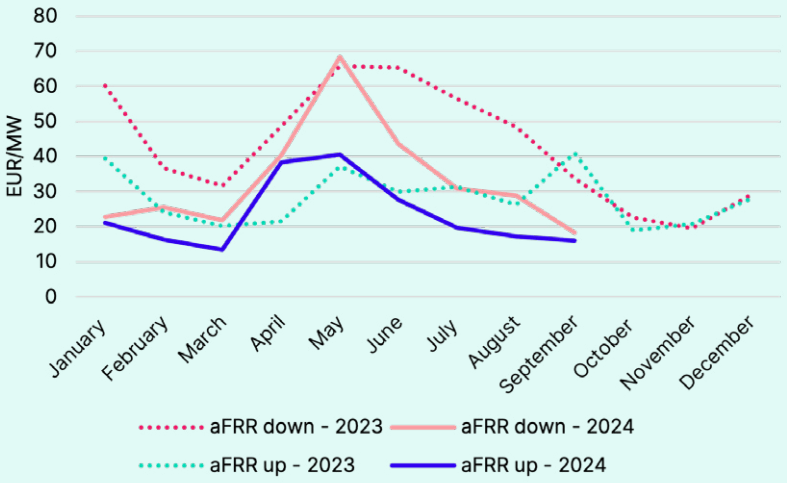
2 340 MW up
2 400 MW down

HOW MANY BSPs ARE QUALIFIED?

6 BSPs

+0 added 2023-2024
+1 added 2022

Historical prices



Prices are affected by season and Nordic exchange

- There is a seasonal pattern in aFRR prices. Prices usually rise as the flexibility of hydro power decreases during the spring flood. This is true for both aFRR upward and downward, but to a larger extent for aFRR downward.
- The price level is generally higher for aFRR downward due to a higher reliance on national capacity to satisfy demand. Conversely, import of relatively cheap capacity from primarily Norway largely satisfy the national demand for aFRR upward, causing a lower price level.

aFRR Capacity market

Since the introduction of a Nordic aFRR capacity market in December 2022, the national Swedish demand has remained largely unchanged. The maximum national hourly demand currently sits at 106 MW for aFRR upward and 111 MW for aFRR downward. During the week demand varies between hours and between days, resulting in procured hourly volume ranging from 53 MW to 111 MW.

Demand is expected to increase going forward. In conjunction with the planned launch of the automated mFRR EAM with quarter-hour resolution in Q1 2025, maximum hourly demand for aFRR capacity may increase. The rationale being to secure a larger margin of safety when launching the automated mFRR EAM.

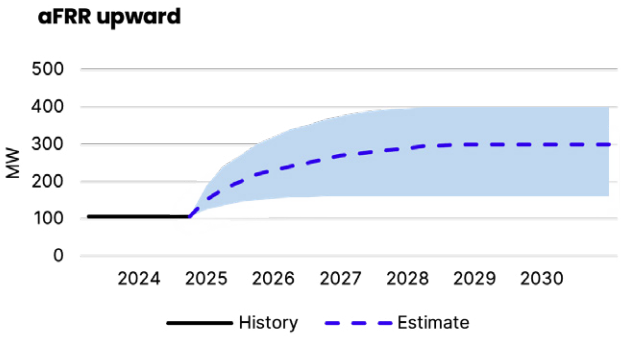
Further ahead Svenska kraftnät is planning to join PICASSO and thus transition to area control error (ACE) based aFRR. Demand is then expected to increase further as ACE-based aFRR will be dimensioned on imbalances per bidding zone instead of frequency quality.

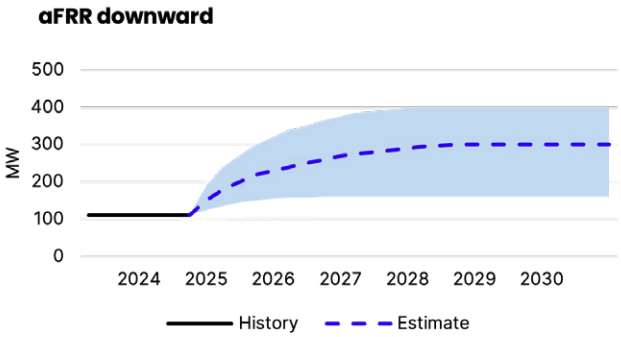
The future demand is uncertain at this point, due to many recently completed or imminent market changes – e.g. transition to 15 min MTU in the energy market, ACE-based mFRR balancing and flowbased capacity allocation. The volume of aFRR energy bids needed to be secured through the capacity market is not known at this point, as it depends on availability of energy activation bids.

