Nordic Balancing Philosophy

Nordic Operations Development Group, 13 June 2025

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1 Abbreviations and definitions

Term	Abbreviation	Definition
Activation Optimization Function	AOF	A Nordic function for bid selection for activation of scheduled mFRR bids, also called Nordic Libra.
Agreed Supportive Power	ASP	An agreed change to earlier plans for energy exchange on interconnections between TSOs.
Area Control Error	ACE	The sum of the power control error ('ΔP'), that is the real-time difference between the measured actual real-time power interchange value ('P') and the control program ('P0') of a specific LFC Area or LFC Block and the frequency control error ('K*Δf'), that is the product of the K-Factor and the frequency deviation of that specific LFC Area or LFC Block, where the area control error equals ΔP+K*Δf.
Available Transmission Capacity	ATC	The grid capacity available for exchange in markets.
Balancing Responsible Party	BRP	A market participant or its chosen representative responsible for its imbalances.
Balancing Service Provider	BSP	A market participant with reserve-providing units or reserve-providing groups able to provide balancing services to TSOs.
Capacity Allocation and Congestion Management Guideline	CACM	A European guideline on Capacity Allocation and Congestion Management, Commission regulation (EU) 2015/1222.
Control Area	CA	A coherent part of a synchronous area (usually coincident with the responsibility area of a TSO, a country or a geographical area) physically demarcated by the position of points for measurement of the interchanged power and energy to the remaining interconnected network. It is operated by a single TSO, which uses physical loads and controllable generation units to maintain and/or restore the balance between generation and demand within the Control Area.
Cross Zonal Capacity	CZC	The capability of the interconnected system to accommodate energy transfer between bidding zones.
Electricity Balancing Guideline	EBGL	The European guideline on electricity balancing, Commission regulation (EU) 2017/2195.
Fast Frequency Reserve	FFR	A reserve providing a very fast active power response, as an addition to the FCR-D in the Nordic Synchronous Area, to ensure transient frequency stability.
Frequency Containment Process	FCP	A process that aims at stabilising the System Frequency by compensating Imbalances by means of appropriate reserves.
Frequency Containment Reserves	FCR	The active power reserves available to contain System Frequency after the occurrence of an Imbalance.
Flow Reliability Margin	FRM	A security margin that copes with uncertainties on the computed TTC values arising from unintended deviations of physical flows emergency exchanges between TSOs in real

		time and inaccuracies, e.g., in data collection and measurements.
Frequency Restoration Control Error	FRCE	The control error for the FRP which is equal to the ACE of a LFC Area or equal to the Frequency Deviation where the LFC Area geographically corresponds to the Synchronous Area.
Frequency Restoration Process	FRP	A process that aims at restoring frequency to the Nominal Frequency and, for Synchronous Areas consisting of more than one LFC Area, a process that aims at restoring the power balance to the scheduled value.
Frequency Restoration Reserves	FRR	Reserves necessary to restore frequency to the nominal value and power balance to the scheduled value proactively and reactively after a sudden system imbalance occurrence.
High-Voltage Direct Current interconnector	HVDC	An electric power transmission system that uses direct current (DC) for transmission of electrical energy.
Imbalance		Deviations between generation, consumption and commercial transactions of a BRP within a given imbalance settlement period.
Imbalance Netting	IN	A process designed to reduce the amount of simultaneous and counteracting FRR activation of different participating and adjacent LFC Areas by Imbalance Netting power exchange.
LFC block monitor		Statnett is the LFC block monitor for the Nordic synchronous area.
Load-Frequency Control Area	LFC Area	A part of a Synchronous Area or an entire Synchronous Area, physically demarcated by points of measurement at interconnectors to other LFC Areas, operated by one or more TSOs fulfilling the obligations of load-frequency control.
Load-Frequency Control Clock	LFC Block	A part of a Synchronous Area or an entire Synchronous Area, physically demarcated by points of measurement at interconnectors to other LFC Blocks, consisting of one or more LFC Areas, operated by one or more TSOs fulfilling the obligations of load-frequency control.
Load shedding		Load shedding is the manual disconnection of load from the Synchronous Area.
Low Frequency Demand Disconnection	LFDD	A backup measure to limit the drop in grid frequency in extreme events.
Manually Activated Reserves Initiative	MARI	A European platform for the exchange of mFRR balancing energy.
Market Time Unit	MTU	The period for which a price is set in each market.
Mutual frequency support		Assistance from one Synchronous Area to another Synchronous Area that experiences a loss of generation or load greater than its N-1 reference incident which it is dimensioned for in accordance with SOGL.
Network Code	NC	A document setting out the code of practice, typically setting standards or operating procedures, agreed by ENTSOE or a European Legislation to with TSOs are required to comply with under their national law. Such legislation referred to in

		the development of this document are SOGL, EBGL, CACM and Clean Energy Package (CEP).
Nominal frequency		The rated value of the frequency for which all equipment connected to the electrical network is designed. The nominal frequency in the Nordic synchronous area is 50.00 Hz.
Nordic synchronous area		The subsystems of Norway, Sweden (including the subsystem of Åland), Finland and Eastern Denmark (DK2) which are synchronously interconnected. The subsystem of Western Denmark (DK1) is interconnected to the Nordic synchronous area using HVDC. The Nordic synchronous area and the subsystem of Western Denmark jointly constitute the interconnected Nordic power system.
N-x (criterion)		The N-x criterion is the rule according to which the elements remaining in operation after x failures of network elements (such as transmission line / transformer or generating unit, or in certain instances a busbar) must be capable of accommodating the change of flows in the network caused by that x number of failures.
Operational security		Operational security is the ability of the power system to maintain or to regain an acceptable state of operational condition after disturbances. It covers dynamic issues and real-time network management issues.
Platform for the International Coordination of Automated frequency restoration and Stable System Operation	PICASSO	A European common platform for activation of automatic frequency restoration reserves.
Production shedding		Manual disconnection of production in the Synchronous Area.
Rate of Change of Frequency	RoCoF	The time derivative of the power system frequency (df/dt). It is a measure of frequency stability linked to inertia and is expressed in terms of how many hertz the frequency decreases in one second.
Reference Incident	RI	The maximum expected instantaneous power deviation between generation and demand in the Synchronous Area in MW for which the dynamic behaviour of the system is designed. Considering the loss of the largest power generation/consumption unit(s) or the loss of a line section, busbar or HVDC interconnector.
Regional Group Nordic	RGN	RGN conduct and promote the cooperation between the Nordic TSOs with the aim of ensuring a reliable operation, optimal management and technical development of the Nordic synchronous area.
Replacement Reserves	RR	Reserves used to restore the required level of reserves to be prepared for a further system Imbalance. This category includes reserves with activation time from 15 minutes up to hours.
Synchronous Area	SA	A set of synchronously interconnected elements that have no synchronous interconnections with other areas. Within a synchronous area the System Frequency is common on a steady state.
Synchronous Area Monitor	SAM	Svenska kraftnät is the Synchronous Area Monitor for the Nordic synchronous area.

