Nordic System Operation Agreement (SOA) – Annex Load-Frequency Control & Reserves (LFCR)

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Version	Approval date	Entry into force	Revision
V1	15/08/2019	17/10/2019	SOA Annex Load-Frequency Control & Reserves (LFCR) – Initial version
V2	28/10/2020	28/10/2020	New chapter 13 on FFR added and updat chapter 9 (exchange), chapter 10 (time cc with aFRR). Also text improvements and u of references, inclusion of references to operational instructions.
V3	24/06/2021	24/06/2021	Text improvements and updates. Regularly changing parameters moved to new appendix, including updated FCRE target levels. Appendices moved to separate documents. NRA approval dates in table 1 and 2 removed.
V4	26/01/2022	26/01/2022	Editorial updates. Clarifications included in some places. Inclusion of FCR-D down and Minimum activation period for FCR.

V5	27/04/2023	27/04/2023	Some editorial and corrective updates. Inclusion of Nordic aFRR CM.
V6	07/02/2024	07/02/2024	Inclusion of principles and allocation of responsibilities for manual demand disconnection (chapter 14) and allocation of responsibilities for some common Nordic tasks (chapter 3).
V7	11/12/2024	04/03/2025	Prepared for implementation of automated and ACE based mFRR activation, sharing of mFRR, inclusion of DK1 in some methods and inclusion of manual production shedding.

NORDIC SYSTEM OPERATION AGREEMENT (SOA) – ANNEX LOAD-FREQUENCY CONTROL & RESERVES (LFCR)

Version 7

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1 Introduction

1.1 Interaction with other related regulations and agreements

This Annex is part of the System Operation Agreement (SOA). This Annex makes references to the requirements set up in:

- Commission Regulation (EU) 2017/1485 of 2 August 2017 establishing a guideline on electricity transmission system operation (hereinafter referred to as "SOGL");
- Commission Regulation (EU) 2017/2195 of 23 November 2017 establishing a guideline on electricity balancing (hereinafter referred to as "EBGL").
- Regulation (EU) 2019/943 of the European Parliament and of the Council of 5 June 2019 on the internal market for electricity (recast)

The Parties have signed the Cooperation Agreement – Nordic balancing cooperation of 8 March 2018 establishing a basis for the LFC structure (as required by SOGL art 141(2)) and for the future cooperation on design, development and operation of balancing in the Nordic region.

1.2 Background

One of the most critical processes in ensuring operational security with a high level of reliability and quality, is the load-frequency control ('LFC'). Effective LFC can be made possible only if there is an obligation for the TSOs and the reserve connecting DSOs to cooperate for the operation of the interconnected transmission systems as one entity and for providers' power generating modules and providers' demand facilities to meet the relevant minimum technical requirements.

SOGL, whereas (12)

The provisions in SOGL, Part IV Load-Frequency Control and Reserves (hereinafter referred to as "LFCR") aim at setting out clear, objective and harmonised requirements for TSOs, reserve connecting DSOs, providers' power generating modules and providers' demand facilities in order to ensure system security and to contribute to non-discrimination, effective competition and the efficient functioning of the internal electricity market. The provisions on LFC and reserves provide the technical framework necessary for the development of cross-border balancing markets.

SOGL, whereas (13)

In order to ensure the quality of the common system frequency, it is essential that a common set of minimum requirements and principles for Union-wide LFC and reserves are defined as a basis for both the cross-border cooperation between the TSOs and, where relevant, for utilising characteristics of the connected generation, consumption and distribution systems. To that end, SOGL addresses the LFC structure and operational rules, the quality criteria and targets, the reserve dimensioning, the reserve exchange, sharing and distribution and the monitoring related to LFC.

SOGL, whereas (14)

Another important aspect to ensure operational security is the coordinated congestion management between TSOs. This aspect is getting more and more focus in the Nordics.

1.3 This Annex

In this Annex the Nordic TSOs agree upon the main principles and requirements on LFC for ensuring system security and to contribute to non-discrimination, effective competition and the efficient functioning of the internal electricity market. SOGL, whereas (13)

This Annex shall be considered in addition to the principles, requirements and conditions included in the SOGL. SOGL, part IV

Some methodologies are required to be approved by the NRAs in accordance with article 6(3) of the SOGL. These methodologies will be separate legal documents and this Annex includes references to these documents. The annex will however give a short introduction to relevant parts of the different methodologies. Some of these methodologies have an implementation date in future, and if so, this Annex describes the existing situation. The methodologies that are not required to be approved by NRAs in accordance with article 6(3) of the SOGL, are described in this annex. SOGL 6(3)

The methodologies included or referred to in this Annex cover the requirements for a Synchronous area operational agreement and a LFC block operational agreement (see section 2.1 and 2.2 of this Annex). SOGL 118(1) SOGL 119(1)

The TSOs anticipate regular updates in order to keep the agreements in this Annex up-to-date. Consequently, this Annex includes mainly the agreements between the TSOs related to the existing situation. Changes shall be first approved by all TSOs, before the change will be implemented in the SOA at the latest when the change enters into force.

This Annex has two appendices. Appendix 1 includes an overview of regularly changing parameters. Appendix 2 includes assessments of arrangements for exchange and sharing of FRR capacity between synchronous systems (see section 9.4.4).

Operational Instructions further detail the implementation of this Annex. In the right-hand column the numbers of Operational Instructions that are relevant to the specific rule of methodology are indicated.

1.4 Geographic area

The geographical area to which the SOA/LFCR annex applies is the Nordic Synchronous area or, when relevant, the Nordic Synchronous area + Western Denmark (DK1). Currently, DK1 is included in the geographic area regarding activation of scheduled mFRR and sharing of mFRR capacity for handling of Reference Incident, as mFRR activation is coordinated in a Nordic activation platform where DK1 is included (see chapter 2.8 (sharing) and 9 (Exchange and sharing of reserves)).

1.5 Structure of this Annex

This Annex has the same structure as Part IV of the SOGL:

- Title 1 of SOGL / Chapter 2 of this Annex: Operational agreements
- Title 2 / Chapter 3: Frequency quality
- Title 3 / Chapter 4: Load-frequency control structure
- Title 4 / Chapter 5: Operation of load-frequency control
- Title 5 / Chapter 6: Frequency containment reserves
- Title 6 / Chapter 7: Frequency restoration reserves
- Title 7 / Chapter 8: Replacement reserves
- Title 8 / Chapter 9: Exchange and sharing of reserves
- Title 9 / Chapter 10: Time control process
- Title 10 / Chapter 11: Co-operation with DSOs
- Title 11 / Chapter 12: Transparency of information
- Chapter 13: Fast Frequency Reserves
- Chapter 14: Principles for allocation of manual load/production shedding

1.6 Definitions

For the purpose of this Annex, the terms used shall have the meaning of the definitions included in Article 3 of SOGL, Article 2 of EBGL and the other items of legislation referenced therein. In addition, NRA approved methodologies include specific definitions.

2 Operational agreements

2.1 Structure of agreements in relation to operation of the Nordic synchronous area

Articles 118, 119, 120 and 121 of the SOGL describe requirements for respectively all TSOs of synchronous areas (118), for all TSOs of LFC blocks (119), for all TSOs of LFC areas (120) and all TSOs of monitoring areas (121). If operated by more than one TSO, these requirements need to be implemented in respectively synchronous area operational agreements (118), LFC block operational agreements (119), LFC area operational agreements (120) and monitoring area operational agreements (120) between the relevant TSOs. The TSOs subject to this Annex are member of the same synchronous area and the same LFC block (see section 4.2.2 Determination of LFC blocks). Consequently, the TSOs need to establish a synchronous area operational agreement and a LFC block operational agreement. This Annex to the SOA implicitly includes the synchronous area operational agreement, the LFC block operational agreement, the imbalance netting agreement, the cross-border FRR activation agreement, the sharing agreement and the exchange agreement. The last two agreements are valid for those TSOs participating in the same sharing/exchange process.

SOGL 118
SOGL 119
SOGL 120
SOGL 121
SOGL 122
SOGL 123
SOGL 125
SOGL 126

Conversely, most Nordic LFC areas and monitoring areas are operated by only one TSO. The only exception is LFC area SE3 and monitoring area SE3 which are operated by Svenska kraftnät and Kraftnät Åland. Svenska kraftnät and Kraftnät Åland established a LFC area operational agreement and a monitoring area operational agreement for SE3 bilaterally. Consequently, these LFC area operational agreement and monitoring area operational agreement are outside the scope of this Annex.

It shall be noted that the LFC block structure in the Nordic system is typically different from the organisation in the Continental Europe (CE) synchronous area in which many LFC blocks exist. For this reason, CE TSOs defined separate synchronous area agreement and LFC block agreements. Another difference with most other European LFC blocks is that the Nordic LFC block consists of more than one control area (four) and two control areas consist of many LFC areas (five for Norway, four for Sweden).

2.2 Synchronous area operational agreement

Article 118(1) of the SOGL requires that all TSOs of each synchronous area shall jointly develop common proposals for a number of methodologies. These methodologies are included in this Annex. Table 1 includes the reference for each of the required methodologies to the section in this Annex where the methodology is presented.

SOGL 118(1)

Table 1: Reference table of methodologies that all TSOs of each synchronous area shall jointly develop common methodologies for.

SOGL 118(1)

article in SOGL	Methodology	section in this Annex
6(3)(g)	determination of LFC blocks	4.2.2
118(1)(a)	the dimensioning rules for FCR	6.4.2 6.4.3
118(1)(b)	the additional properties of the FCR	6.4.4 6.4.5
118(1)(c)	frequency quality defining parameters and the frequency quality target parameter	3.4.1 3.4.2
118(1)(d)	frequency restoration control error target parameters for each LFC block (level 1 and level 2)	3.4.3
118(1)(e)	methodology to assess the risk and the evolution of the risk of exhaustion of FCR of the synchronous area	3.4.5
118(1)(f)	synchronous area monitor	3.3.1
118(1)(g)	calculation of the control program from the netted area AC position with a common ramping period for ACE calculation for a synchronous area with more than one LFC area in accordance	3.4.6
118(1)(h)	if applicable, restrictions for the active power output of HVDC interconnectors between synchronous areas	3.4.7
118(1)(i)	LFC structure	4.2.1
118(1)(j)	if applicable, the methodology to reduce the electrical time deviation	10.4.1
118(1)(k)	specific allocation of responsibilities between TSOs	4.3.1
118(1)(l)	operational procedures in case of exhausted FCR	N/A
118(1)(m)	N/A	N/A
118(1)(n)	operational procedures to reduce the system frequency deviation to restore the system state to normal state and to limit the risk of entering into the emergency state	5.5.1
118(1)(o)	roles and responsibilities of the TSOs implementing an imbalance netting process, a cross-border FRR activation process or a cross-border RR activation	4.3.2
118(1)(p)	requirements concerning the availability, reliability and redundancy of the technical infrastructure	4.4.1
118(1)(q)	common rules for the operation in normal state and alert state in accordance with Article 152(6) and the actions referred to in Article 152(15)	5.4.1
118(1)(r)	the minimum activation period to be ensured by FCR providers	6.4.6
118(1)(s)	the assumptions and methodology for a cost-benefit analysis	6.4.7
118(1)(t)	the limits for the exchange of FCR between TSOs	9.4.1
118(1)(u)	roles and responsibilities of the reserve connecting TSO, the reserve receiving TSO and the affected TSO as regards the exchange of FRR and RR	9.3.2 9.3.3 9.3.4
118(1)(v)	roles and responsibilities of the control capability providing TSO, the control capability receiving TSO and the affected TSO for the sharing of FRR and RR	9.3.5 9.3.6 9.3.7
118(1)(w)	roles and responsibilities of the reserve connecting TSO, the reserve receiving TSO and the affected TSO for the exchange of reserves between synchronous areas, and of the control capability providing TSO, the control capability receiving TSO and the affected TSO for the sharing of reserves between synchronous area	9.3.2 9.3.3 9.3.4
118(1)(x)	methodology to determine limits on the amount of sharing of FCR between synchronous areas	9.4.2

118(1)(z)	limits on the amount of FRR exchange/sharing between synchronous areas	9.3.4
118(1)(aa)	limits on the amount of RR exchange/sharing between synchronous areas	9.4.3

2.3 LFC block operational agreement

Article 119(1) of the SOGL requires that all TSOs of each LFC block shall jointly develop common proposals for a number of methodologies. These methodologies are included in this Annex. Table 2 includes the reference for each of the required methodologies to the section in this Annex where the methodology is presented. SOGL 119(1)

Table 2: Reference table of methodologies that all TSOs of each LFC block shall jointly develop common methodologies for. SOGL 119(1)

article in SOGL	methodology	section in this Annex
119(1)(a)	where the LFC block consists of more than one LFC area, FRCE target parameters for each LFC area defined in accordance with Article 128(4);	3.4.4
119(1)(b)	LFC block monitor	3.3.2
119(1)(c)	ramping restrictions for active power output	3.4.7 3.4.8
119(1)(d)	where the LFC block is operated by more than one TSO, the specific allocation of responsibilities between TSOs within the LFC block	4.3.1
119(1)(e)	if applicable, appointment of the TSO responsible for the tasks in Article 145(6);	4.3.4
119(1)(f)	additional requirements for the availability, reliability and redundancy of technical infrastructure	4.4.1
119(1)(g)	operational procedures in case of exhausted FRR or RR	5.5.3
119(1)(h)	the FRR dimensioning rules	7.4.1
119(1)(i)	the RR dimensioning rules	8
119(1)(j)	where the LFC block is operated by more than one TSO, the specific allocation of responsibilities defined in accordance with Article 157(3), and, if applicable, the specific allocation of responsibilities defined in accordance Article 160(6);	7.3.1
119(1)(k)	the escalation procedure defined in accordance with Article 157(4) and, if applicable, the escalation procedure defined in accordance with Article 160(7);	7.5.1
119(1)(l)	the FRR availability requirements, the requirements on the control quality defined in accordance with Article 158(2), and if applicable, the RR availability requirements and the requirements on the control quality defined in accordance with Article 161(2);	7.4.3 7.4.4
119(1)(m)	if applicable, any limits on the exchange of FCR between the LFC areas of the different LFC blocks within the CE synchronous area and the exchange of FRR or RR between the LFC areas of an LFC block of a synchronous area consisting of more than one LFC block defined in accordance with Article 163(2), Article 167 and Article 169(2);	N/A
119(1)(n)	the roles and the responsibilities of the reserve connecting TSO, the reserve receiving TSO and of the affected TSO for the exchange of FRR and/or RR with TSOs of other LFC blocks;	9.3.2 9.3.3 9.3.4

