

Nordic System Operation Agreement (SOA) – Annex Operational Security (OS)

FINGRID

ENERGINET

 **SVENSKA
KRAFTNÄT**

Statnett 

 **kraftnät
ÅLAND**

Version	Approval date	Entry into force	Revision
V1	11/12/2019	11/12/2019	SOA Annex Operational Security (OS) – Initial version
V2	22/06/2022	22/06/2022	Minor text updates and inclusion of appendices for description of operation of individual interconnectors between TSOs
V3	13/09/2023	13/09/2023	Minor updates and change from "Nordic RSC" to "Nordic RCC".
V4	08/10/2026	08/10/2026	New template, copy of SOGL terms deleted, description of system states developed

Table of contents

1	Introduction	4
1.1	Interaction with regulations, methodologies and Nordic agreements	4
1.2	Geographic area	4
1.3	Definitions	4
2	Operational Security Requirements	4
2.1	System states (operational determination and flagging)	4
2.1.1	Roles and responsibilities	4
2.1.2	Principle for determining system state	5
2.1.3	Nordic thresholds (aligned with ICS)	5
2.1.4	Reserve availability as a system state driver	7
2.1.5	Operational procedures for state determination and EAS flagging	7
2.1.6	Exit from restoration and emergency state	8
2.2	Remedial actions	8
2.2.1	Implementation statement	8
2.2.2	Coordination with capacity calculation and market timeframes	8
2.2.3	Nordic overview of commonly used remedial action categories	8
2.2.4	SPS/SIPS as remedial actions vs topology (Nordic clarification)	8
2.3	Availability of common means, tools and facilities	8
2.3.1	Hosting responsibility	9
2.3.2	Annual review and change management	9
2.4	Operational security limits	9
2.4.1	Implementation	9
2.4.2	Dynamic Line Rating (DLR) – implementation option	9
2.5	Security plan for critical infrastructure protection	9
2.5.1	Implementation statement	9
2.6	Voltage control and reactive power management	10
2.6.1	Steady-state interconnection voltage range	10
2.6.2	Nordic reference voltages (1.0 pu) by system level	10
2.6.3	Coordination on interconnectors	10
2.7	Short-circuit current management	10
2.7.1	Implementation statement	10
2.7.2	Operational use	10
2.8	Power flow management	11
2.8.1	Implementation statement	11
2.9	Contingency analysis and handling	11
2.9.1	Implementation statement	11
2.9.2	Nordic RCC / regional coordination	11
2.10	Protection	11
2.10.1	Implementation statement	11
2.11	Dynamic stability monitoring and assessment	11
2.11.1	Implementation statement	11
3	Data exchange	12
3.1	Implementation statement	12
4	Compliance	12
4.1	Implementation statement	12

5	Training	12
5.1	Implementation statement	12
6	Appendix 1-9 Joint operations between TSOs	12

1 Introduction

1.1 Interaction with regulations, methodologies and Nordic agreements

This Annex is part of the Nordic System Operation Agreement (SOA) and complements:

- SOGL (Commission Regulation (EU) 2017/1485) – Articles 18–63
- CACM (Commission Regulation (EU) 2015/1222) where relevant for coordinated remedial actions and capacity calculation
- Nordic RCC Agreement / MLA (regional coordination)
- KORRR (SOGL Art. 40(6)) – organisational requirements for data exchange
- CSAM (SOGL Art. 75) and supporting documents (coordination of operational security analysis)
- Nordic ROSC methodology (regional operational security coordination in the Nordic CCR)
- RAOCM (SOGL Art. 84) for relevance of assets in outage coordination (interface topic)
- Incident Classification Scale methodology (ICS) used for thresholds and consistency of incident classification

Hierarchy: In case of inconsistency, EU Regulations prevail.

This Annex governs Nordic operational arrangements where the SOGL leaves implementation choices and where Nordic TSOs have agreed common practices.

1.2 Geographic area

This Annex applies to the Nordic synchronous area and, where operationally relevant, interfaces to DK1 (and relevant HVDC/AC interconnectors described in appendices).

1.3 Definitions

Terms used in this Annex have the meaning given in SOGL Article 3 and in the referenced methodologies (e.g., CSAM). This Annex avoids re-defining SOGL terms.

