European Network of
Transmission System Operators
for Electricity

Definitions

Terms defined in this Appendix are written in italics in the Agreement and its Appendices.

The **active reserve** is divided into *automatic active reserve* (FCR) and *manual active reserve (FRR, RR)*.

Adjustment state is a transition from alert state to normal state, characterised in that consumption, production and transmissions in the network are adjusted so that the network can manage a (new) dimensioning fault. The adjustment takes place in 15 minutes from a fault which has involved the disconnection of components. See also *operational states*.

Alert state is an operational state which entails that all consumption is being met and that the frequency, voltage or transmissions are within acceptable limits. The reserve requirements are not fulfilled and faults in network components or in production components will lead to *disturbed state* or *emergency state*. Also see *operational states*.

Annual consumption is the sum of electricity production and net imports in a *subsystem*. Electricity production is the net production in a power plant, i.e. exclusive of the power plant's own consumption of electricity for electricity production.

An **area** is a part of the power system within a *subsystem*; an area can potentially comprise an entire *subsystem*. An area is bordered by *transmission constraints* in the national subsystems or by *cross-border links*.

Area prices are *Elspot prices* within a *bidding area*.

The **automatic active reserve** is the active reserve which is automatically activated during the momentary operating situation. It is divided into *frequency controlled normal operation reserve (FCR-N)*, *frequency controlled disturbance reserve* (FCR-D) and *voltage controlled disturbance reserve*.

Balance areas are areas of the power system where there is continuous regulation in order to maintain the frequency and a physical balance in relation to adjacent areas. In the Nordic area, the *synchronous system* and Western Denmark are separate *balance areas*.

Balance power is the difference between the planned and measured transmissions between the *subsystems*.

Balance regulation is regulation in order to maintain the frequency and *time deviation* in accordance with the set quality requirements. Regulation is also carried out for network reasons.

Bidding areas are the areas of the Elspot market which the *interconnected Nordic power system* is divided into in order to deal with potential capacity limitations (*bottlenecks*) on the *transmission network*. Potential *bottlenecks* give rise to different *Elspot prices* between *bidding areas*.

A **bottleneck** is a capacity limitation on the *transmission network*. On the Elspot market, attention is paid to *bottlenecks* between the *bidding areas*. During *operational planning* and *monitoring and control*, attention is paid to all physical *bottlenecks*.

Counter trading is the purchasing of upward regulation and the sale of downward regulation, on each side of a *bottleneck*, which the *system operators* carry out in order to maintain or increase the *trading capacity* of *Elspot trading* between two *bidding areas,* or in order to eliminate a *bottleneck* during the *day of operation*.

Critical power shortage occurs during the hour of operation when consumption has to be reduced/disconnected without commercial agreements about this.

A **cross-border link** is a link between two subsystems including connecting line feeders on both sides of the link. The limit for a feeder is where feeder connects to the busbar. Control equipment and auxiliary equipment are considered to be part of the cross-border link. Local distribution feeding auxiliary equipment is not part of the auxiliary equipment.

The **day of operation** is the calendar day around the momentary operational situation.

Dimensioning faults are faults which entail the loss of individual major components (production units, lines, transformers, bus bars, consumption etc.) and entail the greatest impact upon the power system from all fault events that have been taken into account.

Disturbed state is an operational state which entails that all consumption is being met, but that the frequency, voltage or transmissions are not within acceptable limits and that *normal state* cannot be achieved in 15 minutes. Also see *operational states*.

Elbas trading is power trading in Elbas at Nord Pool Spot. *Elbas trading* can take place prior to and during the *day of operation* after *Elspot trading* has finished.

Elspot prices are prices in *Elspot trading* within a *bidding area*.

Elspot trading is power trading on the spot market of Nord Pool Spot. *Elspot trading* takes place prior to the *day of operation* in all *subsystems*.

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

Emergency state is an operational state entailing that compulsory load shedding has been applied and that production shedding and network divisions may occur. Also see *operational states.*

ENTSO-E (European Network of Transmission System Operators for Electricity) is an organisation for *system operators in Europe.*

An **exchange plan** is a plan for the total agreed active power to be exchanged hour by hour between two *subsystems*. This can be a plan for a whole calendar day or a number of hours (energy plan) and, whenever *supportive power* occurs during a part of the hour, also a momentary plan during the hour (power plan).

The **fast active counter trading reserve** is the *manual active reserve* (FRR-M) for carrying out *counter trading.*

The **fast active disturbance reserve** is the manual reserve (FRR-M) available within 15 minutes in the event of the loss of an individual principal component (production unit, line, transformer, bus bar etc.). Restores the *frequency controlled disturbance reserve*.

The **fast active forecast reserve** is the *manual active reserve (FRR-M)* for regulation of forecasting errors for consumption and production.

Faults are events which occur in the power system and lead to a reduced capacity or loss of a line, bus bar, transformer, production units, consumption etc. A *fault* causes an *operational disturbance* in the power system. Also see *dimensioning fault.*

The **frequency controlled disturbance reserve** (FCR-D) is the momentarily available active power available for frequency regulation in the range of 49.9 – 49.5 Hz and which is activated automatically by the system frequency.

The **frequency controlled normal operation reserve** (FCR-N) is the momentarily available active power available for frequency regulation in the range of 49.9 – 50.1 Hz and which is activated automatically by the system frequency.

The **frequency response** indicates how production in a power system changes when the frequency in the system changes. The frequency response is indicated in MW/Hz.

The **interconnected Nordic power system** is the interconnected *subsystems* of Finland, Norway, Sweden, Western Denmark and Eastern Denmark for which the Nordic *system operators* have joint *system responsibility*.
Load following entails *players* with major production changes reporting their production plans with a time resolution of less than 1 hour.

Load shedding is the automatic or manual disconnection of consumption.

The **manual active reserve** is the active reserve which is activated manually during the momentary operational situation. This is divided into the *fast active forecast reserve,* the *fast active disturbance reserve,* the *fast active counter trading reserve* and the *slow active disturbance reserve*.

Manual emergency power is power regulation on the HVDC links which is activated manually.

A **momentary area control error** is the disparity (in MW) between the sum of the measured power and the sum of the agreed *exchange plan* on the links between the *subsystems* plus frequency correction, which is the *subsystem's* momentary *frequency response* multiplied by the deviation in the frequency away from 50 Hz. Also called the momentary imbalance.

N-1 criteria are a way of expressing a level of *system security* entailing that a power system can withstand the loss of an individual principal component (production unit, line, transformer, bus bar, consumption etc.). Correspondingly, n-2 entails two individual principal components being lost.

Network collapse is an operational state that entails that all loads in one or more areas are shed and that production shedding and network divisions can occur. Also see *operational states*.

Normal state is an operational state entailing that all consumption requirements are being met, that frequency, voltage and transmission lie within their limits and that reserve requirements are being met. The power system is prepared to deal with *dimensioning faults*. Also see *operational states*.

An **operational disturbance** is a disturbance to the power system. This can be the loss of a line, a bus bar, a transformer, a production unit or consumption.

An **operational instruction** is an instruction given to the control rooms of the *system operators* concerning how they are to behave in an operational situation.

Operational monitoring and control is the monitoring and control of the operation of the power system carried out by the control rooms.

The **operational phase** is the time from the momentary operational situation and the rest of the *day of operation* when trade on the Elspot market has already been determined.

Operational planning is the *system operators'* planning of the operation of the power system.

The **operational reserve** is the reserve that the *system operators* have access to during the *day of operation*. It is divided into the *active reserve* and the *reactive reserve*.

Operational reserves according to ENTSO-E classification:

- Frequency Containment Reserve (FCR)
- Frequency Restoration Reserve (FRR)
- Replacement Reserve (RR)

Operational security standards are criteria which the *system operators* use when conducting *operational planning* in order to uphold the reliable operation of the power system.

The **operational states** are *normal state, alert state, disturbed state, emergency state and network collapse*. See also *adjustment state* and *restoration*. These were earlier referred to as the power system's operational states. See Figure 1.

Outage planning is the planning done by each individual *system operator,* as well as between the *system operators,* of the necessary outages affecting *transmission capacities* between the *subsystems*.

A **Party** is one of the *system operators* entering into this Agreement regarding operation of the *interconnected Nordic power system*. The *Parties* are Energinet.dk, Fingrid, Statnett and Svenska kraftnät.

The **peak load resource** is an *active reserve* which normally has a long readiness time. In the event of anticipated peak loads, the readiness time is reduced so that the *peak load resource* can be used prior to the *day of operation* on the Elspot market or during the *day of operation* on the *regulation market.*

The **planning phase** is the time until which bids submitted for the next calendar day's *Elspot trading* on the power exchange can no longer be changed.

A **Player** is a physical or legal persona active on the physical electricity market in the form of bilateral trading with other *players*, *Elspot trading, Elbas trading* or trading on other existing marketplaces.

The **power operation manager** is the person who has obtained, from the holder, the task of being responsible for managing the electrical facility.

The **power operation responsibility boundary** is the boundary of a well-defined area in the *transmission facilities* between two *power operation managers*.

Power shortage occurs during the hour of operation when a *subsystem* is no longer capable of maintaining the demand for a *manual active reserve* which can be activated within 15 minutes.

A **price area** is a *bidding area* which, due to *bottlenecks* towards another *bidding area,* has been given an *Elspot price* of its own.

Production shedding means the automatic or manual disconnection of a production facility.

Ramping means restricting changes in *Elspot trading* on one or more cross-border links individually and together from one hour to the next. Also see *scaling*.

Ramp regulation means regulation of power based upon a specified ramp in order to even out the transition between two power levels, normally on HVDC cables at the changes of the hour.

The **reactive reserve** is the reactive power which is activated either automatically or manually during the momentary operational situation.

Redundancy is more than one independent opportunity for a piece of equipment to carry out a desired function.

Regulating bids are bids for upward or downward regulation at a specified output power at a specified price.

Regulating power is activated *regulating bids*, upward and downward regulations at power plants as well as the upward and downward regulation of consumption which producers or consumers offer in exchange for compensation. The *system operators* activate these bids during the momentary operational situation to maintain the balance/frequency within the *balance areas* and to deal with *bottlenecks* on the *transmission network*.

Regulation areas are the areas which the *regulation market* for the *interconnected Nordic power system* is divided into in order to manage possible capacity limitations (*bottlenecks*) on the *transmission network*. Potential *bottlenecks* will entail different *regulation prices* in the *regulation areas*.

The **regulation list** is the list of *regulation bids* in ascending and descending order sorted by the price for one hour.

The **regulation margin**, also called **TRM** (Transmission Reliability Margin), is the gap between the *transmission capacity* and the *trading capacity*. It constitutes the scope for the momentary regulation variations as a result of frequency regulation around the planned hourly value for transmission.

The **regulation market** is the market for *regulating power*.

The **regulation price** is the price resulting from implemented regulations during the hour of operation for a *regulation area*. Also called the RK price.

Regulation steps are steps in the *regulation list*.

Restoration is a transition between different operational states characterized by the network being restored, production being regulated upwards, and frequency, voltage and transmission being brought within acceptable limits. Consumption is connected at a pace which the network and production resources can take. Also see *operational states.*

RGCE (Regional Group Continental Europe) is an organisation of the system operators in Continental Europe within ENTSO-E.

A **risk of power shortage** occurs when a forecast suggests that a *subsystem* can no longer maintain the demand for a *manual active reserve* which can be activated within 15 minutes.

Scaling means restricting changes in the *trading capacity* (NTC) between two *bidding areas* from one hour to the next.

Serious operational disturbances are *operational disturbances* entailing greater consequences than activation of the *frequency controlled disturbance reserve.*

Settlement points are reference points for financial settlement between the *subsystems* based on direct measurement.

The **slow active disturbance reserve** is the active power available after 15 minutes.

Special regulation is the activation of *regulating power* in order to deal with *bottlenecks* on the *transmission network.*

A **subsystem** is the power system for which a *system operator* is responsible. A *system operator* can be responsible for several *subsystems.*

Subsystem balance is calculated as the sum of the measured physical transmissions on the *cross-border links* between the *subsystems* within the *synchronous system.* Thus, there is a deficit if this sum shows that power is flowing into a *subsystem* and a surplus if power is flowing out of a *subsystem*. Exchanges on *cross-border links* in/out of the *synchronous system* are not to be included in the calculation. The *manual active reserve (15 min)* must be included in the calculation of the *subsystem balance.*

Supportive power is power that adjacent *system operators* can exchange reciprocally as an element of the regulation of balance in the respective *subsystems*. Exchanges are made specifying the power, price, link and time to the exact minute of the start and finish of the exchange. *Supportive power* is settled as the hourly average value.

The **synchronous system** is the synchronously interconnected power system consisting of the *subsystems* of Norway, Sweden, Finland and Eastern Denmark. Western Denmark is synchronously interconnected with the *RGCE* system.

The **system operator**, also referred to as TSO (transmission system operator), has the *system responsibility* for one or more *subsystem(s).*

The **system price** is a calculated price for the entire Nordic Elspot market without capacity limitations between *bidding areas*. The s*ystem price* is calculated as if there are no capacity limitations on the *transmission network* between the *bidding areas* in Norway, Sweden, Finland and Denmark.

System protection is composed of automatic system protection equipment for the power system. *System protection* can, for instance, be used to limit the impact of faults by shedding production in order to compensate for the defective component and so that overloads do not arise. *System protection* can also be used to increase the capacity of the *transmission network* without simultaneously increasing the risk of diminishing the *system security*. *System protection* requires a level of reliability in line with primary protection. Previously called network protection.

The **system responsibility** is the responsibility for co-ordinating the utilization of electrical facilities in the jointly operated power system, or a part of this, in order that the desired *system security* and network quality may be attained during operational service.

System security is the power system's ability to withstand incidents such as the loss of lines, bus bars, transformers, production units, consumption etc. See *dimensioning fault.*

System services is a generic term for services that *system operators* need for the technical operation of the power system. The availability of *system services* is agreed upon by the *system operator* and the other companies within the respective country. *System services* can be arranged into different forms of *system protection* and *operational reserves* for active and reactive power.

Time deviation is the difference between a synchronous clock driven by the frequency of a power system and planetary time.

The **trading capacity**, also called **NTC** (Net Transfer Capacity), is capacity made available to *Elspot trading* between the *bidding areas* and the highest permitted sum of the *players'* planned trading on an hourly basis. The *trading capacity* is calculated as the *transmission capacity* less the *regulating margin*.

The **trading plan** is the sum of the *players'* electricity trading between the *bidding areas* (Elspot, Elbas).

The **transmission capacity**, also called **TTC** (Total Transfer Capacity), is the maximum transmission of active power in accordance with the system security criteria which is permitted in *transmission constraints* between the *subsystems/areas* or individual installations.

A **transmission constraint** is a constraint on the *transmission network* between the *subsystems* or between *areas* within a *subsystem*. Also referred to solely as constraints.

Transmission facilities are individual installations (lines, bus bars, transformers, cables, breakers, isolators etc.) which form the *transmission network*. This includes protective, monitoring and control equipment.

A **transmission network** is the interconnected network containing the *transmission facilities*.

The **voltage controlled disturbance reserve** is the momentarily available active power used for *operational disturbances* and which is activated automatically by the network voltage. Often established as *system protection*.