Nonetheless, it is safe to assume an increase in demand going forward with estimated future demand ranging from 160 MW to 400 MW. The blue-shaded area in the graphs on the right reflects the uncertainty range.

FRR Dimensioning (SOGL §157):
In the ACE-based Nordic balancing model, reserve requirements for each LFC-area will depend on historical imbalance data as well as current reference incidents. Normal, stochastic imbalances are managed by a combination of mFRR and aFRR. Scheduled activation of mFRR is considered for the forecasted area imbalances and aFRR covers the actual remaining part. Reference incidents are managed by direct activation of mFRR. Thus, these reserve volumes will vary on a daily basis and evolve over time.

Estimated maximum hourly capacity demand 2025–2030



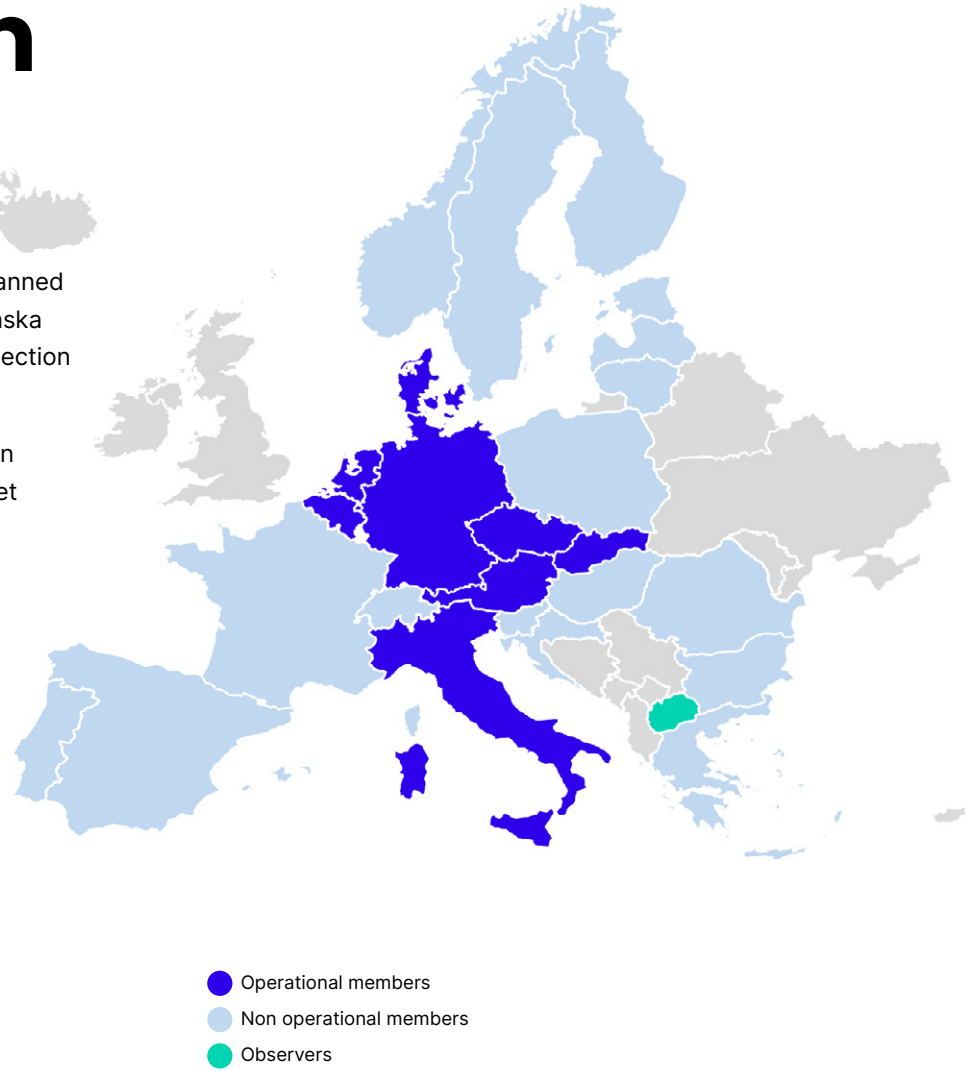


aFRR Energy activation market – PICASSO

About Picasso

- PICASSO (Platform for the International Coordination of Automated Frequency Restoration and Stable System Operation) is a European market platform for the exchange of aFRR balancing energy.
- As of November 2024, eight countries (11 TSOs) are currently connected – with more planned to connect in 2024/2025.
- As for the Nordic TSOs, Energinet connected to PICASSO in October 2024, Fingrid will shortly follow in January 2025.
- Svenska kraftnät and Statnett are planned to connect at a later stage – for Svenska kraftnät, the estimated time for connection is 2027/2028.
- The connection to PICASSO will mean that an aFRR energy activation market is introduced.