119(1)(o)	the roles and the responsibilities of the control capability providing TSO, the control capability receiving TSO and of the affected TSO for the sharing of FRR and RR	9.3.5 9.3.6 9.3.7
119(1)(p)	roles and the responsibilities of the control capability providing TSO, the control capability receiving TSO and of the affected TSO for the sharing of FRR and RR between synchronous areas	9.3.5 9.3.6 9.3.7
119(1)(q)	coordination actions aiming to reduce the FRCE	5.4.2
119(1)(r)	measures to reduce the FRCE by requiring changes in the active power production or consumption of power generating modules and demand units	5.4.3

2.4 LFC area operational agreement

LFC areas are corresponding to bidding zones (see 4.2.2 Determination of LFC blocks). Consequently, LFC areas will be operated by only one TSO (except for LFC area SE3, see section 2.1). Therefore, all responsibilities for the LFC area will be allocated to the TSO responsible for this LFC area. Accordingly, there will be no need to establish separate LFC area operational agreements in which responsibilities are allocated. SOGL 120

The Nordic frequency restoration process with manual Frequency Restoration Reserves is based on the FRCE of the LFC areas and the Nordic frequency restoration process with automatic Frequency Restoration Reserves is based on frequency deviation. This is explained in section 5.3.2. SOGL 128(1, 4)

2.5 Monitoring area operational agreement

The TSOs defined that monitoring areas will be corresponding to bidding zones (see 4.2.2 Determination of LFC blocks). Consequently, monitoring areas will be operated by only one TSO (except for monitoring area SE3, see section 2.1). Therefore, all responsibilities for the monitoring area will be allocated to the TSO responsible for this monitoring area. Accordingly, there will be no need to establish separate monitoring area operational agreements in which responsibilities are allocated. SOGL 121

2.6 Imbalance netting agreement

Article 122 of the SOGL requires that all TSOs participating in the same imbalance netting process shall establish an imbalance netting agreement that shall at least include the roles and responsibilities of the TSOs in accordance with Article 149(3). This Annex implicitly includes this imbalance netting agreement. The roles and responsibilities of the TSOs in accordance with Article 149(3) are detailed in section 4.3.2. SOGL 122

With respect to mFRR, the frequency restoration process is based on use of the energy activation market which includes netting of mFRR requests between individual LFC areas.

With respect to aFRR, the frequency restoration process is based on frequency deviation. Consequently, imbalance netting is done implicitly.

2.7 Cross-border FRR activation agreements

A cross-border FRR activation agreement shall be established between the TSOs participating in the same cross-border FRR activation process. This agreement shall include at least the roles and responsibilities of the TSOs for the cross-border FRR activation in accordance with Article 149(3).

SOGL 123
SOGL 149(3)

The existing situation is that all LFC areas of the Nordic synchronous area participate in the same cross-border aFRR activation process while Western Denmark (DK1) is included in the cross-border activation process for mFRR.

2.7.1 Between Nordic TSOs

The Nordic Load Frequency Controller (LFC) for aFRR determines the required activations of aFRR for each TSO within the synchronous area.

SOGL 123
SOGL 149(3)

The Nordic Automatic Optimisation Function (AOF) for scheduled mFRR, selects bids for activation based on mFRR requests for individual LFC areas and the Nordic Merit Order List.

The Nordic coordination of FRR activation is explained in section 5.3.2 Nordic Balancing. This coordination implicitly results in a cross-border FRR activation agreement between Nordic TSOs.

There is no common Nordic AOF implemented for direct mFRR activation. Each TSO do however have a local AOF for direct mFRR activation for standard bids in addition to specific arrangements for activation of non-standard bids.

The roles and responsibilities of the TSOs in accordance with Article 149(3) are detailed in section 4.3 Roles & Responsibilities.

2.7.2 With TSOs in other synchronous areas

Cross-border FRR activation agreements with non-Nordic TSOs in other synchronous areas shall be made in separate bilateral agreements. Approved assessments of these arrangements are attached to this annex as appendix 2.

SOGL 123
SOGL 149(3)

2.8 Sharing agreement

SOGL 125
SOGL 165(3)
SOGL 171(4)
SOGL 171(9)

A sharing agreement shall be established between the TSOs participating in the same FCR or FRR sharing process. Sharing agreements are separate agreements between TSOs, including the roles and responsibilities of the control capability receiving TSO and the control capability providing TSO. This Annex implicitly includes the Nordic sharing agreement. The roles and responsibilities of the affected TSOs are addressed in chapter 9 of this Annex. Exchange and sharing of reserves, including the process for assessing exchange and sharing arrangements are addressed in chapter 9 of this annex.

2.9 Exchange agreement

SOGL 126
SOGL 165(3)
SOGL 171(4)
SOGL 171(9)

An exchange agreement shall be established between the TSOs participating in the same FCR or FRR exchange process. Exchange agreements are separate agreements between TSOs, including the roles and responsibilities of the reserve receiving TSO and the reserve providing TSO. This Annex implicitly includes the Nordic exchange agreement. The roles and responsibilities of the affected TSOs are addressed in section 9.3.4 Roles and responsibilities for affected TSO as regards the exchange of FRR of this Annex. Exchange and sharing of reserves, including the process for assessing exchange and sharing arrangements, are addressed in chapter 9 of this annex.

3 Frequency quality

3.1 Objective

The frequency of the transmission system, the system frequency, is a direct indicator for the total active power balance in the whole synchronous area:

- If the active power generation exceeds the active power consumption, the system frequency will rise, and,
- if the active power consumption exceeds the active power generation, the system frequency will fall.

and will result in a deviation from the nominal frequency.

Imbalances and therefore frequency deviations cannot be physically avoided for two fundamental reasons:

- The electricity demand is only predictable up to a certain extent and its controllability is limited. Therefore, the dispatch of power plants must rely on forecasts which are subject to errors which cause deviations between generation and consumption.
- At the same time, the controllability of power plants is also physically limited, especially in the case of plants which rely on fluctuating RES to generate electricity. Furthermore, power system components are subject to disturbances.

Since for technical reasons the operational range of generators is limited to a certain system frequency range on both sides of 50 Hz, frequency deviations outside of this range may trigger the automatic protection mechanisms leading to a disconnection of the generators. Very low frequencies may also trigger automatic disconnection of demand. In worst case, these events may lead to blackouts in parts of the synchronous area.

Therefore, the system frequency quality, which can be measured based on the size and duration of frequency deviations with respect to the nominal frequency, is an important measure of security of supply and being a "common good" for all users of the synchronous area. The system frequency quality must be monitored and maintained properly.

3.2 High-level Concept

3.2.1 Evaluation of frequency quality: Criteria Application Process

In the SOGL, the process of evaluation of the frequency quality evaluation criteria is named criteria application process and consists of the gathering of the data needed for the evaluation and the calculation of the different values for each frequency quality evaluation criteria. SOGL 129

The frequency quality evaluation criteria include a series of global reliability indicators regarding both

- the system frequency quality in order to monitor the overall behaviour of load-frequency control; and

- the Frequency Restoration Control Error (FRCE) quality in order to monitor the load-frequency control of LFC blocks and LFC areas.

Some of the frequency quality evaluation criteria will be used to compare with the values of the frequency quality target parameters and FRCE target parameters.

3.2.2 Frequency quality objective

Standard frequency range means a defined symmetrical interval of 100mHz around the nominal frequency of 50 Hz within which the system frequency of the Nordic synchronous area is supposed to be operated. SOGL 3(155)

The number of minutes with a frequency outside the standard frequency range shall be in line with the targets set in section 3.4.2 Frequency quality target parameters.

3.3 Roles & Responsibilities

3.3.1 Synchronous area monitor

The Nordic TSOs appointed Svenska kraftnät as the synchronous area monitor of the Nordic System. SOGL 133(1)

Since the Nordic synchronous area geographically corresponds with the Nordic LFC block, the synchronous area monitor works in close cooperation with the LFC block monitor on the implementation of its tasks.

The synchronous area monitor shall carry out the following tasks, as defined in the SOGL:

The synchronous area monitor shall implement the data collection and delivery process, which includes: SOGL 133(2)

- measurements of the system frequency; SOGL 132
- calculation of the frequency quality evaluation data; and
- delivery of the frequency quality evaluation data for the criteria application process

The synchronous area monitor shall once every 3 months and within 3 months after the end of the analysed period (see chapter 12). SOGL 133(3) and (4)

- collect frequency quality evaluation data; and SOGL 129
- calculate frequency quality evaluation criteria.

With respect to the system states, the synchronous area monitor shall: SOGL 152(4) and (5)

- determine the system state with regard to the system frequency in accordance with Article 18(1) and (2) of the SOGL;
- ensure that all TSOs of all synchronous areas are informed in case the system frequency deviation fulfils one of the criteria for the alert state referred to in Article 18.

The synchronous area monitor shall monitor the electrical time deviation, calculate the frequency setpoint adjustments; and coordinate the actions of the time control process (see section 10.4.1 methodology to reduce the electrical time deviation). SOGL 181(3)

The synchronous area monitor shall notify the results of the criteria application process for their synchronous area to ENTSO for Electricity for publication within three months after the last time-stamp of the measurement period and at least four times a year (see chapter 12). SOGL 185(4)

3.3.2 LFC block monitor

The Nordic TSOs appointed Statnett as the LFC block monitor of the Nordic LFC block. SOGL 134(1)

Since the Nordic LFC block geographically corresponds with the Nordic synchronous area, the LFC block monitor works in close cooperation with the synchronous area monitor on the implementation of its tasks.

The LFC block monitor shall carry out the following tasks, as defined in the SOGL:

The tasks of the Nordic LFC block monitor include the collection of the frequency quality evaluation data for the LFC block in accordance with the criteria application process that will be performed by the Synchronous area monitor (see section 3.3.1 Synchronous area monitor) SOGL 134(2)

The LFC block monitor shall for each quarter deliver the frequency quality evaluation report of the LFC block and its LFC areas. SOGL 134(4)

The LFC block monitor - in cooperation with the synchronous area monitor - shall, according SOGL article 152(12), (13) and (14), be responsible for identifying any violation of the limits specified in article 152(12) and (13) for FRCE, inform the other TSOs of the LFC block and, together with the TSOs of the LFC block, implement coordinated actions to reduce the FRCE. This responsibility is explained in the Explanatory Document for the methodology for coordinated actions aiming to reduce FRCE, referred to in 5.4.2 Coordinated actions aiming to reduce the FRCE and 5.4.3 Measures to reduce the FRCE by requiring changes in the active power production or consumption of power generating modules and demand units. SOGL 152(12)-(13) and (14)

In specific situations when market-based arrangements will not be sufficient to balance the LFC block, the LFC block monitor shall, together with the TSOs of the LFC block, implement coordinated actions to reduce the FRCE (see section 5.4.2 Coordinated actions aiming to reduce the FRCE).

3.3.3 Other allocation of responsibilities agreed between the TSOs

Svenska Kraftnät has coordination tasks for Fast Frequency Reserves (FFR) as described in chapter 13.

Statnett (LFC block monitor) has coordination tasks for allocation of manual load and production shedding as described in chapter 14.3.

Operational instructions LFCR303 and LFCR304

Responsibilities for calculation and reporting tasks:

Tasks	As is	End state
Yearly calculation of FCR distribution between TSOs for next year (SOGL art 153 (1) and (2))	Statnett	Svk
Yearly calculation of FRCE target level for next year (SOGL art 128 (1))	Statnett	Statnett
Annual report to ENTSO-E for FRCE compliance (SOGL art 16)	Statnett	Statnett
Weekly frequency report	Statnett	Svk
Static dimensioning tool (hosting) and static calculation for the LFC block	Statnett	Not decided
Yearly calculation of frequency quality previous year (SOGL art 127(9))	Statnett	Svk
FFR forecasting tool (hosting) and calculation of the FFR procurement needs on daily basis.	Svk	Svk
Calculation and correction of time deviation	Statnett	Svk

The ambition is to change responsibilities for tasks within 3-5 years from January 2024.

3.4 Rules & Methodologies

3.4.1 Frequency quality defining parameters

SOGL 127 (1)-(3) and (5)-(6) SOGL Annex III, table 1

Table 1 of Annex III of SOGL provide default values for all synchronous areas. These values are confirmed in article 3 of the methodology:

"Nordic synchronous area proposal for the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127" and its Explanatory Document[1].

3.4.2 Frequency quality target parameters

SOGL 127 (4)-(6) SOGL Annex III, table 2

Table 2 of Annex III of SOGL provide default values for all synchronous areas. Article 4 of the methodology below specifies the additional Nordic aim of frequency deviations outside the standard frequency range per year and how to calculate the minutes.

[1] As this methodology has been approved by the NRAs, the methodology is in fact not a proposal anymore. However, the name of the approved methodologies has not changed after approval.

"Nordic synchronous area proposal for the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127 and its Explanatory Document[1].

3.4.3 FRCE target parameters for Nordic LFC block

SOGL 128
Operational Instruction LFCR302
Appendix 1

The Nordic synchronous area consists of only one LFC block. Consequently, the quality target parameter for the LFC block shall be the same as for the synchronous area and based on system frequency deviation. In accordance with article 127 of the SOGL, the TSOs apply the 'frequency quality target parameter' (see section 3.4.2 Frequency quality target parameters) for the synchronous area which is considered the main quality target parameter for the Nordic synchronous area. Using the procedure in section 3.5.1 Calculation of level 1 and level 2 FRCE target parameters, this target parameter has been converted into FRCE target parameters for the LFC block to comply with article 128. It has to be noted that monitoring compliance with the FRCE target parameters shall result in the same conclusions as for monitoring the frequency quality target parameter.