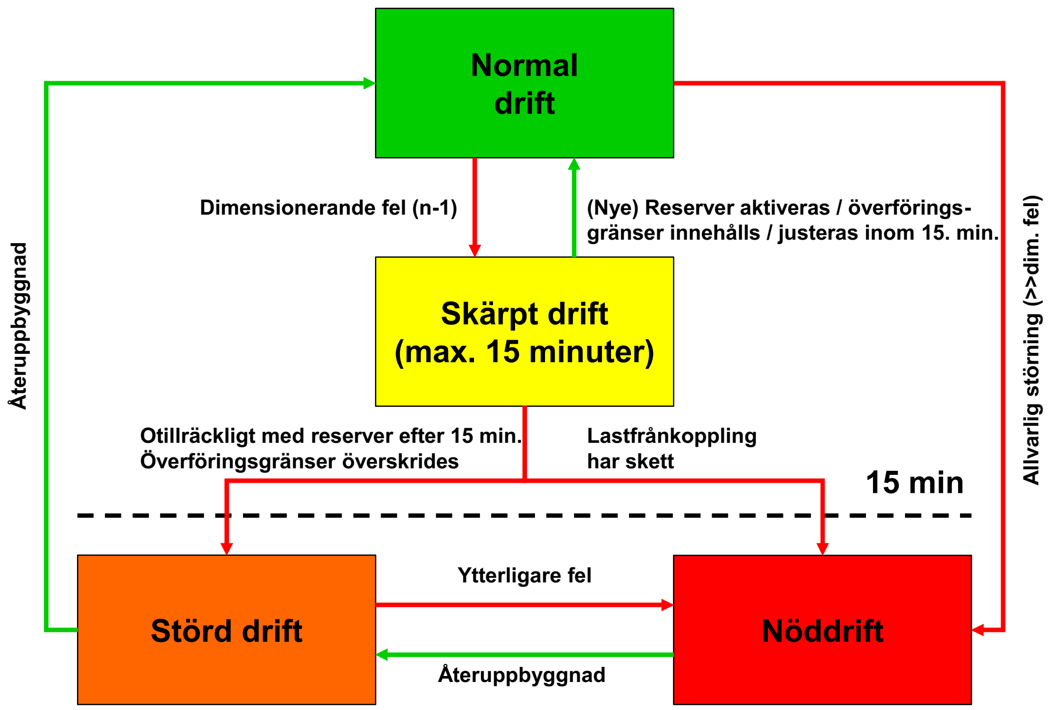

Figure 1. Operational states (network collapse is not specified in the figure).

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Operational security standards

1 System security criteria

The following criteria for *system security* are to be applied in those respects that are of significance as regards enabling operation of the power system to be upheld with the *subsystems* interconnected with each other.

The criteria for *system security* shall be based on the *n-1 criterion*. This is an expression of a level of *system security* entailing that a power system is assumed to be intact apart from the loss of individual principal components (production units, lines, transformers, bus bars, consumption etc.). For faults having the largest impact on the power system, the term *dimensioning faults* is used.

It is not normally the same type of fault that is dimensioning during frequency disturbances as during disturbances to the transmission system. The loss of the power system's largest production unit is normally dimensioning as regards determining the *frequency controlled disturbance reserve*.

The definition of *serious operational disturbances* is *operational disturbances* having a greater impact than activation of the *frequency controlled disturbance reserve*.

The definition of *normal state* is an operational state entailing that all consumption is being met, that the frequency, voltage and transmission lie within normal limits and that the reserve requirements have been met. The power system has been prepared in order to deal with *dimensioning faults*.

For the *interconnected Nordic power system,* the above entails that:

- a *dimensioning fault* on a *subsystem* must not bring about *serious operational disturbances* in other *subsystems*. This places demands on the *frequency controlled disturbance reserve* and the *transmission capacity* within and between the *subsystems*
- if the power system is not in *normal state* following an *operational disturbance, the power* system must have been restored, within 15 minutes, to *normal state*. This places demands on the available *fast active disturbance reserve*. If there are exceptions from the time requirement, or if there is a departure from the above definition of *dimensioning faults*, then there must be consultation between the *system operators* concerned.

2 System protection

System protection is used to limit the consequences of faults over and above the disconnection of defective components. *System protection* can have as its purpose to increase the *system security*, the *transmission capacity,* or a combination of these. For *system protection* that is used to increase the *transmission capacity,* the following requirements have been set:

- An analysis must be implemented which shows the consequences for the power system in the event of a correct, unwarranted and missing function and simultaneously takes into account the other system protection
- 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**
      Redundant telecommunications 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"**
      A *redundant* triggering function, if this relates to breakers, 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 HVDC links

HVDC links shall be regarded as production facilities.
The *system operators* for the individual HVDC links are only responsible for restoring the operation to *normal state* in their own *subsystems* after the loss of the HVDC link or after *emergency power* regulation has been activated.

4 Operational reserves

4.1 Automatic active reserve

The *automatic active reserve* is divided up into the *frequency controlled normal operation reserve*, the *frequency controlled disturbance reserve* and the *voltage controlled disturbance reserve*.

The major part of both the *frequency controlled disturbance reserve* and the *frequency controlled normal operation reserve* will be achieved via automatic frequency regulation for production facilities. To meet the above requirements, the objective for each respective *system operator* must be to place demands on turbine regulator settings, e.g. in the form of demands regarding regulating time constants. There should also be the possibility of monitoring and checking.

4.1.1 Frequency controlled normal operation reserve

The *frequency controlled normal operation reserve* shall be at least 600 MW at 50.0 Hz in the *synchronous system*. It shall be fully activated at f = 49.9/50.1 Hz ($\Delta f = \pm 0.1$ Hz).

In conjunction with a rapid frequency change to 49.9/50.1 Hz, the reserve shall be up regulated/down regulated within 2-3 minutes. The *frequency controlled normal operation reserve* is divided between the *subsystems* within the *synchronous system* on the basis of *annual consumption* (total consumption excluding own consumption by power plants) in the previous year.

The actual division of the *frequency controlled normal operation reserve* between the *subsystems* shall be adjusted each year before 1 March based on the *annual* *consumption* in the previous year, rounded to the closest integer, given in MW, and enter into force on 1 April. The *annual consumption* shall be given in TWh at an accuracy of one decimal.

Each *subsystem* shall have at least 2/3 of the *frequency controlled normal operation reserve* in its own system for potential splitting up and island operation.

The following example (for 2013) shows how the division of power for the *frequency controlled normal operation reserve* takes place:

	Annual consumption 2013 (TWh)	Frequency controlled normal operation reserve (MW)
Eastern Denmark	13.7	22
Finland	85.2	138
Norway	130.0	210
Sweden	142.5	230
Synchronous system	371.4	600

4.1.2 Frequency controlled disturbance reserve

There shall be a *frequency controlled disturbance reserve* of such a volume and composition that a *dimensioning fault* does not cause a frequency below 49.5 Hz in the *synchronous system*.

With regard to the frequency-dependence of consumption, the above requirement entails that the total *frequency controlled disturbance reserve* shall rise to a power which is equal to the *dimensioning fault* deducted by 200 MW. It must be able to utilise the *frequency controlled disturbance reserve* until the *fast active disturbance reserve* is activated.

The activation of the *frequency controlled disturbance reserve* shall not result in other problems in the power system. When the transmission capacity is being determined, the location of the *frequency controlled disturbance reserve* shall be taken into account. Each subsystem shall have at least 2/3 of the *frequency controlled disturbance reserve* in its own system for potential splitting up and island operation.

The *frequency controlled disturbance reserve* shall be activated at 49.9 Hz and shall be fully activated at 49.5 Hz. It shall increase virtually linearly within a frequency range of 49.9-49.5 Hz.

Agreed automatic *load shedding,* e.g. industrial, district heating and electric boiler consumption in the event of frequency drops to 49.5 Hz can be counted as part of the *frequency controlled disturbance reserve*. The following requirements are applicable, however:

Load shedding can be used as *frequency controlled disturbance reserve* in the frequency range of 49.9 Hz to 49.5 Hz, when *load shedding* meets the same technical requirements set below for generators.

In the event of a frequency drop to 49.5 Hz caused by a momentary loss of production:

- 50 % of the *frequency controlled disturbance reserve* in each *subsystem* shall be regulated upwards within 5 seconds
- 100 % of the *frequency controlled disturbance reserve* shall be regulated upwards within 30 seconds.

Distribution of the requirement for the *frequency controlled disturbance reserve* between the *subsystems* of the *interconnected Nordic power system* shall be carried out in proportion to the *dimensioning fault* within the respective *subsystem*. Distribution of the requirement shall be updated once a week or more often if necessary.

The following example (for week 15/2013) shows how distribution of the requirement for the *frequency controlled disturbance reserve* is achieved:

	Dimensioning faults (MW)	Frequency controlled disturbance reserve (MW)	Frequency controlled disturbance reserve (%)
Denmark	600	176.5	14.7
Finland	880	258.8	21.6
Norway	1,200	352.9	29.4
Sweden	1,400	411.8	34.3
Total		**1,200**	**100.0**

Energinet.dk's requirement of the *frequency controlled disturbance reserve* is distributed between Eastern and Western Denmark as follows:

- Western Denmark 75 MW (6.2%), via Konti-Skan

- Eastern Denmark 101 MW (8.4%), of which 50 MW via Kontek, 18 MW via Great Belt, and 33 MW is handled in the shared market for *frequency controlled disturbance reserve.*

Energinet.dk accepts this requirement as long as TenneT and *RGCE* accept the emergency power setting on the HVDC Skagerrak and Konti-Skan links and as long as this entails no financial consequences for Energinet.dk. Energinet.dk will not reserve trading capacity in order to be able to deliver the reserve.

Energinet.dk's AC joint operation of Western Denmark within the *RGCE* system entails that Energinet.dk is required to maintain the frequency and *frequency controlled disturbance reserve* in accordance with *RGCE* rules. This is described in section 5 ”Special conditions for Energinet.dk as a member of *RGCE*”.

The *system operator* shall report an essential and permanent change in the dimensioning fault, such as plans including this, to the Nordic Operations Group (NOG) for the handling and acceptance of the distribution of frequency-controlled reserves proportionally as stated above or in some other manner. A change in the dimensioning fault may be caused by changed composition of a grid, size of generation units connected to the system, necessary events, new information and experiences, or similar factors. The change shall be reported as soon as the new circumstances become known, and the report shall contain information on a corresponding change in the fast active disturbance reserve.

4.2 Fast active disturbance reserve

The *fast active disturbance reserve* shall exist in order to restore the *frequency controlled normal operation reserve* and the *frequency controlled disturbance reserve* when these reserves have been used or lost, and in order to restore transmissions within applicable limits following disturbances.

The *fast active disturbance reserve* shall be available within 15 minutes.

The *fast active disturbance reserve* shall exist and be localized to the extent that the system can be restored to *normal state* following faults.

The size of the *fast active disturbance reserve* is determined by the individual *subsystem's* assessment of local requirements. *Bottlenecks* on the network, *dimensioning faults* and similar are included when assessing this.

The *system operators* have secured, through agreement or ownership, a *fast active disturbance reserve*. This reserve consists of gas turbines, thermal power, hydropower and *load shedding*. In round figures, Fingrid has 1,000 MW, Svenska kraftnät 1,290 MW, Statnett 1,200 MW, and Energinet.dk a total of 900 MW, of which 600 MW in Eastern Denmark (where 300 MW is *slow active disturbance reserve* which, on special occasions, can be made fast). If the reserves cannot be transmitted via Great Belt between Eastern Denmark and Western Denmark, they are bought up to the dimensioning fault in both Eastern Denmark and Western Denmark.

Whenever required, a *subsystem* can hold a certain amount of *fast active disturbance reserve* for another *subsystem*, if there is idle *transmission capacity* for this purpose. The keeping of such reserves is to be agreed upon between the concerned *subsystems' system operators* upon each occasion, and all *system operators* shall be informed of this.

4.3 Slow active disturbance reserve

The *slow active disturbance reserve* is active power available after 15 minutes.

4.4 Reactive reserve

Within each *subsystem,* there must be a reserve of reactive power which is constituted in such a way with regard to size, regulation capability and localization that *dimensioning faults* will not entail a system collapse.

5 Special conditions for Energinet.dk as part of Continental Europe

N-1 security
The *n-1 criterion* also applies to the continent. If n-1 security is maintained with the help of adjacent systems (e.g. using *system protection*), this shall be approved by the adjacent system owners.

Primary regulation
For the entire *continent,* a *frequency response* of 18,000 MW/Hz is required. The *dimensioning production loss* is 3,000 MW. The different countries' share of the primary regulation reserve is distributed in proportion to the individual countries' production capacities. Energinet.dk shall thus, during 2012, be able to deliver 25 MW as *frequency controlled disturbance reserve* in Western Denmark. The volume is determined for each year on the basis of energy produced two years earlier. This *frequency controlled disturbance reserve* shall be fully activated in the event of a momentary frequency change of ± 200 mHz.

Secondary reserve
Generally within *the continent,* it is applicable that the delivery of secondary reserve shall be commenced 30 seconds after an imbalance has arisen between production and consumption and shall be fully regulated out after 15 minutes. There must be sufficient reserve to safeguard each area's own balance following a loss of production.

6 Principles for determining the transmission capacity

6.1 Introduction

The various *system operators'* ability to transmit power shall be calculated for each state of operation. This applies both to transmissions within each *subsystem* and to exchanges between *subsystems*. Most frequently, this is achieved by means of a *transmission constraint* being defined, and static and dynamic simulations determine how much power can be transmitted in any direction through the constraint before thermal overloads, voltage collapse and/or instability arise following a *dimensioning fault* (for the constraint) being added. In the constraint, an arbitrary number of lines on different levels of voltage can be included.

The result of the calculations will be the maximum technical limitation for transmission. For the operational phase, this limit must be reduced as regards the calculatory inaccuracy and normal variations due to frequency controlled normal operation regulation.

6.2 Thermal limitation

In cases when thermal limitations on lines and/or equipment restrict the *transmission capacity* through a *transmission constraint*, the maximum transmission capability through a constraint, or for single lines following a simple fault, can be set at a given percentage over the nominal limit in cases when the constraint/line can be relieved within 15 minutes.

6.3 Voltage collapse

It is neither of interest nor possible to specify exactly at which voltage a voltage collapse occurs as this will vary with the state of operation and access to active and reactive synchronized production at the onset of the fault. Some events that low voltage can lead to are:

- Consumers being affected at a voltage of 0.5-0.7 p.u. (contactors open)
- Risk of overloading equipment at 0.8 p.u.
- Risk of production being shed due to low voltage on auxiliary power equipment (0.85 p.u.)
- Reactive resources being exhausted, i.e. generators are at their current limits for rotors and stators. Can appear at a voltage of 0.85-0.9 p.u.

Neither is it possible to specify a global value for the calculatory inaccuracy. This is different for each *system operator* and *transmission constraint* and primarily depends on the quality of data, representation of the underlying systems and the calculation technique used. The margin for primary voltage regulation is set by each *system operator* for internal constraints and bilaterally between the *system operators* for constraints between systems.

6.4 System dynamics

Dynamic simulation of a power system before, during and after a fault provides, as a typical result, how the different production facilities' generators oscillate against each other. These oscillations can either be attenuated after a while or accelerated. Today there is no accepted norm for how quickly the oscillations must be attenuated in order for the system to be assumed to be stable; rather this is a matter of judgement. In the same way as above, the calculated technical limit is reduced using a calculatory inaccuracy margin.

A fault scenario is to be simulated over a period so lengthy that all conceivable oscillation frequencies can be detected and that these are well attenuated.

European Network of Transmission System Operators for Electricity

Balance regulation standards

The work of *balance regulation* shall be conducted in such a way that regulations take place in the *subsystem* with the lowest regulation cost. *Parties* carrying out regulation shall be compensated for their costs.

1 Balance regulation within the synchronous system

Balance regulation within the *synchronous system* shall be conducted in such a way that the below specified quality standards regarding frequency and *time deviation* are integrated. Requirements regarding *frequency response* and frequency controlled reserves (see appendix 2) shall be maintained. Furthermore, *balance regulation* shall be conducted in such a way that the *transmission capacity* is not exceeded.

Sweden and Norway represent approx. 75% of the *annual consumption* of the *synchronous system*. The *Parties* agree that Svenska kraftnät and Statnett will thus have the task of maintaining the frequency and *time deviation* within the set limits. Fingrid and Energinet.dk will normally only *balance-regulate* after contacting Svenska kraftnät. Energinet.dk West will exchange *supportive power* with the *synchronous system* after contacting Statnett.

The distribution of work between Svenska kraftnät and Statnett is regulated bilaterally and described in document "Frequency regulation in Nordel system" (Instruction for frequency regulation), which is distributed to all the *Parties*.