Synchronous Area Operational Agreement	SAOA	A multi-lateral agreement for TSOs of a single synchronous area. It is requirement of SOGL Article 118.
System frequency		The System frequency is the frequency in a Synchronous Area.
System Operation Agreement	SOA	An agreement between the Nordic Transmission System Operators including both the Nordic Synchronous Area Operational Agreement and the Nordic LFC block agreement.
System Operation Guideline	SOGL	The European guideline on electricity transmission system operation, Commission regulation (EU) 2017/1485.
Time To Restore Frequency	TTRF	Maximum expected time after the occurrence of a Reference Incident in which the frequency is restored inside the Standard Frequency Range.
Total Transmission Capacity	TTC	The total transmission capacity on an interconnector is the maximum transmission of active power in accordance with the system security criteria which is permitted in transmission cross-sections between the Nordic subsystems.
Transmission System Operator	TSO	A company that is responsible for operating, maintaining and developing the transmission system for a Control Area and its interconnections.

2 Purpose

The purpose of this document is to describe the Nordic balancing principles and procedures as information for TSO internal use and for external stakeholders to promote a common understanding of the strategy behind the Nordic rules and procedures for balancing. The document focuses on describing the current rules and procedures but will also indicate some ongoing changes.

The Nordic balancing is undergoing substantial development as earlier frequency-based balancing is migrating to full ACE based balancing, see Nordicbalancingmodel.net.

The Nordic Balancing philosophy covers balancing in normal and alert state conditions and does not address emergency situations.

The document takes account of the changes implemented since last revision of the Balancing Philosophy (May 30th, 2024). These include flow-based capacity allocation, automated mFRR energy activation market (EAM) and 15 minutes MTU in the energy markets (intraday and day-ahead).

3 Framework for balancing

The Nordic TSOs have agreed on principles and procedures for balancing in the Nordic System Operation Agreement (SOA).

Balancing is based on the relevant guidelines such as EBGL, SOGL, CACM, and Clean Energy Package.

3.1 Quality standards

3.1.1 Frequency quality

TSOs aim for keeping the frequency within the standard frequency range, which means a defined symmetrical interval of 100 mHz around the nominal frequency of 50.00 Hz.

The maximum value of minutes outside the standard frequency range is regulated in SOGL (article 127) to be no more than 15 000 min/year. The Nordic TSOs have agreed upon a goal for frequency deviations outside standard frequency range to be no more than 10 000 min/year[1].

Frequency outside the standard frequency range, means an increased risk for insufficient available Frequency Containment Reserves (FCR) to hinder activation of system protection schemes. In addition, the operational range of generators is limited to a certain system frequency range on both sides of 50 Hz for the various units. Frequency deviations outside of this range may trigger the automatic protection mechanisms leading to a disconnection of the generators. In worst case, these events may lead to blackouts in parts of the synchronous area.
The frequency deviations are followed up weekly and a frequency statistics report is created by the Synchronous Area Monitor (SAM) and distributed to all Nordic TSOs. The development over the years is shown in Figure 1.

[1] Ref. to Regional Group Nordic (RGN) decision 9 May 2014.

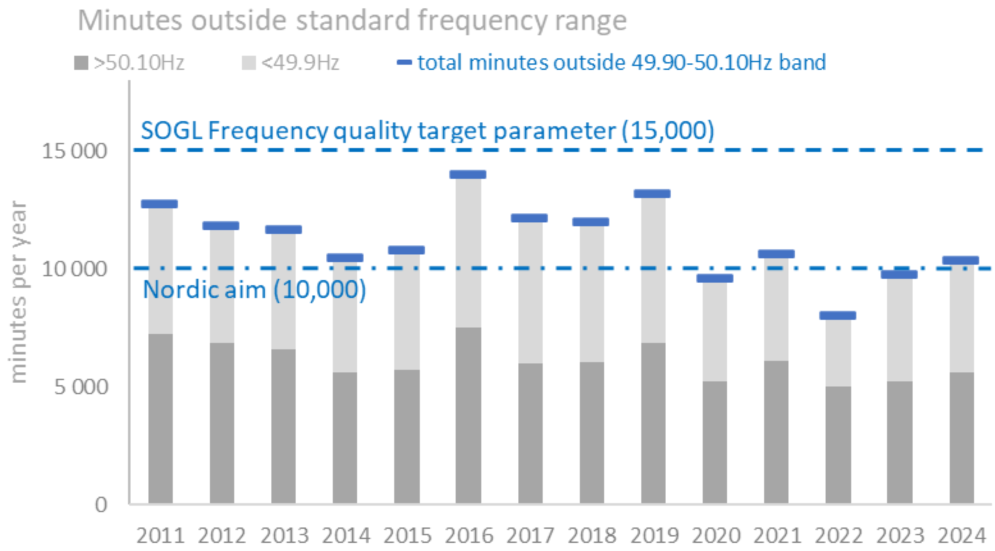

Figure 1: The minutes outside the standard frequency range for each year in the period 2011-2024 compared with the maximum value of 15 000 min/year in SOGL and the target of not more than 10 000 min/year.

3.1.2 ACE control

The TSOs have recently introduced ACE based balancing for mFRR. However, the TSOs are not performing full ACE based balancing. ACE control will be necessary to ensure management of full ACE based balancing and the TSOs are developing ACE control mechanisms.

The LFC block structure divides the Nordic synchronous area in LFC areas corresponding to the bidding zones for the energy markets. The existing situation is that mFRR is activated based on the balancing needs of the LFC areas. However, the automatic frequency restoration process for aFRR is based on frequency deviation. This means that FRCE for LFC areas defined in SOA is not directly controlled. The Nordic TSOs have defined a methodology for calculating FRCE values on LFC block and LFC area level.

3.1.3 Time control process

The objective of the time control process is to maintain the design criteria of 50,00 Hz as the mean frequency and to keep activation of normal Frequency Containment Reserve energy delivery close to zero over time. The Nordic aFRR controller automatically and continuously adjusts the frequency target slightly to keep time deviation low.