In addition to the FRCE target parameter based on the target frequency quality parameter as specified in accordance with SOGL, the TSOs will also determine the aimed FRCE target parameter based on the aimed frequency quality of 10 000 minutes as specified in the methodology referred to in section 3.4.2 Frequency quality target parameters. The calculation will also use the procedure in section 3.5.1, but now with for the 'aimed frequency quality' instead of the frequency quality target parameter. The aimed FRCE target parameters are not legally binding.

SOGL 128(1)

The Nordic TSOs shall at least annually specify the values of the level 1 and level 2 FRCE target parameters based on the maximum number of minutes outside the standard frequency range specified in section 3.4.2. These parameters are included in Appendix 1.

3.4.4 FRCE target parameters for Nordic LFC areas

SOGL 128(4)
SOGL 128(8)
Operational instruction LFCR302

The LFC block structure (see section 4.2.2 Determination of LFC blocks) divides the Nordic synchronous area in LFC areas corresponding to the bidding zones. 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 as explained in section 5.3.2. This means that FRCE for LFC areas is not directly controlled. The Nordic TSOs have defined a methodology for calculating FRCE values on LFC block level. Furthermore, the TSOs have agreed about a process to follow up ACE performance on LFC area level in a separate internal document.

3.4.5 Methodology to assess the risk and the evolution of the risk of exhaustion of FCR

SOGL 131(2)

The Nordic TSOs define 'the risk of exhaustion of FCR' as the situation in which insufficient FCR-D is available to mitigate the reference incident. FCR-D is dimensioned to cover the reference incident of the synchronous area (see section 6.4.2 Dimensioning rules for FCR-D). Under the assumption that only the dimensioned FCR-D is available, it can be stated that as soon as some FCR-D is activated there is not sufficient FCR-D left to cover the reference incident. Consequently, a 'risk of exhaustion of FCR' exists. Since FCR-D is activated only if the system frequency is outside the ± 100 mHz range (see section 6.4.5 Additional properties of the FCR-D), a 'risk of exhaustion of FCR' exists if the system frequency is outside the ± 100 mHz range. On a yearly basis the Nordic TSOs therefore measure 'the risk of exhaustion of FCR' as the time that the system frequency is outside the ± 100 mHz range. Because the ± 100 mHz range is equal to the standard frequency range (see section 3.4.1 Frequency quality defining parameters), reporting on fulfilment of the frequency quality target parameter also covers assessing the risk and the evolution of the risk of exhaustion of FCR.

Note: The most important reason for the Nordic TSOs to apply the 'time outside the standard frequency range (± 100 mHz)' as their main frequency quality parameter is that outside this range the probability increases that insufficient FCR-D will be available to cover the reference incident – and consequently emergency measures, including automatic Low Frequency Demand Disconnection (LFDD) may be activated. It shall be noted that the 'time outside the standard frequency range (± 100 mHz)' does not consider probabilistic considerations such as the different probability and impact at different frequency deviation levels or the probabilities of incidents of different sizes.

3.4.6 Calculation of the control program from the netted area AC position with a common ramping period for ACE calculation for a synchronous area with more than one LFC area

SOGL 136

The current situation for FRR activation is described in chapter 2.7 and in more detail in section 5.3.2. A ramping period of -/+ 5 minutes around MTU shift shall be applied for intended exchange between TSOs.

3.4.7 Restrictions for the active power output of HVDC interconnectors between synchronous areas

SOGL 137(1)-(3)

Since the Nordic synchronous area only consists of one LFC block, the HVDC interconnectors to other LFC blocks are always HVDC interconnectors to other synchronous areas. The restrictions for the active power output of HVDC interconnectors between synchronous areas as referred to in Article 137(1) and (2) of the SOGL shall therefore be the same as the restrictions for the active power output of the HVDC interconnectors referred to in Article 137(3). This section therefore covers both. The ramping restrictions for HVDC interconnectors to other synchronous areas are specified in Article 3-6 of the methodology below.

"Amended Nordic synchronous area methodology for ramping restrictions for active power output in accordance with Article 137(3) and (4)" and its Explanatory Document.

3.4.8 Measures to support the fulfilment of the FRCE target parameter of the LFC block and to alleviate deterministic frequency deviations, taking into account the technological restrictions of power generating modules and demand units

The measures on power generating modules and demand units to fulfil the FRCE target parameters of the LFC block are specified in article 7 of the methodology below. SOGL 137(4)

"Amended Nordic synchronous area methodology for ramping restrictions for active power output in accordance with Article 137(3) and (4)" and its Explanatory Document.

3.5 Operational Procedures

3.5.1 Calculation of level 1 and level 2 FRCE target parameters

SOGL 128

Operational Instruction LFCR302

Appendix 1

The TSOs shall calculate level 1 and level 2 FRCE target parameters for the Nordic LFC block and the LFC areas on a yearly basis.

This section describes the assumptions and the main steps of the methodology for the determination of FRCE target parameters for the LFC block as required by SOGL Article 118(1)(d).

The methodology is based on the following simplifying assumptions:

1. The frequency behaviour can be considered as a sum of two uncorrelated components, the quarter-hourly frequency average (f_{qh}) and the deviation from this average, the frequency noise (Δf_{noise}).
2. Both signals, f_{qh} and Δf_{noise}, can be approximately modelled as normal distributions with mean value equal to zero.

The main steps for the calculation of level 1 and level 2 FRCE target parameters for the Nordic LFC block are the following:

- Calculate the frequency noise distribution;
- Calculate the distribution of quarter-hourly frequency average values which after convolution with the frequency noise distribution will fulfil the frequency quality target parameter (15 000 minutes) and the aimed frequency quality (not more than 10 000 minutes) outside ±100 mHz;
- Calculate the frequency deviations for the probabilities defined by level 1 and level 2.

The determination of FRCE target parameters is based on frequency data for at least one year with a measurement interval equal to or shorter than one second: the instantaneous frequency data *f*.

Step 1: the average frequency f_{qh} for each quarter of an hour[2] is calculated from the instantaneous frequency data f.
In order to obtain the frequency deviation noise Δf_{noise}, f_{qh} is subtracted from the frequency f, i.e.

$$\Delta f_{noise} = f - f_{qh}$$

The standard deviation of Δf_{noise} (σ_{noise}) shall be calculated.

Step 2: SOGL Article 127(3) and Article 127(4) require that the range of ±100 mHz must not be exceeded for more than 15 000 minutes per year. Assuming a normal distribution, the standard deviation of the frequency σ_f is 46 mHz.

Step 3: the value σ_{qh}, which represents the standard deviation for an allowed normal distribution of the quarter-hourly average frequency deviation, is calculated based on the assumption that the two signals are not correlated:

$$\sigma_{qh} = \sqrt{\sigma_f^2 - \sigma_{noise}^2}$$

Step 4: the ranges which correspond to the probabilities required by SOGL Article 128(3) are calculated taking σ_{qh} as basis:

For the FRCE target parameter level 1, 30 % of the quarter hours may be outside the range. For a normal distribution with mean equal to zero, 30 % is outside a range of 1,04 σ. Consequently, the level 1 range is calculated by:

$$r_{level\,1} = \sigma_{qh} \cdot 1{,}04$$

For the FRCE target parameter level 2, 5 % of the quarter hours may be outside the range. For a normal distribution with mean equal to zero, 5 % is outside a range of 1,96 σ. Consequently, the level 1 range is calculated by:

$$r_{level\,2} = \sigma_{qh} \cdot 1{,}96$$

[2] To be calculated between minutes 0:00-14:59, 15:00-29:59, 30:00-44:59, 45:00-59:59 of each hour of the day.

4 Load-frequency control structure

4.1 Objective

Part IV (load-frequency control and reserves) of the SOGL explicitly formulates an obligation for TSOs to take over responsibility for load-frequency control processes and the respective quality. At the same time the SOGL has to consider the fact that due to the physical properties of synchronously operated transmission systems, system frequency is a common parameter of the whole synchronous area on all voltage levels. For this reason, all TSOs operating in a synchronous area are obliged to cooperate and are also depending on cooperation in order to keep the system frequency within acceptable ranges.

In order to organise the cooperation of TSOs in an efficient way and to ensure the operational security, the cooperation among TSOs requires a clear definition of responsibilities for load-frequency control processes, organisation of reserve availability and assignment of individual quality targets.

The SOGL tackles the definition of these responsibilities in a harmonised way for all synchronous areas by formulation of requirements for the load-frequency control structure which has to be implemented and operated in each synchronous area by all TSOs according to Article 139(1):

'All TSOs of each synchronous area shall specify the load-frequency-control structure for the synchronous area in the synchronous area operational agreement. Each TSO shall be responsible for implementing the load-frequency-control structure of its synchronous area and operating in accordance with it.' SOGL 139(1)

The objective of this chapter 4 of the SOA/LFCR annex is to specify the load-frequency-control structure for the synchronous area

4.2 High-level Concept

4.2.1 Load-Frequency-Control structure

SOGL 139

The load-frequency control structure of each synchronous area shall include:

SOGL 139(2)
SOGL 140
SOGL 141

a) a process activation structure; and

b) a process responsibility structure.

The process activation structure defines:

- mandatory control processes which have to be implemented and operated by one or more TSOs in each synchronous area; and
- optional control processes which may be implemented and operated by the TSOs in each synchronous area.

Accordingly, the process responsibility structure defines:

- obligations for TSOs to operate and apply control processes for the respective geographical areas (monitoring areas, LFC areas, LFC blocks and synchronous areas); and

- the responsibilities and obligations related to the control processes applied for geographical areas.

4.2.1.1 Process activation structure

SOGL 139(2)

The process activation structure of the Nordic synchronous area includes: SOGL 140

- *Frequency Containment Process (FCP)*, applying both FCR for normal situation (FCR-N) and FCR for disturbances (FCR-D), which is described in chapter 6; SOGL 142
- *Frequency Restoration Process (FRP)*, applying both manual FRR and automatic FRR, which is described in chapter 7; SOGL 143
- *Cross-border FRR activation*, which is described in chapter 9; SOGL 147
- *Time control process*, which is described in chapter 10. SOGL 181

4.2.1.2 Process responsibility structure

SOGL 139(2)

Section 4.3 describes the roles and responsibilities that together form the Process responsibility structure. SOGL 140

4.2.2 Determination of LFC blocks

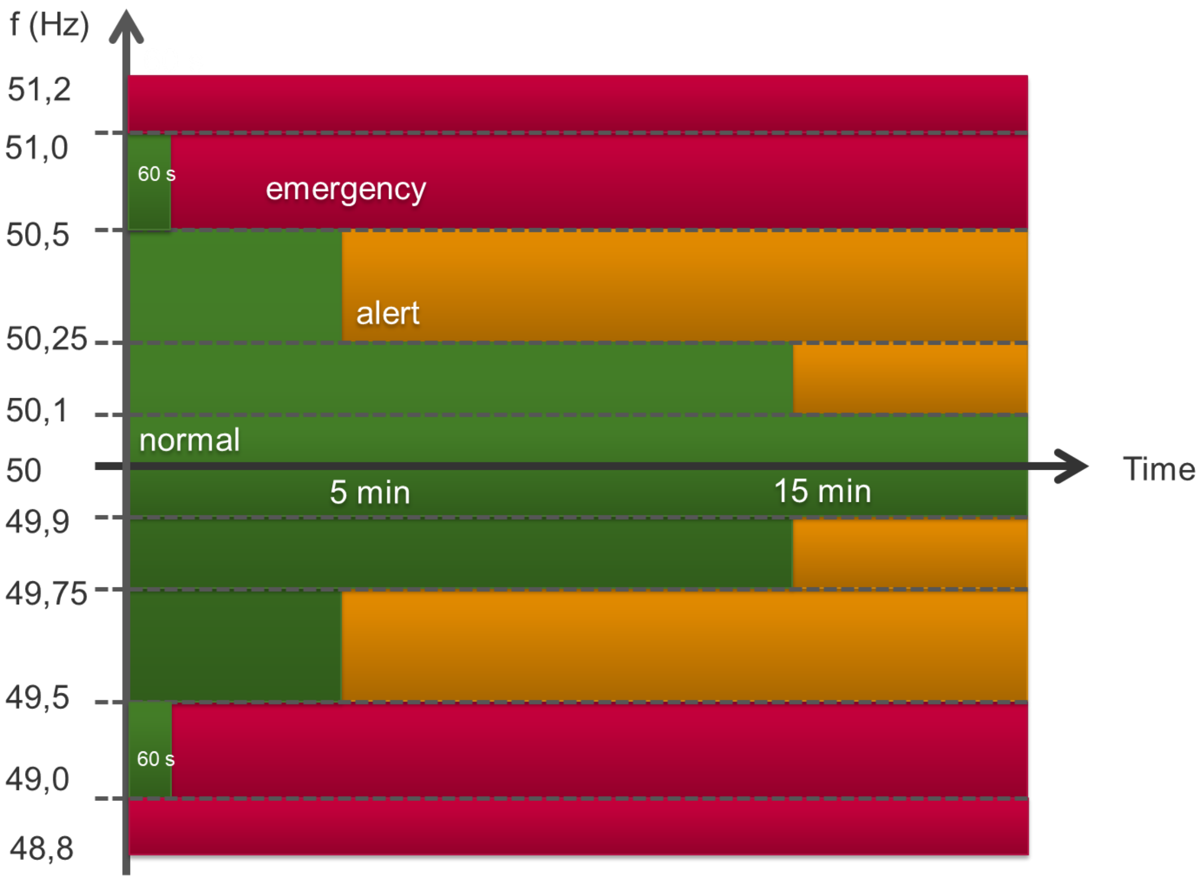
The TSOs have agreed about one common Nordic LFC block, 11 LFC areas/Monitoring area for the synchronous area in article 3 of the methodology below: SOGL 141(2)

ARTICLE 3 of "Nordic synchronous area for the determination of LFC blocks within the Nordic synchronous area in accordance with Article 141(2)" and its Explanatory Document.

