Joint operation between the Norwegian and Swedish subsystems in the AC grid

Appendix 1 to SOA Annex OS (NO 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

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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 AC links between the subsystems of Sweden and Norway.

2 Transmission facilities linking the subsystems of Sweden- Norway

2.1 Transmission facilities which are owned/held by system operators at both ends

Facility	Voltage kV	Settlement point	Remarks
Ofoten-Ritsem	400	*)	
Nedre Røssåga-Gejmån-Ajaure	220	*)	
Nea-Järpströmmen	400	*)	
Hasle-Borgvik	400	*)	Included in Hasle constraint
Halden-Loviseholm	400	*)	Included in Hasle constraint

*) See Settlement agreement concerning balancing energy, system services and transmission losses.

2.2 Other transmission facilities

Facility	Voltage kV	Settlement point	Remarks
Sildvik-Tornehamn	130	Torneham	Vattenfall is the owner on the Swedish side
Eidskog-Charlottenberg*	130	Charlotteberg	Ellevio is the owner on the Swedish side

* This transmission facility is not included in the grid on the Swedish side. The transmission capacity is included in the trading capacity between NO1 and SE3.

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

Responsible for the electrical operation of the facility on the Swedish side is Svenska kraftnät, while on the Norwegian side it is Statnett. The power operation responsibility boundaries for electrical operation for facilities under section 2.1 lie at the national border between Sweden and Norway.

3.3 Switching responsible operator

For each of the cross-border links, there is a specific switching agreement between the parties.

Line	Norway	Sweden
Ofoten-Ritsem	Regional Centre at Alta	Operations Centre in Sollefteå (DCNO)
Nedre Røssåga-Gejmån-Ajaure	Regional Centre at Alta	Operations Centre in Sollefteå (DCNO)
Nea-Järpströmmen	Regional Centre at Alta	Operations Centre in Sollefteå (DCNO)
Hasle-Borgvik	Regional Centre in Oslo	Operations Centre in Sundbyberg (DCSY)
Halden-Loviseholm	Regional Centre in Oslo	Operations Centre in Sundbyberg (DCSY)

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 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.

3.6 Disturbance management

3.6.1 Cross-border link trips – management

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

In the event of disturbances, measures in accordance with issued instructions shall, as quickly as possible, restore the line to operation within defined security limits.

3.6.2 Switching schedule

In the event of faults needing switching which will affect the cross-border link, Statnett and Svenska kraftnät are to be informed before any switching is made. In the case of switching on the Swedish grid, switching schedules are to be drawn up by Svenska kraftnät.

Statnett or Svenska kraftnät may perform switching which will affect the cross-border link without coordination, in exceptional circumstances implying a violation of the operational security limits, to prevent endangering personnel safety or damaging equipment, in accordance with Article 14 of the Network Code Emergency & Restoration.

3.6.3 Fault finding

Initial fault finding will be carried out differently from case to case. Generally speaking, the respective facility owner will be responsible for fault finding in consultation with the switching responsible operator.

3.6.4 Fault clearance, remaining faults

Once the fault has been localized, the respective facility owner will attend to clearing the fault.

4 System operation for facilities under sections 2.1 and 2.2

4.1 Total Transmission Capacity (TTC)

The total transmission capacity (TTC) on the connections is as follows (in MW)	Ambient temperature					
Line	-20 °C	-10 °C	0 °C	10 °C	20 °C	30 °C
Sildvik-Tornehamn (to Sweden)	90	90	90	90	90	90
Sildvik-Tornehamn (from Sweden)	50	50	50	50	50	50

Ofoten-Ritsem (to Sweden)	700	700	700	700	700	700
Ofoten-Ritsem (from Sweden)	600	600	600	600	600	600
Nedre Røssåga-Gejmån-Ajaure (to Sweden)	250	250	178	178	178	81
Nedre Røssåga-Gejmån-Ajaure (from Sweden)	300	300	300	300	300	250
Nea-Järpströmmen (to Sweden)	600	600	600	600	600	600
Nea-Järpströmmen (from Sweden)	1000	1000	1000	1000	1000	1000
Hasle-Borgvik + Halden-Loviseholm (to Sweden)	2 200	2200	2200	2200	2200	1915
Hasle-Borgvik + Halden-Loviseholm (from Sweden)	2150	2150	2150	2150	2150	2150
Charlottenberg-Eidskog	95	95	95	95	95	95

To Sweden in the Hasle constraint: The transmission capacity is 1,600 MW without production shedding. For every 100 MW of production, production shedding increases the transmission capacity by 50 MW. The maximum production shedding is 1,200 MW, corresponding to 2,200 MW of capacity.

The transmission capacity will be reduced due to a high Oslo load, in accordance with the following table:

Oslo load [MW]	3300	4800	5400	6000	6300
Capacity [MW]	2200	2200	1600	1000	0

4.2 Routines for determining the transmission capacity

The transmission capacity between Norway and Sweden shall be jointly determined on a daily basis by the Parties.

4.3 Trading capacity (Net Transmission Capacity - NTC)

When determining the trading capacity of the links, the transmission capacity shall be reduced by the Transmission Regulating Margin (TRM).

The TRM of the Hasle constraint is normally 150 MW.

4.4 Operation monitoring and control in respect of system operation

Operation monitoring of capacities and transmission constraints, which can affect exchanges, are conducted in accordance with the below:

Line	Norway	Sweden
Sildvik-Tornehamn	National Centre in Oslo	Vattenfall Eldistribution's Operations Centre in Trollhättan
Ofoten-Ritsem	National Centre in Oslo	Svenska kraftnät´s Operations Centre in Sollefteå
Nedre Røssåga-Gejmån-Ajaure	National Centre in Oslo	Svenska kraftnät´s Operations Centre in Sollefteå
Nea-Järpströmmen	National Centre in Oslo	Svenska kraftnät´s Operations Centre in Sollefteå
Hasle-Borgvik	National Centre in Oslo	Svenska kraftnät´s Operations Centre in Sundbyberg
Halden-Loviseholm	National Centre in Oslo	Svenska kraftnät´s Operations Centre in Sundbyberg

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 Norwegian side

Voltage is monitored by the National Centre in Oslo and Regional Centres in Alta and Oslo. If the Regional Centres do not have sufficient resources to maintain the voltage within the given limits, the National Centre will be contacted.

The following voltage levels are applied:

Substation	Min voltage (kV)	Normal operation range (kV)	Max voltage (kV)
Ofoten	400	400-415	425
Nedre Røssåga	235	240-250	250
Nea	380	410-415	420
Hasle	380	410-415	420
Halden	380	410-415	420

4.5.2 Voltage regulation on the Swedish side

The Operations Centre in Sollefteå (DCNO) is responsible for voltage regulation in the northern parts of the grid, and the Operations Centre in Sundbyberg DCSY is responsible for voltage regulation in the southern parts of the grid. If the Operations Centres do not have sufficient resources to maintain the voltage within the given limits, Svenska kraftnät's Operations Centre shall be contacted.

The following voltage levels are applied:

Substation	Min voltage kV	Normal operation range kV	Max voltage kV
Ritsem	395	400-415	420
Ajaure	230	235-250	255
Järpströmmen	395	400-415	420
Borgvik	395	400-415	420
Loviseholm	395	400-415	420

4.5.3 Co-ordination of voltage regulation

In normal operation, the goal is the higher voltage within the normal operation range. In conjunction with operational disturbances and switching, the respective operations centres in Sweden and Norway can agree on action to maintain the voltage within the given intervals.

4.6 Outage planning

Svenska kraftnät shall plan the following in consultation with Statnett:

- Outages or other measures on the Swedish network impacting upon the transmission capacity of the links between Sweden and Norway.
- Outages causing a major reduction of the transmission capacity in constraints 1 or 2, or the West Coast constraint in Sweden.
- Control facility works at Borgvik, Grundfors, Järpströmmen, Porjus, Ritsem, Loviseholm, Skogssäter and Vietas.

Statnett shall plan the following in consultation with Svenska kraftnät:

- Outages or other measures on the Norwegian network impacting upon the transmission capacity of the links between Sweden and Norway.
- Outages entailing that, on the Norwegian network, there is no link between Ofoten and Røssåga.

- Outages entailing that, on the Norwegian network, there is no link between Røssåga and Nea.
- Outages entailing that, on the Norwegian network, there is no link between Nea and Hasle.

4.7 Disturbance situation

The term disturbance situation here means that the operational security limits have been violated due to, for instance, long-term line faults or the loss of production. If the transmission capacities are not exceeded during the faults, the situation will be deemed to be normal.

In the event of operational disturbances, measures in accordance with the issued instructions shall, as soon as possible, restore the link to operation within defined security limits.

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

Appendix 2 to SOA Annex OS (FI and SE)

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.

Joint operation between the Norwegian and Finnish subsystems

Appendix 3 to SOA Annex OS (FI and NO)

Approval date	Entry into force	Revision
2022-06-22	2022-06-22	Initial version based on old SOA

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1 Background

The subsystems of Norway, Sweden, Finland and Eastern Denmark are synchronously interconnected. The subsystem of Western Denmark is linked to Norway, Sweden and Eastern Denmark using DC links. This Appendix governs the special circumstances resulting from no separate trade being conducted via the Ivalo-Varangerbotn line. The capacity will instead be included in the day-ahead and intraday trading scope between Norway-Sweden and Sweden-Finland.