1.1 Quality standards

Frequency

The requirement of the highest permissible variation in the frequency during *normal state* is between 49.90 and 50.10 Hz. The goal is to maintain 50.00 Hz.

The number of minutes with frequency deviation shall be kept at a minimum. The goal figures for frequency deviation shall be established annually, and the number of deviations with underfrequency and overfrequency shall be recorded. With regard to *system security*, it is more important to fulfil the requirement for underfrequency than overfrequency.

In certain operational situations it may be necessary to deviate from the normal activation sequence and go over to *regulating bids* on the regulating list in order to maintain the frequency.

Time deviation

The *time deviation* is used as a tool for ensuring that the average value of the frequency is 50.00 Hz.

The *time deviation* ΔT shall be held within the time range of - 30 to + 30 seconds. At ΔT = 15 seconds, Statnett and Svenska kraftnät shall contact each other in order to plan further action.

The frequency target has a higher priority than the *time deviation* and the costs of frequency regulation.

The *time deviation* shall be corrected during quiet periods with high *frequency response* and with a moderate frequency deviation.

Joint operational planning

There shall active communications between Statnett and Svenska kraftnät before each hour of operation and *day of operation* in order to jointly draw up a suitable strategy and to plan future action so that the above goals are achieved. Both parties are responsible for maintaining sufficiently active communications.

Information on planned and taken action in order to achieve the above goals shall be delivered to Fingrid and Energinet.dk.

1.2 Momentary area control error

Momentary area control errors are calculated for each *subsystem* and used as an instrument for measuring the *subsystem's* momentary imbalance. Momentary area control errors are not normally used as regulation criteria.

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

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

P_{mom} = the momentary reading on the links between the *subsystems*
P_{plan} = the exchange plan including *supportive power* between the *subsystems*
Δf = frequency deviation
R = momentary *frequency response*

2 Balance regulation in Western Denmark

Balance regulation in Western Denmark shall take place so that the requirements concerning Western Denmark as a “control block” in *RGCE* are met on the *cross-border links* between Germany and Jutland.

3 Regulation measures and principles of pricing

A joint list of *regulation bids* is compiled, in the order of price, containing bids from both the *synchronous system* and Western Denmark. During the hour of operation, regulation is initially carried out for network reasons and then, if necessary, to maintain the frequency in the *synchronous system* or the balance in Western Denmark. Regulation carried out for network reasons can take place on one or both sides of a bottleneck.

Power exchange between the *subsystems* in the *synchronous system* primarily takes place in the form of *balance power*. *Balance power* can be exchanged as long as this does not cause unacceptable conditions for the adjacent areas. Power exchange between the *synchronous system* and Western Denmark primarily takes place in the form of *supportive power*.

3.1 Regulation of frequency and balance

For the regulation of the frequency of the *synchronous system* and the balance in Western Denmark, the bids on the joint *regulation list* are used in the order of price, with the exception of bids confined behind a *bottleneck*. The activated bids are marked as *balance regulations* and are included when calculating the *regulation price* and regulation volume.

For each hour, the *regulation price* is determined in all *bidding areas*. The *regulation price* is set at the margin price of activated bids in the joint *regulation list*. When *bottlenecks* do not arise during the hour of operation, the prices will be equal. The available capacity during the hour of operation can be utilised even there is a bottleneck in Elspot so that a joint *regulation price* is obtained. If there has been no regulation, the *regulation price* is set as the *area price* in Elspot.

When a *bottleneck* arises during the hour of operation between *bidding areas* which entails that a bid in an area cannot be activated, the relevant area will obtain a *regulation price* of its own. This *regulation price* will be decided by the last bid activated in the joint *regulation list* prior to the *bottleneck* arising.

There is a *bottleneck* between the *bidding areas* when it is not “possible” to carry out *balance regulation* on the basis of a joint *regulation list* without deviating from the normal price order of the list. The reason for this not being “possible” can be for example levels of transmission that are too high on the *cross-border link* itself or on other lines/*transmission constraints* or operational/trading rules which entail that it is not permitted to activate bids in the joint *regulation list*.

If the transmission between *bidding areas* is greater than the *trading plan* and this creates *bottleneck problems* for other *bidding areas*, the area(s) which caused this will regulate against the balance. The area(s) therefore obtain(s) its/their own *regulation price(s)*. This will be decided by *balance regulations* within the area or within several adjacent areas that are affecting the *bottleneck* in the same way.

During bidirectional regulation for an hour in the *synchronous system*, the net regulated energy will decide whether the *regulation price* will be the upward or downward regulation price. If no regulation has taken place or if the net volumes upwards and downwards are equal, the price will be set at the *Elspot price*. Regulation behind a *bottleneck* will only affect the net volume if the *bottleneck* has arisen through activated *balance regulations*. This also applies to Western Denmark.

Bottlenecks to/from an *bidding area* which are caused by imbalances within an *bidding area* are dealt with as *balance regulation* and give rise to a divided *regulation market*. *Bottlenecks* caused by a reduced *transmission capacity* to/from a *bidding area*, after *Elspot pricing*, are managed using *counter trading* and *special regulations*.

A prerequisite for the *system operator* in the *synchronous system* to be able to set his own *regulation price* is that the *trading plan* is exceeded. In the opposite case, *counter trading* could be necessary between the *system operators*.

3.2 Regulation for network reasons

Regulations carried out for network reasons shall not, in the basic case, affect the r*egulation price* calculation, but they are carried out as *special regulations*.

For regulations for network reasons in internal constraints in a *bidding area*, bids are used in the *subsystems* which rectify the network problem. When choosing a regulation object, attention must be paid to both the price and the effectiveness of the regulation.

For regulations carried out for network reasons on the border between *bidding areas*, the cheapest bids are normally used in the *subsystems* which rectify the network problem. When such regulation is caused by an imbalance vis-à-vis the *trading plan* between *bidding areas*, the *regulation price* will be affected in the subnetwork where the regulation was carried out.

4 Pricing of balance power

4.1 Balance power between the subsystems within the synchronous system

Balance power between two *subsystems* is priced at the average of the *regulation prices* in these *subsystems*.

4.2 Balance power between Western Denmark and Sweden

Swedish *regulation prices* apply to the pricing of *balance power* between Western Denmark and Sweden in accordance with the dual price model applied internally within Sweden.

4.3 Balance power between Western Denmark and Norway

Norwegian *regulation prices* apply to the pricing of *balance power* between Western Denmark and Norway.

5 Pricing of supportive power

5.1 Pricing within the synchronous system

When there is a need to *exchange supportive power* between two *Parties*, the price will be set at the regulating *Party's* cost, and conclusively set after the hour of operation. The price of *supportive power* shall not normally affect the *pricing of balance power* between the *subsystems.*

5.2 Pricing between Western Denmark and Norway, and Sweden

The following applies to *supportive power* for *balance regulation* between the *synchronous system* and Western Denmark:

When the balance in the *synchronous system* and Western Denmark is regulated in the same direction, the price of *supportive power* is set to that *regulation price* – if they are different – which is closest to the *system price* in Elspot. The same rule applies when there is no regulation in any of the areas.

When the balance in the *synchronous system* and Western Denmark is regulated in different directions, the price of *supportive power* is set to the *system price* in Elspot.

In the event of *bottleneck situations,* it may be appropriate to carry out *supportive power exchanges* in DC loops between Sweden, Norway and

Denmark. This will not affect the individual *subsystem's* balance and the price of the exchange will be set at 0 EUR. *Supportive power* for balance regulation has priority over DC loops.

5.3 Pricing during operational disturbances on cross-border links

The price of *supportive power* during *counter trading* which is due to an *operational disturbance* on the *cross-border link* itself will be the average of the *area prices* in Elspot in the adjacent systems.

6 Operational/trading rules between the synchronous system and Western Denmark

Exchange of *supportive power* for *balance regulation* between the *synchronous system* and Western Denmark is carried out in accordance with a set model based on the below principles.

Energinet.dk sends plans in advance for each operating hour for exchange between the *synchronous system* and Western Denmark. The plans are given for each 15 minutes and they are drawn up on the basis of forecasts for imbalance in Western Denmark, current bids in the joint *regulation list* and other information exchange between Statnett and Energinet.dk West.

Statnett and Energinet.dk West are jointly responsible for the plan concerning the coming hour being acceptable with respect to regulation in both systems at the latest 15 minutes before the hour shift.

After this, the plan can be altered during the hour of operation in accordance with the rules below.

Supportive power is exchanged between the *synchronous system* and Western Denmark in one direction only during each hour. The volume can increase or decrease during the hour of operation, but not more often than every 15 minutes.

After a decrease in the *supportive power* volume, the volume cannot increase again during the same hour. However, this does not apply to hour shifts if the agreed exchange during the coming hour is higher than the current volume.

Exchange of *supportive power* takes place in accordance with a power plan at 5 minutes' discontinuation. In the activation of *supportive power* during the hour of operation, a change in the power plan shall normally be carried out in a maximum of 15 minutes.

Exchanging information

The purpose of this Appendix is to describe the information which shall routinely be exchanged between the concerned *Parties* to an extent which is significant for the collaboration between the *Parties* in respect of system operation and balance management.

The technical description (network model, network data etc.) of the power system is governed by other agreements.

Information to be provided to the *players* on the electricity market is governed by the *system operators'* agreement vis-à-vis Nord Pool Spot.

1 Outage planning

Plans for outages having impact on the *transmission capacity* between the *subsystems* or which are in some other way significant for *system security* or the electricity market shall be exchanged and co-ordinated between the *Parties* concerned. Plans shall be advised for up to one year forward in time. Alterations to plans shall be advised as soon as possible.

The impact of such outages on the *transmission capacities* between the *subsystems* shall also be exchanged. Preliminary values shall be exchanged as early on as possible. Final values shall be exchanged immediately following approval of the capacities.

Outages having impact on the *trading capacity* between the *subsystems* shall be entered in the joint Nordic outage planning system NOIS (Nordic Operational Information System).

2 Prior to the hour of operation

Information which is to be routinely exchanged between the *Parties* prior to the hour of operation:

- Plans for the *transmission capacities* and *trading capacities* on the links between the *subsystems* on an hourly basis
- Current limitations within the *subsystems*
- Forecast of available *frequency controlled normal operation reserve*, *frequency controlled disturbance reserve* and *fast active disturbance reserve*
- Forecast of *dimensioning faults*
- Changes to the network configuration of significance to the *subsystems' system security* and the impact of these changes
- Changes to settings of regulation equipment and automatic systems

- Hourly *exchange plans* and *trading plans* between the *subsystems*
- Hourly *exchange plans* for non-Nordic links
- Hourly plans or forecasts regarding the overall production and consumption. Quarter-hourly plans for production shall be exchanged to the extent these are available.
- Plans for *counter trading* between the *subsystems*
- *Regulation bids*.

The joint Nordic information system NOIS (Nordic Operational Information System) shall be used for the exchange of information which is necessary in *balance regulation* (regulation bids, production plans and HVDC plans, consumption forecasts etc.).

3 During the hour of operation

Information which must routinely be available to the *Parties* during the hour of operation:

- Ongoing outages
- Authorization-dependent *transmission capacity* and parameters of significance in this regard (e.g. *system protection*)
- *Counter trading*/ *special regulation* and other corresponding measures concerning the other *Parties*
- An account of events and disturbances of a major character, together with implemented measures
- Volume and duration of requested *load shedding* in the event of *power shortages*.

Measured values and status indications to be exchanged between the *Parties* during the hour of operation:

- Transmission of reactive and active power on the individual links, plus the sum of the active power between the *subsystems*
- Transmission of reactive and active power on the individual links, plus the sum of the active power to systems outside the Nordic power system provided that the counterparty approves of this
- Active power in critical *transmission constraints* within the *subsystems*
- Activated regulations and current prices for regulating imbalances upwards and downwards
- Area control errors
- Surpluses/deficits as defined in Appendix 9
- Overall production and consumption
- Production at power plants that are critical to the *interconnected Nordic power system's* operational situation
- *Frequency response* and available *frequency controlled normal operation reserve*, *frequency controlled disturbance reserve* and *fast active*

disturbance reserve. If measured values are not available, forecasts shall be exchanged.

- Measurements that are needed for monitoring the stability of the power system.

4 Following the hour of operation

Information which must routinely be exchanged between the *Parties* following the hour of operation:

- Activated upward and/or downward regulation volume and *regulation prices*
- Reconciliation of previous calendar day's exchanges, *frequency response*, deals, prices etc, in accordance with the settlement routines
- Measured values on the links between the *subsystems* in accordance with other relevant agreements
- An account of events and disturbances, together with implemented and planned measures, to be rendered as soon as possible.

System protection

1 General

Automatic *system protection* is used to limit the impact of faults by means of measures over and above disconnecting the defective component. *System protection* can be used to increase the *system security*, the *transmission capacity,* or a combination of these. For *system protection* which is used to increase the *transmission capacity,* requirements have been set. These are specified in Appendix 2 Operational security standards of the System Operation Agreement.

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:

- regulation of 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 switchings.

Automatic *system protection* is adapted to the combined *operational reserves* of the *interconnected Nordic power system.* Frequency controlled functions are shown in Figure 1. A detailed description of the Figure can be found in the Nordel report ”Rekommandasjon for frekvens, tidsavvik, regulerstyrke og reserve” from August 1996. Minor frequency deviations are dealt with by the *frequency controlled disturbance reserve* on generators. Major frequency deviations start up regulation at the DC facilities. At lower frequencies, automatic *load shedding* starts up.

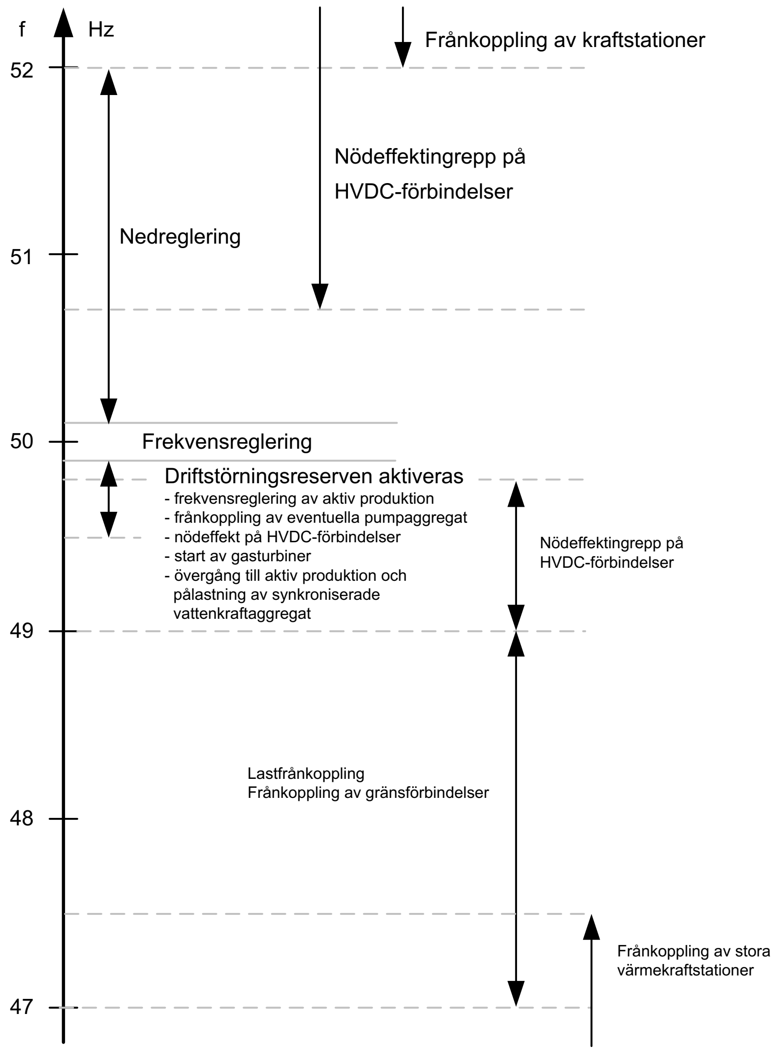

Figure 1. Frequency controlled functions in the synchronous system

2 System protection activated by frequency deviations

Frequency controlled *system protection* activated by a deviating frequency:

- regulation of DC facilities, *emergency power*
- *production shedding* (PFK) or downward regulation of production
- start-up of production
- automatic *load shedding* (AFK)
- network switchings.

