

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

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

Version 5

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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").

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 9.4.7).

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.

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 **Feil! Fant ikke referanseilden.: Feil! Fant ikke referanseilden.**
- Title 11 / Chapter 12: Transparency of information
- Chapter 13: Fast Frequency Reserves

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). 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 agreement and the LFC block agreement (see section 2.2 and 2.3).

SOGL 118
SOGL 119
SOGL 120
SOGL 121

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.

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

SOGL 118(1)

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	9.4.4
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	9.4.5
118(1)(z)	limits on the amount of FRR exchange/sharing between synchronous areas	9.4.6
118(1)(aa)	limits on the amount of RR exchange/sharing between synchronous areas	9.4.6

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.

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);	Feil! Fant ikke referans ekilden.
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

SOGL 119(1)

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). 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 existing situation is that the Nordic frequency restoration process is based on frequency deviation as explained in section 5.3.2.

2.5 Monitoring area operational agreement

The TSOs defined that monitoring areas will be corresponding to bidding zones (see 4.2.2). 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

The existing situation is that the frequency restoration process is based on frequency deviation. Consequently, imbalance netting will be done implicitly. There is therefore no need to establish a separate imbalance netting process nor an imbalance netting agreement.

SOGL 122

2.7 Cross-border FRR activation agreement

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.

SOGL 123

2.7.1 Within the Nordic synchronous area

The existing situation is that the Nordic frequency restoration process is based on frequency deviation. Accordingly, FRR activation is coordinated between the Nordic TSOs which implicitly results in cross-border activation of FRR as explained in section 5.3.2.

SOGL 123
SOGL 149(3)

2.7.2 Between synchronous areas

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

SOGL 123
SOGL 149(3)

The existing situation is that Western Denmark is part of the common Nordic arrangement for mFRR activation, explained in section 5.3.2.

2.8 Sharing agreement

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. The roles and responsibilities of the affected TSOs are addressed in section 9.3.7 of this Annex. Exchange and sharing of reserves, including the process for assessing exchange and sharing arrangements in section 9.5.1, are addressed in chapter 9 of this annex.

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

2.9 Exchange agreement

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. The roles and responsibilities of the affected TSOs are addressed in section 9.3.4 of this Annex. Exchange and sharing of reserves, including the process for assessing exchange and sharing arrangements in section 9.5.1, are addressed in chapter 9 of this annex.

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

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.

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

SOGL 129

- 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.

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.

SOGL 3(155)

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.

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 implement the data collection and delivery process, which includes:

- measurements of the system frequency;
- 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).

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

With respect to the system states, the synchronous area monitor shall:

- 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).

The synchronous area monitor shall notify the results of the criteria application process for their synchronous area to ENTSO for Electricity for publication

SOGL 133(1)

SOGL 133(2)

SOGL 132

SOGL 133(3) and (4)

SOGL 129

SOGL 152(4) and (5)

SOGL 181(3)

SOGL 185(4)

within three months after the last time-stamp of the measurement period and at least four times a year (see chapter 12).

The synchronous area monitor has coordination tasks for Fast Frequency Reserves (FFR) as described in chapter 13.

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 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)

SOGL 134(2)

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 and 5.4.3. Since the limits in article 152(12) and (13) are within the standard frequency range of ± 100 mHz, the Nordic TSOs consider them a bit too strict for taking immediate actions. This may be quite normal operation. The LFC block monitor will therefore not specifically inform the other TSOs of the Nordic LFC block in this situation.

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).

3.4 Rules & Methodologies

3.4.1 Frequency quality defining parameters

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

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

ARTICLE 3 of "Nordic synchronous area proposal for the frequency quality defining parameters and the frequency quality target parameter in accordance with Article 127" and its Explanatory Document¹.

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.

3.4.2 Frequency quality target parameters

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.

ARTICLE 4 of "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.

Yearly statistics for FRCE are reported to ENTSO-E.

3.4.3 FRCE target parameters for Nordic LFC block

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) 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, 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. 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.