2 Transmission facilities linking the subsystems Norway – Finland

Transmission facilities owned/held at both ends by system operators:

Facility	Voltage level	Settlement point
Ivalo-Varangerbotn	220 kV AC	Varangerbotn

2.1 Ownership

Statnett SF owns and operates the 220 kV line from Varangerbotn to the border (up to and including tower no. 130, numbered from Varangerbotn). Statnett owns Varangerbotn (VN) substation: 132 kV switchgear, 22 kV compensation equipment connected to T4, T4 and 220lv1E, 220lv1S and 220lv1j.

Fingrid Oyj (hereafter referred to as "Fingrid") owns and operates the 220 kV line from Ivalo to the border (up to and including tower no. 954, numbered from Ivalo). Fingrid owns the Vaisjänkä (VK) T-branch and underlying substation Utsjoki (UK) including T1 and 22 kV switchgear. Fingrid owns the Ivalo IV substation.

3 Operation of facilities under section 2

3.1 General

The common ground for the electrical safety work of the system operator companies within the Nordic countries 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 operation/

Responsible for the electrical operation on the Norwegian side is Statnett, while on the Finnish side it is Fingrid. The power operation responsibility boundary lies at the border in Pulmanki (PU) between tower 130 (Norwegian side) and 954 (Finnish side).

3.3 Switching responsible operator

Statnett's regional control centre in Alta has switching operations authority, and has been designated as switching responsible operator for Varangerbotn 220 kV bay towards Ivalo. This also applies to the 220 kV line from Varangerbotn up to and including tower no.130 (Norwegian side) according to paragraph 2.1.

3.4 Operations monitoring and control

In accordance with section 3.3.

3.5 Electrical safety supervisor

For the work on the Norwegian side (up to and including tower 130), Statnett's regional control centre in Alta is responsible for designating a safety supervisor after necessary safety measures have been implemented at both transmission line terminals, Vaisjänkä and Varangerbotn.

For the work on the Finnish side (up to and including tower 954), Fingrid's main grid control centre in Helsinki is responsible for designating a safety supervisor after necessary safety measures have been implemented at both transmission line terminals, Vaisjänkä and Ivalo.

3.6 Switching schedule

Switchings on the Ivalo-Varangerbotn line are carried out in accordance with a switching schedule drawn up by Fingrid.

In case of forced outage, pre-made switching schedule for disconnecting and earthing the concerned line shall be applied.

3.7 Switching confirmation

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

Signed repealment of switching confirmation from both parties 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.

3.8 Disturbance management

3.8.1 Cross-border line trips – management

During operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the line to normal state.

3.8.2 Switching schedule in emergency situations

Statnett or Fingrid may perform switching which will affect the cross-border line without coordination, in exceptional circumstances implying a violation of the operational security limits, to prevent endangering personnel safety or damaging equipment, in accordance with Article 14 of the Network Code Emergency & Restoration.

3.8.3 Fault finding

Initial fault finding is conducted differently from case to case. Generally speaking, the respective facility owner will be responsible for fault finding.

3.8.4 Fault clearance, remaining faults

Once the fault has been localized, the respective facility owner will attend to clearing the fault.

4 System operation for facilities under section 2

4.1 Total Transmission Capacity (TTC)

4.1.1 From Norway to Finland

The transmission capacity varies between 40 and 120 MW depending on where the sectioning point in Norway is located and the transmission situation in Finland.

4.1.2 From Finland to Norway

The transmission capacity is 100 MW from Finland to Norway.

4.2 Routines for determining the transmission capacity

In a normal transmission situation, the transmission capacity depends on Ivalo-Varangerbotn, on production and on the network sectioning in Northern Norway. Statnett manages the transmissions on the cross-border line by redistributing production and sectioning in Norway so that the transmission capacity is not exceeded. Statnett draws up a daily transit plan and Fingrid confirms it.

For planned outages, Fingrid and Statnett agree in advance on the transmission capacity.

4.3 Trading capacity (Net Transmission Capacity - NTC)

Statnett and Fingrid shall inform Svenska kraftnät in each case of how much of the trading to and from Sweden shall be reserved for transit on the Ivalo-Varangerbotn line. The reservation may be a maximum of the transmission capacity on the line.

The trading capacity (Net Transmission Capacity - NTC) for the Ivalo-Varangerbotn line is included in the day-ahead and intra-day trading scope between Norway - Sweden and between Sweden - Finland.

4.4 Operations monitoring and control in respect of system operation

In Finland, operations monitoring and control are carried out from the Main Grid Control Centre in Helsinki.

In Norway, operations monitoring and control are carried out from the Regional Centre at Alta following permission from the National Centre in Oslo.

4.5 Voltage regulation

The basic principle for voltage regulation is governed by section 2.5 of the SOA Annex Operational Security.

4.5.1 Voltage regulation on the Norwegian side

At Varangerbotn, the target voltage level is 220 kV in normal operation, but the voltage can range between 205 and 235 kV.

4.5.2 Voltage regulation on the Finnish side

The normal operation range of voltage is 230 – 243 kV, but the voltage can range between 215 and 245 kV. At Utsjoki, there is a stationary reactor of 20 MVA.

4.5.3 Co-ordination of voltage regulation

The line is long and sensitive to voltage variations. The voltage is monitored in co-operation between the relevant control centres.

4.6 Outage planning

Statnett and Fingrid shall plan, in consultation with each other, outages on the line and on their own networks when such outages will impact upon the transmission capacities of the line in accordance to SOA Annex Operational Planning (OP)" Section 4.4.

4.7 Disturbance management

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

In the event of disturbances, measures in accordance with issued instructions shall, as quickly as possible, restore the line to operation within defined security limits.

5 Miscellaneous

5.1 Settlement

The settlement of transmitted electricity on the Ivalo-Varangerbotn line takes place in accordance with a separate agreement between Fingrid and Statnett.

Balance energy for the Ivalo-Varangerbotn line is the measured exchange minus exchange plans. Balance Energy is settled between Statnett and Fingrid.

The plan for transit via Svenska kraftnät is adjusted with the transit plan for Ivalo-Varangerbotn line. The transit plan is included in the daily maximum volume between Norway and Sweden, and between Sweden and Finland.

5.2 Information exchange

Statnett is responsible for Fingrid and Svenska kraftnät obtaining calendar day forecasts for transmissions on the Ivalo – Varangerbotn line.

Joint operation between the Norwegian and Western Danish subsystems on the DC links Skagerrak poles 1, 2, 3 and 4

Appendix 4 to SOA Annex OS (NO and DK1)

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
2025-02-06	2025-02-06	Reference to appendix 5 in old SOA updated

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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 DC links between Norway and Western Denmark.

2 Transmission facilities linking the subsystems of Norway – Western Denmark

Facility	Voltage kV	Settlement point
Kristiansand-Tjele SK1, SK2	250 kV DC	Receiving end
Kristiansand-Tjele SK3	350 kV DC	Receiving end
Kristiansand-Tjele SK4	500 kV DC	Receiving end

Together, SK1, SK2, SK3 and SK4 make up the Skagerrak link.

3 Operation of facilities under 2

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 operation

The responsibility for operation of the transmission facilities is held in Western Denmark by Energinet and in Norway by Statnett. The responsibility for operation is regulated by the operation agreements between Energinet and Statnett.

3.3 Switching responsible operator

3.3.1 Switching

In the event of outages on the HVDC cables, there shall be an exchange of written confirmation, before a work authorization can be dispatched, between Statnett's Regional Control Centre in Oslo and Energinet's control room at Tjele stating that the HVDC disconnectors are open and the line is terminal grounded and blocked against connection.

3.3.2 Switching responsible operator

On the Danish side, the authorization to switch in respect of the switching and switching off of the converter stations is given by Energinet's Control Centre at Erritsø, while authorization for all switching and work authorizations on the HVDC side of the facilities is given by the local operational management at Tjele.

On the Norwegian side, Statnett's Regional Control Centre in Oslo gives the switching authorization, and issues work authorizations on the Norwegian side.

Switching at the AC facilities are normally carried out from Energinet's Control Centre at Erritsø and from Statnett's Regional Control Centre in Oslo.

3.4 Operation monitoring and control

Operation monitoring and control is carried out from:

- Energinet's Control Centres at Erritsø or Tjele.
  Statnett's Regional Control Centre in Oslo.
- The four DC poles can be operated individually from Statnett's Control Centre in Oslo and from Energinet's Control Centre in Tjele.
- The four DC poles can be operated bi-pole level from Erritsø.
- Energinet's Control in Erritsø is only receiving group alarms.

3.5 Outages

Prior to planned outages on the HVDC links, written confirmation shall be exchanged between Statnett's Regional Centre in Oslo and Energinet's control room at Tjele.

Statnett or Energinet may disconnect the link without such written confirmation, to prevent endangering personnel safety, damaging equipment or to ensure system operation in emergency state, according to Article 14 of the Network Code Emergence & Restoration.

3.6 Disturbance management

Faults entailing the disconnection of links are managed via consultation in accordance with internal instructions. For fault localization and clearance, there is a special preparedness plan for submarine cables.

4 System operation for facilities under 2

4.1 Total Transmission Capacity

The transmission capacity of the links is dependent on the temperature of the air, cable runway and earth.

SK1, SK2:	Technical min. 12,5 MW/pole	Nominal 500 MW
SK3:	Technical min. 13 MW	Nominal 500 MW
SK4:	Technical min. 0 MW	Nominal 715 MW

4.2 Routines for determining the transmission capacity

The transmission capacity between Western Denmark and Norway shall be jointly determined on a routine basis by the Parties. In the case of intact connecting networks, the transmission capacity will be determined by the thermal capacity of the facilities' components. The thermal overload capability allowed by monitoring equipment shall be capable of being used as and when required in accordance with special instructions. For any limitations to the connecting AC networks, Energinet's Control Centre at Erritsø is responsible for supportive data on the Western Danish side and Statnett for the equivalent on the Norwegian side.