A low frequency during *operational disturbances* is traditionally dealt with using *frequency controlled disturbance reserve*.
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*, for instance, might curb the frequency drop. The increased use of frequency controlled regulation of DC installations, *emergency power*, is in order to prevent major frequency drops.

A high frequency is traditionally dealt with using the downward regulation of production or, in extreme situations, using *load shedding*. In this case too, there will be an increased use of the frequency controlled regulation of DC installations.

2.1 Frequency controlled regulation of DC installations, Emergency power

The maximum impact of regulation of DC installations during frequency drops can be seen in Figure 2. As illustrated by the Figure, all DC installations between *the synchronous system* and other AC systems contribute frequency controlled *emergency power*. It should be pointed out, however, that if a DC installation is performing a full import to an area with a low frequency, it will not be able to contribute to *emergency power*.

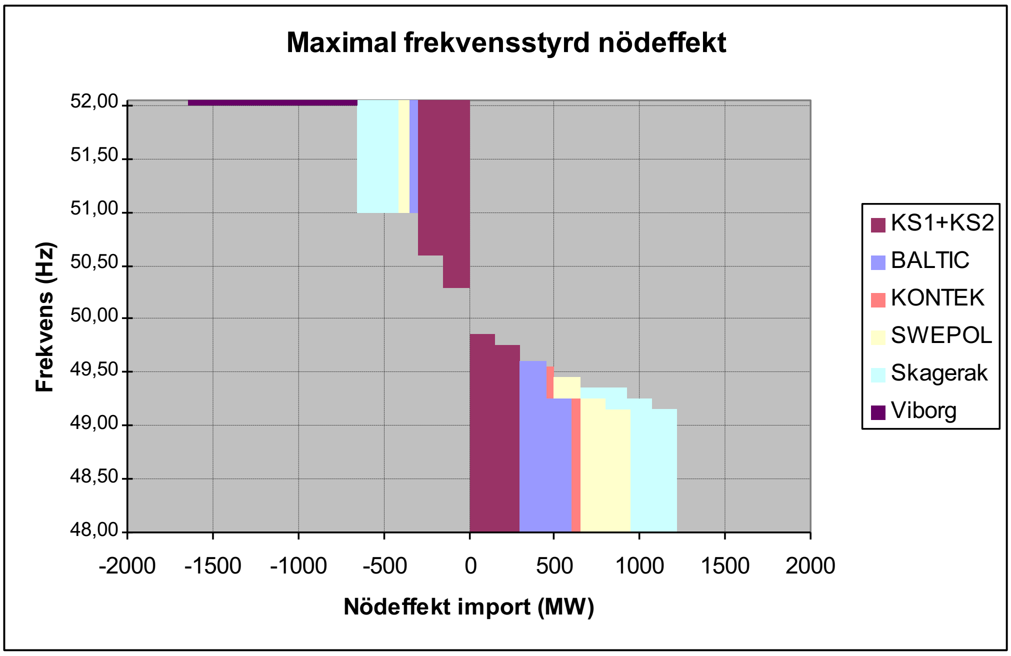

Figure 2. Maximum frequency controlled emergency power

The Vyborg DC link is disconnected at a frequency in Finland of > 52 Hz in 0.5 s.

2.2 Frequency controlled start-up of production

Automatic frequency controlled start-up of production is carried out in order to increase production in the power system during *operational disturbances* in accordance with Table 1.

Table 1. Automatic frequency controlled start-up of production

Frequency (Hz)	Denmark		Norway	Sweden	Finland
	East	West			
49.8		25 MW GT			
49.7-49.5				700 MW GT in three stages of 0.1 Hz	
49.5	18 MW DE				

GT = gas turbine, DE = Diesel engine.

2.3 Frequency controlled 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. This will take place in accordance with Table 2:

Table 2. Automatic load shedding

Denmark	East	10 % of consumption f < 48.5 Hz momentary, f < 48.7 Hz 20 s 10 % of consumption f < 48.3 Hz momentary, f < 48.5 Hz 20 s 10 % of consumption f < 48.1 Hz momentary, f < 48.3 Hz 20 s 10 % of consumption f < 47.9 Hz momentary, f < 48.1 Hz 20 s 10 % of consumption f < 47.7 Hz momentary, f < 47.9 Hz 20 s
	West	10% of consumption f < 49,0 Hz momentary 10% of consumption f < 48,8 Hz momentary 10% of consumption f < 48,6 Hz momentary 10% of consumption f < 48,4 Hz momentary 10% of consumption f < 48,2 Hz momentary
Norway		30% of loads in stages from 48.7 Hz to 47.0 Hz
Sweden	South of constraint 2	electrical boilers and heat pumps P ≥ 35 MW, f < 49.4 Hz in 0.15 s 25 ≤ P < 35 MW, f < 49.3 in 0.15 s 15 ≤ P < 25 MW, f < 49.2 in 0.15 s 5 ≤ P < 15 MW, f < 49.1 in 0.15 s At least 30 % of consumption in 5 stages stage 1. f < 48.8 in 0.15 s stage 2. f < 48.6 in 0.15 s stage 3. f < 48.4 in 0.15 s stage 4. f < 48.2 in 0.15 s, f < 48.6 in 15 s stage 5. f < 48.0 in 0.15 s, f > 48.4 in 20 s
Finland		10 % of consumption f < 48.5 Hz 0.15 s, f < 48.7 Hz 20 s 10 % of consumption f < 48.3 Hz 0.15 s, f < 48.5 Hz 20 s

2.4 Frequency controlled disconnection of lines

Frequency controlled disconnection of lines occurs according to the table 3.

Table 3. Frequency controlled disconnection of lines

Denmark	East	Disconnection of the Öresund link at f < 47.0 Hz in 0.5 s or f < 47.5 in 9 s
	West	-
Norway		-
Sweden		-
Finland		Disconnection of Vyborg DC link at a frequency in Finland of >52 Hz for 0.5 s

2.5 Frequency controlled 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 in to the synchronous system.

3 System protection activated by voltage deviations

In Sweden, there is a *system protection* which is controlled by voltage. The *system protection* regulates down exports to the continent on HVDC links in the event of a risk of voltage collapse or overloads on important lines.

3.1 System protection in Sweden constraint 2

Not in service.

3.2 System protection in 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 six substations: Breared, Hallsberg, Hjälta, Kilanda, Tenhult and Sege.

The criterion for the activation signal of *system protection* is that the voltage in one of these six 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.

3.3 System protection in 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 and 270 kV will provide 200+200 MW of relief.

3.4 System protection in Finland

In Finland, there is *system protection* which is controlled by voltage and the transmission between Sweden and Finland at the critical *transmission constraint* in Finland (north - south). The s*ystem protection* uses *emergency power* regulation with automated systems on the HVDC Fenno-Skan link. The *system protection* provides a power change of 200 or 400 MW to Finland.

The four types of *system protection* are shown in Figure 3.

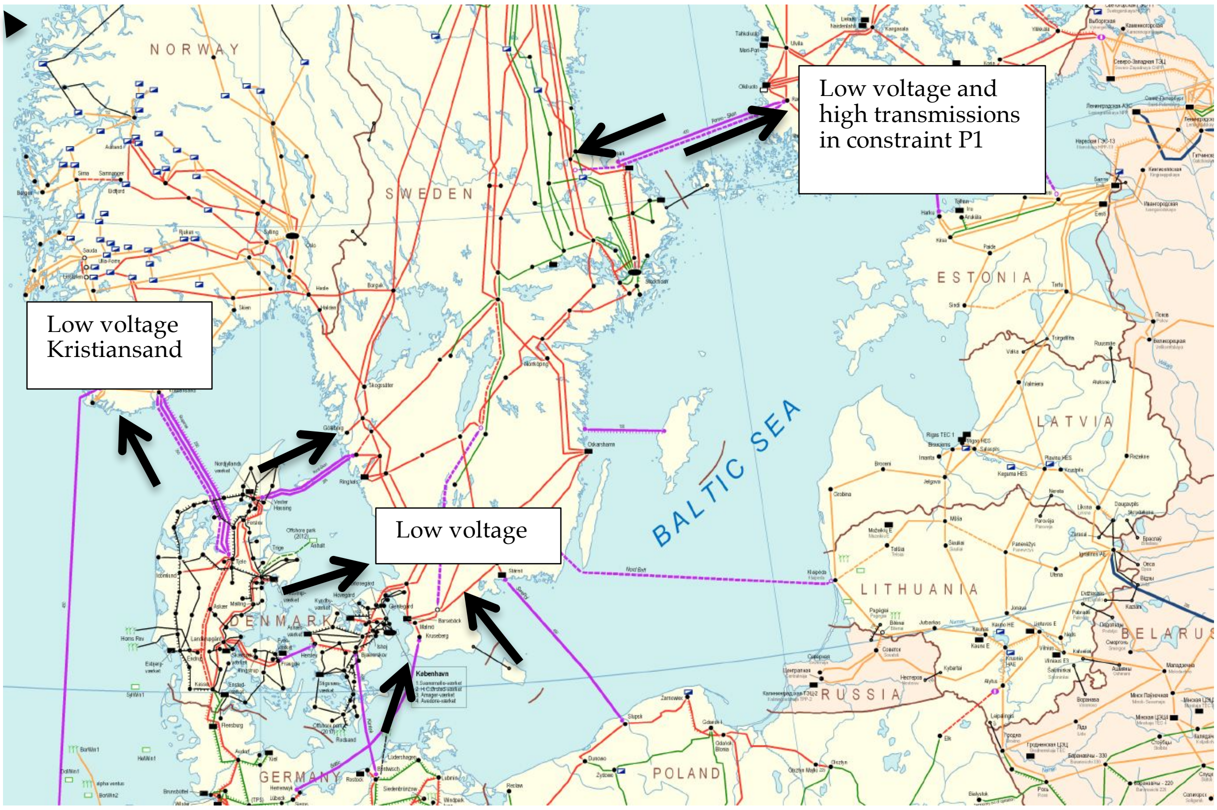

Figure 3. Control of HVDC facilities during low voltage

4 System protection activated by one or more relay signals from the facilities' protective equipment

System protection activated by relay signals is often more complicated and the protection often controls facilities a long way from the relays. Figure 4 shows an overview of *system protection* for *production shedding* and/or control of the HVDC links. Figure 5 shows an overview of *system protection* for *load shedding* and/or network division.

The Figures are followed by a description of the *system protection*.

