# Joint operation between the Finnish and Swedish subsystems on the AC links and Fenno-Skan

## Appendix 2 to SOA Annex OS (FI and SE)

FINGRID ENERGINET SVENSKA KRAFTNÄT Statnett kraftnät åland

| Approval date | Entry into force | Revision |
|---|---|---|
| 2022-06-22 | 2022-06-22 | Initial version based on old SOA |
| 2023-04-27 | 2023-04-27 | Inclusion of Olkiluoto 3 |
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# 1 Background

The subsystems of Norway, Sweden, Finland and Eastern Denmark are synchronously interconnected. The subsystem of Western Denmark is connected to Norway, Sweden and Eastern Denmark using DC links. This Appendix describes the operation of the 400 kV AC links and the Fenno-Skan 1 and 2 DC links.

# 2 Transmission facilities linking the subsystems Sweden – Finland

## 2.1 Transmission facilities which are owned/held by system operators

Northern connections between Finland and Swedish bidding area SE1

| Facility | Voltage level | Settlement point |
|---|---|---|
| Petäjäskoski – Letsi | 400 kV AC | Petäjäskoski 400 kV |
| Keminmaa – Djuptjärn | 400 kV AC | Keminmaa 400 kV |

Southern connections between Finland and Swedish bidding area SE3

| Facility | Voltage level | Settlement point |
|---|---|---|
| Fenno-Skan 1, Rauma-Dannebo | 400 kV DC *) | Rauma 400 kV AC |
| Fenno-Skan 2, Rauma-Finnböle | 500 kV DC | Rauma 400 kV AC |

*) Fenno-Skan 1 installed DC voltage level is 400 kV, but due to cable conditions the operational voltage is permanently reduced to 80 % in order to avoid possible cable failure.

# 3 Electrical safety for facilities under 2.1

## 3.1 General

The common ground for the electrical safety work of the system operator companies within ENTSO-E Regional Group Nordic is constituted by the European standard for managing electrical high-voltage facilities EN 50 110 which governs the organisation and working methods. In addition to the standard, there are national regulations and special instructions which entail certain mutual differences between the system operators as regards dealing with operational issues from an electrical safety point of view.

## 3.2 Responsibility for electrical operation/Operational management

The responsibility for electrical operation for the transmission facilities is held in Finland by Fingrid. In Sweden, Svenska kraftnät holds the responsibility for electrical operation.

The power operation responsibility boundary concerning the 400 kV links lies at the border between Finland and Sweden. The power operation responsibility boundary regarding Fenno-Skan 1 and 2 lies at the ownership boundaries of the cables.

## 3.3 Switching responsible operator

| Facility | Swedish side | Finnish side |
|---|---|---|
| Petäjäskoski – Letsi | Operations Centre at Sollefteå (DCNO) | Main Grid Control Centre in Helsinki |
| Keminmaa - Djuptjärn | Operations Centre at Sollefteå (DCNO) | Main Grid Control Centre in Helsinki |
| Fenno-Skan 1 and 2 | Operations Centre at Sundbyberg (DCSY) | Main Grid Control Centre in Helsinki |

## 3.4 Operations monitoring and control in respect of electrical safety

Same parties as under section 3.3.

## 3.5 Switching schedule

Switchings on the 400 kV links are carried out in accordance with a switching schedule drawn up by Svenska kraftnät. Before the work begins, the Operations Centres shall confirm that the link is grounded and secured against switching on by exchanging switching confirmations.

Switching concerning Fenno-Skan 1 and 2 takes place as follows:

- The necessary switching required to switch off, earth and issue switching confirmations for the polar cables is implemented in accordance with switching schedules drawn up by Svenska kraftnät. Templates for these switching schedules have been drawn up jointly between Fingrid and Svenska kraftnät.
- Switching in Rauma alone takes place in accordance with a switching plan drawn up by Fingrid.
- Switching in Dannebo or Finnböle alone takes place in accordance with a switching schedule drawn up by Svenska kraftnät.