4.3 Trading capacity (Net Transmission Capacity - NTC)

The normal trading capacity (NTC) in "bi-pole operation", in day-ahead-market, is:

1680 MW at 20°C in market sending end
(Market capacity is based on the loss factor, currently at 2,9%)

In the intra-day-market the trading capacity is:

1632 MW at 20°C in receiving end

The trading capacity may also be restricted based on specific operational conditions in the AC grid on either side of the link or in the DC link itself. The following calendar day's trading capacity is decided each day. Scheduled losses is calculated in the market (losses covered by market), the difference between the measured losses and the scheduled losses will be handled in the sending end

Both Parties inform the other Party in good time prior to the relevant calendar day about the transmission capacity seen from each respective side. The values that are the lowest will form the basis for determining the trading capacity.

4.4 Operation monitoring and control in respect of system operation

Operation monitoring and control is carried out from:

- Energinet's Control Centres at Erritsø or Tjele.
  Statnett's Regional Control Centre in Oslo.
- The four DC poles can be operated individually from Statnett's Control Centre in Oslo and from Energinet's Control Centre in Tjele.
- The four DC poles can be operated bi-pole level from Erritsø.
- Energinet's Control in Erritsø is only receiving group alarms.

4.4.1 The power flow and distribution between the DC links

The distribution of the power flow between the poles shall be determined on a routine basis by the Parties taking into account the minimum electrode currents, loss minimization or other technical circumstances in the poles or on the transmission networks on each respective side.

The distribution of power flow between the DC links is described in the agreement for SK1-4.

4.4.2 Control of the link

Control of the Skagerrak link in accordance with agreed exchange plans will be carried out by Statnett and Energinet alternating each month.

The plans are issued as power plans in whole MW for each 5 minutes. The link is controlled in accordance with this power linearly from power value to power value.

The power plan is determined in accordance with the energy and power plan agreements forming the basis for utilizing the Skagerrak link.

Planned power regulation during the operational phase is set at max. 30 MW/min in planning phase.

4.5 Outage planning

Outages on the links and on own networks which affect the transmission capacity shall be planned in consultation between the Parties.

Planning and maintenance are co-ordinated between the respective operational managements.

Outage planning is co-ordinated with the other HVDC links in the Nordic area.

4.6 Disturbance management

4.6.1 General

The Skagerrak link is of great importance to Norway and Denmark, thus outages due to disturbances generally entail major economic losses. In the event of operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the link to normal state.

Automated operational disturbance systems are installed at Kristiansand and Tjele which begin to function during disturbances on the Norwegian or Jutland networks.

4.6.2 Delta power

Delta power consists of control measures which are initiated manually.

Both sides have the right to initiate Delta power in the event of unforeseen losses of production, network disturbances or other operational disturbances.

Delta power without previous notice may be activated with up to 100 MW and 100 MWh/calendar day. Prior to activation over and above this, notification and approval shall occur between Energinet's Control Centre at Erritsø and Statnett's National Centre in Oslo.

4.6.3 System protection

At the DC facilities, system protection is constituted by emergency power settings at the converter stations. Activation criteria can be locally measured frequency and voltage or via telecoms based on the supplied signal. In the event of activation, any ongoing normal control will be interrupted. Activation over and above the agreed limits and control back to plan may not occur until the counterparty has approved this. (See further in Appendix 9 – System protection schemes).

Energinet and Statnett can additionally enter into agreements regarding other types of system services.

5 Miscellaneous

5.1 System services

For the manual activation of operation reserves, the available transmission capacity (the "leftover" from Day ahead and Intraday) can be used.

Both Statnett and Energinet have the right to utilize idle transmission capacity for the transmission of system services. Configuration values, power limits etc. are agreed upon bilaterally.

Energinet and Statnett can also conclude agreements concerning other types of system services.

5.2 Settlement

Energinet and Statnett manage the settlement in cooperation and agrees upon settlements data on daily basis. Each party sends the demand to the other party.

Joint operation between the Western Danish and Swedish subsystems on the Konti-Skan 1 and 2 DC links

Appendix 5 to SOA Annex OS (DK1 and SE)

Approval date	Entry into force	Revision
2022-06-22	2022-06-22	Initial version based on old SOA
2025-02-06	2025-02-06	Reference to appendix 5 in old SOA updated

Table of contents

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 DC links between Sweden and Western Denmark.

2 Transmission facilities linking the subsystems of Sweden – Western Denmark

Facility	Voltage kV
KS1 Lindome - Vester Hassing	285 kV DC
KS2 Lindome - Vester Hassing	285 kV DC

Together, KS1 and KS2 make up the Konti-Skan link.

Settlement presently takes place on the AC side at Vester Hassing.

3 Electrical safety for facilities

3.1 General

The common ground for the electrical safety work of the system operator companies within the Nordic countries 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 of the transmission facilities is held in Western Denmark by Energinet and in Sweden by Svenska kraftnät. The responsibility for electrical operation is regulated by facility agreements between Energinet and Svenska kraftnät.

The power operation responsibility boundary between Svenska kraftnät and Energinet lies at Læsø Øst, at the transition between the submarine and shore-end cables.

3.3 Switching responsible operator

Facility	Swedish side	Danish side
Konti-Skan 1	Svenska kraftnät's Operations Centre in Sundbyberg (DCSY)	Energinets control room at Vester Hassing
Konti-Skan 2	Svenska kraftnät's Operations Centre in Sundbyberg (DCSY)	Energinets control room at Vester Hassing

During work between Lindome and XL1-F at Læsø Øst or Lindome and XL2-F at Læsø Øst, the Operations Centre at Sundbyberg (DCSY) shall be the power operation manager for the entire link up to Vester Hassing.

During work on the Danish parts of the link, Energinets control room at Vester Hassing is the power operation manager for the entire link up to Lindome.

3.4 Operation monitoring and control in respect of electrical safety

Operation monitoring and control is carried out from Energinets Control Centre at Erritsø or Vester Hassing and the Operations Centre at Sundbyberg (DCSY).

- Normally, bipolar operation is applied to Konti-Skan 1 and 2 but each of them can also be operated in monopolar mode.

3.5 Switching schedule

Switching concerning Konti-Skan takes place as follows:

- Switching which concerns Vester Hassing alone takes place in accordance with a switching schedule drawn up by Energinet.
- Switching on the Danish part of the cable takes place in accordance with a switching plan drawn up by Energinet. Before the work begins, the Operations Centres shall confirm that the link is grounded and secured against switching on by exchanging switching confirmations.
- Switching in Lindome alone takes place in accordance with a switching plan drawn up by Svenska kraftnät.

- Switching on the Swedish part of the cable takes place 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.

3.6 Disturbance management

3.6.1 Cross-border link trips – management

During operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the link to normal state.

3.6.2 Switching schedule

In the event of faults requiring switchings impacting upon the cross-border link, Energinets Control Centre at Erritsø and Svenska kraftnät are informed prior to any switchings being made. In the event of switchings on the Swedish grid, a switching schedule will be drawn up by Svenska kraftnät.

3.6.3 Fault finding

Initial fault finding will be carried out differently from case to case. Generally speaking, the respective facility owner will be responsible for fault finding. For fault finding, a special preparedness plan for submarine cables has been drawn up.

3.6.4 Fault clearance, remaining faults

Once the fault has been localized, the respective facility owner will attend to clearing the fault. For fault clearance, a special preparedness plan for submarine cables has been drawn up.

4 System operation for facilities

4.1 Total Transmission Capacity (TTC)

The transmission capacity (TTC) of the link is dependent on the temperature of the air and the ground.

The nominal capacity at the receiving end:

- In bipolar operation, the nominal capacity is 715 MW,
- in monopolar operation (KS1 or KS2), the capacity is 345 MW.
- Technical minimum capacity of KS1: 12 MW; KS2: 9 MW.

4.2 Routines for determining the transmission capacity

The transmission capacity between Jutland and Sweden shall be set on a routine basis by the Parties. In the case of intact connecting networks, the transmission capacity is determined by the thermal capacity of the facilities' components. The thermal overload capability allowed by monitoring equipment shall be capable of being used as and when required in accordance with special instructions. Technical data for the facilities' transmission capacities is reported in the current facility agreement between Energinet and Svenska kraftnät.

For any limitations in the connecting AC networks, Energinets Control Centre at Erritsø is responsible for supportive data on the Western Danish side and Svenska kraftnät for the same on the Swedish side.

4.3 Trading capacity (Net Transmission Capacity - NTC)

The net transmission capacity at the receiving end is:

715 MW from Western Denmark → Sweden

715 MW from Sweden → Western Denmark

For both directions, losses are defined to 30 MW.

The following calendar day's trading capacity is set every day. The trading capacity can be limited by line work, production in the connection area, overhauls etc.

Both Parties inform the other Party in good time prior to the relevant calendar day regarding the transmission capacity seen from the respective sides. The values that are the lowest will be the trading capacity.

4.4 Operation monitoring and control in respect of system operation

Operation monitoring and control is carried out from Energinets Control Centre at Erritsø and Svenska kraftnät's Operations Centre in Sundbyberg.

4.4.1 The power flow and distribution between the poles

Konti-Skan 1 and 2 are normally operated in bipolar mode.

During disturbances and maintenance on one pole, monopolar operation is applied.

4.4.2 Regulating the link

Regulation of the Konti-Skan links in accordance with agreed exchange plans will be carried out, until further notice, from the Danish side. Energinets Control Centre at Erritsø is responsible for its own balance regulation towards Sweden.