4.2.3 System states in relation to frequency

SOGL 18

The system states in general are defined in Annex Operational Security Section 2. The figure below illustrates the specifications related to system frequency.



The figure above shows the definition of the different systems states with regard to system frequency in SOGL article 18 and Table 1 'Frequency quality defining parameters of the synchronous areas' in annex III of the SOGL. The figure is developed assuming an incident at time zero. This Annex and SOGL apply to the Normal and Alert State. The annex on Emergency and Restoration and the Network Code on Emergency and Restoration apply to the Emergency State.

4.3 Roles & Responsibilities

4.3.1 Allocation of responsibilities with respect to the process responsibility structure

SOGL 141(6)+(10)
SOGL 141(5)+(9)

In accordance with SOGL article 141, all Nordic TSOs together shall perform the tasks in the first column of the table below. The second column of the tables below indicates the allocation of responsibilities between TSOs for the implementation of these obligations.

For facilitation of tasks where all TSOs are collectively responsible, see also section 3.3.3.

Obligation in SOGL article 141(6)	Responsibilities
(a) implement and operate a frequency containment process for the synchronous area;	Each TSO is responsible for the implementation and operation of the frequency containment process in their control area.
(b) comply with FCR dimensioning rules	Each TSO is responsible for providing the required information for FCR dimensioning and determination of the shares of each TSO as initial FCR obligation. All TSOs are responsible for calculating the required FCR-N and FCR-D volumes and the shares of each TSO in accordance with the methodologies specified in section 6.4.1 and 6.4.2.
(c) endeavour to fulfil the frequency quality target parameters	Each TSO individually and all TSOs together shall endeavour to fulfil the frequency quality target parameters specified in section 3.4.2.
Obligation in SOGL article 141(4-5)	**Responsibilities**
(a) endeavour to fulfil the FRCE target parameters of the LFC block	Each TSO individually and all TSOs together shall endeavour to fulfil the frequency and FRCE target parameters (see section 3.4.2). Statnett shall maintain and operate the Nordic LFC controller and distribute the aFRR activation volume to the TSOs according to commonly agreed principles.
(b) comply with the FRR dimensioning rules in accordance with Article 157 and the RR dimensioning rules in accordance with Article 160.	The TSOs have agreed about a minimum dimensioning of FRR per LFC area. Each TSO is responsible for the final FRR dimensioning for its own control area. RR is currently not applied.

4.3.2 Allocation of responsibilities for imbalance netting and cross-border control processes

The tables below indicate the allocation of responsibilities between TSOs for imbalance netting and cross-border control processes.

SOGL 149(2)

Obligation in SOGL article 149(2)	Responsibilities
Implementing an imbalance netting process	All TSOs which participate in the same mFRR activation arrangement, do also participate in the imbalance netting process between the TSOs. Imbalance netting is being handled by the Nordic AOF.

Cross-border FRR activation process or a cross-border RR activation process between LFC areas of different LFC blocks or of different synchronous areas	The Cross-border FRR activation process is a responsibility of the TSOs involved in FRR cross-border activation, as explained in section 5.3.2. Since RR is not used at this moment, RR is considered not applicable.
Obligation in SOGL article 149(3)	**Responsibilities**
The provision of all input data necessary for: (i) the calculation of the power interchange with respect to the operational security limits; and the performance of real-time operational security analysis by participating and affected TSOs;	Each TSO is responsible for providing the required information for performing the imbalance netting process and cross-border FRR activation process.
The responsibility of calculating the power interchange	All TSOs are responsible for calculating the power interchange resulting from the imbalance netting process and cross-border FRR activation process
The implementation of operational procedures to ensure the operational security.	Each TSO is responsible for implementation of operational procedures to ensure the operational security.

4.3.3 Appointment of TSO responsible for the automatic Frequency Restoration Process

SOGL 143(4)

The LFC block structure (see section 4.2.2 Determination of LFC blocks) divides the Nordic synchronous area into LFC areas corresponding to the bidding zones. However, the existing situation is that the frequency restoration process for aFRR is based on frequency deviation as explained in section 5.3.2. This means that there is one common automatic LFC controller operated in the Nordic LFC block. Statnett has the specific responsibility for the implementation and operation of this automatic LFC controller.

4.3.4 Appointment of TSO to calculate, monitor and take into account the FRCE of the whole LFC block

SOGL 145(6)

The TSOs do not currently make use of their right to appoint a TSO to calculate, monitor and take into account the FRCE of the whole LFC block in accordance with SOGL article 145(6) Statnett will calculate and monitor the FRCE of the whole LFC block in accordance with SOGL article 145(6) (see also 4.5), but Statnett will not take into account the FRCE of the whole LFC block.

4.4 Rules & Methodologies

4.4.1 Requirements concerning the availability, reliability and redundancy of the technical infrastructure

SOGL 151(2)-(3)

SOGL 151(1)

Technical infrastructure that is required for the processes referred to in the process activation structure (see section 4.2.1 Load-Frequency-Control structure) include:

- Digital control systems such as
  - SCADA/LFC systems
  - Information systems like the Nordic Operation Information System (NOIS)
  - Telephone/messaging systems
  - Common balancing service systems for:
    - Bid selection using Nordic AOF
    - Nordic pricing
    - Situation awareness

- Communication links between the Digital control systems of the Nordic TSOs.

4.4.1.1 Availability, reliability and redundancy of Digital control systems for frequency containment process and frequency restoration process

Digital control systems required for frequency containment process and frequency restoration process have to be available seven (7) days a week and twenty-four (24) hours per day during the whole year. The TSOs shall ensure that the functions in these systems that are related to the frequency containment process and frequency restoration process run with a minimum of interruptions twenty-four (24) hours per day through the year.

SOGL 151(2)(b)

The hardware and software architecture and application design of the Digital control systems required for frequency containment process and frequency restoration process shall be such that normal daily and monthly maintenance does not require system shutdowns and system can be used uninterruptedly. However, during planned maintenance, for example in major hardware or software upgrades, downtime less than 1–2 hours can still be considered acceptable not more than once per month.

SOGL 151(2)(b)

The availability of the functions in these systems that are related to the frequency containment process and frequency restoration process shall be at least 99,5 % as an average over the calendar year, excluding planned maintenance. Short occasional interruptions (10–20 minutes) are allowed once a week. Planned maintenance pauses are acceptable once a month. All TSOs shall be informed of planned maintenance breaks at least twenty-four (24) hours in advance. Planned maintenance can be cancelled at all time on request from one of the TSOs.

4.4.1.2 Availability, reliability and redundancy of Communication links between Digital control systems for frequency containment process and frequency restoration process

The communication lines between the Nordic TSOs and between the Nordic TSOs and other European TSOs are part of the so-called Electronic Highway (EH). The availability and redundancy of the EH are described on a European level.

SOGL 151(2)(c)

4.5 Operational Procedures

SOGL 152(12-14)

Operational instruction LFCR500

The LFC block monitor will, in cooperation with the Synchronous area monitor, follow the development of the frequency. In case of large or long-lasting frequency deviations, the two monitors will check if the deviations can be seen in FRCE in one or some LFC areas. If so, the LFC block monitor will take contact with relevant TSO(s) to find relevant mitigating measures. If no such correlation can be found, the default solution will be that the LFC block monitor will define and inform TSOs about an equally distributed correction factor for each TSOs request for the next scheduled mFRR activation cycle. In some situations, congestions in the grid may lead to that the LFC block monitor will have to deviate from the rule with equally distribution of correction factor. If the situation does not allow for the procedures above, LFC block monitor will request proper direct actions.

5 Operation of load-frequency control

5.1 Objective

The objective of this chapter 5 of the SOA/LFCR annex is to set out the rules for the operation of the load-frequency-control structure for the synchronous area that is specified and explained in chapter 4.

5.2 High-level Concept

This chapter 5 specifies the operational roles, responsibilities, rules and methodologies of the load-frequency-control structure for the synchronous area of which the high-level concept is discussed in section 4.2.

5.3 Roles & Responsibilities

5.3.1 General

The roles and responsibilities are discussed in general in section 4.3.

5.3.2 Nordic Balancing

Balancing shall be conducted in such a way that activations take place with the lowest cost considering congestions in the grid, current legislation and secure operations. There may be two reasons for activations, *activation for balancing purpose* and *activation for system constraints* as specified in the SOA Annex Electricity Balancing art. 1(6).

The Nordic TSOs cooperate in balancing by netting their imbalances and using the most efficient balancing resources. Most of the balancing is expected to be performed as scheduled activation of mFRR and based on the output of the AOF. The following describes the Nordic balancing in normal and alert state as well as preparation for emergency state. Further details are described in Nordic Operational Instruction LFCR500. Actions in Emergency state are described in the Annex Emergency and Restoration.

Operational instruction LFCR500

5.3.2.1 Responsibilities and cooperation in balancing

The main principle is that each TSO is responsible for operational security in their control area and national security of supply. More specifically, all TSOs are responsible for maintaining sufficient FCR and FRR reserves (see sections 6.4 and 7.4), mitigating the imbalances in their own LFC areas and the required (IT) systems to perform balancing. Each TSO is responsible for limiting the imbalance in their LFC areas to maintain frequency quality and system security in the LFC block. Each TSO is also responsible for backup arrangements and remedial actions in case available FRR reserves for their control area are exhausted.

The TSOs shall cooperate to maintain the frequency quality in accordance with the frequency quality target parameters for the Nordic synchronous area described in section 3.4.2, the FRCE target parameters for Nordic LFC areas described in section 3.4.3 and the rules on electrical time deviation in section 10.4.1.

Statnett and Svenska kraftnät in their roles as LFC block monitor and synchronous area monitor for the Nordic synchronous area, will have the coordinating task of maintaining the system frequency and time deviation within the set limits specified in section 3.4 and 10.4. Sections 3.3.1 and 3.3.2 describe the specific responsibilities of the synchronous area monitor and the LFC block monitor. Section 3.3.3 specifies the allocation to TSOs of some common Nordic tasks not described in SOGL.

SOGL 152(1)

Operation instruction LFCR500

The distribution of common Nordic tasks between Svenska kraftnät and Statnett is described in more detail in operational instruction LFCR303 for Synchronous area monitor and LFCR304 for LFC block monitor.

The balancing processes are described in operational instruction LFCR500.

5.3.3 ACE calculations on LFC area level

Each TSO shall calculate their ACE OL on LFC area level according to specifications in Operational instruction LFCR500, Appendix 6 Local calculations of ACE OL. The calculations will be distributed to all TSOs continuously (each minute). These calculations are input to the decisions related to mFRR activations mainly using the common Nordic AOF.

Operation instruction LFCR500

In addition each TSO shall distribute "satisfied demand" for confirmed mFRR activations for balancing (scheduled + direct (standard and non-standard)) to the other TSOs.

Based on the information above, an approximate remaining imbalance for each LFC area can be calculated with quarterly resolution ex post as the difference between ACE OL and satisfied demand.

In addition, some TSOs have calculations of ACE in their Scada systems. These calculations do not consider any FRR activations and are only used as indicators to detect location for incidents quickly.

5.3.4 Balancing in Western Denmark (DK1)

Balancing in Western Denmark shall take place so that the requirements concerning Western Denmark as a LFC area in Continental Europe are met on the cross-border links between Germany and Jutland.

Western Denmark is included in the Nordic mFRR activation process.

5.3.5 Identification of limits in SOGL article 152(12)-(13)

The LFC block monitor (referred to in section 3.3.2 LFC block monitor) is responsible for identifying any violation of the limits in SOGL article 152 (12)-(13) and shall inform the other TSOs of the Nordic LFC block. The limits in SOGL article 152 (12)-(13) are interpreted for the Nordic situation as follows:

SOGL152(14)(a)

SOGL 152(12)-(13)

- The limit in paragraph 12 is specified as "the 1-minute average of the FRCE of a LFC block is above the Level 2 FRCE range (as specified in section 3.4.3) at least during the time necessary to restore frequency (15 minutes) (as specified in section 3.4.1)".
- The limit in paragraph 13 is specified as *"FRCE of a LFC block exceeds 25 % of the reference incident of the synchronous area for more than 30 consecutive minutes"*. The largest reference incident of the Nordic synchronous area is approximately 1 400 MW. Consequently, 25 % of the reference incident is approximately 350 MW, which needs to be converted to a frequency deviation. Assuming 7 000 MW/Hz, this will result in approximately 50 mHz. Consequently, the limit means for the Nordic synchronous area that *'where the frequency deviation exceeds 50 mHz for more than 30 consecutive minutes'*.

The Nordic TSOs aim for keeping the frequency close to 50.00 Hz, e.g. in order to avoid saturation of aFRR to keep aFRR available for the balancing of stochastic variations of normal imbalances. Breaching of the FRCE/frequency levels described above may be incidental, but the LFC block monitor shall check with relevant TSOs with imbalances which actions are taken to reduce imbalances or if additional actions are needed.

5.4 Rules & Methodologies

5.4.1 Common rules for the operation in normal state and alert state

SOGL152(6)
Operational Instructions LFCR500

1. During the operational hour the TSOs' operators follow the trend of the operational situation and continuously estimate upcoming need of readjusting the balancing. In normal and alert state conditions TSOs use automated and manual market based FRR activation as long as possible. These include:
   a. mFRR activation (see section 5.3.2 Nordic Balancing);
   b. aFRR activation (see section 5.3.2).
2. Before and during the operational hour the TSOs' operators continuously monitor the availability of mFRR capacity, both in upward and downwards direction and in all relevant geographic areas.

5.4.2 Coordinated actions aiming to reduce the FRCE

SOGL152(15)
SOGL152(14)

In specific situations when market-based arrangements will not be sufficient to balance the LFC block e.g. when the TSOs' operators expect that there will be a shortage on mFRR bids, the TSOs' operators shall use the actions in article 3 of the methodology below:

Operational Instructions LFCR500

"Amended Nordic synchronous area proposal for coordination actions aiming to reduce FRCE as defined in Article 152(14) and measures to reduce FRCE by requiring changes in the active power production or consumption of power generating modules and demand units in accordance with Article 152(16)" and its Explanatory Document[3].