2 Operational Security Requirements

Reference: SOGL Articles 18–39 (system states, remedial actions, limits, voltage/reactive, short-circuit, power flow, contingency, protection, stability).

2.1 System states (operational determination and flagging)

Reference: SOGL Articles 18–19

2.1.1 Roles and responsibilities

Each TSO monitors its system parameters and determines in real time the system state for its control area and performs contingency analysis as part of its operational security processes.

On regional Nordic level, the TSOs coordinate system state awareness and flagging in the ENTSO-E Awareness System (EAS) using the following Nordic roles:

- Synchronous Area Monitor (SAM): focuses on system security related to frequency excursions on synchronous area level
- LFC Block Monitor (LFC BM): focuses on system security related to availability of reserves and other mitigating measures to avoid violations of operational security limits

Flagging responsibility: Each TSO remains responsible for correct flagging in EAS for its control area/LFC area, while SAM and LFC BM coordinate and challenge the regional consistency of the Nordic flagging.

2.1.2 Principle for determining system state

Each TSO determines the system state of its control area in real time based on:

- operational security limit status (including N and N-1)
- incident indicators aligned with the Incident Classification Scale (ICS)
- availability of key operational tools and facilities

The regional system state for the Nordic synchronous area is coordinated through:

- the Synchronous Area Monitor (SAM) focusing on frequency-related security
- the LFC Block Monitor (LFC BM) focusing on reserve availability and mitigating measures
- the involved TSOs ensuring correct regional flagging in the ENTSO-E Awareness System (EAS).

Deterministic rule (Nordic): the prevailing system state is the most severe state triggered by any applicable criterion at the time of assessment (local or regional). This avoids ambiguity when multiple indicators differ.

2.1.3 Nordic thresholds (aligned with ICS)

The following thresholds are used for consistent classification and operational awareness.

2.1.3.1 Normal state

A transmission system shall be in the normal state when the conditions according to article 18(1) of SOGL are fulfilled.

Incident	Limits
Loss of load	less than 1 % of load in a TSO's control area
Frequency degradation	49,90 – 49,75 Hz, 50,1 – 50,25 Hz ≤ 15 min. OR 49,75 – 49,50 Hz, 50,25 – 50,50 Hz ≤ 5 min.
Incidents on transmission network elements	Without any consequences reaching the threshold of any ICS criteria.
Incidents on power generating facilities	Unexpected reduction of generation within 15 minutes 600 – 1 500 MW
N-1 violation	
Separation from the grid	Separation from the grid involving more than one TSO, where the separated region has a load greater than 0.05·L, where L is the total load of the synchronous area before the incident.
Violation of standards on voltage	U = 1,05 -1,10 pu 15 - 60 min.
Reduction of reserve capacity	More than 20 % reduction, with a duration is less than or equal to 30 minutes

Loss of tools, means and facilities	Loss of any tools, means and facilities for more than 30 minutes without consequences for neighboring TSOs
-------------------------------------	---

2.1.3.2 Alert state

A transmission system shall be in the alert state when the conditions according to article 18(2) of SOGL are fulfilled.

Incident	Limits
Loss of load	Loss of 1 % to 10 % of load in a TSO's control area
Frequency degradation	49,90 – 49,75 Hz, 50,1 – 50,25 Hz > 15 min. OR 49,75 – 49,50 Hz, 50,25 – 50,50 Hz > 5 min.
Incidents on transmission network elements	N-1 criterion ceases to be fulfilled, even after the curative remedial action(s)
Incidents on power generating facilities	Unexpected reduction of generation within 15 minutes 1 500 – 3 000 MW
N-1 violation	At least one contingency from the contingency list can lead to deviations from operational security limits with consequences on neighboring TSOs after the activation of curative remedial action(s) There is at least one deviation from operational security limits after the activation of curative remedial action(s) in N situation.
Separation from the grid	Separation from the grid involving one TSO, where the separated region has a load greater than $0.05 \cdot L$, where L is the total load of the synchronous area before the incident.
Violation of standards on voltage 110 – 420kV	$U < 0,90$ or $U > 1,10$ pu > 30 seconds $U = 1,05 - 1,10$ pu > 60 min. without consequences on neighboring TSOs
Reduction of reserve capacity	More than 20 % reduction, with a duration of more than 30 minutes
Loss of tools, means and facilities	Loss of any tools, means and facilities with consequences for neighboring TSOs for more than 30 minutes or the unplanned evacuation to the back up control room

2.1.3.3 Emergency state

A transmission system shall be in the emergency state when the conditions according to article 18(3) of SOGL are fulfilled.