## 3.6 Switching confirmation

Switching responsible operators shall exchange signed switching confirmation to the other party before work preparation permit can be given. Digitally signed confirmations are legitimate.

Signed repealment of switching confirmation from Fingrid and Svenska kraftnät shall be issued to the other party before safety measures can be removed.

Switching confirmation is applicable in such case where safety measures is done with other switchgear than stated in the switching confirmation.

## 3.7 Disturbance management

When a cross-border link is taken out of operation, the control rooms will contact each other immediately and Fingrid and Svenska kraftnät will use their respective reasonable best efforts to bring the concerned link back in operation.

As and when required, the switching responsible operators issue the necessary switching schedules in order to carry out fault finding and clearance.

The switching responsible operators conduct fault finding in consultation.

Clearance of remaining faults is organised by the switching responsible operators in consultation.

For Fenno-Skan 1 and 2, the Preparedness plan for fault clearance is used.

# 4 System operation for facilities under section 2.1

## 4.1 Total Transmission Capacity (TTC)

### 4.1.1 400 kV AC links

The transmission capacity (TTC) to Finland is dependent upon the temperature in northern Sweden and Finland, as follows:

| Temperature | ≤ 20 °C | > 20 °C |
|---|---|---|
| Capacity | 1650 MW | 1600 MW |

The transmission capacity (TTC) to Finland is also dependant on the generation of Olkiluoto 3, and can be summarized as follows:

| Olkiluoto 3 generation | Transmission capacity FI-SE north | System protection, load disconnection |
|---|---|---|
| 1000 MW | 1600 (> 20 °C) | 0 MW |
| 1300 MW | 1300 (> 20 °C) | 0 MW |
| 1650 MW | 1300 (> 20 °C) | 350 MW |

The transmission capacity to Sweden may be limited because of dynamic reasons as follows:

| Cut 1 in Sweden | Max. transmission to Sweden |
|---|---|
| 3000 MW | 1200 MW |
| 3100 MW | 1100 MW |
| 3300 MW | 1000 MW |

During a planned outage or a disturbance on one of the 400 kV AC link, the transmission capacity of only one 400 kV link in the north is a maximum of:

| | Olkiluoto 3 generation < 1000 MW | Olkiluoto 3 generation ≥ 1000 MW |
|---|---|---|
| To Finland | 500 MW | 300 MW |
| From Finland | 400 MW | 400 MW |

### 4.1.2 Fenno-Skan

The installed transmission capacity of Fenno-Skan 1 is 500 MW. Due to submarine cable conditions Fenno-Skan 1 is permanently operated with reduced DC voltage (80 % level) causing reduction of the transmission capacity down to 400 MW. The temperature dependent transmission capacity of Fenno-Skan 1 is not used during the voltage reduction.

The transmission capacity on Fenno-Skan 2 is normally 800 MW. Fenno-Skan 2 also has a thermal overload capacity which can be used in accordance with valid instructions.

In Fenno-Skan 1 and 2 operations, jointly agreed instruction (*Operating instruction Fenno-Skan_rev5_eng.docx*") shall be taken into consideration considering the restricted use of Fenno-Skan 1.

## 4.2 Routines for determining the transmission capacity

The transmission capacity between the subsystems is set on a daily basis in consultation between the Main Grid Control Centre in Helsinki and Svenska kraftnät's Grid Supervisor at Network Control at Sundbyberg.

Fingrid and Svenska kraftnät shall inform each other in due time before the day of operation of the transmission capacity on Fenno-Skan and on the northern links. The minimum values will be the transmission capacity.

## 4.3 Trading capacity (Net Transmission Capacity - NTC)

When determining the trading capacity of the AC links, the transmission capacity is reduced by a regulation margin of 100 MW. The trading capacity of Fenno-Skan 1 is equal to its transmission

capacity, normally with reduced voltage 400 MW. The trading capacity of Fenno-Skan 2 is equal to its transmission capacity, normally 800 MW.

## 4.4 Operations monitoring and control in respect of system operation

Operations monitoring and control in Finland are carried out from:

- The Main Grid Control Centre in Helsinki as regards AC links and Fenno-Skan 1 and 2.