3.2 Responsibilities for balancing

3.2.1 TSO responsibility for balancing

Within each country the respective TSO is responsible for operational security which includes having sufficient resources available for maintaining the operational security within the operational limits. This may include agreements/arrangements with other TSOs.

Article 152 in SOGL dictates that: “Each TSO shall operate its control area with sufficient upward and downward active power reserve, which may include shared or exchanged reserves, to face imbalances between demand and supply within its control area. Each TSO shall control the FRCE as defined in the Article 143 to reach the required frequency quality within the synchronous area in cooperation with all TSOs in the same synchronous area.”

Each TSO is responsible for balancing its own LFC-area(s) by activation of mFRR, as described in chapter 4 . aFRR activation is initiated commonly for all Nordic LFC areas by Statnett based on frequency and not to balance individual areas.

Each TSO is responsible for having sufficient balancing measures available within its control area. The TSO must handle imbalances that may occur within its LFC area(s) as well as potential fault situations.

The TSOs shall ensure that the flow on the interconnectors to other control areas can be adjusted if needed to correspond to the resulting schedule from the energy markets. The TSOs shall also have measures to handle reduced transmission capacity in case of tripping of lines or for other reasons after confirmation of the schedule from the energy markets or after clearing of the mFRR energy activation market.

Imbalances in one control area shall not lead to violation of the operational security limits in other control areas or burden other control areas (subsystems) in an unacceptable way.

In case of an operational N-1 disturbance, the frequency must have been restored within 15 minutes. The system is restored when it once again complies with the operational security limits. The system is not dimensioned with FRR to handle multiple operational disturbances within the same 15-minute period or if a large disturbance has a duration of longer than 15 minutes. In these situations, the connected TSOs will cooperate with the responsible TSO(s) to solve the balancing issue using extraordinary measures[2]. The LFC block monitor will coordinate between TSOs.

As the Nordic TSOs cooperate in using reserves in a region in common balancing arrangements, a prerequisite for the arrangements is that the TSOs are collectively responsible for making sufficient reserves available for regional balancing with minimum volumes agreed between the TSOs in the region. The volumes are subject to updates and approval by RGN. Location of the reserves may be considered from a regional perspective taking congestions in the grid into account. This does not reduce the national TSO responsibility but contributes to more efficient use of the regional resources.

3.2.2 Distinction of TSO and BRP responsibility of balancing

BRPs are in general expected to balance their portfolio per quarter before each MTU. This is done by trade in day-ahead, in the intraday market and through bilateral trade between BRPs within bidding zones. Gate closure for intraday trading is 1 hour before operational quarter except for Finland which has later internal gate closures. Gate closure for bilateral trade is not harmonised.

After day-ahead trade, the BRPs will provide the TSOs with information needed for balancing such as preliminary production plans for the next day. Possible updates to the production plans can be sent until 45 minutes before operational quarter. As gate closure for intraday trade in Finland is different, Finnish BRPs can update their production plans until 25 min before the start of the MTU.

The BRPs shall follow the production plans delivered to their respective TSO for their portfolio. The TSOs will monitor if there will be large and/or systematic deviations in realised production compared with the plans. If needed, the TSOs will ask for clarification and corrective actions from BRPs.

[2] Extraordinary measures are covered in the methodology for Actions aiming to reduce FRCE.

After gate closure time of the production plans, the responsibility for balancing is taken over by the TSOs.

System imbalances may occur right up until and during the actual operational quarter. Some imbalances are unforeseeable while the TSOs can prepare themselves for others. The imbalances are due to:

- Current market setup where the day-ahead and intraday trade is performed per MTU whilst the consumption changes continuously. This means that there may be imbalances even if the BRP plans are correctly balanced for the MTU.
- Differences between forecasted and actual consumption and production.
- Differences between TSO-requested activations and actual power delivered by BSPs.
- Events causing loss of production or consumption.
- Differences between energy plans and actual flow on interconnectors.
- mFRR activated for system constraints by the TSOs.
- Self-balancing by BRPs.

The Nordic TSOs are the ones who before and during the time of operation have the best overall information regarding the balance situation and potential grid congestions. The Nordic TSOs balance the system by using the cheapest available mFRR bids in the Nordic area considering the congestions.

3.3 Operational planning data for balancing

3.3.1 Productions plans

Production plan is a schedule with quarterly resolution that BRPs send to the TSOs to notify the TSO about expected production.

Additionally, operational schedules for DK1 and DK2 are power schedules with 5 minutes resolution. The schedules shall be updated at any time by the BRP if changes occur in planned production. These schedules are not required to match the energy market positions of the BRPs.

TSOs have various possibilities within national regulation to adjust the production plans in agreement with BRPs.

3.3.2 Production forecast

In addition to the production plans sent by the BRPs, the TSOs make own production forecasts for intermittent production like wind and solar power, which are used in the planning of balancing.

3.3.3 Consumption forecast

Each TSO has its own tools for consumption forecasts which are used in balancing.

3.3.4 HVDC scheduling

The HVDC schedules are based on the quarterly results for exchange between bidding zones in the day-ahead and intraday energy market. These exchange plans are converted to minute-based setpoint power plans according to specific rules on each interconnector. The HVDC scheduling process is operated bilaterally between the connected TSOs.

3.3.5 Interconnector capacity

The available transmission capacity for balancing is based on the flow-based capacity calculation methodology and the already allocated capacity from the common capacity markets, day-ahead, intraday-markets and possible TSO-TSO-trades. The remaining capacity is available for exchange of balancing energy. Additionally, the available transmission capacity (ATC) for balancing time frame may be restricted due to allocation constraints (ramping restrictions, deadbands, zero-crossing restrictions) or due to outages.

3.3.6 Agreed Supportive Power (ASP)

The TSOs may perform TSO-TSO (registered as ASP) trades for several reasons: in case of common interconnector outages, faults within one TSOs control area, countertrade of known imbalances or other balancing needs. These trades result in changes to the interconnector schedules and the need for balancing energy and are hence considered in planning prior to operational quarter.

3.4 Products for balancing

To balance a system, different types of reserves must be available.

Since the grid is not a copperplate and congestions occur in the grid, there is a need for a distribution of the reserves through specific agreements (SOA) or market arrangements.

The reserve products used in the Nordic power system are shown in Figure 2. The speed of activation and duration of response are depicted in Figure 3. The products are further described in following subchapters.