Incident	Limits
Loss of load	Loss of >10 to ≤50% of load
Frequency degradation	49,90 – 49,75 Hz, 50,1 – 50,25 Hz > 15 min. OR 49,75 – 49,50 Hz, 50,25 – 50,50 Hz > 5 min.
Incidents on transmission network elements	there is at least one violation of a TSO's operational security limits wide area consequences on regional or synchronous area level resulting in the need to activate at least one measure of the system defense plan.
Incidents on power generating facilities	Unexpected reduction of generation within 15 minutes > 3 000 MW

N-1 violation	There is at least one wide area deviation from operational security limits after the activation of curative remedial action(s) in N situation.
Separation from the grid	Separation from the grid involving more than one TSO, where the separated region has a load greater than 0.05·L, where L is the total load of the synchronous area before the incident.
Violation of standards on voltage 110 – 420kV	U < 0,90 or U > 1,10 pu > 30 seconds U = 1,05 - 1,10 pu > 60 min. and with consequences at least on one neighboring TSO
Reduction of reserve capacity	Reserve capacity is unavailable for more than 30 minutes,
Loss of tools, means and facilities	Loss of all tools, means and facilities, for more than 30 minutes

2.1.3.4 Blackout state

The transmission system shall be in the blackout state when the conditions according to article 18(4) of SOGL are fulfilled.

- loss of more than 50% of demand in the concerned TSO's control area
- total absence of voltage for at least three minutes in the concerned TSO's control area, leading to the triggering of restoration plan

2.1.3.5 Restoration state

A transmission system shall according to article 18(5) of SOGL, be in the restoration state when a TSO, being in the emergency state or blackout state, has started to activate measures of its restoration plan.

2.1.4 Reserve availability as a system state driver

Reserve availability shall be assessed against the required reserve levels for the concerned LFC block or area, considering both contracted and available activated reserves.

Reserve availability status is evaluated continuously by the LFC BM using agreed operational sources (market/activation systems and real-time monitoring tools).

Where automated classification is not available, TSOs apply a manual fallback procedure to avoid delayed or missing real-time reporting

Reserve availability indicators used for flagging shall be consistent with the Nordic LFC/reserve arrangements.

2.1.5 Operational procedures for state determination and EAS flagging

Each TSO assesses system state continuously using available real-time observability and automated alarms; manual fallback is applied where automated classification is not available.

If multiple indicators apply, the system state is the **most severe** triggered state at the time of assessment.

SAM and LFC BM coordinate regional consistency of flagging and initiate clarification when inconsistencies are detected.

Minimum content for state communications: state, main driver, affected borders, expected evolution/duration, and requested actions (if any).

2.1.6 Exit from restoration and emergency state

A transmission system shall return to alert or normal state when:

- the conditions for the higher severity state are no longer fulfilled
- operational security limits are restored or expected to be restored within agreed operational timeframes

The transition shall be coordinated between affected TSOs and reflected consistently in EAS.

2.2 Remedial actions

Reference: SOGL Articles 20–23; CACM consistency where relevant

2.2.1 Implementation statement

Each TSO maintains operational security in its control area through preventive and curative remedial actions.

Cross-border relevance is handled via Nordic ROSC processes and coordination with Nordic RCC (as applicable).

2.2.2 Coordination with capacity calculation and market timeframes

Remedial actions used in operation shall be consistent with those considered in:

- Nordic CCR coordinated redispatching and countertrading methodology (CACM Art. 35)
- operational security analysis coordination (CSAM)

2.2.3 Nordic overview of commonly used remedial action categories

The list below is maintained for operational clarity of the Nordic toolbox.