5.4.3 Measures to reduce the FRCE by requiring changes in the active power production or consumption of power generating modules and demand units

SOGL152(16)

Operational Instructions LFCR500

If the system is in alert state and measures under 5.4.2 will not be sufficient to limit the risk of entering into the emergency state to remedy the situation, the TSOs' operators shall use the actions in article 4 of the methodology below:

"Amended Nordic synchronous area proposal for coordination actions aiming to reduce FRCE as defined in Article 152(14) and measures to reduce FRCE by requiring changes in the active power production or consumption of power generating modules and demand units in accordance with Article 152(16)" and its Explanatory Document[3].

5.4.4 Calculation of ATC for balancing energy exchange

The ATCs for balancing energy exchange, will be calculated automatically and updated during the balancing process for each bidding zone border. However, operators shall adjust the ATCs manually if needed.

As long as the intraday time frame cannot handle flowbased, an extraction of NTC values for exchange capacity on bidding zone borders must be made.

5.5 Operational Procedures

5.5.1 Operational procedures to reduce the system frequency deviation to restore the system state to normal state and to limit the risk of entering into the emergency state

SOGL 152(10)

Since the Nordic synchronous area only consists of one LFC block, reducing frequency deviation is the same as reducing FRCE of the LFC block. This has been described in section 5.4.1 Common rules for the operation in normal state and alert state, 5.4.2 Coordinated actions aiming to reduce the FRCE and 5.4.3 Measures to reduce the FRCE by requiring changes in the active power production or consumption of power generating modules and demand units.

5.5.2 Operational rules

The exchange of energy between TSOs is divided in intended and non-intended exchange. Intended exchange means automated exchange on interconnections between TSOs for balancing or netting by the common AOF.

[3] As this methodology has been approved by the NRAs, the methodology is in fact not a proposal anymore. However, the name of the approved methodologies has not changed after approval.

Intended exchange between LFC areas, as a result of the activation process, shall be specified with balancing purpose/category.

Two Nordic TSOs can in addition agree on an Agreed Supportive Power (ASP) by exchange of a standard or non-standard product. This exchange is performed in case of needs other than scheduled activation or netting. The procedures for this are specified in the operational instruction LFCR500.

Operational Instruction LFCR500

5.5.3 Operational procedures in case of exhausted FRR or RR

The procedure in case of exhausted FRR is described in chapter 14 of this annex and more detailed in LFCR500. The annex Emergency and Restoration describes procedures in Emergency and Restoration state. RR is currently not applied by the Nordic TSOs.

SOA annex ER

Operational Instruction LFCR500

6 Frequency containment reserves

6.1 Objective

The objective of the Frequency Containment Process (FCP) is to stop the frequency increase or decrease before the instantaneous frequency deviation reaches the maximum instantaneous frequency deviation and consequently to stabilise the frequency deviation at a steady-state value not more than the permissible Maximum steady-state frequency deviation. The objective shall be met by a joint action of FCR within the whole synchronous area.

At times of low system inertia, the FCP process is supported by Fast Frequency Reserve (FFR) which is described in chapter 13.

6.2 High-level Concept

6.2.1 Nordic FCR implementation

The Nordic Frequency Containment Process (FCP) applies two types of Frequency Containment Reserves (FCR), which are explained below.

6.2.1.1 Frequency Containment Reserve - Normal (FCR-N)

The objective of FCR for normal operation (FCR-N) is to ensure continuous frequency stability within the standard frequency range (± 100 mHz). FCR-N is a specific Nordic product that is active between 49,90 Hz and 50,10 Hz.

6.2.1.2 Frequency Containment Reserve - Disturbance (FCR-D)

The purpose of FCR-D is to mitigate the impact of incidents in either direction in the synchronous area. FCR-D upwards is activated when the system frequency drops below 49,90 Hz while FCR-D downwards is activated when the frequency raises above 50,10 Hz. The objective of FCR-D is to facilitate:

- that the maximum frequency deviation does not exceed the maximum instantaneous frequency deviation (see section 3.4.1 Frequency quality defining parameters); and
- continuous frequency stability outside the standard frequency range (see section 3.4.1).

6.3 Roles & Responsibilities

6.3.1 Responsibility for FCR dimensioning

6.3.1.1 Responsibility for FCR-N dimensioning

Section 6.4.1 Dimensioning of FCR-N defines the amount of FCR-N. All TSOs have the responsibility to calculate the initial distribution of FCR-N in accordance with the rules in section 6.4.3 Calculation the initial distribution per TSO.

6.3.1.2 Responsibility for FCR-D dimensioning

All TSOs have the responsibility to dimension FCR-D in accordance with the rules in section 6.4.2 Dimensioning rules for FCR-D and to calculate the initial distribution of FCR-D in accordance with the rules in section 6.4.3 Calculation the initial distribution per TSO.

6.4 Rules & Methodologies

6.4.1 Dimensioning of FCR-N

FCR-N shall be at least 600 MW.

6.4.2 Dimensioning rules for FCR-D

The rules for dimensioning of Nordic FCR-D are defined in article 3 of the methodology below:

"Amended Nordic synchronous area methodology for the dimensioning rules for FCR in accordance with Article 153" and its Explanatory Document.

SOGL 153
Operational Instruction LFCR602

6.4.3 Calculation the initial distribution per TSO

The distribution of FCR-D between TSOs is defined in article 4 of the methodology below:

"Amended Nordic synchronous area methodology for the dimensioning rules for FCR in accordance with Article 153" and its Explanatory Document.

SOGL 153 (2)(d)
Operational Instruction LFCR601

6.4.4 Additional properties of the FCR-N

The methodology for additional properties for FCR defines the activation criteria and response times for activation for FCR-N in article 3.

"Amended Nordic synchronous area methodology for additional properties of FCR in accordance with Article 154(2)" and its Explanatory Document.

SOGL 154(2)

6.4.5 Additional properties of the FCR-D

The methodology for additional properties for FCR defines the activation criteria and response times for activation for FCR-D in both directions in article 4 and 4a.

"Amended Nordic synchronous area methodology for additional properties of FCR in accordance with Article 154(2)" and its Explanatory Document.

SOGL 154(2)

6.4.6 Minimum activation period to be ensured by FCR providers with limited energy resource

The minimum activation period is defined in article 3 of the methodology below:

"Nordic synchronous area methodology for the minimum activation period to be ensured by FCR provider in accordance with Article 156(10)".

SOGL 156(10)

6.4.7 Assumptions and methodology for a cost-benefit analysis

The minimum activation period in 6.4.6 is based on an all-Continental Europe and Nordic TSOs' Cost Benefit Analysis in accordance with Article 156(11) of SOGL.

SOGL 156(11)

6.5 Operational Procedures

This section does not have content in the current version of this Annex.

7 Frequency restoration reserves

7.1 Objective

The main purpose of Frequency restoration reserves (FRR) is restoring FRCE of the Nordic LFC areas (ACE), and the Nordic LFC block (frequency deviation of the Nordic synchronous area). Consequently, FRR replaces activations of FCR. FRR shall be sufficiently available to maintain the FRCE quality, and to be within system security limits.

7.2 High-level Concept

In order to fulfil the objective in section 7.1, the high-level concept of FRR includes the characteristics as defined in section 7.2.1 and applies the products defined in section 7.2.2.

7.2.1 Characteristics of FRR

The main characteristics of FRR as applied in the Nordic LFC block are:

- FRR aims to replace FCR activation and to restore the balance of the LFC block and the LFC areas respecting potential congestions in the grid;
- FRR is provided by balancing service providers (BSPs), who shall activate FRR when instructed by their TSO;
- The TSOs' instructions to activate FRR in normal operation can be:
    - Automatically (for aFRR), as an instruction of the TSOs' Load Frequency Controller;
    - Automated for scheduled mFRR activation, as an instruction of the Nordic TSOs' Activation Optimization Function (AOF);
    - Automated or manually for direct mFRR activation, as instructed by the TSOs' dispatchers if needed

7.2.2 FRR products

7.2.2.1 Manual FRR (mFRR)

mFRR shall be activated in order to avoid activation of the faster reserves FCR-N, FCR-D and aFRR or restore these reserves when they have been activated and to control flows in the grid within applicable limits. Two types of activation are used by all Nordic TSOs. Firstly, scheduled activation is used pro-actively based on forecasted imbalance. Scheduled activationcan be used only once per ISP. The other type is direct activation. Direct mFRR activation is applied re-actively following unexpected needs for balancing.
The mFRR shall exist and be localized to the extent that the synchronous area can be balanced at any time.

7.2.2.2 Automatic FRR (aFRR)

The aFRR product shall be seen as an automatic "complement" to mFRR in the Frequency Restoration process. aFRR activations shall handle short term variations in imbalance which are not appropriate to be handled by mFRR activations.

The Nordic LFC block centrally activates aFRR from a single Load Frequency Controller (LFC). Based on the measured frequency, this LFC calculates the required activation of aFRR and distributes the activation requests to the Nordic TSOs pro-rata. Consequently, each Nordic TSO distributes the requests to the contracted aFRR providers in its control area. Statnett and Svenska kraftnät also activate service providers pro-rata while both Fingrid and Energinet use the PICASSO platform for national activation according to merit order.

7.3 Roles & Responsibilities

7.3.1 Responsibility for FRR dimensioning

7.3.1.1 Responsibility for mFRR dimensioning

Each TSO is responsible for the dimensioning of mFRR for their control area and for determining the required geographical distribution of mFRR capacity within their control area. The rules for dimensioning are specified in 7.4.2. SOGL157(3)

7.3.1.2 Responsibility for aFRR dimensioning

Nordic TSOs agree about total Nordic volumes for each hour. The distribution between TSOs is decided by unanimous agreement between TSOs (appendix 1). Each TSO is responsible for the physical availability of aFRR per LFC area. SOGL157(3)

7.4 Rules & Methodologies

7.4.1 FRR dimensioning methodology

An amended methodology for dimensioning of FRR was approved on autumn 2022. It describes the dimensioning when all TSOs are connected to the European platforms for mFRR (MARI) and aFRR (PICASSO) activation respectively. The principles in the dimensioning methodology will be gradually implemented before that. A common Nordic group will continuously assess the reserve needs. The calculations and facilitation are governed by the group and the RCC while each TSO shall approve the end result. SOGL157(1)

The FRR dimensioning is formally regulated in the methodology:

"Amended Nordic LFC block methodology for FRR dimensioning in accordance with Article 157(1)" and its Explanatory Document.

The Full Activation Times (FAT) for automatic FRR and manual FRR are defined in article 4 of the methodology above. The methodology further determines the necessary input to perform the dimensioning (article 5), dimensioning of FRR for disturbances (article 7), dimensioning of FRR for normal imbalances (article 8) and requirements on the total reserve volume on FRR (article 6). The process for FRR dimensioning is described in article 9 and the ratio between mFRR and aFRR is described in article 3.

7.4.2 Current FRR dimensioning

7.4.2.1 mFRR dimensioning rules

The TSOs have agreed about a minimum confidence level corresponding to a minimum FRR capacity. Each TSO can, however, dimension with more reserves than the minimum capacity. Each TSO shall however be able to handle the reference incident of its LFC area(s) at any time which means that remedial actions may have to be used in extreme situations (see chapter 14). The 'reference incident' is defined as 'the largest imbalance that may result from an instantaneous change of active power of a single power generating module, single demand facility, single AC or HVDC interconnector or from a tripping of an AC line within the control area'.

Each TSO will, from implementation of the automated mFRR activation process (mFRR EAM), dimension the needed mFRR capacity for their control area separately. However, some coordination between TSOs is needed e.g. exchange of data including netting/sharing options. The mFRR need is calculated for upwards and downwards separately for each LFC area. Some TSOs will, from mFRR EAM start, use a dynamic dimensioning where FRR need may change each hour, while other TSOs will use static dimensioning where requirements are more firm for longer periods.

TSOs will dimension for Normal imbalance plus Reference Incident. Netting and sharing for handling of Reference Incident considers, and are dependent on, available grid capacity. Dynamic dimensioning of mFRR will make it possible to best estimate the mFRR needed for each hour of the next day. The mFRR need is then evaluated by the individual TSOs, including an assessment of voluntary bids, to find the amount of mFRR capacity to procure in the mFRR capacity market.

The approved minimum confidence interval for LFC areas is defined in Appendix 1.

7.4.2.2 aFRR dimensioning rules

The dimensioned amount of Nordic aFRR capacity shall be based on the targeted frequency quality and FRCE quality specified in section 3.4 and the following:

- Procured Nordic aFRR capacity shall be determined by a common Nordic decision.
- The distribution of aFRR capacity between TSOs shall be based on short term imbalances.
- aFRR shall be available in all hours.
- In case of frequent saturation of aFRR, increased aFRR may be chosen instead of increased use of mFRR direct activations if mFRR is seen unfeasible or inefficient.
- Monitoring of frequency and ACE performance shall be followed up regularly as basis for decision about potential adjustments of the Nordic aFRR capacity requirement.
- Each TSO distributes their national share of the total Nordic volume (see appendix 1 to this annex) as input to the Nordic aFRR capacity market for demand per LFC area. The initial values for this distribution, are set according to the short term imbalances.