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

The LFC block structure (see section 4.2.2) divides the Nordic synchronous area in LFC areas corresponding to the bidding zones. However, the existing situation is that the frequency restoration process is based on frequency deviation as explained in section 5.3.2. This means that FRCE for LFC areas is not explicitly controlled. The Nordic TSOs have defined a methodology for calculating FRCE values on LFC area level which will be implemented when balancing is based on area control error per LFC area.

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

SOGL 128
Operational
Instruction
LFCR302
Appendix 1

SOGL 128(1)

SOGL 128(4)

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

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). 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), 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), reporting on fulfilment of the frequency quality target parameter also covers assessing the risk and the evolution of the risk of exhaustion of FCR.

SOGL 131(2)

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

Since the load-frequency control in the Nordic synchronous area is currently performed for the entire synchronous area based on system frequency and congestion/operational security in the system, ACE is not explicitly applied. Therefore, it is not meaningful to specify a common ramping period of aggregated netted schedules between the LFC areas in the synchronous area.

SOGL 136

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

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

SOGL 137(1)-(3)

interconnectors to other synchronous areas are specified in Article 3 of the methodology below.

ARTICLE 3 of "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 ramping rules on power generating modules to fulfil the FRCE target parameters of the LFC block are specified in article 4 of the methodology below.

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

SOGL 137(4)

3.5 Operational Procedures

3.5.1 Calculation of level 1 and level 2 FRCE target parameters

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

The present 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 .

SOGL 128
Operational
Instruction
LFCR302
Appendix 1

Step 1: the average frequency f_{qh} for each quarter of an hour² 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:

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

²To 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.

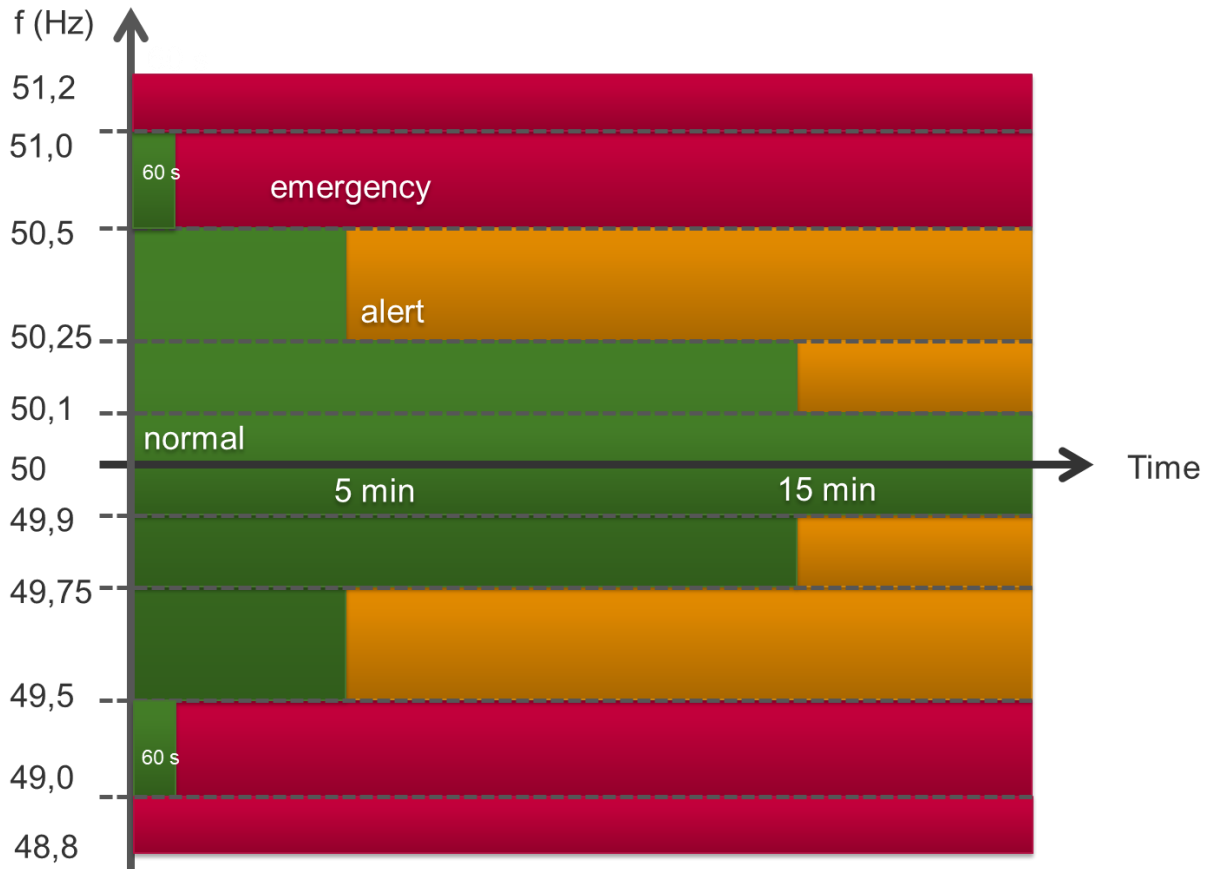
The process activation structure defines:

- 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

<ul style="list-style-type: none"> the responsibilities and obligations related to the control processes applied for geographical areas. 	
<h4>4.2.1.1 Process activation structure</h4> <p>The process activation structure of the Nordic synchronous area includes:</p> <ul style="list-style-type: none"> <i>Frequency Containment Process (FCP)</i>, applying both FCR for normal situation (FCR-N) and FCR for disturbances (FCR-D), which is described in chapter 6; <i>Frequency Restoration Process (FRP)</i>, applying both manual FRR and automatic FRR, which is described in chapter 7; <i>Cross-border FRR activation</i>, which is described in chapter 9; <i>Time control process</i>, which is described in chapter 10. 	<p>SOGL 139(2)</p> <p>SOGL 140</p> <p>SOGL 142</p> <p>SOGL 143</p> <p>SOGL 147</p> <p>SOGL 181</p>
<h4>4.2.1.2 Process responsibility structure</h4> <p>Section 4.3 describes the roles and responsibilities that together form the Process responsibility structure.</p>	<p>SOGL 139(2)</p> <p>SOGL 140</p>
<h4>4.2.2 Determination of LFC blocks</h4> <p>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:</p> <p>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.</p>	<p>SOGL 141(2)</p>
<h4>4.2.3 System states in relation to frequency</h4> <p>The system states in general are defined in Annex Operational Security Section 2. The figure below illustrates the specifications related to system frequency.</p>	<p>SOGL 18</p>



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

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.

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

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(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 specified in section 3.4.2. Svenska kraftnät and Statnett will have the task of maintaining the frequency in cooperation with Energinet and Fingrid in accordance with 5.3.2.
(b) comply with the FRR dimensioning rules in accordance with Article 157 and the RR dimensioning rules in accordance with Article 160.	Each TSO is responsible for FRR dimensioning for its own control area in accordance with the FRR dimensioning methodology specified in section 7.4. RR is currently not applied.

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

Obligation in SOGL article 149(2)	Responsibilities
Implementing an imbalance netting process	The frequency restoration process is based on frequency deviation. Consequently, imbalance netting will be done implicitly. There is therefore no need for a separate imbalance netting process nor an imbalance netting agreement.
Cross-border FRR activation process or a cross-border RR activation process	The Cross-border FRR activation process and the coordination with Statnett and Svenska kraftnät is a responsibility of the

SOGL 149(2)

between LFC areas of different LFC blocks or of different synchronous areas	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.
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4.3.3 Appointment of TSO responsible for the automatic Frequency Restoration Process

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

SOGL 143(4)

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

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).

SOGL 145(6)

4.4 Rules & Methodologies

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

SOGL 151(2)-(3)

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

SOGL 151(1)

- Digital control systems such as
 - SCADA/LFC systems
 - Information systems like the Nordic Operation Information System (NOIS) and
 - Telephone/messaging systems
- 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.