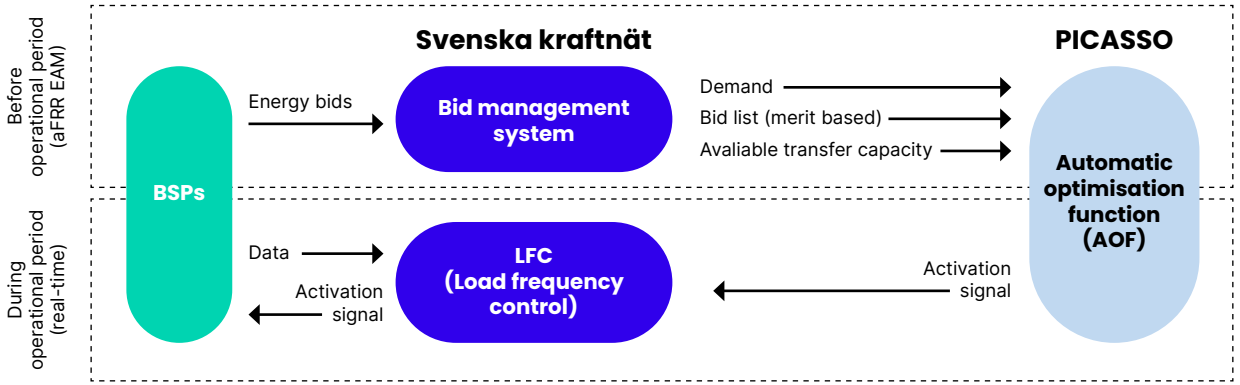
Picasso price development:
Since the introduction of PICASSO there has been relatively frequent occasions of extreme price spikes (both high and low prices). This has several reasons, e.g. a limited bidding list and recurring limited transmission capacity. Italy disconnected from PICASSO in March 2024 as a result. Several measures have been or will be implemented to reduce price spikes such as price-dependent elastic demand and a new algorithm for price calculation.



aFRR Energy activation market - PICASSO

Introduction of an aFRR EAM and ACE balancing

- When the aFRR energy activation market is introduced, the activation of energy during operations will then change from pro-rata activation of all accepted CM bids, to merit-based activation. This means that the bids with the lowest prices are activated first – similar to how mFRR is activated today.
- The balancing will be based on the area control error (ACE) for each bidding zone instead of the current method which is based on the frequency in the entire Nordic region.
- The calculation of the imbalance price will also change – from being based solely on activated mFRR energy, to be based on both activated mFRR and aFRR energy.
- At the latest when Svenska kraftnät connects to PICASSO, new BSPs will be able to connect to the aFRR market.
- The updated aFRR process after PICASSO connection can be described as follows:
  - Before the operational period BSPs will send in energy bids to the aFRR EAM.
  - After the bidding period closes, Svenska kraftnät will send the bids (in merit order) to PICASSO, together with the aFRR demand for the operational period as well as available transfer capacity.
  - PICASSO will optimize the demand and available bids from all connected TSOs, taking into account available transfer capacity.
  - In real-time, PICASSO will continuously send activation signals based on ACE for each LFC-area.



MANUAL FREQUENCY RESTORATION RESERVE

mFRR

INTRODUCTION AND SUMMARY

What is mFRR?

Manual Frequency Restoration Reserve (mFRR) is designed to restore the frequency to 50 Hz in the event of an imbalance or disturbance. mFRR for upwards and downwards regulation are procured in separate products, which are activated separately.

Activation of mFRR is done manually upon request by Svenska kraftnät. mFRR is activated after the automatic ancillary services, relieving them to handle new imbalances and disturbances.

In the new area control error (ACE) based balancing model, mFRR will be more proactive. The area imbalances can be accurately forecasted for the pending operational time period, and balanced mainly by scheduled activation of mFRR.