7.5 FRR availability requirement

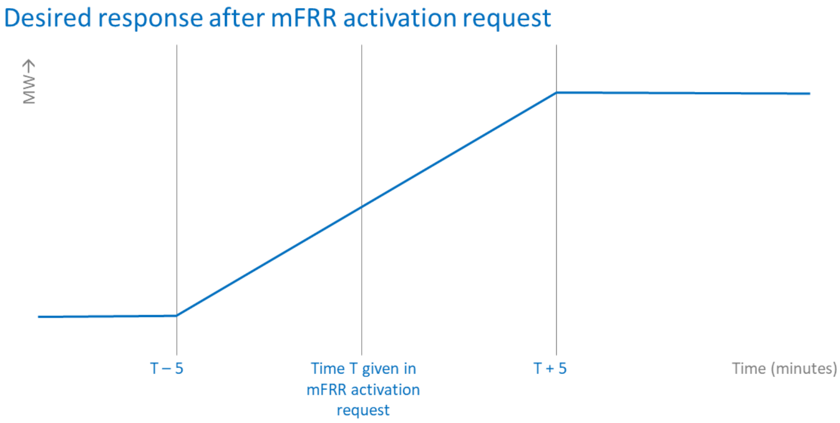
The availability of FRR providing units and FRR providing groups shall be 100 %. SOGL158(2)

7.6 FRR control quality requirement

7.6.1.1 mFRR control quality requirement

The requested mFRR shall be completely activated within the full activation time (FAT) for the bid, which is 12,5 minutes included 2,5 minutes preparation time. SOGL158(2)

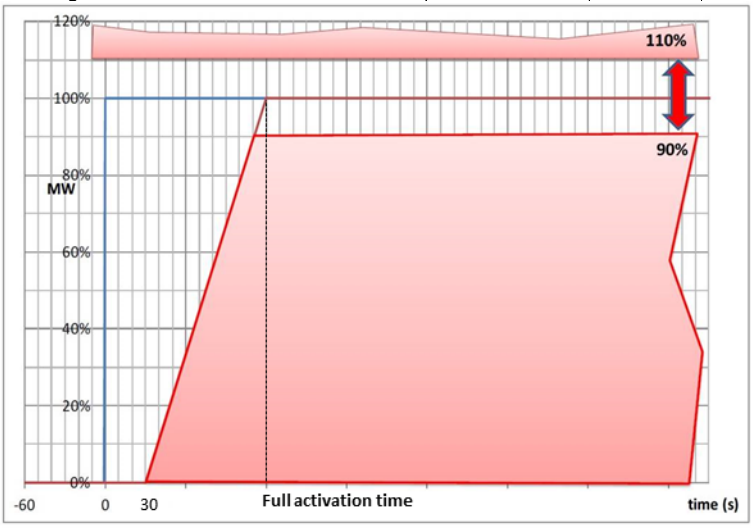
Ideally, the physical response after an activation of mFRR starts 5 minutes before the time given in the activation request and linearly ramps to the volume in the activation request that will be reached after 10 minutes. For de-activation, the ideal response is the same in the other direction.



The response from BSPs may deviate from this profile in practice. Which deviations are permitted is determined by each TSO.

7.6.1.2 aFRR control quality requirement

The requested aFRR shall be completely activated within the specified full activation time (FAT) for the bid in the national market rules. The control quality of an aFRR providing unit or a group of aFRR providing units is defined in terms of how accurately it responds to a change of the set-point. The change of generated power output should be no more than 10 % different from the change in TSO set-point at Full Activation Time; i.e.: If the set-point changes from 20 to 30 MW, the increase of the total generation of the generators should be between 9 and 11 MW. Power output should start within 30 seconds. The figure below shows the envelope for the required response.



7.7 Operational Procedures

7.7.1 Escalation procedure for cases of severe risk of insufficient reserve capacity on FRR

In cases of severe risk of insufficient reserve capacity on FRR, the procedure referred to in section 5.5.3 Operational procedures in case of exhausted FRR or RR will be applied. SOGL157(4)

8 Replacement reserves

Currently not applied in the Nordic synchronous area, therefore this chapter is empty.

9 Exchange and sharing of reserves

9.1 Objective

A geographically even distribution of reserves and a sufficient amount of reserve capacity in the system are key requisites for ensuring operational security. As the exchange of reserves impacts the geographical distribution and the sharing of reserves impacts the reserve capacity within the system, it is important to set technical limits for the exchange and sharing of reserves to maintain operational security. The basic principles for exchange, sharing and the according limits are treated in this chapter.

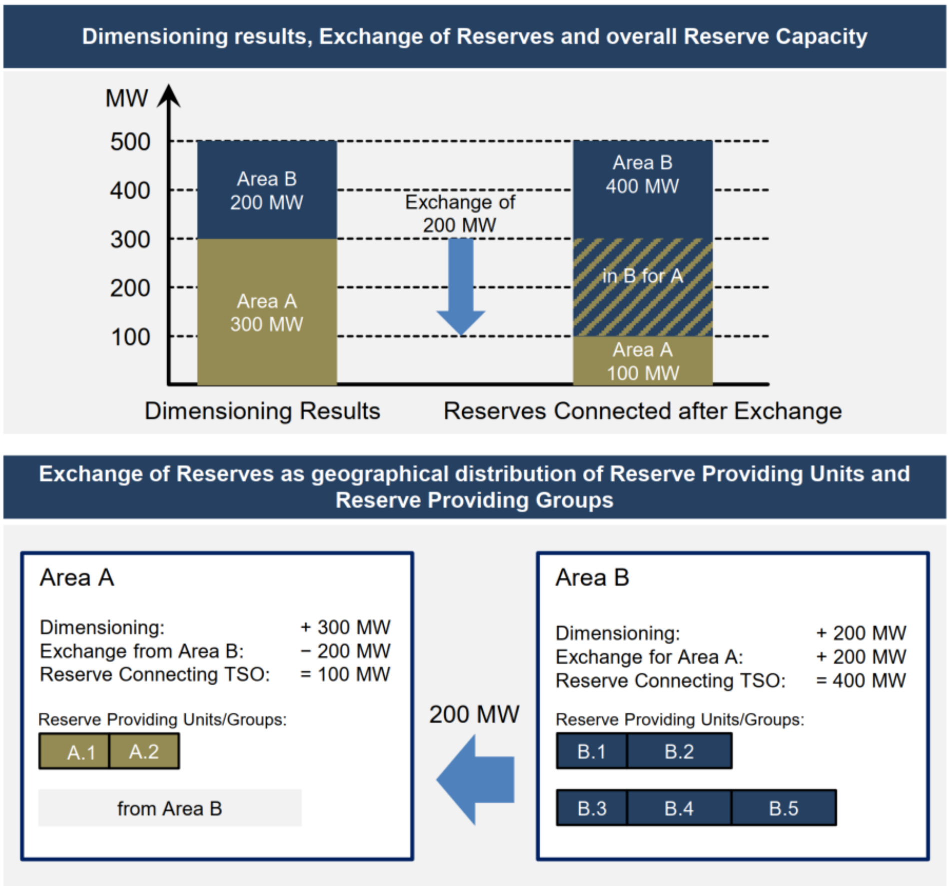
The aim of the exchange and sharing of reserves is to improve the economic efficiency in performing LFC within the pan-European electricity system thereby maintaining the high standards for operational security set forth in the SOGL. Whereas market and optimisation aspects have been defined in the EBGL, the SOGL defines technical limits and requirements to be respected in case of the exchange and sharing of reserve capacity to ensure operational security.

9.2 High-level Concept

9.2.1 Exchange of reserve capacity

The exchange of reserve capacity allows TSOs to organise and to ensure the availability of reserve capacity resulting from FCR dimensioning (see chapter 6) and FRR dimensioning (see chapter 7), by relying on reserve providing units and reserve providing groups which are connected to an area operated by a different TSO.

The figure below illustrates the exchange of 200 MW of reserve capacity (FCR, FRR or RR) from Area B to Area A.



Suppose that the dimensioning results in the need of 300 MW for Area A and 200 MW for Area B. Without the exchange of reserve capacity, the respective reserve capacity has to be provided by reserve providing units or reserve providing groups connected to the Area which means that 300 MW have to be connected in Area A and 200 MW in Area B.

As a result of the exchange of reserve capacity of 200 MW from Area B to Area A, 200 MW of reserve capacity needed for Area A are now located within Area B, whereas Area A still ensures in addition the availability of the full amount of its own reserve capacity.

Although the geographical location of the reserve capacity is different from the dimensioning results for each area, the total amount of reserve capacity within Area A and B is still 500 MW which is equivalent to the total amount without then exchange. The table below shows references to the limits for exchange of FCR and FRR.

Table 3: Exchange limits

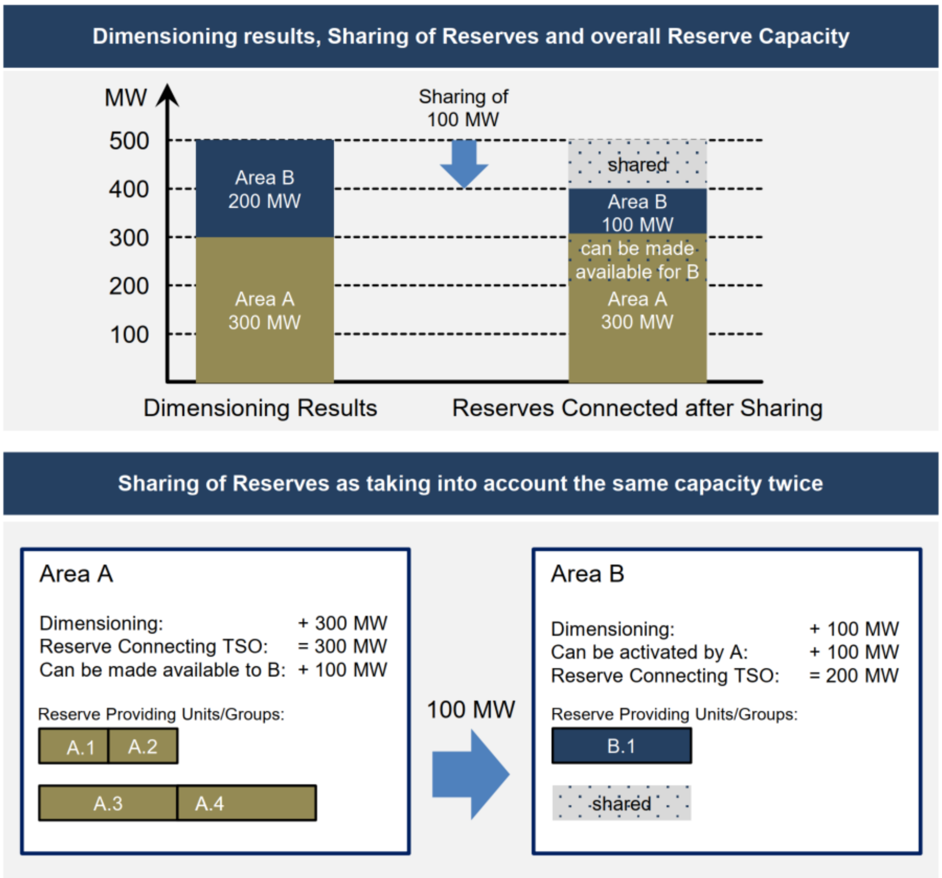
	FCR	FRR	RR
Within Nordic Synchronous areas	See section 9.4.1	No limits defined	RR currently not applied in Nordic SA

Between Synchronous areas	See section 9.4.1	See section 9.4.3	RR currently not applied in Nordic SA

9.2.2 Sharing of reserve capacity in general

The sharing of reserve capacity allows the TSOs to organise and to ensure the availability of reserve capacity resulting from FCR dimensioning (see chapter 6) and FRR dimensioning (see chapter 7), by relying on the same reserve capacity as relied on by a different TSO.

The figure below illustrates the sharing of 100 MW of reserve capacity between the TSOs of Area A and the TSOs of Area B.



Suppose that the Dimensioning Rules for Area A and Area B result in the need of 300 MW FRR for Area A and 200 MW for Area B (same amounts as in the figure above). Without the sharing of reserve capacity, the TSOs of Area A and Area B have to ensure the availability of respectively 300 MW and 200 MW.

However, assuming that in some cases it might be very unlikely that both TSOs need to activate the full amount reserve capacity at the same time, the TSOs of Area A and Area B can 'share' part of their reserve capacity. In practice this means that the TSOs of Area B can make use of e.g. 100 MW of the reserve capacity of the TSOs in Area A. Such an arrangement can be unilateral (TSOs of Area B can make use of 100 MW of the reserve capacity of the TSOs in Area A but not vice versa) or bilateral (in which case the TSOs of Area A can also access 100 MW of the reserve capacity of the TSOs in Area B).

As a result, the TSOs of Area A and Area B now need to ensure the availability of 300 MW and 100 MW. The TSOs of Area A now make 100 MW of their own reserve capacity also available to the TSOs of Area B. The total amount of the reserve capacity within the system is now 400 MW, whereas it was 500 MW without the sharing agreement (leading in this example to reduction of 100 MW of reserve capacity in the total system).

In contrast to the exchange of reserve capacity which only changes the geographical distribution of reserve capacity, the sharing of reserve capacity changes the total amount of active power reserves in the synchronous area, with an impact on the geographical distribution as an additional implicit effect. The sharing agreement defines priority rights to the shared reserve capacity in the situation where both TSOs have a simultaneous need.

Table 4 shows references to the limits for sharing FCR and FRR.

Table 4: Sharing limits

	FCR	FRR	RR
Within Nordic Synchronous areas	Not allowed by SOGL	See section below	RR currently not applied in Nordic SA
Between Synchronous areas	NA	See section below	RR currently not applied in Nordic SA

9.2.3 Nordic sharing principles for mFRR

Generic sharing principles within the Nordic interconnected system, including DK1, are agreed between TSOs for mFRR EAM start and included in the dimensioning calculation, see figure below. The need is found as the summation of Reference Incident (RI) and the normal imbalance (NI), where sharing for RI, and netting for NI can reduce the need for reserves if Cross Zonal Capacity (CZC) is available. For both sharing and netting, a two-step approach is followed, allowing optimization within control areas first, and optimizing cross control area afterwards.

Within a control area, each TSO can freely locate the RI needs in the LFC areas, respecting available CZC after energy markets (unused CZC), while ensuring that the reference incident in each LFC area can be covered, when the total control area need for RI is optimized with sharing.