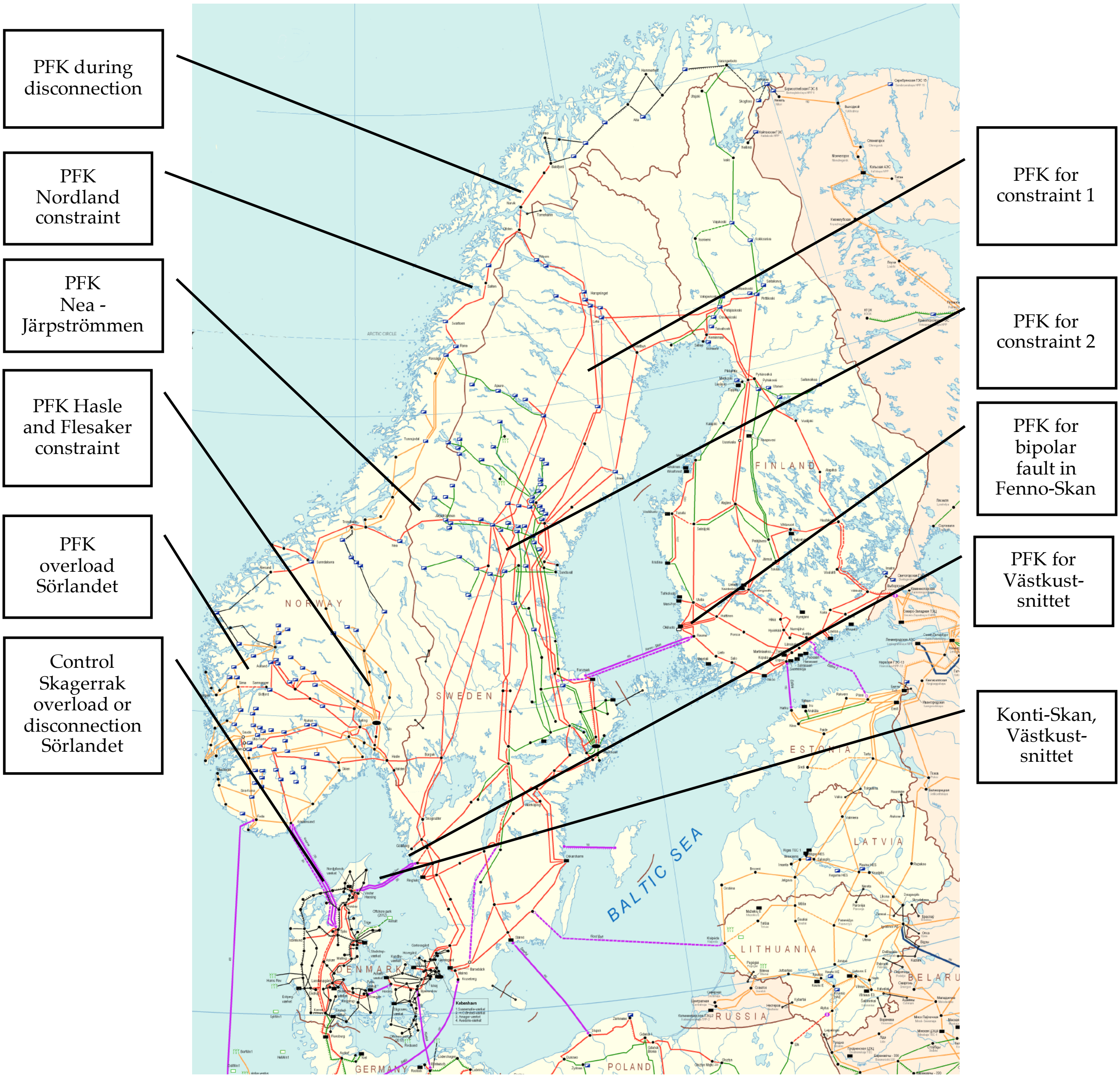

Figure 4. System protection for production shedding or control of HVDC

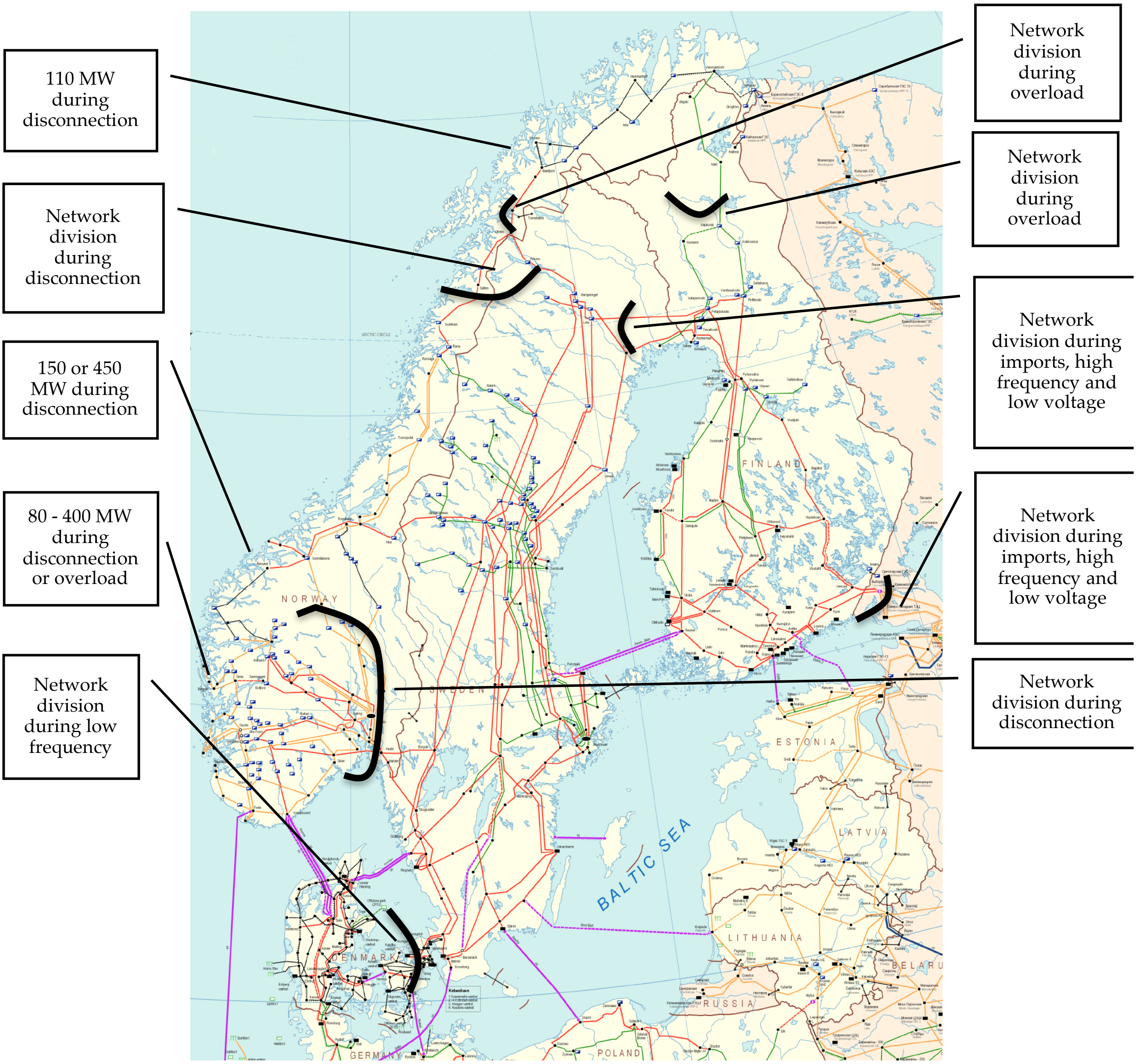

Figure 5. System protection for load shedding or network division

4.1 Eastern Denmark: System protection for stability in Eastern Denmark

4.1.1 System protection Ishøj east
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 protecion will reduce the production on AVV B02 to 150 MW and disconnect the gas turbines.

4.1.2 System protection Hovegård North
This system protection has been installed in order to protect the two 400 kV Øresund cables at both N-1 and intact grid. The system protection is only armed if certain operational criteria have been met. If armed it can be activated by tripping of one of the 400 kV lines connecting DK2 to SE4. The result of activation will be reduction of infeed from Great Belt1 to DK2 to 0 MW.

4.1.3 System protection Hovegård South
The two 400 kV lines leading south from Hovegård are protected by the system protecion. If one line is disconnected and certain operational criteria have been met it is armed. If the other line trips it is activated causing Great Belt1to reduce infeed to either 150 MW or 0 MW depending on operating criteria.

4.1.4 System protection Bjæverskov West
The two 400 kV lines leading east from Great Belt1are protected. The logic is the same as in 4.1.3. I.e. if one line is disconnected and the other one trips Great Belt1infeed to DK2 will be reduced to 0 MW.

4.2 Sweden: System protection with production shedding for limiting overloads on lines in Sweden

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 Porjus and Ofoten will disconnect production in northern Norway.

In case of loss of the link between Nea in Norway and Järpströmmen in Sweden, the *system protection* will disconnect production in Sweden and shed load in Norway.

4.3 Sweden: System protection in the West Coast constraint (Kilanda-Horred and Stenkullen-Strömma)

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, Kilanda-Stenkullen or Stenkullen-Strömma 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 downward regulates import to DK2 from Great Belt11, given that certain operational criteria have been met.

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, after which Ringhals 1 and 2 will be regulated down.

4.4 Sverige: Systemvärn Forsmark

At Forsmark and at the adjacent substations Tuna, Hagby and Odensala, there is system protection that regulates downward the production at Forsmark in the event of faults which could lead to the overloading of the Tuna transformer and the 220 kV network.

4.5 Sweden: System protection Långbjörn (PFK)

Production at Ångermanälven is fed out at Långbjörn and Betåsen transformer. The *system protection* at Långbjörn will disconnect the Långbjörn-

Korsselbränna-Stalon line or line Linnvasselv-Blåsjön-Junsterforsen-Gäddede-Bågede-Långbjörn with its connected production when the link between Kilforsen and Långbjörn is broken, to prevent transformer overload. In addition, overload protection in Betåsen will trip production in the area.

4.6 Sweden: System protection 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.

4.7 Sweden: System protection in 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 Loviseholm - Skogssäter and Hasle - Borgvik towards Sweden is larger than 1,200 MW and Loviseholm - Halden is lost, the transformer I Loviseholm will be disconnected to protect the system.

4.8 Sweden: System protection 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.

4.9 Norway: System protection in the Hasle and Flesaker constraint (PFK)

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 Hasle-Borgvik, Tegneby-Hasle, Rød-Hasle, Hasle-Halden, Halden-Loviseholm, Loviseholm-Skogssäter, Kvilldal-Sylling and Sylling-Tegneby.

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

4.10 Norway: System protection in the Nordland constraint (PFK)

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 1,200 MW.

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

- The loss of Ofoten-Ritsem, Ritsem-Vietas, Vietas-Porjus, Ofoten-Kobbelv or Svartisen-Rana-Nedre Røssåga.
- High levels of current on 300 kV Tunnsjødal-Verdal or 300 kV Tunnsjødal-Namsos.

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-Porjus might also lead to network division south of Kobbelv. The *system protection* is also described under section 4.2.

4.11 Norway: Local system protection at Kvilldal (PFK)

System protection at Kvilldal carries out automatic *production shedding* at Kvilldal in the event of a loss of a line or overload, because otherwise the transmissions will become too high in the westbound direction (towards Saurdal).

4.12 Norway: Network division in southern Norway

System protection establishes separate operation for the southern Norway area during simultaneous stoppages on both the 420 kV links between southern Norway and Sweden.

4.13 Norway: System protection for load shedding

System protection which disconnects 450 MW SU4 or 150 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-Viklandet. The network supplies general consumption and important industrial centres in Nord-Vestlandet.

4.14 Norway: System protection at 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 four stations and overload on the 420 kV at one station. 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 three stations and overload on the 420 kV at one station. The *system protection* regulates 200 or 300 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 and the 420 Rød-Grenland-Bamble_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, the system protection reduces the imports by 200 or 300 MW and/or reduces production at the Tonstad power plant (4 x 160 MW installed power).

4.15 Norway: System protection Run-back NorNed

With high exports from Southern Norway to the Netherlands, 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 HVDC link NorNed. System protection measures the loads on the 300 kV line Tonstad - Feda 1 and 2. System protection shall reduce the exports on NorNed down to 300 MW within 0.5 s. When exporting less than 300 MW, no downward regulation is performed. In case of trigging the breaker failure protection on the busbar failure protection in Tonstad, the system protection shall reduce the export on NorNed down to 200 MW and reduce the import on NorNed down to 300 MW.

4.16 Western Denmark: Great Belt1

In DK1 system protection has been installed in order to protect the remaining grid in the event of a trip from the line KAS_400_LAG. Certain operational criteria have to be met in order to arm the system protection. If it is armed it can be activated by a trip from KAS_400_LAG. The result will be a reduction to 0 MW flow on Great Belt1.

4.17 Finland: Frequency regulation (during island operation) 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.

4.18 Finland: 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.

4.19 Finland: Network division system protection in northern Finland

The *system protection* disconnects the line Vajukoski-Meltaus 110 kV when the power on the line is over 100 MW in 0.2 s. The *system protection* also disconnects the Pirttikoski-Kokkosniva 220 kV line when the 400/220 kV transformer in Pirttikoski is disconnected.

4.20 Finland: System protection to protect Finland in island operation situation

The *system protection* is used when one of the two 400 kV AC lines between Finland and Sweden is in revision. If there is a fault on one 400 kV line, the *system protection* disconnects the DC link Vyborg after 0.6 s when the frequency in Yllikkälä and Kymi exceeds 50.5 Hz. The *system protection* can be taken into use whenever necessary in remote control.

The *system protection* disconnects the 220 kV line Ossauskoski-Kalix after the power on the line from Finland to Sweden is over 200 MW in 1.0 s. The *system protection* also ensures that the 220 kV interconnection between the two countries is disconnected if both 400 kV AC lines between Finland and Sweden have tripped.

4.21 Finland: System protection for protecting against delayed synchronous operation between Finland and Russia during the shift-over of North West Power Plant from or to the Nordic system

The system protection is used for connecting the North West Power Plant (NWPP) from the Nordic system to the Russian system or vice versa without changing the power of the power plant and for ensuring that the Nordic and Russian systems do not remain in synchronous operation. The system protection disconnects the line Yllikkälä-Vyborg if the power from Yllikkälä is over 300 MW or to Yllikkälä over 700 MW in 0.4 s.

4.22 Finland: System protection to protect against bipolar fault in Fenno-Skan 1 & 2

The system protection is used in export situations when Fenno-Skan 2 is in operation, when the transmissions from Finland to Sweden via Fenno-Skan are over 900 MW and when the transmissions from Southern Finland to Northern

Finland are over 1,000 MW. The system protection disconnects the Vyborg DC link after 0.5 s if both Fenno-Skan 1 and Fenno-Skan 2 are disconnected from the network or if the total power of the links from Finland to Sweden is less than 1,000 MW for over 0.5 s, i.e. longer than a network failure.

System services

System services is a generic term for services that the *system operators* need for the technical operation of the power system. The availability of *system services* is agreed upon between the *system operator* and the other companies within the respective *subsystem*.

1 Survey of system services

1.1 System services defined in Appendix 2 Operational security standards of the System Operation Agreement

1.1.1 Frequency controlled normal operation reserve

The frequency controlled normal operation reserve is activated automatically within a ± 0.1 Hz deviation and shall be regulated out within 2-3 minutes. The joint requirement for the *synchronous system* is 600 MW. This means a joint requirement for *frequency response* in the *synchronous system* of 6,000 MW/Hz.
This service can be exchanged to a certain degree. Each *subsystem* shall have at least 2/3 of the *frequency controlled normal operation reserve* within its own system in the event of splitting up and island operation. A major exchange of the service between the *subsystems* can require a greater need for *regulating margin* (the difference between the *transmission* and *trading capacities*). Elspot exchanges and joint Nordic *balance regulation* take priority over the exchange of *automatic active reserve*. Thus, the exchange of this service is agreed after the Elspot has closed.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Droop control at thermal power plants.	Yes
Energinet.dk West	No requirement regarding frequency controlled normal operation reserve from the continent.	
Fingrid	Measured droop control at hydropower and thermal power plants. DC link towards Russia.	Yes Yes
Statnett	% turbine opening/Hz in hydropower.	Yes
Svenska kraftnät	% turbine opening/Hz in hydropower.	Yes

1.1.2 Frequency controlled disturbance reserve

The frequency controlled disturbance reserve is activated automatically at 49.9 Hz and fully activated at 49.5 Hz. At least 50 % shall be regulated out within 5 s and 100 % within 30 s. Joint requirement for the *interconnected Nordic power system* is approx 1,200 MW, depending on the relevant *dimensioning fault*.

The service is closely linked to *frequency controlled normal operation reserve*, and the principle of exchange is the same.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Disconnection of district heating. Turbine opening at thermal power plants. Droop control from thermal power plants. HVDC interventions.	Yes
Energinet.dk West	Condensate stoppage at thermal power plants. Droop control (modified gliding pressure) at thermal power plants.	No (only exchanged between Energinet.dk West and *RGCE*)
Fingrid	Droop control at hydropower and thermal power plants. Sheddable load.	Yes Yes
Statnett	% turbine opening/Hz in hydropower. HVDC interventions, in stages depending on freq	Yes
Svenska kraftnät	% turbine opening/Hz in hydropower. HVDC interventions, in stages depending on freq. Automatic start-up of gas turbines, in stages depending on freq. Some with 5 s start-up delay.	Yes

1.1.3 Voltage controlled disturbance reserve

The voltage controlled disturbance reserve becomes relevant when low voltage activates *emergency power* on HVDC links out from the *synchronous system*. The service is applicable to exchanges.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Not used.	
Energinet.dk West	Not used.	
Fingrid	Not used.	
Statnett	Emergency power Skagerrak.	Yes
Svenska kraftnät	Automatic export restriction on HVDC links south of constraint 4 in Sweden. SwePol Link, Baltic Cable and Kontek.	Yes

1.1.4 Fast active disturbance reserve

The fast active disturbance reserve restores *frequency controlled disturbance reserve* and shall be activated within 15 minutes.

This service can be exchanged between the *subsystems* of the joint Nordic *regulation market* or as *supportive power.* However, in the event of *power shortages,* Appendix 9 Rules for managing power shortages during high consumption, bottlenecks or disturbances comes into force.

The fast active disturbance reserve is also used in conjunction with bottleneck situations and network disturbances.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Contract with producer. Gas turbines, upward regulation of rolling reserve, fast-start thermal power plants.	Yes
Energinet.dk West	Contract with producer, bids can be made via *regulation market*.	Yes
Fingrid	Gas turbines. Sheddable load. DC link Vyborg.	Yes Yes Yes
Statnett	Contracted *regulating power*: Options market for *regulating power* (production and consumption). Voluntary bids on *regulation market*.	Yes Yes
Svenska kraftnät	Voluntary bids in the regulation market. Contracted regulating power from gas turbines.	Yes

1.1.5 Slow active disturbance reserve

The requirement for *slow active disturbance reserve* for each *system operator* to comply with will depend on national legislation. Activation is slower than 15 minutes. The service is not yet relevant to exchanges between the *subsystems*. However, in the event of *power shortages,* Appendix 9 Rules for managing power shortages during high consumption, bottlenecks or disturbances comes into force.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Thermal power plants with a start-up time of up to 4 hours and rearrangement of production types at thermal power plants.	
Energinet.dk West	There are no plants with a start-up time of less than 4 hours.	
Fingrid	Power available after 15 minutes, market is responsible.	No
Statnett	Not used	
Svenska kraftnät	Most frequently replaced by a surplus of *fast active disturbance reserve*. Between 15 November and 15 March, the system service is contracted in the power reserve.	No

1.1.6 Reactive reserve

Reactive reserve is of a local nature. Consequently, it cannot be exchanged between the *subsystems*.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Over and under magnetization of production plants. Synchronous condenser operation in one generator. Connection/disconnection of capacitor batteries and reactors. SVC plants	No
Energinet.dk West	Over and under magnetization of central production plants. Change of Mvar production at power plants. Synchronous condensers at Tjele and Vester Hassing. Connection and disconnection of capacitors. Connection and disconnection of reactors.	No
Fingrid	Over and under magnetization of production plants. Synchronous condenser operation at certain hydropower plants. Connection and disconnection of power lines. Connection and disconnection of capacitor batteries and reactor. SVC plants and HVDC (VSC) facilities	No No No No
Statnett	Over and under magnetization of production plants. Connection and disconnection of power lines. Connection and disconnection of capacitor batteries. Static phase compensation (SVC plants).	No
Svenska kraftnät	Over and under magnetization of production plants. Connection and disconnection of power lines. Connection and disconnection of capacitor batteries, reactors. Static phase compensation (SVC plants).	No

[1]) Payment for production of reactive power in generators outside certain limits for tan φ.