Planning

Dimensioning process

The required volumes of mFRR reserves are dimensioned to manage:

1. The largest failure scenario, and
2. Continuous normal imbalances

This dimensioning applies to both upward and downward regulation for each bidding zone, considering available transfer capacity (ATC) between bidding zones. Updated volume requirements are communicated on a quarterly basis.

While the mFRR energy activation market (EAM) is a common Nordic market, each TSO must have sufficient balancing resources in its control area.

Securing capacity

mFRR Capacity Market

In addition to voluntary mFRR energy bids, there is also an mFRR capacity market (CM) to ensure access to further energy bids available for each bidding zone. mFRR CM has daily auctions the day before the delivery period, and accepted capacity bids means an obligation to submit corresponding volumes of energy bids to mFRR EAM.

Capacity demand and bids are submitted per bidding area, and the demand can also be satisfied by bids from other areas by reservation of transmission capacity.

Accepted capacity bids are remunerated based on marginal price (pay-as-cleared).

Activating energy

mFRR Energy Activation Market

mFRR EAM will soon be an automated Nordic energy activation market with quarter-hour resolution, consisting of Nordic bids. The need for mFRR balancing energy for each bidding zone is based on an imbalance forecast generated before each quarter-hour. An Automatic Optimization Function (AOF) matches needs with available bids, considering ATCs. The AOF has a scheduled activation that runs every quarter-hour and initiates direct activations in response to incidents.

Compensation is provided for the activated energy based on the marginal price. Bids must be submitted no later than 45 minutes before the delivery period, and bids are activated during the operational phase.

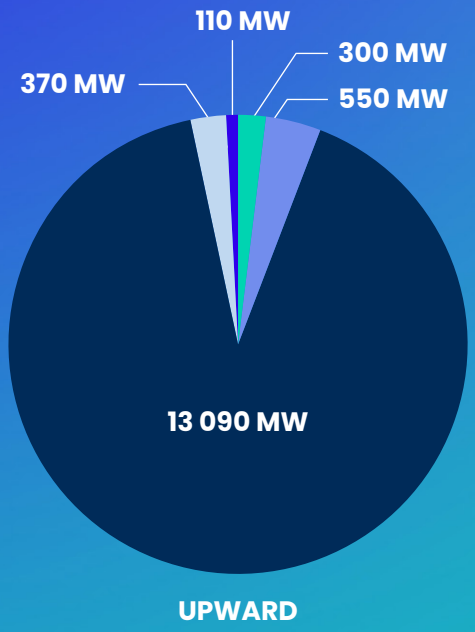
It is possible to participate solely in the energy activation market.