The hardware and software architecture and application design of the Digital control systems required for frequency containment process and frequency

SOGL 151(2)(b)

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.

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.

SOGL 151(2)(b)

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)

4.4.1.3 Communication protocols

Communication protocols that are used between the Nordic TSOs are ICCP, Elcom and Tase 2.

SOGL 151(2)(d)

4.5 Operational Procedures

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

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).

5.3.2.1 Balancing in the Nordic synchronous area

Balancing in the synchronous area shall be based on frequency and conducted in such a way that the transmission capacities are not exceeded. The quality standards for frequency and time deviation shall be followed. Requirements regarding FCR and FRR volumes shall in normal state be maintained (see sections 6.4 and 7.4).

Sweden and Norway represent approx. 75 % of the annual consumption of the synchronous area. The TSOs agree that Svenska kraftnät and Statnett will thus have the task of maintaining the frequency and time deviation within the set limits specified in section 3.4 and 10.4. Fingrid and Energinet will normally only balance after contacting Svenska kraftnät or Statnett. Svenska kraftnät and Statnett perform their task by activating mFRR and aFRR from their control areas and initiating FRR activation for other control areas (see also section 7.2 and the EB Annex). As balancing has to consider congestions in the grid, the responsibility of Svenska Kraftnät and Statnett include that some activations for system constraints are integrated in the same process.

Detailed instructions on balancing shall be agreed by all TSOs.

The distribution of work between Svenska kraftnät and Statnett is regulated bilaterally and described in a separate instruction, which is distributed to all the TSOs.

5.3.2.1.1. Momentary area control error

Momentary area control errors are calculated for each control area. These calculations do however not consider changes in planned exchange due to FRR activations and are currently only used as an indicator to detect location for incidents quickly.

Area control errors (I) are calculated in accordance with the following formula:

$$I = P_{\text{mom}} - P_{\text{plan}} + \Delta f \times R$$

P_{mom} = the momentary reading on the links between the control areas

P_{plan} = the exchange plan from Day ahead and Intraday markets

Δf = frequency deviation

R = momentary frequency response

5.3.2.2 Balancing in Western Denmark

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 market. Section 5.5.2 describes the operational rules for exchanging mFRR between the Nordic Synchronous area and Western Denmark.

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

The LFC block monitor (referred to in section 3.3.2) 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)

- 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 (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*'. Since 50 mHz is within the standard frequency range of ± 100 mHz, the Nordic TSOs consider

this limit a bit too strict for informing the other TSOs in accordance with SOGL article 152 (14).

The FRCE/frequency levels described above may be quite normal operation. The LFC block monitor will therefore not specifically inform the other TSOs of the Nordic LFC block in these operational situations. However, the Nordic TSOs aim for keeping the frequency close to 50 Hz, e.g. in order to avoid saturation of aFRR and keep aFRR available for balancing.

5.4 Rules & Methodologies

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

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 market based FRR activation as long as possible. These include:
 - a. mFRR activation (see section 5.3.2);
 - 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.

SOGL152(6)
Operational
Instructions
LFCR501
LFCR502
LFCR503
LFCR504

5.4.2 Coordinated actions aiming to reduce the FRCE

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:

ARTICLE 3 of "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 Document³.

SOGL152(15)
SOGL152(14)
Operational
Instructions
LFCR501
LFCR502
LFCR503

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

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:

ARTICLE 4 of "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

SOGL152(16)
Operational
Instructions
LFCR502
LFCR503

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.

modules and demand units in accordance with Article 152(16)" and its Explanatory Document³.

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

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, 5.4.2 and 5.4.3.

SOGL 152(10)
Operational
Instructions
LFCR502
LFCR503

5.5.2 Operational rules between the synchronous area and Western Denmark

These operational rules apply to the following definitions and interpretations:

'Balancing' means activations by TSOs due to BRP imbalances

'Intended exchange' means agreed exchange on interconnections between TSOs for balancing or netting

'Supportive power' means agreed energy exchange on interconnections between TSOs in case of needs other than balancing or netting.