Regulation takes place, in principle, in accordance with a power plan using ramping transitions between different power levels. The plans are issued as power plans in whole MW for each 5 min of plan value. The links are regulated in accordance with this power linearly from power value to power value.

The power plan is determined in accordance with the exchange plan for Konti-Skan.

4.5 Outage planning

The Parties shall, in consultation, plan outages on the link itself and on their own networks when these outages impact upon the transmission capacity of the link.

Operational planning and maintenance are co-ordinated between Svenska kraftnät's Operational Department and Energinets Control Centre at Erritsø.

Overhaul planning is co-ordinated with the other HVDC links in the Nordic area.

4.6 System protection - emergency power

4.6.1 General

The Konti-Skan link is of major importance to Sweden and Denmark and outages due to disturbances thus generally entail major economic losses. In the event of operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the link to normal state.

Automated operational disturbance systems are installed at Lindomen and Vester Hassing which can begin to function during operational disturbances on the Swedish or Jutland networks.

4.6.2 Delta power control, DPC1-4

Delta Power control is regulating measures which are initiated manually (manual DPC)

On the Western Danish side, Energinets Control Centre at Erritsø has the right to initiate Delta power controls in the event of disturbances to the power balance or transmission network.
 On the Swedish side, Svenska kraftnät has the right to initiate Delta Power Controls in the event of disturbances to the power balance or transmission network.

Delta Power controls of less than 100 MW and 100 MWh/calendar day may be activated without previous notification. Prior to activation over and above this, notification and approval shall take place between the staff of Energinets Control Centre at Erritsø and SvK-VHI at Network Control at Sundbyberg.

4.6.3 Emergency power (EPC) and System protection

At the DC facilities, system protection is installed in the form of an emergency power function. Activation criteria for emergency power can be locally-measured frequency and voltage or via telecommunications on the basis of a supplied signal. In the event of activation, any ongoing normal regulation will be interrupted. Activation over and above the agreed limits and regulation back to plan may not occur until the counterparty has approved this. (See further in Appendix 9 – System protection schemes).

5 Miscellaneous

5.1 System services

5.1.1 Transmission scope for operation reserves

Available transmission capacity can be used for the automatic or manual activation of operational reserves.

Both Svenska kraftnät and Energinet have the right to utilize idle transmission capacity after Elspot trading and XBID trading for the transmission of system services. Configuration values, power limits etc. are agreed upon bilaterally.

Joint operation between the Eastern Danish and Swedish subsystems on the AC links across Öresund and to Bornholm

Appendix 6 to SOA Annex OS (DK2 and SE)

Approval date	Entry into force	Revision
2022-06-22	2022-06-22	Initial version based on old SOA

Table of contets

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 AC links across Öresund and to Bornholm.

2 Transmission facilities linking the subsystems of Eastern Denmark and Sweden

2.1 Transmission facilities owned/held by system operators at both ends

Facility	Voltage level	Settlement point
Hovegaard-Söderåsen (FL25)	400 kV	Söderåsen
Görlöse-Söderåsen (FL23)	400 kV	Görlöse

The ownership structure of the facilities is set out in "Anlægsaftalen for 400 kV forbindelserna" between Svenska kraftnät and Elkraft Transmission (merged with Energinet as of 1 January 2005), dated 12 December 2001.

Svenska kraftnät owns three single phase 400 kV cables included in FL23, cables K4001, K4002 and K4003, between Kristinelund and Ellekilde Hage, including the corresponding share belonging to the oil equipment at Kristinelund and Ellekilde Hage. The ownership boundary between wholly-owned Danish and Swedish facilities is constituted by the splicing points between the land lines and submarine cables on the Danish side. The cable joints belong to the Swedish-owned facilities.

A single phase 400 kV cable K4004 between Kristinelund and Ellekilde Hage, including the corresponding share belonging to oil equipment at Kristinelund and Ellekilde Hage, is owned to 50 % by Svenska kraftnät and to 50 % by Energinet. The boundary between K4004 and surrounding facilities is composed of the splicing points between the land lines and submarine cables on both the Danish and Swedish sides. The cable joints are part of K4004.

Energinet owns three single phase 400 kV cables which are included in FL25, cables K4005, K4006 and K4007, between the Swedish shore and Ellekilde Hage, with associated oil equipment at Kristinelund and Skibstrupgaard. The ownership boundary between the Danish and Swedish-owned facilities is constituted by the splicing points between the submarine cables and land lines on the Swedish side. The cable joints belong to the Danish-owned facilities.

2.2 Other transmission facilities

Facility	Voltage level	Settlement point
Teglstrupgaard 1-Mörarp	130 kV	Mörarp
Teglstrupgaard 2-Mörarp	130 kV	Teglstrupgaard
Hasle, Bornholm-Borrby	60 kV	Borrby

The ownership structure of the 130 kV links is set out in ”Anlægsaftalen for 132 kV forbindelserna” between Sydkraft and Elkraft Transmission (merged with Energinet as of 1 January 2005), dated 13 May 2002.

The ownership structure of the 60 kV facility is set out in ”Anlægsaftale for 60 kV forbindelsen” between E.ON Elnät Sverige AB and Energinet.

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 the Nordic countries 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

Responsibility for electrical operation of the 400 kV Öresund links on the Swedish side is held by Svenska kraftnät, and operational management on the Danish side is carried out by Energinet.

The power operation responsibility boundaries for electrical operation/operational management are the same as the ownership boundaries, see under 2.1.

The power operation manager of K4004 is Svenska kraftnät.

3.3 Switching responsible operator/Switching leader

Facility	Swedish side	Danish side
Söderåsen – Kristinelund – Görlöse (FL23)	Operations Centre at Sundbyberg (DCSY)	Energinet's Control Centre at Erritsø
Söderåsen – Kristinelund Hovegaard (FL25)	Operations Centre at Sundbyberg (DCSY)	Energinet's Control Centre at Erritsø

The power operation manager for the 400 kV Öresund links on the Swedish side is Svenska kraftnät's Operations Centre at Sundbyberg (DCSY), and on the Danish side Energinet's Control Centre at Erritsø.

Switchings on the links take place after agreement between Svenska kraftnät's Operations Centre at Sundbyberg (DCSY) and Energinet's Control Centre at Erritsø.

The party which initiates a planned outage is the switching responsible operator/switching leader for the switchings and other operational measures carried out (leading switching leader) if not otherwise agreed upon.

In the event of faults which require switchings that have an impact on the 400 kV Öresund links, that party whose facility suffers from the fault is the switching responsible operator/switching leader for the switchings and other operational measures carried out (leading switching leader). If the fault cannot be located, the switchings shall take place on the basis of mutual consultation.

If a party needs switchings by the other party because of electrical safety reasons, the other party shall carry out such switchings without delay.

3.4 Operation monitoring and control in respect of electrical safety

Operation monitoring and control of the 400 kV Öresund links is managed on the Danish side by Energinet's Control Centre at Erritsø and on the Swedish side by Svenska kraftnät's Operations Centre at Sundbyberg (DCSY).

Both parties' switching responsible operators/switching leaders have access to status indications and electronic measured values via remote control from each other's facilities and from those stations where the 400 kV Öresund links are connected to the respective parties' grids.

3.5 Operational orders/Switching schedule

Switchings on the links are carried out in accordance with operational orders drawn up by Svenska kraftnät. Energinet's Control Centre at Erritsø shall acknowledge the receipt of order. Before the work begins, the Operations Centres shall confirm that the link is grounded and secured against switching on by exchanging switching confirmations. After the work is finished, switching confirmations shall be exchanged.

3.6 Disturbance management

3.6.1 Cross-border link trips – management

In the event of operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the link to operation within defined security limits.

3.6.2 Switching schedule/Operational orders

In the event of faults requiring switchings which have an impact on the 400 kV Öresund links, Energinet's Control Centre at Erritsø and Svenska kraftnät's Operations Centre at Sundbyberg (DCSY) are informed prior to any switchings are made.

For switchings in the Swedish grid, a switching schedule/operational order is drawn up by Svenska kraftnät's Operations Centre at Sundbyberg (DCSY).

For switchings in the Danish grid, a switching programme is drawn up by Energinet's Control Centre at Erritsø.

3.6.3 Fault finding

Initial fault finding is carried out differently from case to case. Generally, it is the respective facility owner who is responsible for fault finding.

3.6.4 Fault clearance, remaining faults

Once the fault has been localized, the respective facility owner will look after fault clearance. For fault clearance, a special preparedness plan for submarine cables has been drawn up.

4 System operation for facilities under 2.1 and 2.2

4.1 Total Transmission capacity (TTC)

4.1.1 Transmission capacity in MW per cable bundle

Line	5 °C	15-20 °C	30 °C
Hovegaard – Söderåsen	830	830	830

Görlöse – Söderåsen	830	830	830
Teglstrupgaard 1 – Mörarp	182	182	154
Teglstrupgaard 2 – Mörarp	173	173	157
Hasle, Bornholm - Borrby,	60	60	60

4.1.2 Transmission capacity in MW per link

- To Eastern Denmark

Link	Capacity (MW)
Öresund (Zealand)	1,350
Bornholm	60

- To Sweden

Link	Capacity (MW)
Öresund (Zealand)	1,750
Bornholm	60

The transmission capacities (TTC) of the links are technically dependent and can be affected by the current operational situation in Zealand.

4.2 Routines for determining the transmission capacity

The transmission capacity between Eastern Denmark and Sweden shall be set on a daily basis by the Parties.