- Redispatching
- Countertrading
- Demand Side Response
- Topology changes (switching)
- Phase-shifting transformers (where applicable)
- Reactive power management (shunt devices, SVC/STATCOM, etc.)
- Voltage support from generators
- HVDC control actions
- Special protection schemes (SPS/SIPS)

2.2.4 SPS/SIPS as remedial actions vs topology (Nordic clarification)

Where a scheme is used:

- primarily to increase transfer capacity, it is treated consistently with CACM remedial action concepts for capacity calculation/operation interfaces
- primarily to limit disturbance consequences, it is treated as an operational security remedial action and described/maintained in Appendix 9 (System Protection Schemes)

2.3 Availability of common means, tools and facilities

Reference: SOGL Article 24.

2.3.1 Hosting responsibility

For critical common tools/means/facilities (used by multiple Nordic TSOs), the host organisation is responsible for adopting and maintaining a business continuity plan in cooperation with the Nordic TSOs.

2.3.2 Annual review and change management

Business continuity plans for critical common tools are reviewed at least annually and upon significant changes.

Interoperability needs and fallback communication channels are documented for each common tool.

2.4 Operational security limits

Reference: SOGL Article 25

2.4.1 Implementation

Adjacent TSOs agree and maintain common operational security limits per interconnector, including:

- voltage limits at interconnection points
- thermal/current limits (including temporary overload where applicable)
- short-circuit current limits (min/max) where relevant for correct protection operation and equipment ratings

These limits are maintained in the interconnector appendices to this Annex (Appendix 1–8). Each appendix shall include:

- reference values
- operational ranges
- update procedures agreed between adjacent TSOs

2.4.2 Dynamic Line Rating (DLR) – implementation option

Thermal current limits may be based on DLR. Where DLR is used for an interconnector, online values and the applied methodology are made available to the adjacent TSO(s) with agreed update frequency and fallback.

2.5 Security plan for critical infrastructure protection

Reference: SOGL Article 26

2.5.1 Implementation statement

Nordic TSOs maintain a joint view of common critical assets used for cross-border operation (e.g., common coordination platforms, critical interfaces enabling secure interconnector operation, and other agreed shared dependencies).

Each TSO remains responsible for national physical/cyber security controls; the Nordic layer focuses on cross-border impact assessment, contact points, and minimum coordination steps for major scenarios.

2.6 Voltage control and reactive power management

Reference: SOGL Articles 27–29 and SOGL Annex II where applicable.

2.6.1 Steady-state interconnection voltage range

The Nordic steady-state reference range for operational coordination at interconnection points is 0.90–1.05 pu, unless otherwise agreed between adjacent TSOs in the relevant appendix

2.6.2 Nordic reference voltages (1.0 pu) by system level

The reference voltage (1,0 pu) in the Nordic countries:

	Norway	Sweden	Finland	Denmark (DK2)	Denmark (DK1)
400 kV	400	400	400	400	400
300 kV	285	-	-	-	-
220 kV	220	220	220	234	220
150 kV	-	-	-	-	152
132 kV	132	-	-	138	-
110 kV	-	-	110	-	-

2.6.3 Coordination on interconnectors

Adjacent TSOs shall agree on voltage control ranges and associated operational measures for each interconnector.

If voltage deviates from the agreed limits, the adjacent TSOs shall coordinate remedial actions, including reactive power resources, tap changes and HVDC control settings where applicable.

2.7 Short-circuit current management

Reference: SOGL Articles 30–31.

2.7.1 Implementation statement

Adjacent TSOs shall:

- maintain a shared understanding of min/max short-circuit levels relevant for protection dependability and equipment ratings
- perform and exchange short-circuit studies for cross-border sensitivity where changes occur (topology, generation mix, new assets)
- define a change-notification process when changes may affect the other side's short-circuit conditions

The maximum and minimum short-circuit current are maintained in the interconnector appendices to this Annex (Appendix 1–8).

2.7.2 Operational use

Short-circuit current limits shall be used by TSOs to:

- verify protection performance
- assess equipment capability
- evaluate cross-border impacts of topology changes

2.8 Power flow management

Reference: SOGL Article 32.