Intended exchange for balancing between the synchronous area and Western Denmark is carried out in accordance with a set model based on the below principles.

- Before each operating hour, Energinet makes a prognosis for expected balancing energy price in Western Denmark and Statnett does the same for the Nordic synchronous area.
- Based on these expectations, Energinet sends proposed schedules in advance for each operating hour for intended exchange to perform a mix of imbalance netting and price optimization between the synchronous area and Western Denmark.
- Svenska kraftnät, Statnett and Energinet are jointly responsible for the intended exchange concerning the coming hour being acceptable with respect to balancing in both systems at the latest 15 minutes before the hour shift.
- After this, the intended exchange can be altered during the hour of operation in accordance with the rules specified in an instruction.
- Svenska kraftnät, Statnett and Energinet can also agree supportive power on relevant interconnectors (ASP).

5.5.3 Operational procedures in case of exhausted FRR or RR

The procedure in case of exhausted FRR is described in operational instructions that cover mFRR activation to avoid alert state and emergency state and mFRR activation in alert state, emergency state and restoration state. RR is currently not applied by the Nordic TSOs.

Operational
Instruction
LFCR502 and
LFCR503

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); 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 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.

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 and to calculate the initial distribution of FCR-D in accordance with the rules in section 6.4.3.

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:

ARTICLE 3 of "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:

ARTICLE 4 of "Amended Nordic synchronous area methodology for the dimensioning rules for FCR in accordance with Article 153" and its Explanatory Document^{Feil!} Bokmerke er

ikke definert.

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.

ARTICLE 3 of "Amended Nordic synchronous area methodology for additional properties of FCR in accordance with Article 154(2)" and its Explanatory Document^{Feil!}

Bokmerke er ikke definert.

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.

ARTICLE 4 of "Amended Nordic synchronous area methodology for additional properties of FCR in accordance with Article 154(2)" and its Explanatory Document^{Feil!}

Bokmerke er ikke definert.

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:

ARTICLE 3 of "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 in the Nordic LFC block and consequently replace activations of FCR. mFRR can also be pro-actively activated to prevent for FRCE deviations, e.g. in case of (expected) deterministic frequency deviations. 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 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 can be:
 - Automatically (for aFRR), as an instruction of the TSOs' Load Frequency Controller;
 - Manually (for mFRR), as instructed by the TSOs' dispatchers.

7.2.2 FRR products

The Nordic TSOs apply manual FRR (mFRR) and automatic FRR (aFRR).

7.2.2.1 Manual FRR (mFRR)

mFRR shall exist in order to restore the faster reserves FCR-N, FCR-D and aFRR when these reserves have been activated and to control flows in the grid within applicable limits. mFRR can also be pro-actively activated to prevent for frequency deviations, e.g. in case of (expected) deterministic frequency deviations. 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.

7.3 Roles & Responsibilities

7.3.1 Responsibility for FRR dimensioning

7.3.1.1 Responsibility for mFRR dimensioning

Each TSO is responsible for 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

Each quarter of a year, all Nordic TSOs are responsible for determining the hours for which aFRR shall be dimensioned; The TSOs also agree about total Nordic volumes for each dimensioned 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 rules (after implementation of the FRR dimensioning rules in accordance with SOGL article 157(1))

The current situation is that dimensioning is regulated in the methodology:

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

SOGL157(1)

7.4.2 FRR dimensioning (until implementation of the FRR dimensioning rules in accordance with SOGL article 157(1))

7.4.2.1 mFRR dimensioning rules

The mFRR capacity dimensioned for the control area shall at least cover the reference incident of the control area, in which 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’. Both upward and downward mFRR shall be dimensioned.

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:

- The hours for which aFRR shall be dimensioned shall at least include the hours where the frequency variations are most challenging.
- Dimensioned aFRR capacity will be at least 300 MW.
- Each TSO distribute 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 according to the short term imbalances.