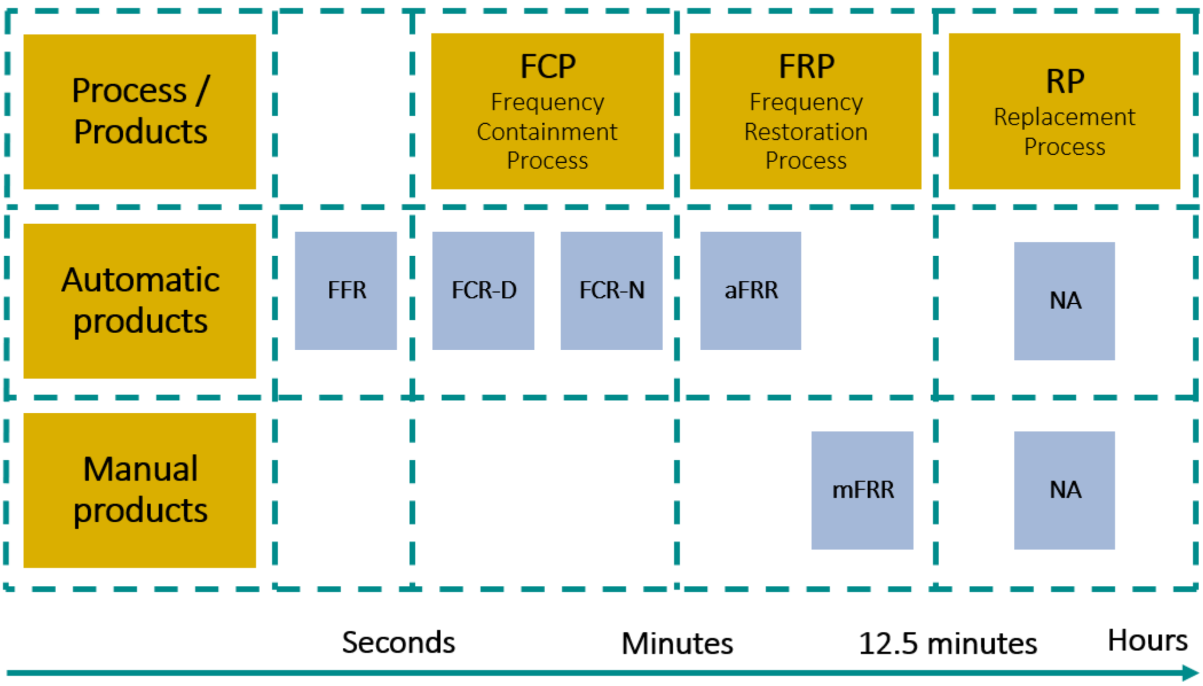

Figure 2: Reserve products in the Nordic Power system.

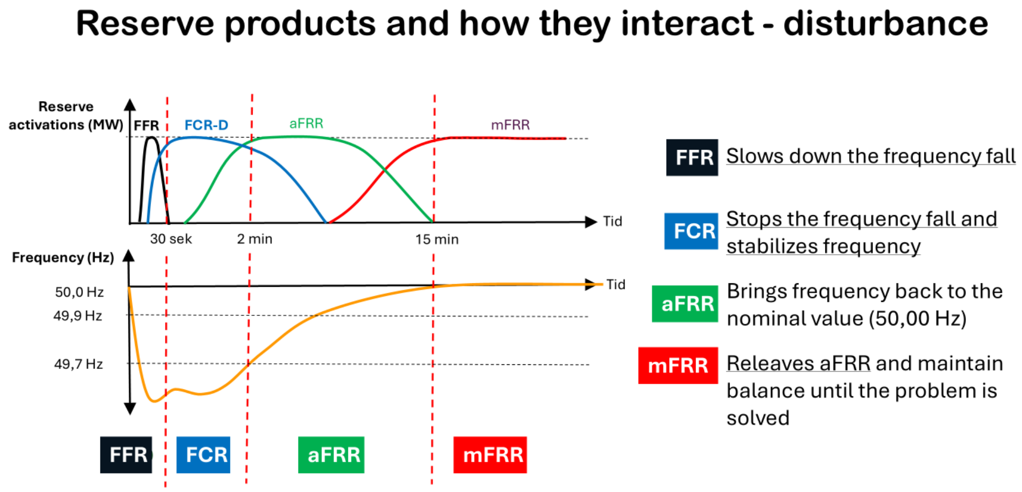

Figure 3: The purpose and activation timeline of reserve products.

3.4.1 Fast Frequency Reserves (FFR)

The objective of the FFR is to assist the Frequency Containment Process (FCP) during times of low system inertia to such an extent that after a sudden imbalance the frequency change can be successfully stopped before the instantaneous frequency deviation would have reached the maximum instantaneous frequency deviation. The ultimate objective of FFR is to prevent for Low Frequency Demand Disconnection (LFDD).

FFR is procured only as upward capacity when the system inertia is low with respect to the size of the reference incident. In these situations, it is evaluated that FCR-D alone is not able to hinder that the maximum instantaneous frequency deviation is reached in case the reference incident were to occur.

The Nordic volume needed is distributed between TSOs according to an agreed distribution key described in SOA.

3.4.2 Frequency Containment Reserves (FCR-N and FCR–D)

FCR-N is a specific Nordic product with the purpose of balancing the system within the standard frequency range (49.90<f<50.10 Hz). FCR-N is not used in Western Denmark (DK1).

According to SOA, the FCR-N shall be at least 600 MW in the synchronous area. This volume is divided between the control areas within the synchronous area as national requirements on basis of annual consumption and production in Eastern Denmark (DK2), Finland, Norway, and Sweden. The consumption and production for the previous calendar year are used for calculating the required control area volumes for the coming year.

FCR-D has the purpose of stabilizing the frequency in case of disturbances where frequency drops below 49,90 Hz or rises above 50,10 Hz. After a large disturbance in production, consumption or on HVDC, inertia slows the rate of change of frequency (RoCoF) from dropping below or rising above an acceptable level before FCR-D stabilizes the frequency at a steady state level.

According to SOA, there shall be FCR-D of such a volume and composition that a Reference Incident (RI) (largest fault of production or HVDC interconnectors) does not cause a steady state frequency below 49.5 Hz or above 50.5 Hz, and maximum instantaneous frequency deviation is not violated in the synchronous area.