2.8.1 Implementation statement

The Nordic TSOs shall:

- Operate within thermal and temporary overload limits defined per element/interconnector, using preventive and curative actions,
- coordinate cross-border congestions through agreed redispatch/countertrade arrangements (Nordic CCR methodology) when market outcomes create constraints that require operational intervention.

2.9 Contingency analysis and handling

Reference: SOGL Articles 33–35 and CSAM.

2.9.1 Implementation statement

Each TSO maintains a contingency list covering internal and external contingencies within its observability area and exchanges relevant external contingencies with impacted neighbours.

Exceptional contingencies are included and handled consistently with CSAM processes.

2.9.2 Nordic RCC / regional coordination

Nordic RCC shall provide regional operational security coordination services, including as a minimum:

- coordinated security analysis outputs supporting TSOs' decision-making
- identification of cross-border constraints and proposed remedial actions
- structured communication channels for time-critical cross-border issues

2.10 Protection

Reference: SOGL Articles 36–37

2.10.1 Implementation statement

Adjacent TSOs coordinate interconnector protection settings and principles before commissioning or changing settings.

SPS/SIPS coordination is documented and maintained in Appendix 9; updates are handled on request and through agreed change management.

After any protection operation impacting outside the control area, the affected TSO assesses correct operation and shares conclusions when cross-border relevant.

2.11 Dynamic stability monitoring and assessment

Reference: SOGL Articles 38–39

2.11.1 Implementation statement

Nordic TSOs shall:

- exchange relevant model/data needed for stability studies

- perform coordinated studies covering the synchronous area or agreed parts
- maintain a common Nordic position on inertia needs based on periodic common studies

Nordic common studies on inertia and stability may be referenced from Nordic reports endorsed by the relevant Nordic governance (e.g., RGN) and linked to relevant Nordic operational agreements/annexes as applicable.

Method for inertia calculation and the operational use of FFR should be referenced to the Nordic LFCR annex/documentation

3 Data exchange

Reference: SOGL Articles 40–54 and KORRR.

3.1 Implementation statement

Data exchange supports the operational security processes described in Section 2, including real-time monitoring, schedules, structural/forecast data and analysis inputs

The Nordic TSOs implement data exchange organisation/roles/quality requirements through KORRR and associated procedures.

4 Compliance

Reference: SOGL Articles 55–57

4.1 Implementation statement

Each TSO annually reviews the appropriateness of real-time operation tools relevant for operational security and implements improvements as needed (national responsibility; Nordic coordination when common tools are impacted).

Operational tests affecting neighbouring TSOs are notified in advance; if adverse cross-border impacts occur, the test is ceased upon request.

5 Training

Reference: SOGL Articles 58–63.

5.1 Implementation statement

Nordic TSOs shall:

- run joint training activities with neighbouring TSOs focusing on cross-border coordination under different system states,
- use English as the common contact language in writing and orally; Nordic languages may be used orally when all participants agree.
- shall coordinate joint training activities through a common forum, including planning of joint exercises and experience exchange (e.g., Nordic Training Group).

6 Appendix 1-9 Joint operations between TSOs

Appendices 1–8 describe interconnector joint operations and the associated operational security limits. Appendix 9 describes Nordic System Protection Schemes.

Appendix no	Title	Involved countries
1	Joint operation between the Norwegian and Swedish subsystems in the AC grid	NO and SE
2	Joint operation between the Finnish and Swedish subsystems on the AC links and Fenno-Skan	FI and SE
3	Joint operation between the Norwegian and Finnish subsystems	FI and NO
4	Joint operation between the Norwegian and Western Danish subsystems on the DC links Skagerrak poles 1, 2, 3 and 4	NO and DK1
5	Joint operation between the Western Danish and Swedish subsystems on the Konti-Skan 1 and 2 DC links	DK1 and SE
6	Joint operation between the Eastern Danish and Swedish subsystems on the AC links across Öresund and to Bornholm	DK2 and SE
7	Joint triangular operation between the Norwegian, Swedish and Western Danish subsystems	NO, SE and DK1
8	Joint operation between the Western and Eastern Danish subsystems on DC Link Great Belt	DK1 and DK2
9	Special protection schemes	Nordic system