7.4.2.3 Note on FRR dimensioning

The results of FRR dimensioning rules give a minimum obligation to the required amount of FRR, i.e., this does not prevent TSOs from procuring more FRR in case they deem this necessary.

7.4.3 FRR availability requirement

The availability of FRR providing units and FRR providing groups shall be 100 %.

SOGL158(2)

7.4.4 FRR control quality requirement

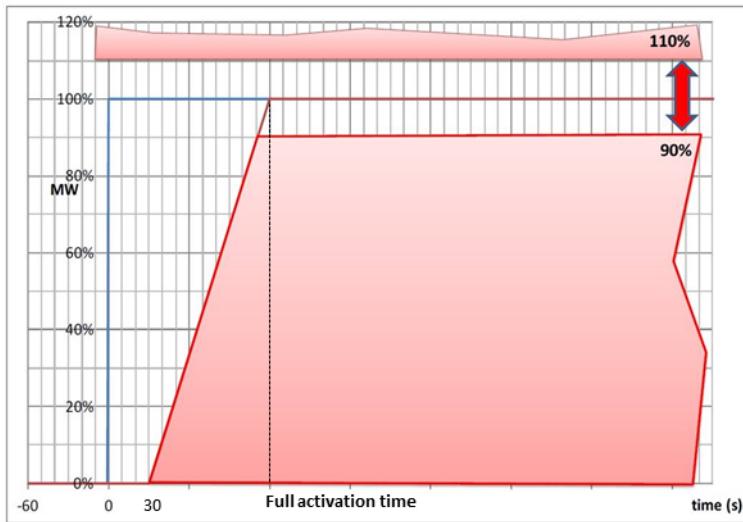
7.4.4.1 mFRR control quality requirement

The requested mFRR shall be completely activated within the specified full activation time (FAT) for the bid in the national market rules.

SOGL158(2)

7.4.4.2 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.



7.5 Operational Procedures

7.5.1 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 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.

Figure 1 illustrates the exchange of 200 MW of reserve capacity (FCR, FRR or RR) from Area B to Area A.