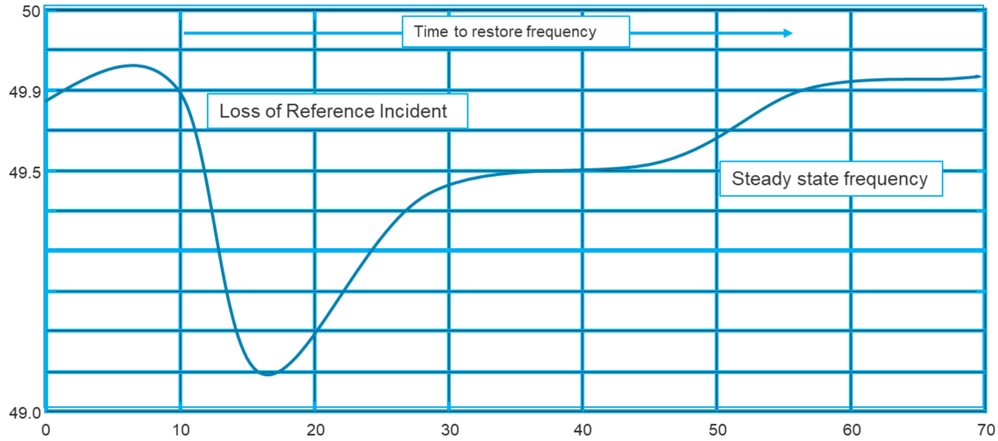

Figure 4: Simplified you may say that the inertia together with FCR-D response define the lowest frequency point after the Nordic RI, the FCR-D defines the steady state frequency and the FRR defines the time to restore frequency (TRF). The minimum acceptable steady state frequency is 49.5 Hz.

The activation of the FCR-D shall not result in other problems in the power system. When the transmission capacity is being determined, the location of the FCR-D shall be considered in the TTC calculation.

Distribution of the requirement for the FCR-D between the TSOs shall be according to the same distribution key as for FCR-N.

<u>The 2/3 rule:</u>
According to the SOA, each TSO shall have at least 2/3 of their initial FCR obligation in its own control area. The 2/3 obligation can be partly fulfilled by guaranteed FCR provision from another synchronous area. Within the Nordic synchronous area, under certain circumstances, exemptions from the 2/3 rule can be granted by RGN.

Statnett also practices a limitation on sale of FCR of max 1/3 of Norway's FCR requirement. This means e.g., that Norway cannot deliver 1/3 of the requirement of both Sweden and Finland in the same hour.

3.4.3 Frequency Restoration Reserves (aFRR and mFRR)

FRR are necessary to balance each LFC area and to keep the frequency close to 50 Hz. FRR can be both automatically and manually activated.

mFRR is activated primarily proactively based on imbalance forecasts or to mitigate congestions. aFRR is only activated reactively after a frequency deviation has occurred.

<u>Automatic Frequency Restoration Reserve (aFRR)</u>

The aFRR product shall be seen as a "complement" to mFRR in the FRR process. aFRR activations shall handle fast variations in imbalance which are not possible or appropriate to be handled by mFRR activations. aFRR has a faster response than mFRR and will therefore restore the frequency faster than mFRR.

The aFRR differs from FCR in the way that the reserve is remotely controlled by a Nordic controller at Statnett (sending signals to each TSO's local controller based on the synchronous area frequency) while FCR is locally controlled by each BSP (based on frequency in the grid). There is also a difference in activation time. When aFRR is active, there is interaction between FCR and aFRR where FCR stabilizes the frequency while aFRR brings frequency back to 50.00 Hz given sufficient available volumes. aFRR activation replaces the activation of fastresponding FCR. Denmark West (DK1) has their own LFC controller for aFRR activation, as DK1 is part of the Continental synchronous area.

TSOs are in a transition period to migrate aFRR activations from pro-rata frequency based to local ACE-based related to the accession to PICASSO.

aFRR volumes and procurement hours for the Nordic synchronous area are decided on a Nordic level and distributed between TSOs according to an agreed distribution key described in SOA.

The dimensioned amount of aFRR capacity in the Nordic synchronous area is currently based mainly on the targeted frequency quality.

Manual Frequency Restoration Reserve (mFRR)

The mFRR product is used for balancing and to handle congestions in normal and disturbance situations on a 15-minute basis, hereafter referred to as MTU. mFRR is the main balancing resource and is primarily activated proactively based on imbalance prognosis (an mFRR request in the scheduled mFRR activation market) for the coming operational quarter.

When activated in case of disturbances or unforeseen imbalances as a direct activation, mFRR replaces both remaining FCR and aFRR activations and reduces the ACE of each scheduling area.

In case of proactive activations, the mFRR may be activated in the opposite direction of FCR and aFRR. Due to small volume of aFRR and many congestions in the grid, the Nordic system is dependent on mFRR activations. It is expected that mFRR will continue to be the main balancing resource in the system but aFRR volumes have increased in the past years and is now used continuously.

3.4.4 The Nordic FRR dimensioning method

Each TSO shall constantly be able to cover the reference incident of their LFC areas. The 'reference incident' is defined as the maximum positive or negative power deviation occurring instantaneously between generation and demand. This means the largest imbalance that may result from an instantaneous change of active power of a single power generating module, single demand facility, a single AC-line or single HVDC interconnector. Reference incident shall be defined in both upward and downward direction.

The principle for dimensioning of mFRR and associated procurement of mFRR capacity is illustrated in Figure 5.