1.2 System services not defined in Appendix 2 Operational security standards of the System Operation Agreement

1.2.1 Load following

Load following entails that *players* with major production changes report production plans with a resolution of 15 minutes. *Load following* with a quarter-hourly resolution improves the quality of the frequency of the *synchronous system*.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Not used.	
Energinet.dk West	Production balance centres with variable production deliver running schedules with a resolution of 5 min.	Partly, 5 min and 15 min. plans are sent to other TSOs
Fingrid	Hour shift regulation. Balance centres inform Fingrid about hours containing more than 100 MW of changes in their balance.	Yes
Statnett	Players with major production changes make their production plans using a quarter-hourly resolution. Statnett can move planned production changes for all players by up to 15 minutes.	Yes Yes
Svenska kraftnät	Players with major production changes plan production plans with a quarter-hourly resolution and report the production plans with a quarter-hourly resolution to Svenska kraftnät. Svenska kraftnät has the right to move production by at least 15 minutes.	Yes

1.2.2 System protection

The system protection service is exchanged to some degree today. It is imaginable that the Nordic power system will become more integrated in the future. Then, events in one *subsystem* will be able to activate *system protection* in another *subsystem*.

TSO	Generation of system service	Exchange

		between subsystems
Energinet.dk East	Automatic downward regulation and/or disconnection of power plants, Kontek and/or Great Belt automatic upward regulation of Kontek. Specified in Appendix 5 System protection.	No
Energinet.dk West	*Emergency power* on Konti-Skan and Skagerrak. Downward regulation of Konti-Skan in the event of an overload on transformers. Downward regulation of Skagerrak 3 and Great Belt upon the loss of some 400 kV lines (downward regulation in respect of voltage quality).	Yes
Fingrid	Automatic production shedding. Network division. Specified in Appendix 5 System protection.	No
Statnett	Automatic disconnection of power plants and smelting works. *Emergency power* on Skagerrak.	Yes Yes
Svenska kraftnät	Automatic downward regulation of SwePol link, Baltic Cable and Kontek. *Production shedding* and automatic *load shedding*.	Yes

1.2.3 Black starts

Black start services are listed below.

TSO	**Generation of system service**
Energinet.dk East	Diesel generator and/or gas turbines.
Energinet.dk West	2 gas turbines.
Fingrid	Some hydropower plants and gas turbines.
Statnett	Some selected hydropower plants.
Svenska kraftnät	Some selected hydropower plants and via NordBalt

1.2.4 Automatic load shedding

Automatic load shedding (AFK) is relevant during major *operational disturbances*. The *subsystems* will then hardly be interconnected and the service will not be relevant to exchanges.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Frequency controlled load shedding and disconnection of links between Sweden and Zealand. Specified in Appendix 5 System protection, table 2.	No
Energinet.dk West	Load shedding. Link with Germany is not disconnected. Load shedding between 48.7 Hz and 47.7 Hz. Specified in Appendix 5 System protection, table 2.	No
Fingrid	Automatic load shedding between 48.7 Hz – 48.3 Hz. Specified in Appendix 5 System protection, table 2.	No
Statnett	Automatic load shedding between 49.0 Hz – 47.0 Hz. Specified in Appendix 5 System protection, table 2.	No
Svenska kraftnät	Automatic load shedding between 48.8Hz – 48.0 Hz. Specified in Appendix 5 System protection, table 2.	No

1.2.5 Manual load shedding

Manual load shedding (MFK) service is used during major *operational disturbances* and *power shortages* and cannot be exchanged between the *subsystems*. This is regulated by Appendix 9 Rules for managing power shortages during high consumption, bottlenecks or disturbances.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	The load can be shed to eliminate non-approved transmissions on the network, for managing power shortages, during island operation and when automatic load shedding has not been sufficient.	No
Energinet.dk West	The load can be shed to eliminate non-approved transmissions on the network, for managing power shortages, during island operation and when automatic load shedding has not been sufficient.	No
Fingrid	Sheddable load used as fast active disturbance reserve, can also be used during power shortages when only 600 MW of fast active disturbance reserve remains in the synchronous system.	No
Statnett	Used during power shortages when only 600 MW of fast active disturbance reserve remains in the synchronous system.	No[1]
Svenska kraftnät	Used during power shortages when only 600 MW of fast active disturbance reserve remains in the synchronous system.	No

[1]) No particular compensation is paid to the players. However, when the service is activated, Statnett will obtain the CENS (Compensation for Energy Not Supplied) liability, entailing a reduction of the revenue limit.

1.2.6 Fast active forecast reserve

The fast active forecast reserve restores the *frequency controlled normal operation reserve*. Using this, deviations in consumption and/or production forecasts are adjusted. Requirements for each *system operator* to comply with will depend on national legislation. Activation time is 10-15 min.

The service is exchanged between the *subsystems* in the joint Nordic *regulation market* as voluntary or contracted *regulation power*, but in the event of *power shortages,* Appendix 9 Rules for managing power shortages during high consumption, bottlenecks or disturbances will come into force.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Contract with producers regarding bids (as bids in the regulation market).	Yes
Energinet.dk West	Contract with producers regarding minimum bids (as bids in the regulation market). Voluntary bids in the regulation market.	Yes Yes
Fingrid	Voluntary bids in the regulation market.	Yes
Statnett	Contracted regulation power: Options market for regulation power (production and consumption). Voluntary bids in the regulation market.	Yes Yes
Svenska kraftnät	Voluntary bids in the balance regulation (secondary regulation).	Yes

1.2.7 Fast active counter trading reserve

Requirements for each *system operator* to comply with will depend on national legislation. The service can be exchanged between the *subsystems* during the *operational phase*.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Particular purchases from producers.	
Energinet.dk West	Particular purchases from producers and bids in the regulation market can be used.	Yes
Fingrid	Voluntary bids in the regulation market can be used.	Yes
Statnett	Contracted regulation power: Options market for regulation power (production and consumption). Voluntary bids in the regulation power market.	Yes Yes
Svenska kraftnät	Voluntary bids in the balance regulation (secondary regulation).	Yes

1.2.8 Peak load resource

The requirements for peak load resource for each *system operator* to comply with will depend on national legislation.

By *peak load resource* is meant active reserve which is not normally used. For anticipated peak load periods, the preparedness time is reduced so that the capacity, as and when needed, can be used. The service can be exchanged between the *subsystems* in the joint Nordic *regulation market*. However, in the event of *power shortages,* Appendix 9 Rules for managing power shortages during high consumption, bottlenecks or disturbances will come into force.

The peak load resource can be offered to Elspot at Nord Pool Spot.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Not used.	
Energinet.dk West	Not used.	
Fingrid	The service is referred to as peak load capacity in Finland. It is provided through contracts with electricity producers and users.	
Statnett	Not used.	
Svenska kraftnät	The service is referred to as peak load capacity in Sweden. It is provided through contracts with electricity producers and users.	

2 Description of routines for trading in system services

2.1 General

Trading in *system services* shall not be an obstacle to either *Elspot trading* or *balance regulation*.

2.2 Trading in frequency controlled normal operation reserve and frequency controlled disturbance reserve

Trading in *frequency response* can be simultaneously trading in *frequency controlled normal operation reserve* and *frequency controlled disturbance reserve* depending on how the individual services are acquired in the separate *subsystems*.

System operators can inform each other on a daily basis after the Elspot has closed regarding surpluses of *frequency response* that can be offered to the other *system operators*.

System operators that have a need to purchase can contact the relevant *system operator* to obtain information on prices and volumes.

When the total purchasing requirement is larger than the supply, distribution shall take place on the basis of the basic requirement for the *frequency controlled normal operation reserve and frequency controlled disturbance reserve*.

Trading is carried out bilaterally between *system operators*.

If trading involves transit transmission through a *subsystem*, the *system operator* in whose network the transit transmission will take place shall be informed before making the agreement.

In the event of selling to several *system operators,* all will pay the same price, the marginal price.

2.3 Exchanges using other types of reserves

Services linked to the joint Nordic *regulation market* are described in Appendix 3 Balance regulation standards. If it is necessary to deviate from the normal reserve acquisition principles, each individual case shall be handled by RGN.

European Network of Transmission System Operators for Electricity

Joint operation between the Norwegian and Swedish subsystems on the AC links

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 Rössåga-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 power, system services and transmission losses, 2014-01-01

2.2 Other transmission facilities

Sildvik-Tornehamn	130	Tornehamn	Vattenfall owner on Swedish side

2.3 Other transmission facilities than those under 2.2

Eidskog-Charlottenberg	130	Charlottenberg	Fortum owner on 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 at Sollefteå (DCNO)
Nedre Rössåga-Gejmån-Ajaure	Regional Centre at Sunndalsöra	Operations Centre at Sollefteå (DCNO)
Nea-Järpströmmen	Regional Centre at Sunndalsöra	Operations Centre at Sollefteå (DCNO)
Hasle-Borgvik	Regional Centre in Oslo	Operations Centre at Sundbyberg (DCSY)
Halden-Loviseholm	Regional Centre in Oslo	Operations Centre at 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

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* needing switchings which will affect the *cross-border link,* Statnett and Svenska kraftnät are to be informed before any switchings are made. In the case of switchings on the Swedish grid, switching schedules are to 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 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 Transmission capacity (TTC)

The *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)	120	120	120	120	120	100
Sildvik-Tornehamn (from Sweden)	70	70	70	70	70	70
Ofoten-Ritsem	1 350	1 350	1 350	1 350	1 170	880
Nedre Rössåga-Gejmån-Ajaure	536	496	451	398	334	250
Nea-Järpströmmen	1420	1420	1420	1420	1275	815
Hasle-Borgvik	2 100	2 000	1 900	1 780	1 650	1 510
Halden-Loviseholm	3 070	2 900	2 700	2 490	2 260	2 000
Charlottenberg-Eidskog	95	95	95	95	95	95

The *transmission capacity* is limited by defined *transmission constraints*, stability conditions or similar. The *transmission capacity* thus varies in accordance with how it is distributed between the links.

To Norway in the Hasle constraint: The *transmission capacity* is dependent on the temperature as follows (at temperatures below 0°C, the transmission capacity is restricted by voltage in Sweden):

Temperature [°C]	-20	-10	0	10	20	30
Capacity [MW]	2,150	2,150	2,150	2,150	2,050	1,900

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]	2 800	3 150	3 500	3 600	3 700	3 800	3 900	4 000	4 100
Capacity [MW]	2 200	2 100	2 000	1 900	1 800	1 700	1 600	1 500	1 400

Oslo load [MW]	4 200	4 300	4 400	4 500	4 600	4 700	4 800	4 900	5 000
Capacity [MW]	1 300	1 200	1 100	1 000	800	600	400	200	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 (NTC)

When determining the *trading capacity* of the links, the *transmission capacity* shall be reduced by the *regulating margin*.

The *regulating margin* of the Hasle constraint is normally 150 MW. The total *regulating margin* of the other links is normally 50 MW.

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

For the *trading capacity,* a weekly forecast is established for the coming week. The forecast is sent to Nord Pool Spot by at the latest the Tuesday of the week before.

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 at Trollhättan
Ofoten-Ritsem	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Sollefteå
Nedre Rössåga-Gejmån-Ajaure	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Sollefteå
Nea-Järpströmmen	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Sollefteå
Hasle-Borgvik	National Centre in Oslo	SvK's Operations Centre at Sundbyberg
Halden-Loviseholm	National Centre in Oslo	SvK's Grid Supervisor at Network Control at 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, Sunndalsöra 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 Rössåga	235	240-250	250
Nea	380	410-415	430
Hasle	380	410-415	430
Halden	380	410-415	430

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, SvK'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	245-255	260
Järpströmmen	395	400-410	420
Borgvik	395	400-415	420
Loviseholm	395	400-415	420

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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 Rössåga.
- Outages entailing that, on the Norwegian network, there is no link between Rössåga 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 means that the *transmission capacities* have been exceeded 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 *normal state.*

European Network of Transmission System Operators for Electricity

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

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 Disturbance management

When a *cross-border link* is taken out of operation, the control rooms will contact each other immediately.

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 Transmission capacity

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	1,650 MW	1,600 MW

The *transmission capacity* to Sweden is limited because of dynamic reasons as follows:

Constraint 1	Max. transmission to Sweden
3,000 MW	1,200 MW
3,100 MW	1,100 MW
3,300 MW	1,000 MW

The *transmission capacity* of only one 400 kV link in the north is a maximum of:

	Planned outage in the other link	Disturbance in the other link
To Finland	500 MW	500 MW
From Finland	400 MW	400 MW

With the *system protection* that protects Finland against island operation (Appendix 5 System protection), the capacity from Finland to Sweden can be raised to 900 MW, but this shall be agreed separately in each case between the control centres of Svenska kraftnät and Fingrid.

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.

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.

Both parties shall inform the other *party* in good 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 (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:

– SvK'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 on an alternating basis per half calendar year: the first half by Svenska kraftnät's Operations Centre at Sundbyberg and the second half 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

For voltage regulation, there are reactors on the tertiary windings of transformers and capacitors in the 110 kV system.

At Keminmaa, the capacitor is connected for reactive power on the 110 kV side of transformers. The reactors are connected by means of automation for 400 kV voltages. The automation has three windows of ±4 kV and it can be adjusted upwards and downwards from the Main Grid Control Centre.

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

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

The *Parties* 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.

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 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 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 hours when a disturbance situation is in force, loss minimization is not employed.

During disturbance situations, both *Parties* 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, the *Parties* 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-Skan1 and 2 shall be regulated within 15 minutes to such a value that the *counter trading* requirement ceases.

5 Distribution of capacity utilization and loss optimisation between Finland and Sweden

The distribution of capacity utilization on the *cross-border links* is governed by a separate agreement between Fingrid and Svenska kraftnät. The main principles are as follows:

The *transmission capacity* of the *cross-border links* is defined for the AC links in the north and for Fenno-Skan 1 and 2. The *transmission capacity* shall be determined continuously by the *parties* in accordance with the relevant technical conditions of the System Operation Agreement. The *trading capacity* is determined by calculating the *transmission capacity* minus determined *regulating margin*.

Loss minimization shall only take place during hours when the *Elspot price* is the same in *bidding areas* SE1, SE2, SE3 and FI. If the price in *Elspot* is different between *bidding areas* SE1, SE2, SE3 or FI, transmissions shall be divided between the north and south connections on the basis of trading in *Elspot*.

The purpose of loss optimization is to minimize the total losses in the Finnish and Swedish grids by adjusting the target value of Fenno-Skan. Loss optimization must not result in exceeding the *trading capacities*.

Joint operation between the Norwegian, Finnish and Swedish subsystems in Arctic Scandinavia

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 link. The capacity will instead be included in the trading scope for Nord Pool Spot's *Elspot* trading and *Elbas* trading between Norway-Sweden and Sweden-Finland.

2 Transmission facilities linking the subsystems of Norway-Finland

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

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

3 Electrical safety for 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 electrical operation/Operation management

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 between Finland and Norway.

3.3 Switching responsible operator

Line	Norway	Finland
Ivalo-Varangerbotn	Regional Centre at Alta	Main Grid Control Centre in Helsinki

3.4 Operations monitoring and control in respect of electrical safety

In accordance with section 3.3.

3.5 Switching schedule

Switchings on the links are carried out in accordance with a switching schedule drawn up by the *Party* with the outage requirement. The *Party* drawing up the switching schedule is also the switching responsible operator.

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

Same as under section 3.5.

3.6.3 Fault finding

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

3.6.4 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 section 2

4.1 Transmission capacity

4.1.1 From Norway to Finland

The *transmission capacity* varies between 50 and 130 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 link* 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.

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

4.3 Trading capacity

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* (NTC) for the Finnmark line is included in the trading scope of Nord Pool Spot's *Elspot* trading and *Elbas* trading between Norway - Sweden and between Sweden - Finland.

4.4 Operations monitoring and control in respect of system operation

In Finland, *operations monitoring* is carried out from the System Operation Centre in Helsinki. *Control* is carried out from the Tavastehus Network Centre following permission from the System Operation Centre.

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 7 point 7.5 in the agreement.

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

4.6 Outage planning

Outage planning and maintenance are co-ordinated in in co-operation between Fingrid's Main Grid Control Centre in Helsinki and Statnett's National Centre in Oslo/Regional Centre at Alta.

4.7 Disturbance management

The term disturbance situation means that the *transmission capacities* have been exceeded 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 link to *normal state*.