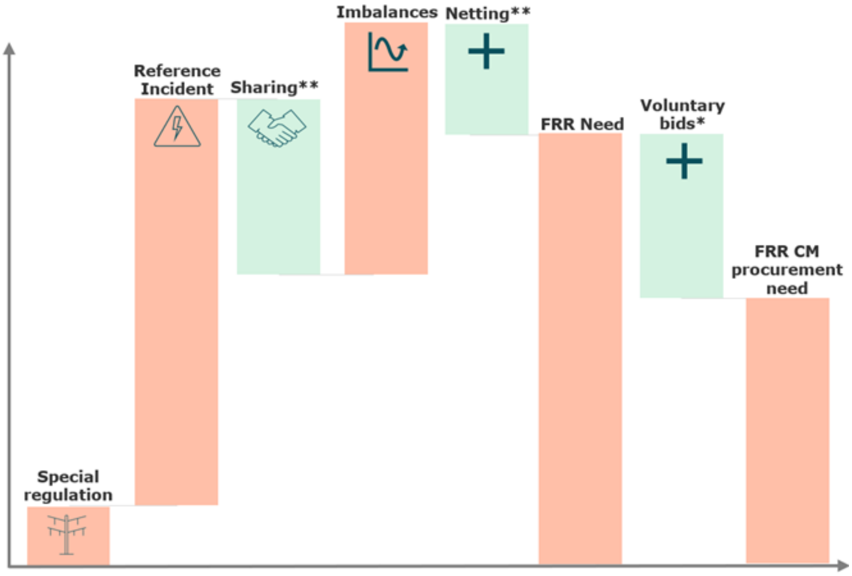
For sharing cross control area, the generic sharing principles are formulated as an optimization problem, minimizing the Nordic need for RI, while respecting the following restrictions:

- Sharing can never exceed available transmission capacity on an interconnector.
- The control area can never share more than locally available.

Sharing benefits are intended to be distributed equally whenever possible.

Besides the generic sharing principles there are several bilateral sharing agreements in the Nordic system: Finland-Estonia, DK1-DK2 and DK2-SE4.

Appendix 2



*Expected reduction of voluntary bids following mFRR EAM go-live, must be assessed and included (Maximum weighting factor of ~0.8).

- **When available, ATC from FlowBased will function as input to the calculation, most likely reducing possible sharing and netting.

The figure illustrates the individual components included in the dimensioning calculation per LFC area.

9.3 Roles & Responsibilities

9.3.1 Introduction

Sharing of reserve capacity is a concept which allows a TSO to take a cross-border activation process into account while organising the availability of the required active power reserves. This means that sharing of reserve capacity cannot be technically linked to a specific reserve providing unit or a reserve providing group. Generally speaking, sharing of reserve capacity provides a control capability offered by one TSO to another without ensuring the availability of additional corresponding reserve capacity. The exchange of reserves provides a control capability and additional corresponding reserve capacity at the same time.

In order to define clear and consistent responsibilities for TSOs involved in exchange of reserves or sharing of reserves, the SOGL introduces the respective roles for the involved TSOs. These roles and their responsibilities are explained in this section.

Note to this section: Since the Nordic synchronous area geographically corresponds with the Nordic LFC block (see section 4.2.2 Determination of LFC blocks), exchange of FRR between a TSO within the Nordic LFC block and a TSO of another LFC block, implicitly means an exchange of FRR between TSOs of different synchronous areas. Similarly, the exchange of FRR between TSOs of different LFC blocks implicitly results in an exchange of FRR between TSOs of different synchronous areas. Furthermore, the roles and responsibilities of the TSOs are the same for exchanges of FRR between TSOs within the Nordic synchronous area / LFC block and for exchanges between one or more TSOs within the Nordic synchronous area and one or more TSOs in other synchronous areas / LFC blocks. Consequently, sections 9.3.2 to 9.3.7 below cover several SOGL articles at the same time.

9.3.2 Roles and responsibilities for reserve connecting TSO as regards the exchange of FRR

'Reserve connecting TSO' means the TSO responsible for the monitoring area to which a reserve providing unit or reserve providing group is connected. SOGL 3(2)(150)

In context of exchange of reserves the role of the reserve connecting TSO is being responsible for operating the monitoring area to which a reserve providing unit or a reserve providing group is physically connected while a certain amount of the reserve capacity is required by a different TSO, the reserve receiving TSO, to fulfil its dimensioning requirements.

The responsibilities of the reserve connecting TSOs include:

- Implementation of the FRR prequalification for the reserve capacity on FRR subject to exchange in accordance with SOGL article 159; SOGL165(1) SOGL171(2) SOGL165(6)
- Providing the affected TSO with the information on the (intended) exchange of reserves that is needed for the analysis and maintenance of operational security;
- Concluding an approved assessment on the intended exchange agreement in accordance with the rules in section 9.4.4;
- Concluding an exchange agreement with the reserve receiving TSO that specifies the roles and the responsibilities of the reserve connecting TSO and the reserve receiving TSO in accordance with SOGL article 165(3);
- Contracting reserves from BSPs;
- Making sure that their obligations resulting from the FRR dimensioning process and additional exported FRR will be fulfilled;
- Activation of contracted reserves on behalf of the reserve receiving TSO;
- Monitor the fulfilment of the FRR technical requirements and FRR availability;
- Ensure that the exchange of FRR/RR does not lead to power flows which violate the operational security limits;
- Settlement with the BSP;
- Settlement with reserve receiving TSO;
- Follow the Notification Process for the exchange of reserves in accordance with SOGL article 150;
- Comply with applicable rules in section Rules, Arrangements & Methodologies

9.3.3 Roles and responsibilities for reserve receiving TSO as regards the exchange of FRR

'Reserve receiving TSO' means the TSO involved in an exchange with a reserve connecting TSO and/or a reserve providing unit or a reserve providing group connected to another monitoring or LFC area; SOGL 3(2)(151)

The responsibilities of the reserve receiving TSOs include:

- Providing the affected TSO with the information on the (intended) exchange of reserves that is needed for the analysis and maintenance of operational security; SOGL165(1) SOGL171(2) SOGL165(6)
- Concluding an approved assessment on the intended exchange agreement in accordance with the rules in section 9.4.4;
- Concluding an exchange agreement with the reserve connecting TSO that specifies the roles and the responsibilities of the reserve connecting TSO and the reserve receiving TSO in accordance with SOGL article 165(3);
- Making sure that their obligations resulting from the FRR dimensioning process will be fulfilled;
- In case of exchange between synchronous areas: Making sure that the reserves are provided over the HVDC interconnector;
- Ensure that the exchange of FRR does not lead to power flows which violate the operational security limits;
- Settlement with reserve connecting TSO;
- Follow the Notification Process for the exchange of reserves in accordance with SOGL article 150;
- Comply with specific rules in section Rules, Arrangements & Methodologies

9.3.4 Roles and responsibilities for affected TSO as regards the exchange of FRR

'Affected TSO' means a TSO for which information on the exchange of reserves and/or sharing of reserves and/or imbalance netting process and/or cross-border activation process is needed for the analysis and maintenance of operational security; SOGL 3(2)(150)

In context of exchange of reserves the role of the affected TSO is being a third TSO that is or may be affected by exchange of reserves.

The responsibilities of the affected TSOs include:

- Receiving the information on the (intended) exchange of reserves that is needed for the analysis and maintenance of operational security, and perform the required analysis; SOGL165(1) SOGL171(2) SOGL165(6)
- Taking part in the approval process of the assessment on the exchange agreement in accordance with the rules in article 9.4.4.

9.3.5 Roles and responsibilities of control capability providing TSO for sharing of FRR

The role of the control capability providing TSO is triggering the activation of its reserve capacity for a control capability receiving TSO under the conditions of an agreement for sharing reserves. SOGL 3(2)(103)

The responsibilities of the control capability providing TSO include:

- Implementation of the FRR prequalification for the reserve capacity on FRR subject to sharing in accordance with SOGL articles 159; SOGL166(1) SOGL166(7)
- Providing the affected TSO with the information on the (intended) sharing of reserves that is needed for the analysis and maintenance of operational security;
- Concluding an approved assessment on the intended sharing agreement in accordance with the rules in article 9.4.4;
- Concluding a sharing agreement with the control capability receiving TSO that specifies the roles and the responsibilities of the control capability providing TSO and the control capability receiving TSO in accordance with SOGL article 166(3);
- Contracting reserves from BSPs;
- Activation of contracted reserves on behalf of the control capability receiving TSO;
- Making sure that their obligations resulting from the FRR dimensioning process will be fulfilled;
- Monitor the fulfilment of the FRR technical requirements and FRR/RR availability;
- Ensure that the sharing of FRR does not lead to power flows which violate the operational security limits;
- Settlement with the BSP;
- Settlement with control capability receiving TSO;
- Follow the Notification Process for the sharing of reserves in accordance with SOGL article 150;
- Comply with applicable rules in section Rules, Arrangements & Methodologies

9.3.6 Roles and responsibilities of control capability receiving TSO for sharing of FRR

The role of the 'control capability receiving TSO' taking into account reserve capacity which is accessible through a control capability providing TSO under the conditions of an agreement for sharing reserves. SOGL 3(2)(104)

The responsibilities of the control capability receiving TSO include:

- Providing the affected TSO with the information on the (intended) sharing of reserves that is needed for the analysis and maintenance of operational security; SOGL166(1) SOGL166(7)

- Concluding an approved assessment on the intended sharing agreement in accordance with the rules in section 9.4.4;
- Concluding a sharing agreement with the control capability providing TSO that specifies the roles and the responsibilities of the control capability providing TSO and the control capability receiving TSO in accordance with SOGL article 166(3);
- Making sure that the obligations resulting from the FRR dimensioning process will be fulfilled, taking into account the requirements in article 166(6);
- In case of sharing between synchronous areas: Making sure that the reserves are provided over the HVDC interconnector;
- Ensure that the sharing of FRR does not lead to power flows which violate the operational security limits;
- Settlement with control capability providing TSO;
- Follow the Notification Process for sharing of reserves in accordance with SOGL article 150;
- Comply with specific rules in section Roles & Responsibilities

9.3.6 Roles and responsibilities for affected TSO as regards to sharing of FRR

'Affected TSO' means a TSO for which information on the exchange of reserves and/or sharing of reserves and/or imbalance netting process and/or cross-border activation process is needed for the analysis and maintenance of operational security; SOGL 3(2)(150)

In context of sharing of reserves the role of the affected TSO is being a third TSO that is or may be affected by sharing of reserves.

The responsibilities of the affected TSOs include:

- Receiving the information on the (intended) sharing of reserves that is needed for the analysis and maintenance of operational security, and perform the required analysis; SOGL166(1) SOGL166(7)
- Taking part in the approval process of the assessment on the sharing agreement in accordance with the rules in article 9.4.4.

9.4 Rules, Arrangements & Methodologies

9.4.1 Arrangements for exchange of FCR capacity

Energinet and Svenska Kraftnät have agreed about a common arrangement for Sweden and DK1 for exchange of FCR capacity. Bids from the Finnish and Norwegian FCR capacity markets are checked against the Swedish/Danish market in the evening D-1 to determine FCR capacity exchange between the TSOs.

9.4.2 Arrangements for exchange and sharing of mFRR capacity

The current situation is that there is a common mFRR capacity market for mFRR in Finland, Sweden and Denmark. There are also bilateral exchange and sharing agreements with TSOs in other synchronous areas and between Svenska Kraftnät and Energinet within the synchronous area (appendix 2 to this annex).

9.4.3 Arrangements for exchange and sharing of aFRR capacity

The Nordic TSOs have agreed to organize exchange of aFRR capacity in a common aFRR capacity market for the Nordic synchronous area. Exchange of aFRR between bidding zones will be secured by reservation of grid capacity. The aFRR demand in each LFC area will be decided by each TSO according 7.4.2.2. In addition, there are bilateral exchange and sharing agreements with TSOs in other synchronous areas (appendix 2 to this annex).

9.4.4 The limits for the exchange of FCR between TSOs within the synchronous area and between synchronous areas

9.4.4.1 Limits for the exchange of FCR-N

The limits for exchange of FCR-N between control areas are defined in article 3 of the methodology below. SOGL163(2)

"Nordic synchronous area proposal for limits for the exchange of FCR between the TSOs in accordance with Article 163(2)" and its Explanatory Document[4].

9.4.4.2 Limits for the exchange of FCR-D

The limits for exchange of FCR-D between control areas are defined in article 4 of the methodology below: SOGL163(2)

"Nordic synchronous area proposal for limits for the exchange of FCR between the TSOs in accordance with Article 163(2)" and its Explanatory Document[4].

9.4.5 Methodology to determine limits on the amount of sharing of FCR between synchronous areas

There are currently no arrangements for sharing of FCR between the Nordic synchronous areas and other synchronous areas. Potential new arrangements will require fundamental Nordic analysis to be implemented. Consequently, there is no reason to include these limits yet. SOGL174(2)

9.4.6 Limits on the amount of FRR exchange/sharing between synchronous areas

9.4.6.1 Limits for the exchange of aFRR and mFRR

[4] As this methodology has been approved by the NRAs, the methodology is in fact not a proposal anymore. However, the name of the approved methodologies has not changed after approval.

The limits for exchange of aFRR and mFRR are defined in article 3 of the methodology below: SOGL176(1) SOGL177(1)

"Amended Nordic synchronous area Proposal for the methodology to determine limits on the amount of exchange of FRR/RR between synchronous areas defined in accordance with Article 176(1)/178(1) and the methodology to determine limits on the amount of sharing of FRR/ RR between synchronous areas defined in accordance with Article 177(1)/179(1)" and its Explanatory Document[4].

9.4.6.2 Limits for sharing of aFRR and mFRR

The limits for sharing of aFRR and mFRR are defined in article 4 of the methodology below: SOGL176(1) SOGL177(1)

"Amended Nordic synchronous area Proposal for the methodology to determine limits on the amount of exchange of FRR/RR between synchronous areas defined in accordance with Article 176(1)/178(1) and the methodology to determine limits on the amount of sharing of FRR/ RR between synchronous areas defined in accordance with Article 177(1)/179(1)" and its Explanatory Document[4].