mFRR – PREQUALIFIED VOLUMES

Prequalified capacity Q4 2024

14 420 MW

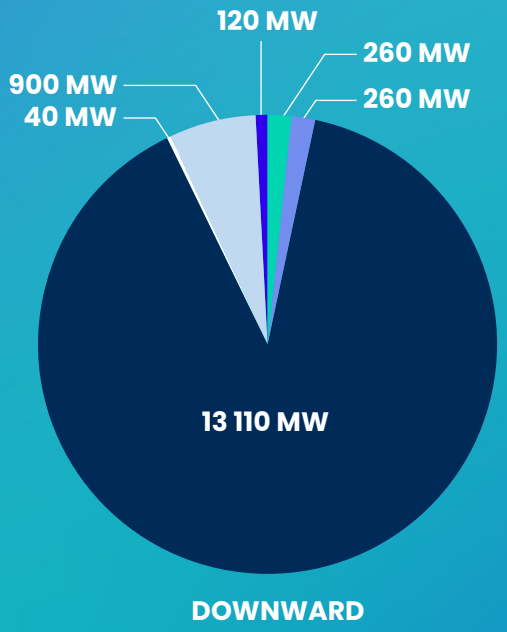
Trending technology is Demand Response



UPWARD

14 690 MW

Trending technology is Wind power



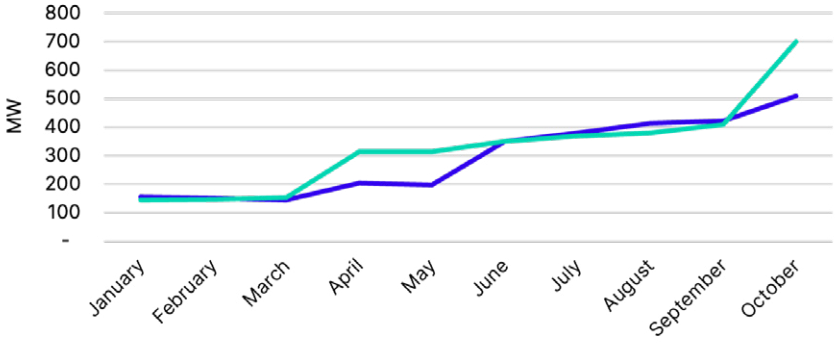
DOWNWARD

BESS CHP Demand response Hydro Hydro + BESS Wind

mFRR – KEY HIGHLIGHTS

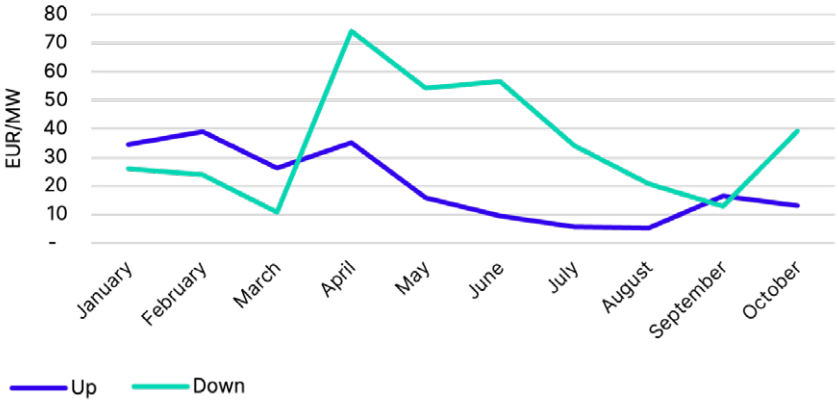
mFRR Capacity market

Procured capacity 2024



Current max volume
Up: 630 MW
Down: 750 MW

Historical prices – National Capacity Market



New emerging market:
Swedish mFRR CM since October 2023

- The national mFRR capacity market started on 18 October 2023. Since then, the demand has been gradually increased to cover current needs, and also aligning to future needs for an automated mFRR EAM.
- Volume demand and bids are submitted per bidding area, and part of local demand can be covered by bids from other areas by reservation of transmission capacity. There is a corresponding marginal price per bidding zone, where differences in price mainly occur due to limitations in transmission capacity. There are significant seasonal variations in the overall price level so far.
- Since 19 November 2024, Sweden is part of a common, trilateral mFRR capacity market with Denmark and Finland.

HOW MANY BSPs PARTICIPATE?