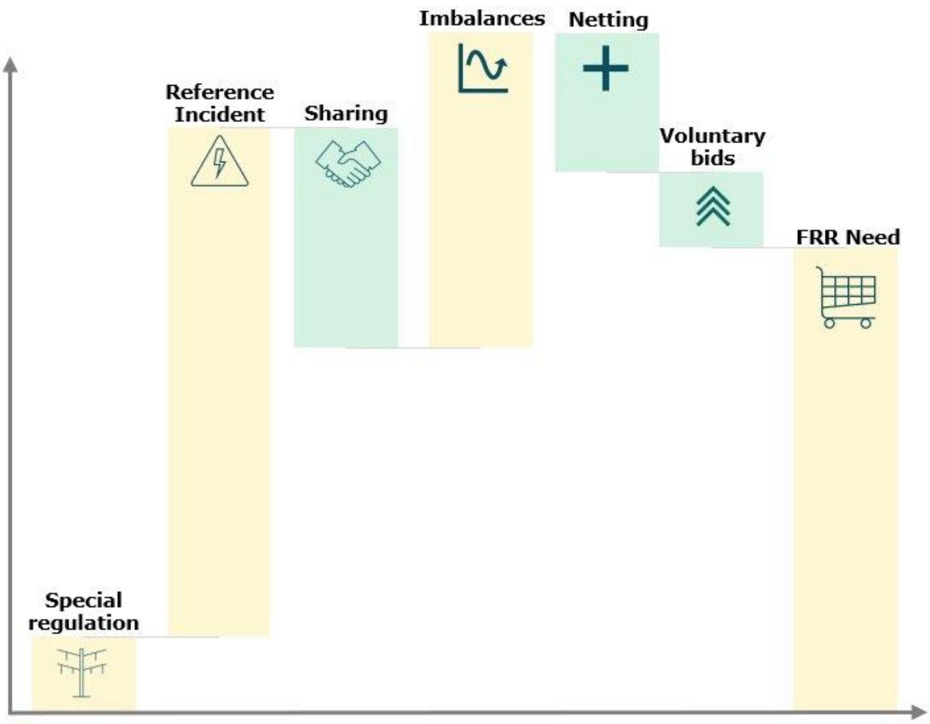

Figure 5: Illustration of Nordic dimensioning and capacity procurement of mFRR.

The TSOs must use some activation bids to solve local congestions (special regulation). The next bar illustrates the need for resources to cover the reference incident. The first green bar illustrates that there may be a possibility to share reserves between LFC or control areas and if so, the reserve requirement will be reduced. The next bar illustrates that reserves for what is called "normal imbalances" must be added. Also, for these reserves there will be a possibility for reduction of the requirement if netting of imbalances is possible. By adding and subtracting of required reserve volumes as described here, the needed FRR capacity can be found as illustrated and called FRR need. The Nordic TSOs organizes capacity markets for mFRR and by estimating the expected availability of voluntary bids, the needed capacity for procurement in the mFRR capacity market can be found.

3.5 Market arrangements

The Nordic TSOs operate markets for both capacity (MW) and energy (MWh). Capacity is procured prior to the time of operation to ensure that TSOs have balancing energy available at time of operation, when the need arises. Capacity is secured for handling of imbalances, disturbances or congestions.

3.5.1 aFRR and mFRR capacity markets and pricing principles

In the common Nordic aFRR capacity market for the synchronous area and in the trilateral (Fingrid, Energinet and Svenska kraftnät) or national (Statnett) mFRR capacity markets, BSPs can offer bids for aFRR or mFRR capacity to the Nordic TSOs. The most socio-economic efficient bids in each market are selected through an optimization function. Hereby the reserve requirements can be fulfilled each hour for up- and downwards balancing in each bidding zone. The reserve requirements in one bidding zone can be fulfilled by selecting bids in another, if it is deemed more efficient. This results in a cross zonal capacity (CZC) reservation of up to 10% (total of aFRR and mFRR) of the transmission capacity.

The aFRR and mFRR up- and down capacity prices for each bidding zone is determined by the marginal prices (EUR/MW) for procured aFRR and mFRR CM bids.

3.5.2 Energy activation markets (EAMs)

aFRR EAM

BSPs delivering aFRR is activated based on pro-rata principle for TSOs not on PICASSO (Statnett and Svenska kraftnät). Each BSP with procured aFRR CM volumes will be activated in case of a need for aFRR with an activation volume relative to the total need for aFRR energy.

Fingrid and Energinet participate in the common European aFRR EAM, PICASSO. TSOs collect bids from their BSPs and send these along with the need of the TSO for aFRR energy activation. An activation optimisation function (AOF) matches the bids and needs, considering available cross-zonal capacities. The aFRR bids are activated in bid price order, as selected in PICASSO.

aFRR balancing energy price

The aFRR balancing energy price (up- and/or down) for aFRR-bids selected through PICASSO is determined by the marginal prices for activated aFRR energy bids (EUR/MWh).

For bids activated in Norway and Sweden, the BSPs are renumerated with the mFRR price up or down, depending on the activation direction of aFRR.

mFRR EAM

The Nordic TSOs have a common mFRR EAM, where the needs of all Nordic TSOs are cleared. The Nordic mFRR EAM is designed and developed based on the requirements from the European mFRR Implementation Framework. The Nordic mFRR EAM is seen as a necessary step prior to the accession of the Nordic TSOs to the European mFRR balancing energy activation platform, MARI.

The mFRR EAM is based on a clearing algorithm (Nordic Libra AOF) which seeks to satisfy the mFRR request of all Nordic bidding zones whilst maximizing the social welfare under given constraints. The algorithm has a weighting coefficient on flows on connectors between bidding zones aiming for taking activations close to the request if competing bid prices are almost equal. The aim of this is to minimize transmission losses specifically on HVDC compared to AC. BSPs send their bids to their TSO at the latest 45 minutes prior to the MTU. The TSO forwards the available bids to Nordic Libra. The algorithm is run every 15 minutes (scheduled activation run), providing activation volumes for the upcoming operational quarter. Based on the algorithm clearing result, each TSO activates the selected bids of its BSPs. This is considered an efficient (and a socio-economic) way of using the Nordic resources.

In addition to the scheduled activation run, direct activation is available to TSOs if a need arises at a point in time between two scheduled activation runs. I.e. if a disturbance occurs or if the scheduled activated volumes result in a big rest imbalance, TSOs must apply direct activatable bids. Direct activatable bids are mFRR standard product bids, that can be activated at any point in time. They are activated based on a local merit order list.

The required full activation time (FAT) of the standard products in mFRR EAM market is 12.5 minutes. Products with different FAT or with other divergent characteristics may be activated as specific products locally at each TSO to compliment the activation of standard products. Examples of specific products are slower resources at Energinet, reserve power plants at Fingrid, disturbance and strategic reserves at Svenska kraftnät and disturbance and power shortage reserves (mFRR-D) at Statnett.

mFRR balancing energy prices

For each pricing period (15-minutes), the mFRR balancing energy prices (up and down) are determined for all bidding zones. The mFRR balancing energy prices are set per LFC area at the marginal price of activated mFRR balancing energy bids in either common merit order list or national merit order list. When physical or market-based congestion[3] do not occur (i.e. if there is only one uncongested area), the prices in all bidding zones will be equal. In case of direct activation or fallback[4] (market-based congestions), prices will be set by national bid selections only. In case of no activation of mFRR in one or both directions, the respective mFRR price is set to the day-ahead price of the bidding zone. All activations respecting merit order regardless of activation purpose may set the mFRR prices. Bids not activated in price order (for instances activations for local congestion management), do not set the mFRR price.