Operations monitoring and control in Sweden are carried out from:

- Svenska kraftnät's Grid Supervisor at Network Control at Sundbyberg concerning 400 kV AC links and Fenno-Skan 1 and 2.

Regulation of Fenno-Skan 1 and 2 is carried out by the Main Grid Control Centre in Helsinki.

## 4.5 Voltage regulation

The basic principle for voltage regulation is governed by section 7 point 7.5 in the agreement.

### 4.5.1 Voltage regulation on the Swedish side

The Operations Centre in Sollefteå (DCNO) is responsible for voltage regulation in the northern parts of the grid.

The following voltage levels are applied:

| Substation | Min voltage (kV) | Normal operation range (kV) | Max voltage (kV) |
|---|---|---|---|
| Letsi | 395 | 400-410 | 415 |
| Djuptjärn | 395 | 400-415 | 420 |

The minimum voltage is a voltage which the power system can withstand with a certain margin against a voltage collapse. The maximum voltage is the design voltage of the equipment. The target value for voltage lies within the normal operation range.

### 4.5.2 Voltage regulation on the Finnish side

Main Grid Control Centre in Helsinki is responsible for voltage regulation in Finland. For 400 kV voltage regulation, there are reactors on the tertiary windings of transformers.

At Petäjäskoski, the reactors are connected manually.

The following voltage levels are applied:

| Substation | Min voltage (kV) | Normal operation range (kV) | Max voltage (kV) |
|---|---|---|---|
| Petäjäskoski | 380 | 400-417 | 420 |

| | | | |
|---|---|---|---|
| Keminmaa | 380 | 399-417 | 420 |

### 4.5.3 Co-ordination of voltage regulation

Fingrid and Svenska kraftnät shall monitor and manage reactive power flow on the 400 kV AC lines to avoid unnecessary transmission of reactive power.

Problems can arise on the Djuptjärn - Keminmaa line if the Swedish side does not pay attention to the Finnish voltage regulation principle. There can be consequential impacts between reactor connections at Svartbyn and corresponding connections at Keminmaa on account of the size of the reactor at Svartbyn, 150 MVAr. The voltage at Svartbyn shall be held within 406 - 414 kV. If problems occur, the relevant control centres shall contact each other.

## 4.6 Outage planning

Fingrid and Svenska kraftnät shall plan, in consultation with each other, outages on the links and on their own networks when such outages will impact upon the transmission capacities of the links in accordance with the SOA Appendix "*Operational Procedure for Outage Planning Coordination (OPC)*".

Planned outages on Fenno-Skan 1 and 2 are to be co-ordinated with the other HVDC links of the Nordic area.

## 4.7 Disturbance management

The term disturbance situation here means that the transmission capacity has been exceeded due to, for instance, long-term line faults or the loss of production. If the transmission capacity has not been exceeded during the faults, the situation will be deemed to be normal.

When a cross-border link is disconnected, the control rooms will immediately contact each other and jointly reduce the transmission level to permissible values.

During disturbance situations, Fingrid and Svenska kraftnät have the right to regulate Fenno-Skan 1 and 2 to support their networks. Fenno-Skan 1 and 2 can be used as much as possible facility-wise and to an extent not entailing any difficulties in the other party's network.

During a disturbance situation, Fingrid and Svenska kraftnät shall immediately contact each other and agree that it is a disturbance situation. In conjunction with this, it must also be agreed how much Fenno-Skan is to be regulated and who will regulate. If the situation is very serious and the situation in the other party's network can be assumed to be normal, then Fenno-Skan can be regulated by the party affected by the disturbance without any previous contact. Such unilateral regulation may not, however, exceed 300 MW counted from the current setting.

If Fenno-Skan 1 and 2's emergency power regulation has been activated, this will also be deemed to be a disturbance situation. If the emergency power intervention entails counter trading requirements for a party not being affected by a disturbance, then Fenno-Skan 1 and 2 shall be regulated within 15 minutes to such a value that the counter trading requirement ceases.