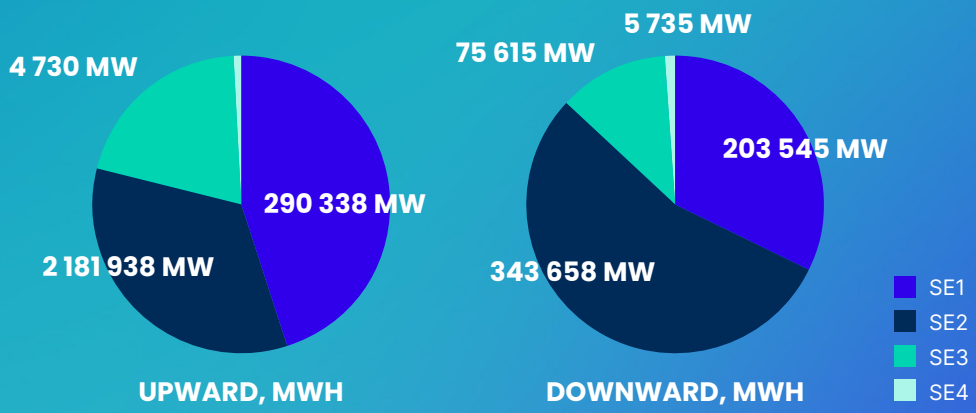
12 BSPs

+5 added 2024

mFRR – KEY HIGHLIGHTS

mFRR energy activation market

Activated energy in Sweden 2023



Total activated energy 2023

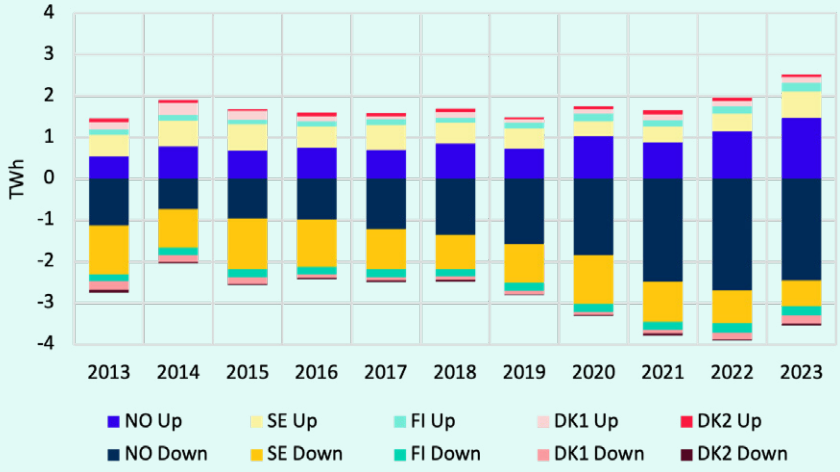
Up: 643 GWh
Down: 629 GWh

HOW MANY BSPs ARE QUALIFIED?

15 BSPs

+3 added 2024
+2 added 2023

Activated energy in Nordic area 2013-2023



More local mFRR-activations ahead

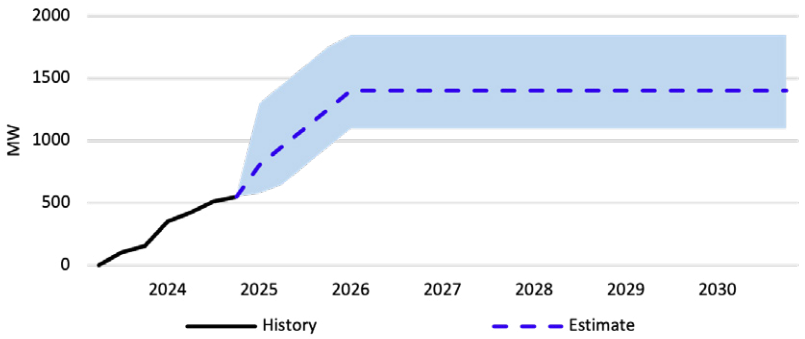
- The power system imbalances show an increasing trend over the last ten years. Until recently, the remaining available transmission capacity has enabled netting of imbalances between bidding areas. With the current frequency-based balancing, mFRR energy bids can be used largely independent of their location. Thus a lot of the balancing energy has been delivered from Norway.
- To provide sufficient transmission capacity to the day-ahead market, and to manage further evolving system imbalances, an updated balancing model is needed.
- ACE-based balancing per area will correspondingly require available reserves for each area, also in Sweden, and the recently added mFRR capacity market will help ensure sufficient liquidity.

mFRR – OUTLOOK 2030

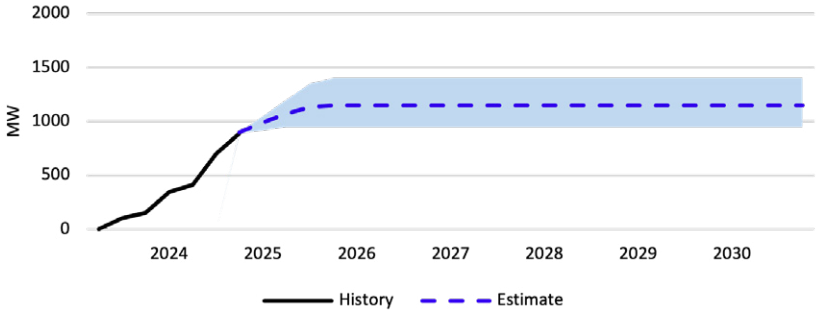
- The diagrams to the right show average procurement and indicative range for future mFRR capacity demand.
- In general, the capacity demand amounts to the volume requirements from the FRR dimensioning. Those total volume requirements for each bidding zone will evolve over time, depending on historical imbalance data as well as current reference incidents. When voluntary energy bids are abundant, the capacity demand may be a lower share.
- The capacity procurement has been gradually increased during 2024 to prepare for the projected demand on start-up of automated mFRR EAM, but also to support current needs of locally available balancing capacity.
- The capacity demand is expected to further increase in the coming years, to cover the actual and evolving need in the ACE-based balancing model, and possible changes in availability when connecting to European market platform for the exchange of mFRR balancing energy, MARI.