3.5.3 Price for BRP imbalances

There are different national rules regarding imbalance price design. In general, the imbalance price is set by the mFRR price or aFRR price in the dominating direction defined by the TSO. If there has been no activation (or the sum of activations is zero) the day-ahead price will be used as imbalance price.

The imbalance price is applied in the settlement of all BRPs regardless of whether their imbalance follows the ACE direction of the LFC area or not.

3.5.4 Publishing of balancing information

The mFRR balancing energy prices are determined after the pricing period has passed and prices and activated volumes are published no later than 30 minutes after the end of the pricing period. It is important that the market receives a correct price signal on an accurate base.

aFRR balancing energy prices are likewise published for TSOs that are connected to PICASSO.

In addition, individual TSOs can publish information regarding their forecasted balancing needs.

3.6 Ramping of exchange on interconnectors

HVDC
The trading plans on the HVDC interconnectors from the Nordic synchronous area can change so much from one MTU to the next that the rate of change (MW/min) around the MTU shift must be restricted to handle ramping operationally. Restrictions are placed on speed of change of the flows.

As a basic rule, the ramping rate is a maximum of 30 MW/min for 10 minutes (300 MW/MTU) ramping period (+/- 5 min around the MTU) on each of the interconnectors.

AC
A ramping period of -/+ 5 minutes around MTU shift shall be applied for intended exchange of FRR between TSOs.

[3] Market-based congestions refer to situations, where there is no common market between TSOs and the prices can only be set based on local merit order lists.
[4] Fallback refers to situations where the common AOF is not applied in the activation process. This can be caused by failure in the AOF or IT-issues amongst TSO(s).

3.7 Tools for the operators

The Nordic TSOs have both common and local systems to support operators in balancing.

The common systems provide all TSOs with information regarding the Nordic reserve availability, the mFRR EAM results, common capacity market results, inertia forecast, ancillary service information, etc. There are also common systems for forecasting of adequacy.

The local systems provide information on ACE, capacity in the grid, the available reserves and the mFRR and aFRR requests. In addition, the operators also see the system frequency. The TSOs also have their own systems for forecasting consumption and wind and even if the bases for them are similar there are some differences as well.

An important part in the balancing process is the ability to compare the planning data with real time measurements. This gives valuable and immediate information on trends that can be used when deciding balancing actions.

4 Balancing process

The Nordic balancing process shall be conducted in such a way that activation of balancing resources takes place in the most socio-economic beneficial way considering congestions in the grid, current legislation and secure operations. Balancing energy activation within the synchronous area shall be done so specified quality standards regarding frequency performance, ACE and time deviation are met.

Balancing in the Nordics has historically been based on frequency. The Nordic TSOs are in a transition phase to balance their LFC areas based on ACE.

Nordic TSOs have agreed that Svenska kraftnät has the role as Synchronous Area Monitor while Statnett has the role as LFC block monitor. The responsibilities and tasks for these two roles are described in the SOA and specified in more detail in operational instructions.

Energinet belongs to two different synchronous areas. Although DK1 is part of the Nordic mFRR market, DK1 is balanced as its own area inside the Central European synchronous system and shall keep its balance on the Danish – German and Danish - Dutch borders.

The balancing process is a long process that starts years ahead and is described in below subchapters.

4.1 Long- to short term planning

The operational balancing process can be considered as a long-term process starting years ahead with adequacy analyses, followed by long to short term outage planning, long to short term grid capacity planning on interconnectors, ending up with short term planning with forecasts for power balance and dynamic stability from weeks before, days ahead up to the quarter of operation.

The following text focuses on the short-term balancing process.

4.1.1 Adequacy for mFRR

A common Nordic objective is to assess sufficiency in available resources in the balancing with respect to always being able to respect the N-1 criteria. If sufficiency cannot be ensured by normal procedures, specific actions need to be taken. Thus, this is especially important in situations with risk of power shortage or lack of mFRR bids in either direction. For the assessment, each TSO makes a power balance evaluation in various time frames.

All TSOs are contracting upwards- and downwards mFRR capacity in accordance with commonly agreed minimum volumes to secure the Nordic power system in monthly to daily markets. The minimum volumes take account of netting of ACE and possibilities to share reserves across LFC area boundaries.

In addition, Svenska kraftnät and Fingrid have reserve power plants (gas turbines) available to ensure the sufficiency of reserves and maintain grid integrity.

Also, Svenska kraftnät contracts a strategic reserve during winter season. The volumes are only available to Svenska kraftnät, not to the market.

Furthermore, Energinet procures strategic reserves for Bornholm and Læsø (islands).

4.1.2 Allocation of grid capacity for exchange of reserves

The fact that the grid is not a copperplate, leads to requirements for distribution of all types of reserves. The reserves can however be exchanged and shared between bidding zones according to agreed rules and limitations.

A market-based allocation process determines the grid capacity to be allocated to the FRR capacity markets. The TSOs define needed FRR volumes for each bidding zone and an algorithm distributes the BSP contracts according to a merit order principle and available exchange capacity. The Nordic capacity markets are cleared in the morning D-1 and grid capacity is allocated for FRR capacity exchange between bidding zones whenever socioeconomically beneficial compared to giving all the available grid capacity to the day ahead market. The FRR allocation can be up to 10% (20% if necessary to ensure reserve adequacy) of the total cross-zonal capacity. The FRR capacity allocation covers the sum of aFRR and mFRR.

4.2 Planning after day-ahead market closing

After the day-ahead clearing, the BRPs/BSPs submit preliminary plans on production and mFRR bids for the next day. Together with exchange plans between bidding zones due to trade on the day-ahead market, this gives the TSOs a first overview on how the next day is planned quarter by quarter. It gives e.g. indication if there will be congestions in some hours.

To ensure that sufficient resources are available, an assessment is made separately by each TSO. If there is suspicion that there will a power shortage or other system problems the following day, the Synchronous area/LFC block monitors will coordinate different TSOs assessments. These assessments are made based on the following information:

- Preliminary forecast on consumption
- Preliminary production plans
- Day-ahead exchange plans on AC- and DC-connections
- Potential congestions from exchange schedules in the energy market
- Preliminary mFRR bids

Should there be a risk for lack of mFRR, the responsible TSO asks for additional mFRR bids from the BSPs in the mFRR market. This is however only a request as there are no legal obligations for the BSP to participate in the markets with all their available capacity.