9.4.7 Assessment of arrangements for FRR exchange and sharing

Relevant TSO shall for each arrangement for exchange and sharing of FRR make an assessment against the agreed principles in the methodologies referred to in sections 9.4.6.1 and 9.4.6.2. The assessment shall be approved by RGN. The TSOs shall follow the process described in section 9.5.1.

Appendix 2 includes the approved assessments for exchange and sharing of FRR.

9.4.8 Limits on the amount of RR exchange/sharing between synchronous areas

The TSOs currently do not apply Replacement Reserves (RR). For this reason, the proposal[4] "Amended Nordic synchronous area Proposal for the methodology to determine limits on the amount of exchange of FRR/RR between synchronous areas defined in accordance with Article 176(1)/178(1) and the methodology to determine limits on the amount of sharing of FRR/RR between synchronous areas defined in accordance with Article 177(1)/179(1)" does not specify rules for exchange of RR. SOGL178(1) SOGL179(1)

9.5 Operational Procedures

9.5.1 Process for assessing arrangements for FRR exchange and sharing

The process for assessing arrangements for FRR exchange and sharing includes the following steps:

1. The TSO or TSOs willing to enter an arrangement for exchange or sharing of FRR shall for each arrangement make an assessment against the agreed principles in the methodology.
2. The TSO or TSOs fill in a specific template for the assessment;
3. The assessment is delivered to RGN in due time before a relevant RGN meeting;

4. RGN either approves the assessment, or RGN reveal gaps and asks relevant TSO to present on a process for closing the gaps for final approval.
5. Approved assessments shall be included in Appendix 2 of this Annex.

10 Time control process

10.1 Objective

The objective of the time control process is to maintain the design criteria of 50,00 Hz as the mean frequency and to keep FCR-N activations energy neutral over time.

10.2 High-level Concept

In case that the frequency is different from the nominal frequency of 50 Hz, the electrical time starts deviating from the UTC. By changing the setpoint frequency, the TSO can mitigate this deviation in order to maintain synchronization of electrical time to UTC.

10.3 Roles & Responsibilities

The synchronous area monitor is responsible for implementing the time control process. The synchronous area monitor is fulfilling this responsibility in close cooperation with the LFC block monitor. SOGL 181(3)

SOGL article 181(3) describes the responsibilities of the synchronous area monitor.

10.4 Rules & Methodologies

10.4.1 methodology to reduce the electrical time deviation

Synchronous area monitor shall endeavour to maintain the electrical time deviation within a time range of ± 30 seconds. SOGL181

If the time deviation has reached ±15 seconds, operators of Synchronous area monitor shall make a plan to reduce the time deviation. Operational Instruction LFCR1001

Manual time deviation control shall have a lower priority than frequency control and should therefore be avoided in difficult periods for the frequency control. Actions to increase or decrease the average system frequency by means of active power reserves include that the time-control function in the LFC controller shall be active to continuously reduce time deviation;

10.5 Operational Procedures

This section does not have content in the current version of this Annex.

11 Co-operation with DSOs

If applicable, the TSOs conclude agreements with one or more DSOs in their control area. There are no methodologies for SAOA or LFC block OA or otherwise to be agreed by the TSOs subject to this SOA.

12 Transparency of information

The rules and methodologies on transparency of information are included in article 183 to 190 of the SOGL. TSOs shall publish information to avoid "an actual or potential competitive advantage or disadvantage to any individual party or category of party". The required information is partly about content of agreements and partly about historical numbers for reserves, frequency quality etc. The information is published on ENTSO-E transparency platform.

The TSOs have also agreed to publish the Nordic SOA including annexes, appendices, associated methodologies and supporting documents together with other operations reports on:
https://www.entsoe.eu/publications/system-operations-reports/#nordic

Each TSO will in addition publish relevant information on their own web-site.

13 Fast frequency reserves

13.1 Objective

The objective of the Fast Frequency Reserves (FFR) is to assist the Frequency Containment Process (FCP, see chapter 6) during times of low system inertia to such an extent that after a sudden imbalance the frequency change can be succesfully stopped before the instantaneous frequency deviation would have reached the maximum instantaneous frequency deviation (see section 3.4.1 Frequency quality defining parameters). The ultimate objective of FFR is to prevent for low frequency demand disconnection (LFDD). FFR is procured when the system inertia is so low and the size of the reference incident is so high that the Frequency Containment Reserve for Disturbances (FCR-D) alone is not able to contain the frequency before reaching the maximum instantanteneous frequency deviation in case the reference incident were to occur.

FFR is procured for under frequency events.

13.2 High-level Concept

A sudden imbalance in the power system is followed by a decreasing or an increasing system frequency, which will usually be stopped by the FCP. However, if the system inertia is too low, the system frequency changes very rapidly and consequently the instantaneous frequency deviation may reach the maximum instantaneous frequency deviation before the FCP can stop the decreasing or increasing frequency. The speed at which the frequency changes, depends on the size of the imbalance, the level of inertia in the system and the activation of reserves. Inertia is traditionally provided by synchronous machines, including synchronous generators and synchronous motors.

In some hours, the inertia provided by synchronous machines in the Nordic synchronous area together with the FCP is insufficient to ensure that the reference incident of the synchronous area will not cause an instantaneous frequency deviation of more than the maximum instantaneous frequency deviation.

For this reason, the TSOs carefully forecast and monitor the level of inertia in the synchronous area. If the amount of inertia is or will be insufficient, the Nordic TSOs take measures, including the procurement of FFR. FFR will provide an additional reserve response to the FCR-D response with the objective that the reference incident shall not result in an instantaneous frequency deviation of more than the maximum instantaneous frequency deviation.

13.3 Roles & Responsibilities

13.3.1 Responsibility for FFR dimensioning

All TSOs - coordinated by the synchronous area monitor - are responsible for defining the FFR dimensioning (see section 13.4.3).

13.3.2 Responsibility for real time FFR monitoring

The synchronous area monitor shall monitor the frequency stability in real time (see section 13.4.5).

The synchronous area monitor shall coordinate measures that are required in case of insufficient FFR (see section 13.4.6).

13.3.3 Responsibility for procurement of FFR

Each TSO is responsible to procure FFR according to the forecast and the FFR-sharing key (see section 13.4.4).

13.3.4 Responsibility for actions to increase FFR

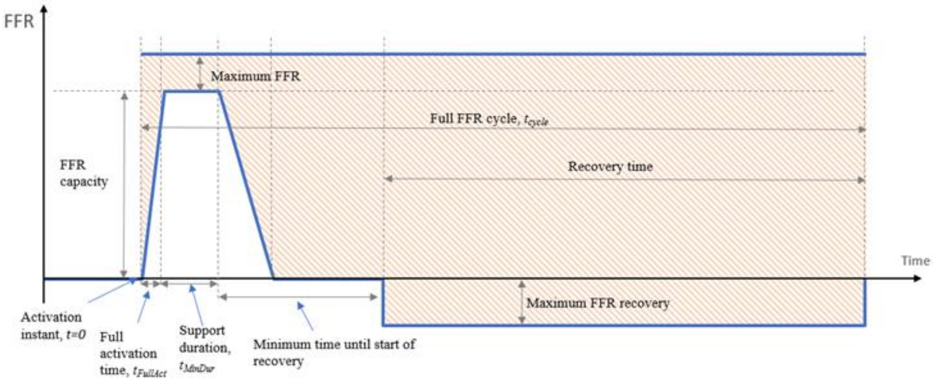
In case of a shortage on FFR, the TSOs with a FFR deficit will take the ownership of the issue. All TSOs – coordinated by the synchronous area monitor - are responsible to propose and take actions in case of insufficient FFR in the Nordic synchronous area.

13.3.5 Prequalification of FFR providers

Each TSO shall be responsible for prequalification of their FFR providers (see section .13.4.2).

13.4 Rules & Methodologies

13.4.1 Requirements for FFR provision



The figure illustrates the sequential diagram for the activation of FFR

The following requirements apply:

- The activation instant is at time equal to zero (0);
- Different combinations of frequency activation level and full activation times are allowed: The maximum time for full activation is 0.70 s (for the activation level 49.5 Hz), 1.00 s (for the activation level 49.6 Hz), and 1.30 s (for the activation level 49.7 Hz);
- Different minimum support duration is allowed: 5.0 s (for short support duration) and 30 s (for long support duration);

The prequalified FFR capacity is the minimum support power in MW from the providing entity, within the time slot of the support duration. The maximum acceptable over-delivery is 20% of the prequalified FFR capacity. However, the reserve connecting TSO may allow up to 35% over-delivery upon request, depending on the national procurement process.

There is no limitation in the rate of deactivation for the long support duration FFR; the deactivation can be stepwise. For the short support duration FFR, the rate of deactivation is limited to maximum 20% of the prequalified FFR capacity per second, as an average over any integration time of one second, and with no single step larger than 20%.

The FFR providing entity must be ready for a new FFR activation cycle within 15 minutes after the activation instant. There is no requirement on the shape of recovery, it may be stepwise. However, the recovery must not exceed 25% of the prequalified FFR capacity and must not start before a time corresponding to the activation time, plus the support duration, plus the deactivation time, plus 10 seconds has elapsed from the activation instant.

13.4.2 Prequalification of FFR

The TSO that connects the FFR provider shall make sure that all FFR providers are prequalified and fulfil the requirements as set in section 13.4.1. The pre-qualification process includes pre-qualification tests.

13.4.3 Definition of FFR need

The TSOs forecast the FFR need for seven days ahead based on inertia forecasts.

The FFR need is specified on an hourly resolution one day before operation.

Operational Instruction LFCR1301

13.4.4 FFR sharing key for the procurement of FFR

The sharing key shall be agreed on an annual basis.

13.4.5 Real time FFR monitoring

The synchronous area monitor shall monitor the frequency stability in real time using a tool that is implemented in the SCADA systems at the TSOs. The tool generates an alarm if the estimated instantaneous frequency deviation caused by one or more contingencies on the contingency list is larger than the maximum instantaneous frequency deviation (an accuracy margin may be applied).

The tool uses inputs of the real time kinetic energy, power of each incident in the contingency list and the maintained FFR volume. The TSOs shall make sure that this input data is provided and consists of the most actual information.

13.4.6 Insufficient FFR

If there is insufficient FFR in the synchronous area, the synchronous area monitor will coordinate the required measures. This includes taking an inventory of possible actions to increase FFR at all TSOs and initiating actions to increase FFR.

Operational Instruction LFCR1302

If none of the TSOs have the ability to take actions to increase the FFR capacity, the TSOs – coordinated by the synchronous area monitor - may decide on reduction of the reference incident. If it takes more time to reduce the reference incident compared to the duration of the FFR deficit, there is no need to reduce the reference incident.

13.5 Operational Procedures

This section does not have content in the current version of this Annex.

14 Allocation of manual load/production shedding between TSOs

14.1 Objective

NCER 22

Manually controlled load/production shedding shall be used as a measure of last resort in case of problems with system balance or overloads in the grid, which cannot be solved by other measures. This may be relevant for the whole Nordic synchronous area or for parts of the synchronous area.

Already used measures like activation of mFRR from the bid list or outside of the bid list, assistance by other TSOs including available support from neighbouring systems over HVDC or the activation of flexible load must be activated (or agreed to be activated) before load shedding/production shedding is initiated.

Manually controlled load shedding is thus intended to prevent the frequency from falling so low that automatic demand disconnection will be activated before the manual load shedding takes effect and improves the situation.

Manually controlled load shedding shall thereby operationally not interfere with forced/automatic demand disconnection, while the volumes for both types of demand reduction might overlap to some extent.

Manually controlled production shedding is intended to prevent the frequency from raising so high that automatic tripping of generators will be activated before the manual production shedding takes effect and improves the situation in a controlled way.

14.2 High level concept

Annex OS, 2.2 System states, 2.2.1 Rules & Methodologies, Normal state

Manual load/production shedding shall be used in alert state to avoid entering into an emergency situation.

The TSOs agree that the goal is to keep frequency close to 50 Hz in scarce reserve situations. When all mFRR resources are activated, manual load/production shedding shall be used as a last resort to keep activations of frequency controlled reserves like FCR and aFRR low.

In case of overloads in the grid (excess of TTC), manual load/production shedding shall be used as a last resort to avoid that the overload lasts for a period of more than 15 minutes.

The manual shedding shall be allocated to the TSO/LFC areas with largest lack of reserves to cope with the imbalances in relevant responsibility areas.

14.3 Roles and responsibilities

All TSOs are responsible for the manual load/production shedding within their responsibility area. When sufficient time is available, LFC BM shall, in cooperation with individual TSOs, select the control areas/LFC areas in which the potential load/production shedding must take place in accordance with the principles in 14.4.

If it is difficult to determine where to perform load/production shedding based on available information or the TSOs have different opinions, the LFC BM shall make quick decisions about volume and localization of the manual load/production shedding after contact with the relevant TSOs.

14.4 Allocation principles – Rules and methodologies

1. Manual load/production shedding shall be allocated to areas with **largest lack of reserves** according to the net reserve situation in the different areas. The Net reserve situation is defined by if an area has sufficient available mFRR to cover the ACE OL for the area.
2. In case of sharing of reserves, the TSO that will be rewarded for the reserves is the TSO where the reserves are physically located.
3. In case of an **uncongested Nordic synchronous area**, manual load/production shedding shall be executed by the TSO which has the largest lack of reserves in its control area according to the net reserve situation.
4. In case of a **congested Nordic synchronous area**, manual load/production shedding shall be executed by the TSO which has the largest lack of reserves in its relevant LFC area(s) according to the net reserve situation considering the deficit/surplus area "behind" the congestion(s).
5. If the calculations result in "**similar reserve situations**" (difference in net reserve situation ≤ 200 MW) in relevant areas for two or more TSOs, the TSOs will be responsible for an equal share of the total need for manual load/production shedding.

14.5 Operational procedures

The operational procedures are described in an operational instruction.

Operational Instruction LFCR500