Estimated capacity demand 2025-2030 - Average procurement and forecast

mFRR upward



mFRR downward



FRR Dimensioning: In the ACE-based Nordic balancing model, reserve requirements for each LFC-area will depend on historical imbalance data as well as current reference incidents. Normal, stochastic imbalances are managed by a combination of mFRR and aFRR. Scheduled activation of mFRR is considered for the forecasted area imbalances and aFRR covers the actual remaining part. Reference incidents are managed by direct activation of mFRR. Thus, these reserve volumes will vary on a daily basis and evolve over time.

mFRR energy activation market - MARI

About MARI

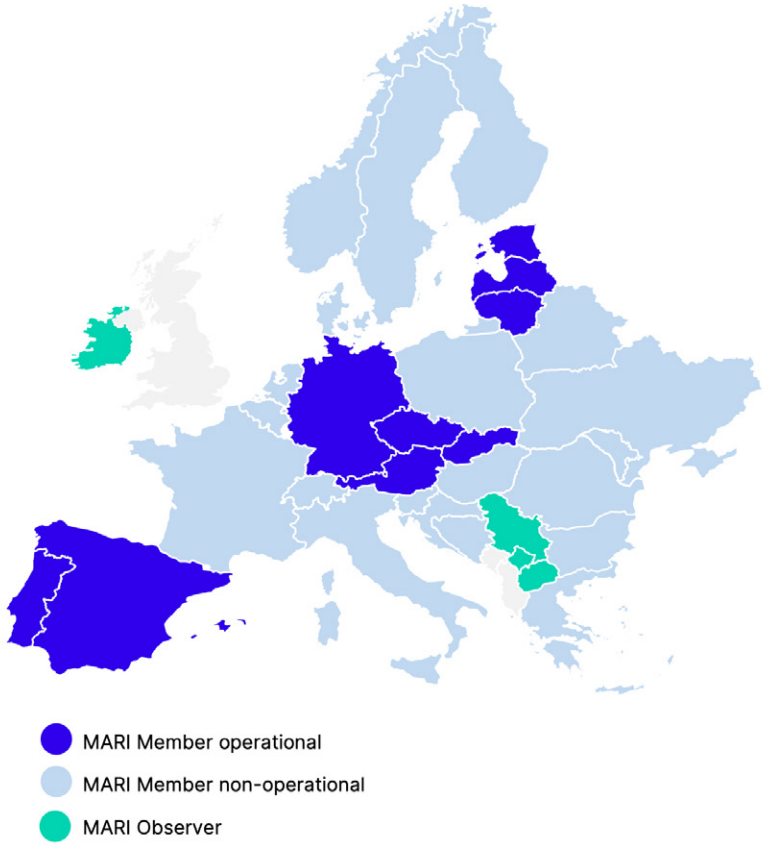
- MARI (Manually Activated Reserves Initiative) is a European market platform for the exchange of mFRR balancing energy.
- The MARI project started in 2017 and consists of 29 European TSOs from 26 countries.
- Technical go-live of the platform was in September 2022.
- As of December 2024, nine countries (12 TSOs) are currently connected – more are planned to connect in 2025.
- The Nordic TSOs are planning to connect together in 2027/2028.

Introduction of a European mFRR EAM

- The automated Nordic energy activation market for mFRR (mFRR EAM) is an intermediate step for connecting to MARI.
- The Nordic and European mFRR EAM platforms are based on the same algorithm and the only difference is that there will be an exchange of balancing energy outside the Nordic synchronous area.
- With MARI, European mFRR bids can be activated for balancing the Nordic region as well as local bids can be activated for needs on the continent.
- The floor for upregulation bid prices and the ceiling for down regulation bid prices will no longer be the spot price.

MARI status update

- Initially there has been low activity on the MARI platform due to few connected TSOs with low mFRR demand.
- When more TSOs connect in the near future the mFRR demand, activations and liquidity will increase.
- Through MARI, the least expensive European mFRR bids can be activated to balance the system, which will increase the economic surplus of the region.



CHAPTER 4

Financing of ancillary services

Cost allocation

Ancillary services are financed through three mechanisms. Yearly updated price lists for the grid tariff and BRP fee are decided by the board of Svenska kraftnät.

The grid tariff – everyone who is connected to the transmission grid pays a tariff for transporting energy. This fee finances the ancillary services needed for handling disturbances and incidents in the power system.