4.3 Trading capacity (Net Transmission Capacity – NTC)

Determination of the capacity is based on the combined transmission capacity of the 400, 130, and 60 kV transmission facilities. When determining the trading capacity (NTC) of the links, the applicable regulation margin of 50 MW is taken into account. A weekly forecast for the trading capacity shall be established for the coming week.

If a country can guarantee *counter trading* and the existence of sufficient *fast active disturbance reserve*, the *trading capacity* may be increased.

4.4 Operation monitoring and control in respect of system operation

Operation monitoring of borders and transmission constraints, which can affect exchanges, is managed on the Danish side by Energinet's Control Centre at Erritsø and on the Swedish side by Svenska kraftnät's Operations Centre at Sundbyberg (Svk-vhi).

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 Sundbyberg (DCSY) is responsible for voltage regulation in the southern parts of the grid.

The following voltage levels are applied:

Substation	Min voltage (kV)	Normal operation range (kV)	Max voltage (kV)
Söderåsen	395	400-410	420

4.5.2 Voltage regulation on the Danish side

The Control Centre at Erritsø is responsible for voltage control in Zealand.

The following voltage levels are applied:

Substation	Min voltage (kV)	Normal operation range (kV)	Max voltage (kV)
Hovegaard	380	390-410	420
Görlöse	380	390-410	420
Teglstrupgaard 1	130	130-137	137
Teglstrupgaard 2	130	130-137	137

4.5.3 Co-ordination of voltage regulation

Mvar contribution from the cables is distributed between Svenska kraftnät and Energinet in the same proportion as their ownership.

At a voltage of 400 kV, the facilities FL23 and FL25 each will generate 150 – 170 Mvar. The reactors at Hovegaard and Söderåsen compensate this generation by 110 Mvar per line.

The 400 kV voltage at Hovegaard and Söderåsen shall be regulated so that the given Mvar distribution is achieved as well as possible. Minor deviations in the region of 25 Mvar are accepted in normal operation. Short-term deviations from this Mvar range can occur for example in conjunction with the connection of capacitor batteries or reactors. There can be deviations in the Mvar distribution in conjunction with disturbances.

4.6 Outage planning

The Parties shall, in consultation, plan outages on the links and on their own networks if the transmission capacity of the links is affected.

Operational planning and maintenance are co-ordinated in consultation between Energinet's Operational Planning at Erritsø and Svenska kraftnät's Outage Planning at Sundbyberg.

Operational planning and maintenance which affects the entire Nordic system shall, whenever possible, be co-ordinated in consultation with all system operators.

4.7 Disturbance management

The term disturbance situation here means that the operational security limits have been violated due to, for instance, long-term line faults or the loss of production. If the transmission capacities are not exceeded during the faults, the situation will be deemed to be normal.

In the event of operational disturbances, measures in accordance with the issued instructions shall, as soon as possible, restore the link to operation within defined security limits.

5 Miscellaneous

5.1 Parallel operation 130 kV

Power transmitted via the 130 kV network does not entail any liability to render payment or any other reimbursement of expenses from Svenska kraftnät or Energinet.

5.2 Transmissions to Bornholm

As regards balance, Bornholm is managed as a part of the Eastern Danish subsystem. Energinet shall be responsible for the production resources on Bornholm being capable of being utilized for general system operation requirements in the same way as the production resources in the rest of Eastern Denmark.

5.3 Co-ordination of fast active disturbance reserve south of constraint 4

Svenska kraftnät and Energinet shall ensure that there is sufficient fast active disturbance reserve to cope with dimensioning faults based upon each subsystem's responsibility for its own reserves. Svenska kraftnät and Energinet's Control Centre at Erritsø shall exchange information regarding how much fast active disturbance reserve there is which can restore the operational situation to normal state following a fault.

During normal state, Svenska kraftnät and Energinet's Control Centre at Erritsø co-ordinate the fast active disturbance reserve in Southern Sweden and Eastern Denmark by summing up all available reserves in SE4 and DK2. If the total amount of reserves is not enough, the requirements should be distributed in accordance with the following distribution rules:

(Dimensioning fault) x (own fault) / (own fault + counterparty fault)

Dimensioning fault = largest fault in area south of constraint 4

Own fault = largest fault in own area south of constraint 4

Counterparty fault = largest fault in counterparty's area south of constraint 4

In Sweden, south of constraint 4, the largest fault is typically the result of:

- Network part of constraint 4
- Baltic Cable
- SwePol Link
- NordBalt

In Eastern Denmark, the largest fault is typically the result of:

- Unit at the Avedöre plant
- Kontek
- Great Belt

Joint triangular operation between the Norwegian, Swedish and Western Danish subsystems

Appendix 7 to SOA Annex OS (NO, SE and DK1)

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

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1 Transmission facilities triangularly linking the subsystems Sweden – Western Denmark – Norway

Facility	Voltage kV	Other information
Hasle-Borgvik	400 kV AC	Part of Haslesnittet
Halden-Loviseholm	400 kV AC	Part of Haslesnittet
Lindome-V Hassing	285 kV DC	Konti-Skan 1
Lindome-V Hassing	285 kV DC	Konti-Skan 2
Kristiansand-Tjele 1 and 2	250 kV DC	Skagerrak 1 and 2
Kristiansand-Tjele 3	350 kV DC	Skagerrak 3
Kristiansand-Tjele 4	500 kV DC	Skagerrak 4

2 Principles for the distribution of exchange plans on the links

The NEMOs utilizes the trading capacity which the system operators have set in order to try to avoid price differences between the bidding zones.

Energinet's Control Centre at Erritsø sets a trading capacity to and from the bidding zone in Western Denmark, DK1, which can entail a limitation of the trading capacities between the bidding zones Western Denmark – Norway, DK1-NO2, and Western Denmark – Sweden, DK1-SE3. Distribution between the interconnectors takes place on a pro rata basis, depending on the DC links' trading capacities. In the event of a price difference between the zones, the trading capacity will be redistributed so that it is increased from a low-price area to a high-price area within the framework of the overall trading capacity.

For ramping on the interconnectors, Svenska kraftnät, Statnett and Energinet agree to follow the methodology for Ramping Restrictions.

Based on hourly plans from the NEMOs, Energinet's Control Centre at Erritsø draws up preliminary power plans on the DC links towards Sweden and Norway with ramping transitions between the different power levels, taking into account the agreed ramping rate. Energinet also has an opportunity to minimise network losses in the triangular link. Energinet's Control Centre at Erritsø is responsible for the plans meeting the stipulated requirements.

The RGCE system has a requirement that the entire regulation must be completed within ±5 minutes at hour shifts.

Transits through Western Denmark entail that power plans and regulations for the DC links reflect the RGCE requirement.

These power plans can later be re-planned as a result of exchanges of supportive energy, either bilaterally between two of the relevant system operators or between all three system operators.

The exchange of equal volumes of supportive energy between all three system operators in a triangle (DC loop) is used to relieve heavily loaded links on the network, to obtain scope for regulating the frequency and to minimise the need for counter trading. All three system operators can take the initiative as regards supportive energy trading via the relevant DC links or the Hasle constraint. Statnett has a co-ordinating function. Triangular trading requires the approval of all three Parties.

Energinet's Control Centre at Erritsø is responsible for drawing up new power plans for the DC links in accordance with the stipulated requirements and for informing the other system operators.

All Parties shall be informed about the potential transmission capacity of all three links as regards the allocation of balancing energy and supportive energy.

Joint operation between the Western and Eastern Danish subsystems on DC Link Great Belt

Appendix 8 to SOA Annex OS (DK1 and DK2)

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
2025-02-06	2025-02-06	Reference to appendix 5 in old SOA updated

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AGREEMENT ON JOINT OPERATION BETWEEN THE EASTERN AND WESTERN SUBSYSTEMS OF DENMARK ON THE DC LINK GREAT BELT

As a consequence of the commissioning of the Great Belt interconnector between Denmark East and Denmark West the transmission system operators in Sweden, Finland, Norway and Denmark have agreed to add an appendix 7.8 "Joint Operation Between The Eastern and Western Subsystems of Denmark on the DC Link Great Belt" to System Operation Agreement dated 13th of June 2006.

Appendix 7.8 is available in Swedish (Bilaga 7.8 Samdrift mellan de väst- och östdanska delsystemen på likströmförbindelsen Storebælt) in the version dated 30th of January 2014.

For Svenska Kraftnät

For Fingrid

For Statnett

ØIVIND RUE

For Energinet.dk

Revision history

Version	Date	Comments
1. Final	2014-01-30	First version.

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 conditions for the operation of the DC link between Western and Eastern Denmark linking the synchronous systems in the Nordic area and Continental Europe.

2 Transmission facilities linking the subsystems of Eastern Denmark and Western Denmark

Facility	Voltage kV
Great Belt	
Fraugde - Herslev	400 kV DC

It is decided on a weekly basis whether the settlement takes place in Fraugde or Herslev.

3 Electrical safety for facilities

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

Energinet is responsible for the electrical operation of Great Belt.

3.3 Switching responsible operator

Energinet is the switching responsible operator for the whole of Great Belt.

3.4 Operational monitoring and control in respect of electrical safety

Operational monitoring and control of the DC link are carried out from Energinet's Control Centre at Erritsø.

3.5 Switching schedule

Switching concerning Great Belt takes place as follows:

- Switching which concerns Great Belt takes place in accordance with a switching schedule drawn up by Energinet.

3.6 Disturbance management

3.6.1 Cross-border link trips – management

During operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the link to normal state.

3.6.2 Switching schedule

Energinet draws up switching schedules for switching concerning Great Belt.

3.6.3 Fault finding

Initial fault finding is carried out differently from case to case. Energinet is responsible for fault finding. For fault finding, a special preparedness plan for submarine cables has been drawn up.