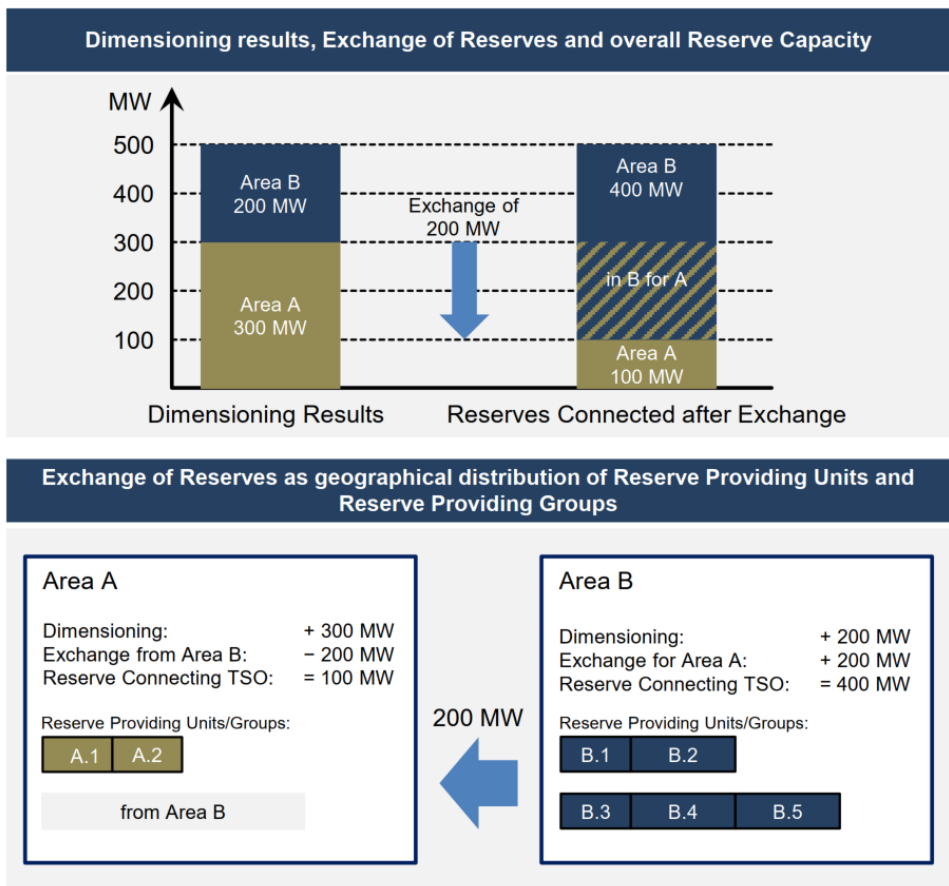


Figure 1: Exchange of reserve capacity – simple example

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 the exchange.

Table 3 shows references to the limits for exchange of FCR and FRR.

Table 3: Exchange limits

	FCR	FRR	RR
Within Nordic Synchronous areas	See section 9.4.4	No limits defined	RR currently not applied in Nordic SA
Between Synchronous areas	See section 9.4.4	See section 9.4.6	RR currently not applied in Nordic SA

9.2.2 Sharing of reserve capacity

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.

Figure 2 illustrates the sharing of 100 MW of reserve capacity between the TSOs of Area A and the TSOs of Area B.

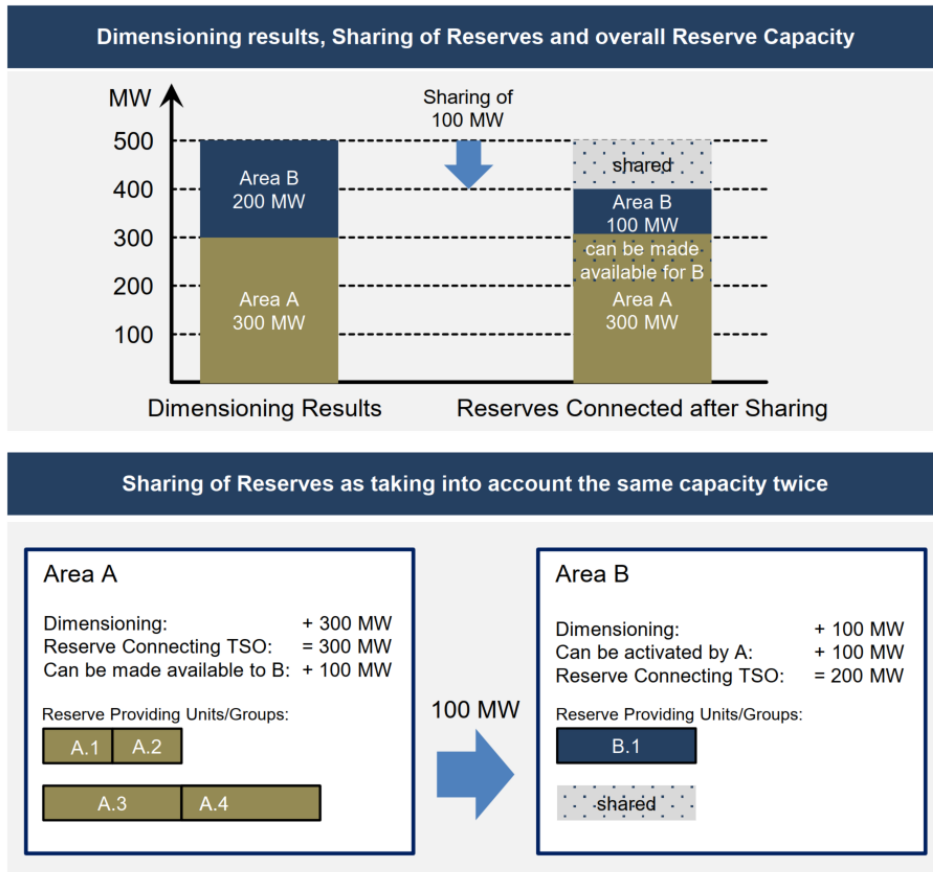


Figure 2: Sharing of reserve capacity – simple example

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 Figure 1). 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	No limits defined	RR currently not applied in Nordic SA
Between Synchronous areas	See section 9.4.5	See section 9.4.6	RR currently not applied in Nordic SA