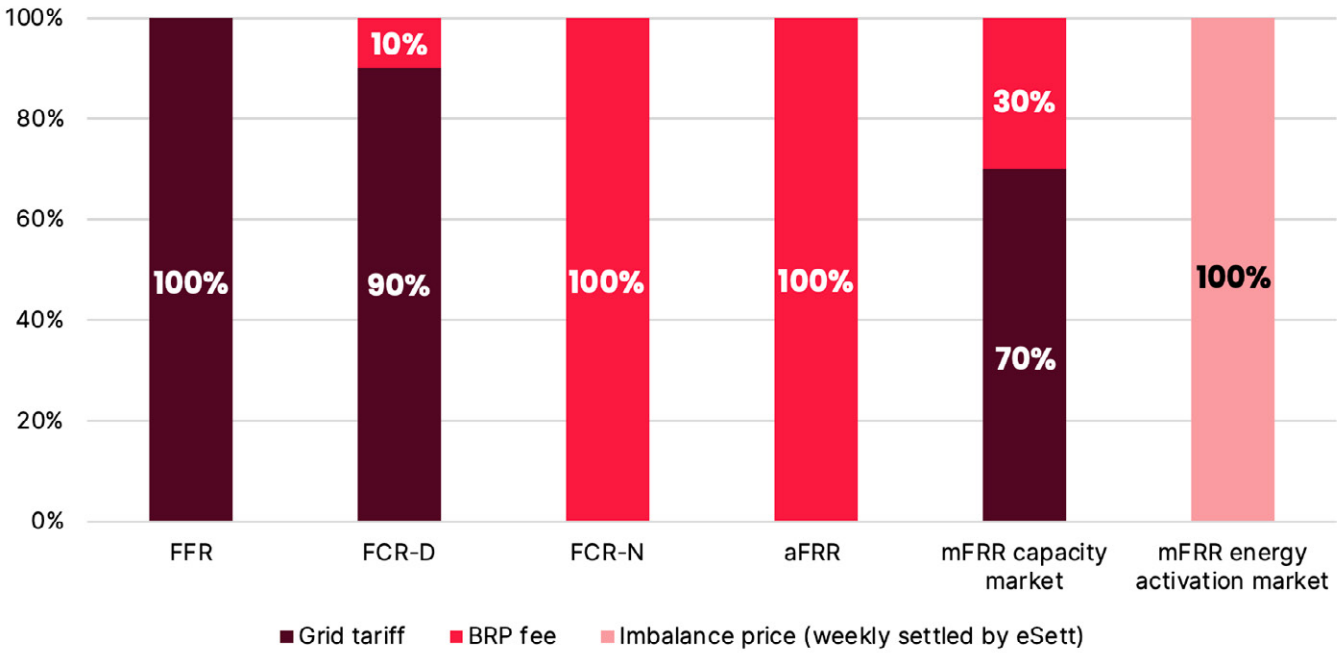
BRP fee – each BRP pays for reserves needed for balancing. The BRP fee has different components such as an imbalance fee based on the BRP's imbalances, a fixed fee for administration and a component based on the size of the BRP portfolio.

Imbalance price – Polluter pays principle. The actual energy activations of mFRR energy are covered by the BRPs that had imbalances for the specific ISP. The imbalances are settled weekly by eSett.

OUTLOOK:
The imbalance price in the future will be based on both mFRR and aFRR energy activations. The imbalance price shall give correct incentives for the chosen balancing model.

How different ancillary services are financed

In the chart below the cost allocation between grid tariff, BRP fee and imbalance price for each ancillary service market is shown. The allocation is valid for year 2025.



Cost allocation principle for balancing capacity
The costs for procurement of balancing capacity are split between the grid tariff and the BRP fee. The allocation principle is to use polluter pays towards the BRPs when adequate and related to the possibility to plan and trade into balance, and to socialize costs for services that do not derive from the BRP's performance.

Consequently, ancillary services to manage unforeseen events and disturbances in the power system are covered by the grid tariff. Ancillary services for imbalances caused by forecast errors or normal mismatches between production and consumption are covered by the BRP fee.

More information and contact

We hope this report has provided some new insights and we look forward to Your feedback to keep improving the format and content. Please send your feedback to balansmarknad@svk.se.

Contact

More information on ancillary service markets can be found on our webpage svk.se/aktorsportalen/bidra-med-reserver.
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