3.6.4 Fault clearance, remaining faults

Energinet is responsible for fault clearance. For fault clearance, a special preparedness plan for submarine cables has been drawn up.

4 System operation for facilities under 2

4.1 Total Transmission capacity (TTC)

The total transmission capacity (TTC) of the link is dependent on the temperature of the air and the earth.

Nominal capacity:	600 MW
Technical minimum capacity:	18 MW

4.2 Routines for determining the transmission capacity

Energinet determines the transmission capacity between Western Denmark and Eastern Denmark. In the case of intact connecting networks, the transmission capacity is determined by the thermal capacity of the facilities' components. The thermal overload capability allowed by monitoring equipment shall be capable of being used as and when required in accordance with special instructions.

4.3 Trading Capacity (Net Transmission Capacity - NTC)

The normal trading capacity is:

590 MW from Western Denmark → Eastern Denmark

600 MW from Eastern Denmark → Western Denmark

The following calendar day's trading capacity is set every day. The trading capacity can be limited by line work in the connection area, production in the connection area, overhauls on the link etc.

4.4 Operational monitoring and control in respect of system operation

Operational monitoring and control are carried out from Energinet's Control Centre at Erritsø.

4.4.1 Regulating the link

Regulation of Great Belt in accordance with agreed exchange plans is carried out from Energinet's Control Centre at Erritsø.

Regulation takes place, in principle, in accordance with a power plan using ramping transitions between different power levels. The plans are issued as power plans in full MWs for each 5 min plan value. The links are regulated in accordance with this power plan linearly from power value to power value.

The power plan is determined in accordance with the exchange plan for Great Belt.

4.5 Outage planning

Energinet shall plan outages on the link itself and in the network when the outages impact upon the transmission capacity of the link.

Overhaul planning is co-ordinated with the other HVDC links in the Nordic area.

4.6 System protection - emergency power - stopping of ramping

4.6.1 General

The Great Belt link is of major importance to Denmark, and outages due to disturbances thus generally entail major economic losses. In the event of operational disturbances, measures in accordance with issued instructions shall, as soon as possible, restore the link to normal state.

Automated operational disturbance systems are installed at Fraugde and Herslev. These can begin to function during operational disturbances in the network in Eastern or Western Denmark.

At the DC facility, system protection is installed in the form of an emergency power function and stopping of ramping function.

4.6.2 Delta Power Control (DPC 1-4)

Delta power consists of control measures which are initiated manually.

Energinet's operations centre at Erritsø has the right to initiate less than 100 MW of manual delta power on Great Bælt without advance notice. If the delta power activation is more than 100 MW, notification and approval shall take place between the staff of Energinet's operations centre at Erritsø and SvK-VHI at Network Control at Sundbyberg.

4.6.3 Stopping of ramping

Stopping of ramping represents regulating measures which are initiated automatically when the frequency in the network in Eastern or Western Denmark exceeds the established limits. Stopping of ramping is used to avoid a frequency deviation from the nominal frequency.

4.6.4 Emergency power

The activation criteria for emergency power and stopping of ramping can be locally measured frequency and voltage or those measured via telecommunications on the basis of a supplied signal. In the event of activation, any ongoing normal regulation will be interrupted. Activation beyond the agreed limits and regulation back to plan can only take place following approval by and between the staff of Energinet's operations centre at Erritsø and SvK-VHI at Network Control at Sundbyberg. (See also Appendix 9 System protection schemes.)

4.6.5 System protection schemes

System protection schemes are initiated automatically (see 4.6.4) by means of a control signal being transmitted to the converter stations by means of telecommunications.

Typically system protection schemes will utilize the Emergency power bipole control Emergency Power functionality. The activation of emergency power shall be documented retroactively and communicated to the Parties to this agreement. The reason for activation shall be given.

5 System services

5.1.1 Manual reserves

The purchases of manual reserves are decreased by 300 MW in Western Denmark under normal circumstances, and approximately 600 MW of manual reserves are maintained in Eastern Denmark.

In situations where the outcome from the spot market has resulted in a flow in excess of 300 MW from east to west on Great Belt, Energinet assesses whether there is a need for up to 300 MW of manual reserves in Western Denmark in the afternoon, in other words after the spot market has closed.

When Great Belt is out of operation, manual reserves are purchased to Western Denmark for dimensioning faults.

5.1.1.1 Intraday market

Available capacity remaining after the spot market is allocated to XBID.

5.1.2 Manual frequency support

Energinet supports, as far as possible, the frequency of the Nordic synchronous system via Great Belt in the same way as via Skagerrak and Konti-Skan.

5.1.3 Automatic frequency support

Great Belt is constructed for automatic power regulation. The function is used for the transmission of Frequency Restoration Reserve Automatic (FRR-A) to the Nordic synchronous system from Western Denmark.

When Konti-Skan cannot contribute to the frequency controlled disturbance reserve because Konti-Skan or the emergency power function is out of operation, Konti-Skan's contribution to the frequency controlled disturbance reserve is placed on Great Belt.

5.1.4 Transmission scope for operational reserves

Available transmission capacity can be used for the automatic or manual activation of operational reserves in accordance with this Agreement.

System Protection Schemes

Appendix 9 to SOA Annex OS

FINGRID ENERGINET SVENSKA KRAFTNÄT Statnett kraftnät åland

Approval date	Entry into force	Revision
2025-02-06	2025-02-06	Initial version based on old SOA

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1 Background

Automatic *system protection* is used to limit the impact of faults by means of measures beyond disconnecting the defective component. *System protection* can be used to increase *system security*, *transmission capacity,* or a combination of these.

Automatic system protection uses two different principles of operation. One of these is system protection that is activated via measurements of the system state, e.g. the voltage at a critical point or the system frequency. The other is system protection that is activated by predetermined events, e.g. one or more relay signals from the facilities' protective equipment.

Automatic system protection limits the consequences of operational disturbances in one or more of the following ways:

- quick changes in flows on DC facilities, *emergency power*
- production shedding (PFK) or downward regulation of production
- automatic *load shedding* (AFK) and, in some cases, reactive shunts
- start-up of production
- network switching

This appendix describes the automated system protection schemes used in the Nordic power system. Manual operations to handle overload and temporary increased system security are not covered in this appendix.

2 General requirement to system protection schemes

For *system protection* the following requirements have been set:

- An analysis must be done which shows the consequences for the power system in the event of a correct, unwarranted, and missing function considering simultaneously the other system protections.
- In the event of a correct or unwarranted function, *serious operational disturbances* will not be accepted in other *subsystems.*
- If the above consequence analysis shows that a missing function can entail *serious operational disturbances* for other *subsystems,* the following technical requirements shall apply to the *system protection* function:
  - Redundant telecommunications shall exist in cases where system protection is dependent on telecommunications. This means that communications between the stations concerned shall be entirely duplicated. If the auxiliary power feed for one of the communications systems fails, then the other must not be affected. In practice, this means that batteries, telecom terminals, converters and communication paths must be duplicated. Communication paths may not, on any section, share connections, leads, opto cables or similar. They must take geographically separated routes. Multiplexed links can be used but communications shall use separated multiplexes that are not fed by the same battery. Having separate fuses on the same battery, does not constitute full redundancy.
  - There must be real time monitoring of telecommunications.
  - There must be a redundant and independent "triggering function". If this relates to breakers, it means that the breaker has two trip magnets. Breaker fault protection shall be used to safeguard breaker operation if the ordinary breakers are not functioning correctly

- The control facility and telecommunications standard shall be on the same acceptable reliability level as the one applicable to primary relay protection
- If a consequence analysis shows that a missing function will not entail *serious operational disturbances* for other *subsystems*, the relevant *subsystem's system operator* will decide which requirements apply to the *system protection* function.
- *If a consequence analysis shows that a correct, unwarranted or missing function can lead to more extensive consequences than dimensioning faults, system protection must be accepted* separately between the parties.

3 System protection activated by frequency deviations

A low frequency during *operational disturbances* is traditionally dealt with using *frequency-controlled disturbance reserve* (FCR)

Frequency controlled disturbance reserve is dimensioned to maintain the frequency within permissible limits in the event of *operational disturbances*. If this is not successful and the frequency continues to drop, *load shedding* might curb the frequency drop. The use of frequency-controlled changes in flows on HVDC installations, *emergency power*, is to prevent major frequency drops.

A high frequency is traditionally dealt with using the downward regulation of production or, in extreme situations, using *production shedding.* In this case too, use of the frequency-controlled changes in flows on HVDC installations is implemented to prevent major frequency increase.

3.1 Emergency Power Control (EPC) from HVDC interconnections

Emergency power is power control on HVDC links activated by automatic systems on both sides of the respective HVDC link.

At the DC facilities, system protection is constituted by emergency power settings at the converter stations. Activation criteria can be locally measured frequency and voltage or via telecoms based on the supplied signal. In the event of activation, any ongoing normal regulation will be interrupted. Activation over and above the agreed limits and regulation back to plan may not occur until the counterparty has approved this.

The maximum impact on flows of different HVDC interconnections during frequency deviations in the Nordic area can be seen in table 1. It should be pointed out, however, that if a HVDC installation is performing a full import to an area with a low frequency, it will not be able to contribute to *emergency power*.

SOC decided in their 62nd meeting 30 September 2020 that the proposed Mutual Frequency Support framework was applicable to current operational HVDC links (where technically possible) and all future HVDC links. TSOs that have an HVDC interconnector shall initiate the implementation with the objective of completing the technical adaptations within a period of no longer than 5 years. According to this the Requirements for LFSM on HVDC must be implemented by January 1st, 2026. This might have an impact on the existing EPC as described in table 1.