5 Miscellaneous

5.1 Settlement

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

Balance power for the Finnmark line is the measured exchange minus exchange plans. Balance power is settled between Statnett and Fingrid.

The plan for transit via Svenska kraftnät is adjusted with the transit plan for Ivalo-Varangerbotn. 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.

European Network of Transmission System Operators for Electricity

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

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 Electrical safety for 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 electrical operation/Operational management

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

3.3 Switching responsible operator

3.3.1 Switchings

In the event of outages on the HVDC links, 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.dk's control room at Tjele stating that the HVDC isolators 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.dk's Control Centre at Erritsö, while authorization for all switchings 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.

Switchings at the AC facilities are normally carried out from Energinet.dk's Control Centre at Erritsö and from Statnett's Regional Control Centre in Oslo. Switchings at the HVDC facilities, once these have been disconnected from the AC network, are carried out from Kristiansand and Tjele.

3.4 Operation monitoring and control in respect of electrical safety

Operation monitoring and control in Western Denmark is carried out from:
- Energinet.dk's Control Centres at Erritsö or Tjele.

Operation monitoring and control in Norway is carried out from:
- Statnett's Regional Control Centre in Oslo.
- The four DC links can be operated individually.

3.5 Switching schedule

Prior to planned outages on the HVDC links, written confirmation shall be exchanged between Statnett's Regional Centre in Oslo and Energinet.dk's control room at Tjele. *Outage planning* for the links will be carried out in accordance with section 4.5.

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 Transmission capacity

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

SK1, SK2:	Technical min. 10 MW/pole	Nominal (500 + 40) MW
SK3:	Technical min. 13 MW	Nominal 500 MW
SK4:	Technical min. 0 MW	Nominal 700 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.dk's Control Centre at Erritsö is responsible for supportive data on the Western Danish side and Statnett for the equivalent on the Norwegian side.

4.3 Trading capacity (NTC)

The normal *trading capacity* (NTC) in ”bipolar operation” is:

1632 MW in receiving end

The following calendar day's *trading capacity* is decided each day. Losses will be bought in sending end hour by hour on basis on a common forecast for the exchange.

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 in Western Denmark is carried out from:
- Energinet.dk's Control Centre at Erritsö.

Operation monitoring and control in Norway is carried out from:
- Statnett's Regional Centre in Oslo.

The four poles can be operated individually.

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 Regulating the link

Regulation of the Skagerrak link in accordance with agreed *exchange plans* will be carried out by Statnett and Energinet.dk alternating each week.

The plans are issued as power plans in whole MW for each 5 minutes. The link is regulated 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.

Overhaul 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 Emergency power

Emergency power consists of regulating measures which are initiated manually (*manual emergency power*) or automatically by means of a control signal being transmitted to the converter stations using telecoms.

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

Manual emergency power without previous notice may be activated within 100 MW and 100 MWh/calendar day. Prior to activation over and above this, notification and approval shall occur between Energinet.dk's Control Centre at Erritsö 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 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 5 – System protection).

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

5 Miscellaneous

5.1 Ancillary services

100 MW of the NTC on the Skagerrak link is normally dedicated for exchange of secondary reserves. The service is delivered from Norway to Denmark, and contains both up- and downregulation. Secondary reserves are activated from Denmark according to the balance of Western Denmark.

10 MW primary reserves are also delivered from Norway to Denmark on the Skagerrak link. The delivery does not affect NTC, but is delivered on the overload capacity on the link. Primary reserves are activated in both directions according to frequency deviations in Western Denmark.

5.2 System services

For the automatic or manual activation of *operation reserves,* the available *transmission capacity* can be used.

The *Parties* have the right to utilize idle *transmission capacity* for the transmission of *system services.* Configuration values, power limits etc. are agreed upon bilaterally.

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

5.3 Settlement

Energinet.dk 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

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.dk and in Sweden by Svenska kraftnät. The responsibility for electrical operation is regulated by facility agreements between Energinet.dk and Svenska kraftnät.

The *power operation responsibility boundary* between Svenska kraftnät and Energinet.dk lies at Läsö Öst, 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)	Energinet.dk's control room at Vester Hassing
Konti-Skan 2	Svenska kraftnät's Operations Centre in Sundbyberg (DCSY)	Energinet.dk's control room at Vester Hassing

During work between Lindome and XL1-F at Läsö Öst or Lindome and XL2-F at Läsö Öst, 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, Energinet.dk's 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 Energinet.dk's Control Centre at Erritsö 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.dk.
- Switching on the Danish part of the cable takes place in accordance with a switching plan drawn up by Energinet.dk. 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,* Energinet.dk's Control Centre at Erritsö 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 Transmission capacity

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

In bipolar operation, the nominal capacity is 740 MW, and in monopolar operation (KS1 or KS2), the capacity is 370 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.dk and Svenska kraftnät.

For any limitations in the connecting AC networks, Energinet.dk's Control Centre at Erritsö is responsible for supportive data on the Western Danish side and Svenska kraftnät for the same on the Swedish side.

4.3 Trading capacity (NTC)

The normal *trading capacity* is:

740 MW from Western Denmark → Sweden
680 MW from Sweden → Western Denmark

The above applies when Vester Hassing is the exchange point (30 MW of losses).

The following calendar day's *trading capacity* is set every day. Similarly, a weekly forecast is established for the coming week's *trading capacity*. The forecast is submitted to Nord Pool Spot by at the latest the Tuesday of the week before. 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 Energinet.dk's Control Centre at Erritsö 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. Energinet.dk's Control Centre at Erritsö 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 Energinet.dk's Control Centre at Erritsö.

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 Emergency power

Emergency power is regulating measures which are initiated manually (*manual emergency power*) or automatically by means of a control signal being transmitted to the converter stations by means of telecommunications.

On the Western Danish side, Energinet.dk's Control Centre at Erritsö has the right to initiate *manual emergency power* in the event of disturbances to the power balance or *transmission network*.

On the Swedish side, Svenska kraftnät has the right to initiate *manual emergency power* in the event of disturbances to the power balance or *transmission network*.

Manual emergency power 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 Energinet.dk's Control Centre at Erritsö and SvK-VHI at Network Control at Sundbyberg.

4.6.3 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 5 – System protection).

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*.

The *Parties* have the right to utilize idle *transmission capacity* after *Elspot trading* and *Elbas trading* for the transmission of *system services*. Configuration values, power limits etc. are agreed upon bilaterally.

European Network of Transmission System Operators for Electricity

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

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.dk 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.dk. 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.dk 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.dk 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.dk.

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.dk.

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.dk's Control Centre at Erritsö
Söderåsen – Kristinelund Hovegaard (FL25)	Operations Centre at Sundbyberg (DCSY)	Energinet.dk's Control Centre at Erritsö

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

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

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.dk's Control Centre at Erritsö 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.dk's Control Centre at Erritsö 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 *normal state*.

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.dk's Control Centre at Erritsö 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.dk's Control Centre at Erritsö.

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 Transmission capacity

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

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.dk's Control Centre at Erritsö 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 Erritsö 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.dk in the same proportion as their ownership.
At a voltage of 400 kV, the facilities FL23 and FL 25 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.dk's Operational Planning at Erritsö 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 means that the *transmission capacity* has been exceeded due to, for instance, long-term line faults or losses of production. If the *transmission capacities* are not exceeded during the faults, the situation will be deemed normal.

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

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.dk.

5.2 Transmissions to Bornholm

As regards balance, Bornholm is managed as a part of the Eastern Danish *subsystem*. Energinet.dk 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.dk 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.dk's Control Centre at Erritsö 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.dk's Control Centre at Erritsö co-ordinate the *fast active disturbance reserve* in Southern Sweden and Eastern Denmark 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 or Asnäs plant
- Kontek
- Great Belt

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

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

Facility	Voltage kV	Other information
Hasle-Borgvik	400 kV AC	Ingår i Haslesnittet
Halden-Loviseholm	400 kV AC	Ingår i Haslesnittet
Lindome-V Hassing	250 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

2 Principles for the distribution of exchange plans on the links

Nord Pool Spot utilizes the *trading capacity* which the *system operators* have set in order to try to avoid price differences between the *bidding areas*.

Energinet.dk's Control Centre at Erritsö sets a *trading capacity* to and from the *bidding area* in Western Denmark DK1 which can entail a limitation of the *trading capacities* between the *bidding areas* Western Denmark - Norway DK1-NO2 and Western Denmark - Sweden DK1-SE3. Distribution between the cables takes place on a pro rata basis, depending on the DC links' *trading capacities*. In the event of a price difference between the areas, 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*.

Svenska kraftnät, Energinet.dk and Statnett agree that *trading plans* between Western Denmark, Norway and Sweden will not be changed more than 600 MW from one hour to the next. Tthis applies partly to the overall net regulation between Western Denmark and Sweden/Norway and partly to each individual link.

The planned *ramping* rate on Konti-Skan and the Skagerrak link is a maximum of 30 MW/min.

Based on hourly plans from Nord Pool Spot, Energinet.dk's Control Centre at Erritsö 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 *ramping* rate. Energinet.dk also has an opportunity to minimise network losses in the triangular link. Energinet.dk's Control Centre at Erritsö 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 power*, either bilaterally between two of the relevant *system operators* or between all three *system operators*.

The exchange of equal volumes of *supportive power* 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 power* 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.dk's Control Centre at Erritsö 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 *balance power* and *supportive power*.

European Network of Transmission System Operators for Electricity

APPENDIX 7.8 JOINT OPERATION BETWEEN THE WESTERN AND EASTERN DANISH SUBSYSTEMS ON DC LINK GREAT BELT

2014-01-30 APPENDIX TO THE SYSTEM OPERATION AGREEMENT OF ENTSO-E REGIONAL GROUP NORDIC

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

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.dk is responsible for the electrical operation of Great Belt.

3.3 Switching responsible operator

Energinet.dk 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.dk's Control Centre at Erritsö.

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.dk.

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.dk 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.dk 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.dk 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 Transmission capacity

The *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.dk 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 (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. Similarly, a weekly forecast is established for the coming week's *trading capacity*. The forecast is submitted to Nord Pool Spot at the latest on the Tuesday of the week before. 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.dk's Control Centre at Erritsö.

4.4.1 Regulating the link

Regulation of Great Belt in accordance with agreed *exchange plans* is carried out from Energinet.dk's Control Centre at Erritsö.
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.dk 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 Emergency power

Emergency power represents regulating measures which are initiated mainly automatically (see 4.6.4) by means of a control signal being transmitted to the converter stations by means of telecommunications. *Emergency power* can also be initiated manually.
Emergency power is used when system security requires immediate intervention in the power system. The activation of *emergency power* shall be documented retroactively and communicated to the Parties to this agreement. The reason for activation shall be given. Energinet.dk's operations centre at Erritsö has the right to initiate less than 100 MW of manual *emergency power* on Great Bält without advance notice. If the *emergency power* is more than 100 MW, notification and approval shall take place between the staff of Energinet.dk's operations centre at Erritsö 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 System protection

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.dk's operations centre at Erritsö and SvK-VHI at Network Control at Sundbyberg. (See also Appendix 5 System protection.)

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.dk 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 Elbas.

5.1.2 Manual frequency support

Energinet.dk 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.

Managing transmission limitations between subsystems

1 Background

All *trading capacity (NTC)* shall be put at the disposal of the electricity market.

System operators may need, for reasons of *system security* or the state of affairs in their own or adjacent networks, to limit the *transmission capacity* of the links between the *subsystems*.

Supportive power agreed in advance between the *system operators,* with reference to start-ups of thermal power or similar, has a higher priority than *balance power*.

2 Transmission limitations during the planning phase, prior to completed trading on Elspot

Elspot is used to balance transmission limitations between the *subsystems* during the *planning phase*. The involved *Parties* reach agreement on a daily basis regarding the *trading capacity* for exchanges between the *subsystems*.

In the event of limited-duration reduced *transmission capacity* between the *subsystems*, the *system operators* will be able to agree to use *counter trading.*

In the event of transmission limitations within a *bidding area,* it will be the respective *system operator's* responsibility to manage the limitation by using *counter trading* or by limiting the *trading capacity*.

3 Transmission limitations during the operational phase, following completed trading on Elspot

During the *operational phase*, reduced *transmission capacity* between the *subsystems*, as a consequence of an *operational disturbance*, is managed by means of *counter trading*. There is no limitation of the *players'* planned power trading on Elspot. *Counter trading* takes place during the remainder of the current period when *Elspot trading* has been fixed.

For *Elbas trading*, the *trading capacity* is reduced but prearranged trading will be *counter traded* for the remainder of the current Elspot period.

In the event of an *operational disturbance* in a *Party's subsystem*, the responsible *Party* will bear the full technical, financial and operative liability for eliminating the effects of the incident in its own *subsystem* and minimising the effects in other *subsystems*.

In the event of an *operational disturbance* on the *cross-border links* themselves, the *system operators* on both sides of the link will bear the technical, financial and operative liability for eliminating the effects of the incident on their own *subsystems*.

If the agreed trading exceeds the reduced *trading capacity* between *subsystems*, *supportive power* is exchanged between the parties concerned. The volume of *supportive power* in *counter trading* as a result of an *operational disturbance* on the *cross-border link* itself is normally the difference between the agreed trading capacity and current *trading capacity*.

Acute situations, such as during a general *power shortage* or during *power shortages* resulting from *operational disturbances* in networks or during *bottleneck situations*, when compulsory *load shedding* has to occur, are managed in accordance with Appendix 9 Rules for managing power shortages during high consumption, bottlenecks or disturbances.

4 Step by step of the trading capacity

Major changes to the *trading capacity* between two *bidding areas* can result in major changes in power flows from one hour to the next. These major changes can be difficult to manage in balance regulation. Thus, restrictions are placed on changes to *trading capacities* from one hour to the next. This change may be a maximum of 600 MW from one hour to the next, unless otherwise agreed. This procedure is called *scaling*.

5 Ramping of trading plans on HVDC connections

Major changes to the *trading plans* on the HVDC connections from the Nordic *synchronous area* can result in major changes in power flows at the change of hours. These major changes can be difficult to manage in *balance regulation*. Thus, restrictions are placed on the magnitude of changes to the *trading plans* from one hour to the next. This change may be a maximum of 600 MW from one hour to the next on each of the following connections: NorNed, Estlink, Skagerrak, Konti-Skan, Kontek, Great Belt, Baltic Cable, NordBalt and SwePol Link.

For Skagerrak and Konti-Skan, the total changes to the *trading plans* on the two connections may be a maximum of 600 MW from one hour to the next.

6 Elspot trade in the event of "extensive grid disturbance"

6.1 General

In the event of a grid disturbance which changes the opportunities of the market to trading and to make plans and give bids to the spot market, the TSO in question shall declare an "extensive grid disturbance", which entails that:

- all imbalance is calculated in accordance with specific rules where the market players' risks are restricted
- all bids to the spot market shall be given as if the grid was intact (with no limitations caused by the disturbances) with the exception of the ongoing disturbance.

Once the disturbance has been cleared and a normal state has been restored, the relevant TSO shall declare that the system is intact and that normal conditions and pricing rules apply.

The purpose of the above procedure is that:

- The system will be in a planned and managed balance after the disturbance has been cleared and once the grid is intact again (however, deviations will happen during the restoration phase).
- A "normal" *Elspot price* can be calculated and communicated to the market.
- The settlement of financial contracts can continue in the normal manner.
- The risk of a major imbalance being created during a spot day is smaller if individual players can guess how great an impact the disturbance has on the system and to what extent the disturbance influences the system.
- The restoration phase should be more stable as all parties have a balance goal to attain when the deviation is exclusively the result of the disturbance, measures ordered by the TSO(s) and/or imbalance as a result of normal variation.

6.2 Planning phase

In the planning phase, before pricing in Elspot, the relevant TSO shall inform the market of the lines and transformers which are most likely going to be out of operation during the next day. This information shall be sent via Nord Pool Spot as Urgent Market Message (UMM).

Calculation of capacities takes place in the normal manner. The calculations must take into account the lines and production facilities which are most likely going to have an ongoing fault in the next day.