In critical operational situations with a lack of resources however, providers can be ordered by phone to deliver up- or downward balancing energy activation from any available resource. This may be both consumption and production. Power shortage/surplus situations are described in chapter 4.4

4.3 The mFRR activation process

The balancing process is divided in three phases, the pre-phase for handling of local congestions in the grid (filtering of bids), the common Nordic schedule activation of mFRR standard products by an Activation Optimization Function (AOF) and national direct activations to reduce significant rest imbalances, mitigate an overload in the grid or reduce a lasting frequency deviation.

In addition to the mFRR standard product, specific products and automatic reserves secure that the system, after an operational disturbance, can be restored within the standard frequency range within Time to Restore Frequency (TRF) which is 15 minutes.

There may be a need to perform activations of mFRR bids for both ACE and potential congestions simultaneously to mitigate the risk of long-lasting frequency deviation. In these situations, the LFC block monitor will coordinate the actions if needed.

4.3.1 Evaluation and filtering of mFRR bids

TSOs can implement automatic functionality to perform bid filtering (suspend bids that should not be activated) and identification of system regulation (select bids that should be activated to relieve system constraints and avoid overload).

All TSOs have a manual possibility for the balancing operator to suspend bids from participation in the automatic activations (specific quarterly auctions) or based on resource object(s) on a local or regional level for a limited period of time. The bids should be available for manually triggered activations in the same period.

4.3.2 The scheduled mFRR activation process

When plans and mFRR bids are known 45 minutes before operational quarter hour, the TSO operators have the following updated information as basis for their planning of the balancing:

- Updated forecast on consumption or production
- Updated production plans
- Updated exchange plans on AC- and DC-connections
- Potential congestions from exchange schedules in the energy market
- Available transmission capacity (ATC) for balancing time frame
- Available mFRR bids
- Real time information about imbalances including trends and flows in the grid

The balancing strategy for the Nordic TSOs is to handle forecasted imbalances proactively, utilizing scheduled activated mFRR. The objective is to minimize the rest imbalance to an agreed performance level. Rest imbalance is the remaining imbalance after the mFRR scheduled activation run.

The ATCs for balancing energy exchange will be calculated automatically at each TSO and updated during the balancing process for each bidding zone border. ATCs are calculated based on the Nordic Capacity Calculation Methodology[5] for the balancing timeframe, which dictates to apply leftover capacity after the intraday-market possibly restricted by potential allocation constraints to respect physical/technical limitations.

Bid selection for the common scheduled activation is made by the Nordic AOF. The results are sent from Nordic Libra (AOF) to the TSOs local systems, and include satisfied mFRR request,

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[5] Proposal for a Capacity Calculation Methodology for the balancing timeframe for the Nordic Capacity Calculation Region in accordance with Article 37(3) of Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing, August 16, 2023

selected bids, cross border flow and cross border marginal price (CBMP) resulting from scheduled activation.

4.3.3 The direct mFRR activation process

During the operational quarter, each TSO follow the trend of the operational situation and continuously estimate the need for adjusting the balancing. This is done in the same way as planning before the operational quarter hour (as described above).

There is, however, currently no IT support for direct activation between the TSOs. Consequently, each TSO will normally have to use national bids in each TSOs' arrangements for direct activation of mFRR standard bids or national specific products.

Direct activation can be based on a demand for a volume of mFRR for a specific bidding zone or on a demand for a specific location due to a system constraint.

There are always risks of unpredictable events such as trip of production etc. When this occurs, the operators must make fast decisions on how to relieve the situation. The operators make a judgement based on the available real time information. Sometimes the TSOs together or the LFC block monitor have to coordinate needed actions.

4.3.4 Additional measures within normal operation

TSOs determine manually Agreed Supportive Power (ASP) contracts for exchange of mFRR between each other or with TSOs outside of the Nordics. The exchange is agreed bilaterally on the telephone and the ASPs are registered in the TSOs' local systems.

Bids can be traded from a power system outside the common Nordic mFRR activation market to support or balance any Nordic LFC area.

Bids can be activated in Nordic Libra or in local activation markets to support or balance a power system outside the common Nordic mFRR activation market. Such activations respecting merit order may set the mFRR prices.

There is also the possibility to use imbalance surplus or deficit without activating mFRR for exchange with other systems, i.e. netting of imbalances.

4.3.5 Use of mFRR for system constraints

mFRR for system constraints means activation of mFRR bids by a TSO for a reason other than the needs of balance management. For this purpose, the TSO uses mFRR bids which are suitable in terms of congestion management or other specific reasons, and the mFRR bids are not necessarily used in the price order. In case a TSO needs to activate bids for handling internal congestion, the TSO can activate local resources prior to the Nordic Libra scheduled activation or direct activate bids.

4.4 Manual load/production shedding

In a power shortage/surplus situation, the TSOs might have to decide an area where load/production shedding is required. The area(s) selected for load/production shedding is the area(s) with the largest gap between its imbalances(shortage/surplus) and its available reserves. The LFC block monitor will coordinate between TSOs if needed.

5 Topics for/under development

This chapter lists identified projects and activities which are supposed to be implemented in the near future, and which will have impact on the future Nordic balancing philosophy.

This chapter is not necessarily complete and dealing with all topics which are under development.

5.1 Dynamic dimensioning of mFRR

To complement the Nordic static dimensioning method for mFRR (minimum reserve requirements) the TSOs are transitioning into dynamic dimensioning method for mFRR. Dynamic dimensioning means that the reserve need may change each hour for the following day in both balancing directions for all LFC areas.

A similar method will be introduced for aFRR when the Nordics join PICASSO and the Nordic synchronous area will be fully ACE balanced.

5.2 aFRR energy activation market (PICASSO)

The Nordic TSOs will join the common European energy activation market for aFRR (PICASSO). Fingrid and Energinet are already connected to the platform.

For more information: https://nordicbalancingmodel.net/roadmap-and-projects/

5.3 mFRR energy activation market (MARI)

The Nordic TSOs will join the common European energy activation market for mFRR (MARI).

For more information: https://nordicbalancingmodel.net/roadmap-and-projects/

5.4 30 min intraday cross-zonal gate-closure time (ID CZ GCT)

The EU's electricity market reform of June 13, 2024 (EMDR) amended Article 8(1) of the Electricity Market Regulation, changing the intraday cross-zonal gate closure time (ID CZ GCT) from 60 minutes before delivery to as close to real-time as possible, with a maximum of 30 minutes before delivery. The change must be implemented by Jan 1st 2026, unless a request for derogation is approved by the relevant regulatory authority.