Table 1: Frequency controlled emergency power

Bipol	f(Hz)	dP (MW)	Delay (ms)
Skagerak 1-2	49,0	120	60
Skagerak 3-4	49,0	120	60
NordBalt	49,1	300	500
SwePol	49,1	300	500
Baltic Cable	49,2	300	500
Skagerak 1-2	49,3	140	60
Skagerak 3-4	49,3	130	60
SwePol	49,4	150	500
NordBalt	49,4	150	500
Estlink 1	49,5	0...50	0
Konti-Skan 1-2	49,5	150	50
Kontek	49,5	50	100
Baltic Cable	49,55	150	500
Konti-Skan 1-2	49,6	150	100
Estlink 2	49,7	0...50	3000
Konti-Skan 1-2	49,8	150	300
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Konti-Skan 1-2	50,3	150	100
Kontek	50,5	50	100
Konti-Scan 1-2	51,0	150	50
Baltic Cable	51,0	50	500
SwePol	51,0	60	500
NordBalt	51,0	60	500
Skagerak 3-4	51,0	240	60

3.2 Start-up of production

Automatic frequency-controlled start-up of production is carried out to increase production in the power system during *operational disturbances*. In the Nordic synchronous area, the only start-up of production is the gas turbine in Sweden starting up 800 MW in three stages of 0.1 Hz in the area 49.7-49.5 Hz.

3.3 Load shedding

If a frequency drop cannot be curbed by the regulation of DC installations and the frequency continues to drop, automatic *load shedding* will occur. The load shedding (LFDD) shall be activated in all the countries in the Nordic synchronous area in a 4-step scheme shedding 20 % of the load in 5% steps activating at 48,8 Hz, 48,6 Hz, 48,4 Hz and 48,2 Hz. In addition, there will be some load shedding activated at 48,0 Hz. This amount may differ between the TSOs.

3.4 Disconnection of lines

Frequency controlled disconnection of the Öresund link (DK2 – SE4) occurs at f < 47.0 Hz in 0.5 s or f < 47.5 in 9 s.

3.5 Stop ramping

If the frequency is below 49,92 Hz and NordBalt is ramping out of the synchronous system, the ramping will be automatically stopped. Similarly, the ramping will also be stopped if the frequency is above 50,08 Hz and NordBalt is ramping into the synchronous system.

If the frequency is below 49,85 Hz and SwePol is ramping out of the synchronous system, the ramping will be automatically stopped. Similarly, the ramping will also be stopped if the frequency is above 50,15 Hz and SwePol is ramping into the synchronous system.

4 System protection activated by voltage deviations

4.1 Sweden constraint 4

The *System protection* will regulate down the transmissions on three DC links to the continent when the voltage in southern Sweden falls below 390 kV. In doing so, constraint 4 will be relieved immediately in the event of an *operational disturbance*. When *system protection* is in operation, a higher level of transmission will be allowed in constraint 4 (2/3 of the *emergency power* intervention). The increased capacity in constraint 4 may only be used when consumption south of constraint 4 is less than 4,500 MW. *System protection* obtains the measured values from seven substations: Breared, Hallsberg, Hedenlunda, Hjälta, Kilanda, Tenhult and Sege.

The criterion for the activation signal of *system protection* is that the voltage in one of these seven points goes under 390 kV for 4 seconds. Upon activation, there will be a power change of 200 MW northbound for Baltic Cable (BC emergency power control entry 3), 250 MW northbound for Kontek, and 300 MW northbound for the SwePol Link (SwePol emergency power control entry 4). For the SwePol Link to become activated, it is also necessary that the voltage at Stärnö is lower than 415 kV.

The Kontek power change will only be initiated if the Øresund flow towards Sweden is below 1400 MW and the northbound flow in the central part of the DK2 grid is below 1700 MW. This is implemented in system protection of Energinet.

4.2 Southern Norway

In Norway, there is *system protection*, which is voltage-controlled. The Skagerrak cables have *emergency power* regulation which is controlled by local voltage measurements at Kristiansand. A low voltage of 275 in 0,8 s results in 200 MW reduced flow towards Denmark within 2 seconds on Skagerrak 1&2 and 270 kV in 0,8 s gives 200 MW reduced flow towards Denmark within 1 second on Skagerrak 3&4.

5 System protection activated by one or more relay signals

5.1 Denmark

5.1.1 Ishøj east, DK2

The purpose of this system protection is to protect the three lines leading out from AVV_400 in case one line is disconnected and another trips. The system protection will reduce the production on AVV B02 steam turbine to 150 MW and disconnect the gas turbines.

5.1.2 Hovegård North, DK2-SE4

This system protection has been installed to protect the two 132 kV Øresund cables if the last 400 kV line is disconnected. The system protection is only armed if one of the 400 kV cables are disconnected and the Øresund power flow is above certain thresholds. If armed, it can be activated by tripping of one of the 400 kV lines connecting DK2 to SE4. The system protection consists of four pre-fault power flow scenarios:

- Øresund flow direction SE4 between 350 MW and 540 MW: 300 MW power flow change on Great Belt1 direction DK1.
- Øresund flow direction SE4 above 650 MW: 600 MW power flow change on Great Belt1 direction DK1.
- Øresund flow direction DK2 above 150 MW: 250 MW power flow change on Great Belt1 direction DK2.
- Øresund flow direction SE2 above 150 MW and Great Belt1 flow direction DK2 above 350 MW: 250 MW power flow change direction DK2 on both on Great Belt1 and Kontek.

The regulation speed is 500 MW/s for Great Belt1 and 100 MW/s for Kontek. HVDC reversal of power direction is allowed.

5.1.3 Hovegård South, DK2

The three 400 kV lines leading south from Hovegård 400 kV station (DK2) are equipped with system protection to protect the 400 kV, 220 kV and 132 kV grid from overload. If one 400 kV line is disconnected and the grid power flow is above certain thresholds, and another 400 kV line trips, the system protection is activated. The system protection consists of three pre-fault power flow scenarios:

- Southbound power flow above 1000 MW: Runback of Great Belt1 to 150 MW and activation of weak grid mode.
- Northbound power flow between 1000 and 1300 MW: 300 MW power flow change on Great Belt1 direction DK1.
- Northbound power flow above 1300 MW: 600 MW power flow change on Great Belt1 direction DK1.

The regulation speed is 500 MW/s for Great Belt1. HVDC reversal of power direction is allowed.

5.1.4 Bjæverskov West, DK2

The two 400 kV lines leading west from Bjæverskov 400 kV stations (DK2) are equipped with system protection. The purpose is to protect the 132 kV grid from overload and secure stable operation on Great Belt1 HVDC. If one 400 kV line is disconnected and the other one trips, Great Belt1 infeed to DK2 will be reduced to 150 MW and weak grid mode is activated. The regulation speed is 999 MW/s.

5.1.5 Kriegers Flak transformer, DE-DK2

If one of the 500 MVA 400/220 kV transformers connecting the Kriegers Flak offshore system to DK2 is tripped and the power flow to DK2 is above 650 MW a runback to 240 MW on the Danish Kriegers Flak wind farm is initiated. This can result in a maximum power change into DK2 of 370 MW. The down regulation speed of the wind farm is 60 MW/s.

5.1.6 Kriegers Flak Master controller, DE-DK2

The Kriegers Flak offshore system between DK2 and Germany (called Combined Grid Solution) is equipped with automatic load flow control (master controller) controlling the agreed power exchange at the offshore border and keeping the loading of components below their limits. The offshore grid is operated without N-1 security. This is done by first controlling the power flow on the HVDC back-to-back converter in Bentwisch(Germany) and secondly curtailing offshore wind generation in either the Danish or German part of the system depending on the location of the grid constraint and the power flow direction. If an offshore 220 or 150 kV cable trips the power flow change into DK2 can be up to 350 MW depending on the prefault power flow. The regulation speed is slow, 100 MW/min., due to the large thermal time constants of the offshore cables.

5.1.7 Fraugde-Landerupgård, DK1

The two 400 kV lines west of 400 kV station Landerupgård (DK1) is equipped with system protection to protect the 150 kV grid. If one line is disconnected and the other one trips and the Great Belt1 power flow is above 25 MW a runback of Great Belt1 is initiated. The regulation speed is 999 MW/s.

5.1.8 Kassø-Landerupgård, DK1

The 400 kV line south of 400 kV station Landerupgård (DK1) is equipped with system protection to protect the 150 kV grid and ensure voltage stability when the regions 400 kV connection to Germany is lost. If the line trips, the flow on the line is above 50 MW and the flow on Great Belt1 is above 250 MW a runback of Great Belt1 to 250 MW is initiated. The regulation speed is 999 MW/s.

5.2 Sweden

5.2.1 Production shedding for limiting overloads on lines

System protection carries out the shedding of hydropower production in northern Sweden via remotely transmitted signals from activated protection functions. Total extent of approx. 1,600 MW of installed power. Upon disconnection of lines in constraint 1, there is a risk that other lines will become overloaded. The *system protection* will disconnect production so that the lines will be relieved. The signals originate from Grundfors, Betåsen, and Hjälta and are sent to stations northwards. The setting of the automated equipment is adapted to the state of operation.

The *system protection* also includes a link with Norway so that the loss of a link between Porjusberget and Ofoten will disconnect production in northern Norway.

In case of loss of the 400 kV line between Midskog and Järpströmmen or loss of the 400/220 kV transformer in Järpströmmen, the system protection will disconnect the generators in Järpströmmen and the 220 kV line Järpströmmen-Juveln-Olden-Stensjön in order to avoid overloading the 220 kV grid between Midskog and Järpströmmen.