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), 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;
- 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 9.4.7;
- 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;

SOGL165(1)
SOGL171(2)
SOGL165(6)

- Follow the Notification Process for the exchange of reserves in accordance with SOGL article 150;
- Comply with applicable rules in section **Feil! Fant ikke referanseilden..**

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;
- Concluding an approved assessment on the intended exchange agreement in accordance with the rules in section 9.4.7;
- 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 **Feil! Fant ikke referanseilden..**

SOGL165(1)
SOGL171(2)
SOGL165(6)

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;
- Taking part in the approval process of the assessment on the exchange agreement in accordance with the rules in article 9.4.7.

SOGL165(1)
SOGL171(2)
SOGL165(6)

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;
- 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 9.4.7;
- 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 **Feil! Fant ikke referansekilden..**

SOGL166(1)
SOGL166(7)

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;
- Concluding an approved assessment on the intended sharing agreement in accordance with the rules in article 9.4.7;

SOGL166(1)
SOGL166(7)

- 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 **Feil! Fant ikke referanseilden..**

9.3.7 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;
- Taking part in the approval process of the assessment on the sharing agreement in accordance with the rules in article 9.4.7.

SOGL166(1)
SOGL166(7)

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 no organized exchange of mFRR capacity in the Nordics. There are however 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 to 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.

ARTICLE 3 of "Nordic synchronous area proposal for limits for the exchange of FCR between the TSOs in accordance with Article 163(2)" and its Explanatory Document⁴.

SOGL163(2)

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:

ARTICLE 4 of "Nordic synchronous area proposal for limits for the exchange of FCR between the TSOs in accordance with Article 163(2)" and its Explanatory Document⁴.

SOGL163(2)

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)

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.

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

The limits for exchange of aFRR and mFRR are defined in article 3 of the methodology below:

SOGL176(1)
SOGL177(1)

ARTICLE 3 of "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 Document⁴.

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)

ARTICLE 4 of "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 Document⁴.

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 proposal⁴ "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.

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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:

- *For hours with aFRR:* The time-control function in the LFC controller shall be active to continuously reduce time deviation;
- *For hours without aFRR:* increase or decrease mFRR activation to aim for a frequency slightly different from 50 Hz, depending on the total imbalance and direction of time deviation.

10.1 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 successfully stopped before the instantaneous frequency deviation would have reached the maximum instantaneous frequency deviation (see section 3.4.1). 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 instantaneous 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

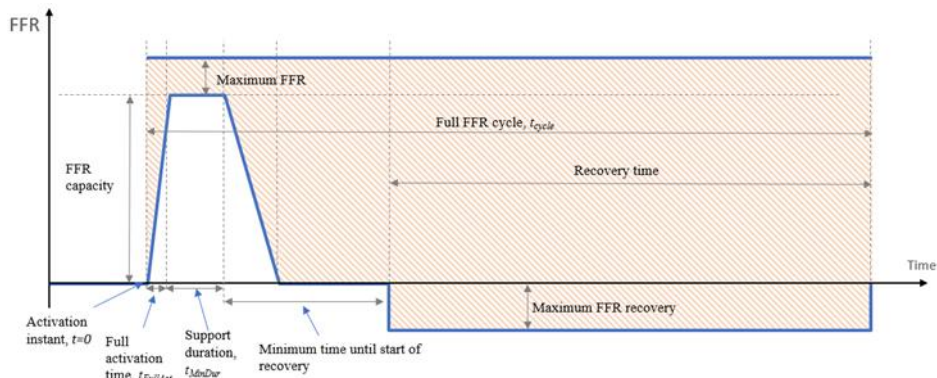


Figure 3: Sequential diagram for the activation of FFR

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.

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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.

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.

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13.5 Operational Procedures

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