The loss of Midskog-Järpströmmen line will also lead to disconnection of the 400 kV line Järpströmmen-Högåsen-Nea (in Norway) and a signal is sent to Norway for load shedding in NO3 (in case of export from SE2 to NO3).

The loss of the 400 kV line Järpströmmen-Högåsen-Nea (in Norway) will result in load shedding in NO3 (in case of export from SE2 to NO3).

5.2.2 The West Coast constraint

During imports from Poland, Germany, Zealand and Jutland and a high level of production at Ringhals, simultaneous to exports towards Norway, there is a risk of overloads on the remaining line in Västkustsnittet in the event of a long-term fault on one of the lines. To protect against overloads, there is system protection that, in the event of the loss of Kilanda-Horred or Kilanda-Stenkullen and with transmissions in excess of 500 MW in the northern direction in Västkustsnittet, makes a power change on Konti-Skan 2 down to 0 MW or at 300 MW against Western Denmark based on the selection.

This *system protection* does not provide increased capacity, rather it increases the *system security*. To Eastern Denmark, there is a channel that is activated by system protection and makes a power change of 300 MW direction DK1 on Great Belt1, given that certain operational criteria have been met. The Great Belt power change will only be initiated if the flow on Øresund towards Sweden is above 1000 MW.

In addition, *system protection* protects the underlying 130 kV network against overloads in conjunction with exports on Konti-Skan. If Konti-Skan 2 becomes isolated from the grid but remains connected to the 130 kV network, a signal that controls the exports down to 0 MW is sent, when the regional network cannot supply power both to the Gothenburg region and for exports on Konti-Skan 2, if the supply from the grid is lost in Lindome. During imports, Konti-Skan 2 supply to the Gothenburg region is enhanced for the same situation and remains connected.

Alongside these *system protection* means, there is a “Last Line” protection that disconnects Konti-Skan 1 if contact with the 400 kV network is lost.

There is system protection for protecting the 130 kV network Lindome against overloading, to be introduced when the connection Stenkullen-Strömma or Strömma-Breared is not in operation.

During a fault on the remaining line, system protection will automatically disconnect the Lindome transformers.

It shall be noted that the power change into DK1 shall respect the reference incident of DK1 of 700 MW. The maximum possible power change into DK1 by this system protection is 600 MW (300 MW from Konti-Skan and 300 MW from Great Belt).

5.2.3 Sege

In the event of a relay protection function which disconnects the remaining line in Sege, system protection activates the disconnection of Baltic Cable. System protection is activated irrespective of the direction of transmissions on Baltic Cable.

5.2.4 Loviseholm for the Hasle constraint

During high export levels from southern Norway to Sweden, there is a risk that the loss of a line can bring about overload, voltage or stability problems.

If the total power flow of Halden - Loviesholm and Hasle - Borgvik towards Sweden is larger than 1,200 MW and Loviseholm - Skogssäter is lost, the transformer in Loviseholm will be disconnected to protect the system.

5.2.5 NordBalt

In the event of a relay protection function which disconnects one of the 400 kV lines to the station Nybro, the connection point of NordBalt, NordBalt will be reduced to 0 MW, depending on which of the 400 kV lines that is disconnected and the direction of power transfer on NordBalt.

5.2.6 East-west flow

In the event of a relay protection function which disconnects on of the following lines Hamra - Åker, Åker - Hedenlunda, Hall – Hedenlunda, Hedenlunda – Glan – Kolstad or Hedenlunda – Glan – Kimstad and the current on that line is above a predefined level before the fault, EPC on Konti-Skan and Fenno-Skan 2 will be activated. Konti-Skan will change 300 MW towards Sweden. Fenno-Skan 2 will change 400 MW towards Finland.

5.3 Norway

5.3.1 Hasle and Flesaker constraint (PFK), NO2/NO1 – SE3

During high export levels from southern Norway to Sweden, there is a risk that the loss of a line can bring about overload, voltage or stability problems. In the event of critical losses, the *system protection* must relieve the constraints by means of automatic *production shedding* at Kvilldal, Sima, Aurland, Tonstad, Tokke, Vinje, Oksla and Songa. The maximum permissible *production shedding* is 1,200 MW and activation will occur as a result of the following events:

Loss of Sylling-Tegneby, Tegneby-Hasle, Hasle-Borgvik, Rød-Hasle, Hasle-Halden, Halden-Loviseholm, Loviseholm-Skogssäter, Skogssäter-Kilanda, .

If the loss of the line Ådal-Frogner is critical, system protection that automatically disconnects production in Aurland and/or Sima can be activated.

The *system protection* is also partly described under section 4.2.6.

5.3.2 Nordland constraint 1 (PFK), NO4- SE1

In the event of a large power surplus in northern and central Norway, there is a risk of *network collapse* in the event of losing critical lines. The *system protection* must rapidly relieve the constraint by means of automatic *production shedding* or through network division so that the *surplus area* is separated from the rest of the *synchronous system*. The largest permissible *production shedding* is 1,400 MW.

The *system protection* will be activated by the following events:

- The loss of Ofoten-Ritsem, Ritsem-Vietas, Vietas-Porjusberget, Porjusberget – Harsprånget, Porjusberget-Grundfors, Ofoten-Kobbvatnet, Kobbvatnet-Salten, Salten-Svartisen, or Svartisen-Rana-Nedre Røssåga.

The *system protection's* setting will depend on the operational situation and can result in *production shedding* at Vietas, Ritsem, Kobbelv and/or Svartisen. Loss of the lines Ofoten-Ritsem-Vietas-Porjusberget, Porjusberget – Harsprånget or Porjusberget-Grundfors might also lead to network division south of Kobbelv and/or network division between Norway and Finland. The *system protection* is also described under section 4.2.1.

5.3.3 Nordland constraint 2 (PFK), NO4/NO3-SE2

In the event of a large power surplus in central Norway, there is a risk of *network collapse* in the event of losing critical lines. The *system protection* must rapidly relieve the constraint by means of automatic *production shedding*. The largest permissible *production shedding* is 1,200 MW.

The *system protection* might be activated by the following events:

- The loss of one of the 300 kV connections Nedre Røssåga-Marka-Trofors-Tunnsjødal-Verdal-Strinda-Klæbu or 420 kV Klæbu-Nea-Järpströmmen-Midskog, or 420 kV Nedre Røssåga-Tunnsjødal-Namsos-Ogndal-Verdal-Klæbu-Surna-Viklandet or 420/300 kV Nedre Røssåga transformer or 420/300 kV Klæbu transformer.

The *system protection's* setting will depend on the operational situation and can result in *production shedding* at Svartisen, Harbaksfjellet, Kvenndalsfjellet, Storheia, Roan (Harheia and Einarsdalen) and/or Sørmarksfjellet.

5.3.4 System protection for load shedding

System protection which disconnects 470 MW SU4 or 180 MW SU3 of industrial loads in the event of the loss of one or two 300 kV lines adjacent to Møre or in the event of the loss of at least one of the 420 kV lines Midskog-Järpströmmen-Nea- Klæbu-Surna-Viklandet. The network supplies general consumption and important industrial centres in Nord-Vestlandet.

5.3.5 Sørlandsnittet (PFK and HVDC control)

During abundant exports from Southern Norway to Denmark and with simultaneous low local production, there is a risk of loss of a line, which can lead to overload or voltage problems. During a critical loss of a line, the *system protection* will relieve the constraint through automatic downward regulation of the Skagerrak HVDC line. The *system protection* measures overload on the 300 kV lines at three stations. The *system protection* regulates 400 or 600 MW of exports down on Skagerrak 34 during 1-2 s.

During abundant imports to Southern Norway from Denmark and with simultaneous high local production, there is a risk of loss of a line, which can lead to overload or voltage problems. During a critical loss of a line, the *system protection* will relieve the constraint through automatic downward regulation of the Skagerrak HVDC line or PFK at Tonstad. The *system protection* measures overload on the 300 kV lines at two stations and overload on the 420 kV at one station. The *system protection* regulates 300 or 600 MW of imports down on Skagerrak 34 during less than 1 s and/or regulates production down at the Tonstad power plant (4 x 160 MW available).

During high exports or in the event of an outage in Southern Norway, there is system protection that, in the event of the loss of the 420 kV line Kristiansand-Brokke-Holen or the 420 Rød-Grenland-Bamble-Arendal-Kristiansand, reduces the exports by 400 or 600 MW on Skagerrak. During import in the event of loss of the 420 kV line Kristiansand- Brokke-Holen or the 420 Rød-Grenland-Bamble-Arendal-Kristiansand, the system protection reduces the imports by 300 or 600 MW and/or reduces production at the Tonstad power plant (4 x 160 MW installed power).

5.3.6 NSL

During high exports and imports from/to Southern Norway to/from Great Britain, a loss of a line can lead to overload problems. In critical line losses, system protection shall relieve the lines by means of automatic downward regulation of the NSL HVDC link. System protection measures the load on several lines in Southern Norway. System protection shall reduce the exports/imports on NSL by 600 MW within 1.0 s or 1200 MW within 1.7 s.

5.4 Finland

5.4.1 Frequency regulation with automated systems on the HVDC Fenno-Skan link

The *system protection* can be used when the AC connection between Finland and Sweden is broken to control the frequency when Finland is in island operation.

5.4.2 Power modulation for Fenno-Skan (Power modulation control)

The *system protection* can be used to attenuate large power oscillations between the countries. Uses the frequency difference between Sweden and Finland as a signal and modulates the power ± 100 MW. Not in service at the moment.