Plans and forecasts shall be given as if the grid was intact with the exception of the ongoing disturbance. Disturbances in production facilities shall be reported immediately with a forecast of the duration of the disturbance.

6.3 Operational phase

In the operational phase, after pricing in Elspot, the relevant TSO shall inform the market players directly to the extent that is required of swift and reliable restoration of the grid. Information which has an impact on the market must generally be sent via Nord Pool Spot as Urgent Market Message (UMM).

Physical regulation in the regulation power market can be managed as normally. Active regulations are priced as normally in accordance with a bid list but the regulation costs are borne by the TSO.

The relevant TSO can decide when to apply special rules to the pricing of the players' balance power. This decision is made primarily when a TSO can no longer manage its system in accordance with the normal rules.

Subsystems which are not inflicted by the disturbance are managed as normally.

Pricing of balance power and supportive power between the *bidding areas* takes place in accordance with normal principles. If it turns out that pricing has become unreasonable, for example due to frequency regulation, this is corrected afterwards.

European Network of Transmission System Operators for Electricity

Rules for managing power shortages during high consumption, bottlenecks or disturbances

1 Purpose

This appendix describes how the *system operators* (TSOs) of the *Nordic power system* shall jointly manage *power shortages* partly in the planning phase, partly in the operational phase.

The main goal is to prevent network collapse in a part or the entire *synchronised system*.

Appendix 9 is applicable when the requirements of Appendix 2 Operational security standards can no longer be met as far as *fast active disturbance reserve* is concerned.

The handling of *fast active disturbance reserve* and *manual load shedding* shall then follow the principles of this Appendix.

The purpose of lowering the requirement for *fast active disturbance reserve* is to able to better manage a *power shortage* situation with a smaller probability of a need to resort to *manual load shedding*, but with slightly poorer possibilities to manage an *operational disturbance* in the event of a *fault*.

When there is a power shortage in all of the *synchronous system* or in some parts of it, the management of the physical shortage situation with frequency and capacity is of the highest priority and the maintaining of planned trading is secondary.

Each TSO prepares instructions which comply with these regulations. The content of the instruction is to be co-ordinated between the TSOs.

2 Definitions: Extracts from Appendix 1

A **subsystem** is the power system for which a *system operator* is responsible. A *system operator* can be responsible for several *subsystems*.

Subsystem balance is calculated as the sum of measured physical transmissions on the *cross-border links* between the *subsystems* within the *synchronous system*. Thus, there is a deficit if this sum shows that power is flowing into a *subsystem* and a surplus if power is flowing out of a *subsystem*. Exchanges on *cross-border links* into/out of the *synchronous system* are not to be included in the calculation. The *manual active reserve (15 min)* must be included in the calculation of the balance of the *subsystems*.

A risk of power shortage defines the state when a forecast shows that a *subsystem* can no longer maintain the demand for a *manual active reserve,* which can be activated within 15 minutes.

Power shortage occurs during the hour of operation when a *subsystem* is no longer capable of maintaining the demand for a *manual active reserve* which can be activated within 15 minutes.

Critical power shortage occurs when consumption has to be reduced/disconnected without commercial agreements about this.

3 Manual active reserve

Manual active reserve is an active reserve that is activated manually in the momentary operational situation. Each *subsystem* shall have a *manual active reserve*, which can be activated within 15 minutes, equivalent to or greater than the *dimensioning fault* in the *subsystem.* When a *subsystem* in normal balance regulation is approaching the limit of the required *manual active reserve* in its own *subsystem*, the other TSOs shall be informed in accordance with valid instructions. This shall also be done even if the *subsystem* has a surplus in its balance.

The *TSO* concerned assesses whether the *manual active reserve* in its own *subsystem* can also be used for upward regulation purposes in normal *balance regulation.* This means that the *subsystem* will no longer have sufficient reserves to cover the need for *manual active reserve*. If further *upward regulation* is needed in the system, the parties shall ascertain whether there are available market-based upward regulation bids in the neighbouring systems to cover the *subsystem*'s deficit of *manual active reserve* . If there are market-based bids and if there is sufficient *transmission capacity* between the *subsystem*s, the parties may agree to maintain some of the need for *manual active reserve* in another *subsystem.* In this case, upward regulation can continue to take place in the price order on the joint Nordic regulation list.

If there are not available market-based upward regulation bids in the neighbouring systems to cover the *subsystem*'s deficit of *manual active reserve*, a *power shortage* takes place in accordance with section 6.

4 Risk of power shortage

When a risk of *power shortage* emerges, the relevant TSO shall inform the other TSOs as soon as possible. If necessary, the market shall also be informed.

600 MW of the most expensive *manual active reserve* in the regulation list is earmarked. During *bottlenecks* in Elspot, 600 MW of electricity with the highest Elspot price in the area(s) is earmarked.

Any other local measures by the respective TSO are carried out in accordance with the TSOs' own instructions.

5 Power shortage

When a *subsystem* is no longer capable of meeting the requirement for *manual active reserve* and there are not sufficient available market-based bids in the neighbouring systems, there is a power shortage. The other *TSOs* and the market are to be informed as quickly as possible.

If additional upward regulation is needed, market-based bids in the regulation list are used. Regulation takes place in accordance with normal regulation principles. Bids that are trapped behind *bottlenecks* or are unavailable for other reasons are skipped and marked as unavailable in NOIS.

Prearranged trading between *players* is fixed and cannot be changed. If necessary, intra-day trading in Elbas can be limited. Any other local measures by the respective TSO are carried out in accordance with the TSOs' own instructions.

6 Preparations for critical power shortage

When all market-based bids have been activated, it is checked that the earmarked reserve of 600 MW is in the regulation list. If *bottlenecks* have emerged in system operation, it may be necessary to redistribute the earmarked reserve.

If a *power shortage* occurs suddenly (without time for preparation) in the hour of operation, 600 MW have to be earmarked at the latest when all the market-based bids are activated.

At the same time preparations must be made for manual *load shedding*. The parties agree on the *subsystem* in which the potential *load shedding* must take place in accordance with the principles below.

6.1 Power shortage without bottlenecks between bidding areas

If there are no *bottlenecks* between *bidding areas*, the planning of *load shedding* shall take place in that *subsystem* which has the largest negative balance as defined in chapter 2. *Manual active reserve* that is not activated and that is not trapped behind local *bottlenecks* shall be included in the balance. If two *subsystems* have an equally large deficit, the *load shedding* shall be divided between these *subsystems*.

6.2 Power shortage with bottlenecks between bidding areas

If there are *bottlenecks* between *bidding areas*, the planning of *load shedding* shall take place in that part of the Nordic *synchronous system* that relieves the *bottlenecks*. In the calculation of the balance, only the balances in those *bidding areas* within each *subsystem* which relieve the *bottlenecks* shall be examined, not the balance of the entire *subsystem*. The calculation of the balance of a *bidding area* shall also include imports to/exports from other *bidding areas* in the *synchronous system*. *Manual active reserve* that is not activated and that is not trapped behind local *bottlenecks* shall be included in the balance.

The balance of the *subsystems* shall not be recalculated after *load shedding* has been implemented. *Load shedding* shall continue in the same *subsystem* until the frequency is stable at over 50.00 Hz. If there is anything that changes the operational situation, for example a *fault* in the power system, it may be necessary to re-calculate the balance of the *subsystems*.

7 Critical power shortage

When only the earmarked bids are left at 50.00 Hz but the frequency drops, the following takes place:

1. Activation of the earmarked reserve (600 MW)
2. Manual load shedding is ordered
3. Whereupon *load shedding* takes place and the frequency rises, and upward regulation of hydropower is deactivated

The deactivation of upward-regulated hydropower is done to restore the requirement of 600 MW of *manual active reserve* in the *synchronous system*. This helps to maintain the requirement for *frequency controlled normal operation reserve*.

Attention shall be paid to the practical procedures, and *load shedding* in steps of 200-300 MW at a time is considered as a suitable level. *Load shedding* and the deactivation of upward-regulated hydropower shall take place in steps until the requirement of 600 MW of *manual active reserve* in the *synchronous system* is met and the frequency is stable at 50.00 Hz. In the deactivation of hydropower, attention shall be paid to the location of a bid in relation to the *bottleneck*s, and to the size of the bid. A bid with a small volume can be skipped to simplify the procedures. If the frequency fell again under 50.00 Hz, hydropower bids which were deactivated shall be activated and *load shedding* shall be ordered. When the frequency rises, hydropower shall be deactivated again until the requirement of 600 MW of *manual active reserve* in the *synchronous system* is met.

The TSO that carries out *load shedding* shall inform the market and the other TSOs of *critical power shortage*.

8 Switching on of loads

When the power balance in the deficit area improves, loads can be switched on in small steps. The frequency must have stabilized to over 50.00 Hz and least 600 MW of *manual active reserve* must be available in the *synchronous system*.

The interconnected Nordic power system's joint operation with other systems

1 Western Denmark's joint operation with the *RGCE* system

1.1 Western Denmark's joint operation with Germany

Since the middle of the 1960's, Western Denmark has been parallel-connected with the German high-voltage network and has thus been a part of the synchronous continental *RGCE* system. Energinet.dk has been formally a member of *RGCE since March 2008*.

Energinet.dk's relationship with TenneT GmbH is such that Energinet.dk does not have a formal system operation agreement with TenneT, but there is a draft which is being processed.

In Germany, there is a "Grid Code" for the collaboration conditions relating to the technical system operation between the German *system operators*.

1.1.1 System operation collaboration with TenneT GmbH

Energinet.dk is connected to TenneT via the following links:

- 220 kV Kassø – Flensburg, *settlement point* Kassø
- 220 kV Ensted – Flensburg, *settlement point* Ensted
- Two 400 kV Kassø – Audorf, *settlement point* Kassø.

The *transmission capacity* is normally 1,750 MW southbound. Taking into account the risk of faults at major production facilities, the *transmission capacity* northbound is 1,500 MW. A suggestion for increased capacity is being studied.

Energinet.dk and TenneT are discussing a system operation agreement. Irrespective of this agreement, Energinet.dk must comply with the following *RGCE* requirements:

- Contribute to the combined momentary reserve of the synchronous continental system. The proportion is determined by the *dimensioning faults* for the entire *synchronous system*, and the requirement is in relation to the *system operator's* production in his own area. See Appendix 2 Operational security standards section 5.

- Each area inside *RGCE* must be able to manage its own balance.

Technically, the balance is managed via a load frequency controller function on the Danish-German border.

- *Trading plans* are specified in quarter-hourly and hourly energy.

- The energy plan is converted into a power plan. To include the energy as per the *trading plan,* regulation is commenced between five minutes before and five minutes after a quarter shift.

- The *load shedding* is co-ordinated.

The ramping requirement for exchanges with TenneT has a direct impact on transiting between the *synchronous system* and the continent. This means that the five-minute requirement is directly transferred to the transiting, when changes are made in the same direction during hour shifts.

1.1.2 Commercial conditions

The *transmission capacity* across the Danish-German border is utilized for commercial purposes in accordance with the following principles; a detailed description can be found on Energinet.dk's and TenneT's websites.

Annually and monthly, some of the *transmission capacity* in each direction is offered at auction. The winners of the auction obtain the right to submit bilateral *trading plans* via the Danish-German border on the morning prior to the day of operation. These plans are binding. Unutilized capacity is lost. The capacity can be handled between the players.

The remaining portion of the capacity is allocated to market coupling, which is performed by a separate company EMCC (European Market Coupling Company) in Hamburg.

Any excess capacity is allocated to intraday trading managed by Deutsche Börse.

Idle capacity permitting, Energinet.dk can conclude power transactions with TenneT GmbH.

1.2 Western Denmark's joint operation with Flensburg

Since the beginning of the 1920's, Stadtwerke Flensburg (SWF) has conducted AC collaboration across the Danish-German border. This collaboration has, with time, become more and more intensive, and a 150 kV link between Flensburg and Ensted is now established.

Energinet.dk and SWF have entered into an agreement which regulates the system operation and market conditions.

1.2.1 System operation collaboration with SWF

Stadtwerke Flensburg is connected to Energinet.dk via the following links:

- 150 kV Ensted – Flensburg, settlement point Ensted
- 60 kV links between Kruså and Flensburg.

The *transmission capacity* is normally 150 MW in both directions.

SWF has the opportunity to carry out exchanges with TenneT GmbH via the 60 kV network. Exchanges are regulated via a transverse voltage transformer.

1.2.2 Commercial conditions

SWF has a limited-duration prioritized transmission for utilizing the capacity of the network between Energinet.dk and SWF, i.e. on the 150 kV link between Flensburg and the Ensted station.

In SWF's area, there are no other market players than SWF as a producer. When other players emerge, and there are capacity limitations, an auction system will be introduced which will correspond to that which applies between Energinet.dk and TenneT today.

2 The synchronous system's joint operation with the *RGCE* system

2.1 The synchronous system's joint operation with Germany via the Baltic Cable

The Baltic Cable is an HVDC link between Sweden and Germany. The link goes between Trelleborg on the Swedish side and Lübeck on the German side. Baltic Cable AB owns the cable link. Baltic Cable AB, in turn, is owned by Statkraft Energy Europe AS.

The capacity is 600 MW.

2.1.1 System operation collaboration with TenneT

There is no system operation agreement. The *system services* that exist have been produced vis-à-vis Baltic Cable AB. The link is equipped with an *emergency power* function. There is also a *system protection* function, which provides a greater *transmission capacity* in southern Sweden.

2.1.2 Commercial conditions

Baltic Cable links together two electricity exchanges: NordPool Spot in the Nordic countries and EEX in Germany. Market coupling is carried out by a separate company EMCC (European Market Coupling Company) in Hamburg. Intra-day trading via the cable is only available to the owners of the cable. Idle capacity permitting, there are opportunities for Svenska kraftnät to do *supportive power* deals via Statkraft.

2.2 The synchronous system's joint operation with Germany via Kontek

Kontek is an HVDC link between Eastern Denmark and Germany.
The link goes between Bjaeverskov on the Danish side and Bentwisch on the German side. Energinet.dk is the owner of the facilities in Denmark and the cable link across to the German coast. 50Hertz Transmission GmbH is the owner of the facilities in Germany. The link is connected to the 400 kV network in Zealand and Germany. The *transmission capacity* is 600 MW.

2.2.1 System operation collaboration with Vattenfall Europe Transmission

The combined suite of agreements (entered into between the former VEAG and the former ELKRAFT) contains rules for system operation as well as allocation. As yet, there is no separate system operation agreement.
There is an agreement regarding a *system protection* function, which could yield a higher transmission capability in southern Sweden.

2.2.2 Commercial conditions

The link's *transmission capacity* is utilized as follows:

Southbound:
585 MW is made available to European Market Coupling Company and Nord Pool Spot for *Elspot trading* and *Elbas trading*.
50 MW overload is utilized as *frequency controlled disturbance reserve*.

Northbound:
600 MW is made available to European Market Coupling Company and Nord Pool Spot for *Elspot trading* and *Elbas trading*.
50 MW overload is utilized as *frequency controlled disturbance reserve*.

Settlement point: Bentwisch.

2.3 The synchronous system's joint operation with Poland

SwePol Link is an HVDC link between Sweden and Poland. The link goes between Karlshamn on the Swedish side and Slupsk on the Polish side. Svenska kraftnät och Polskie Sieci Elektroenergetyczne S.A. (PSE) own the cable link.

The capacity is 600 MW.

The *system operator* on the Polish side is PSE.

2.3.1 System operation collaboration with PSE

The system operation collaboration is regulated by a system operation agreement. This agreement regulates, for instance:

- Technical limitations
- Outage co-ordination
- Handling of *supportive power*
- *Emergency power functions*
- *Capacity allocation*

- Settlement

The link is regulated half-yearly from the respective *system operator*.

2.3.2 Commercial conditions

SwePol Link connects two electricity exchanges: Nord Pool Spot in the Nordic countries and POLPX in Poland. Market coupling is carried out by Nord Pool Spot. The cable is not available for intraday trading. Idle capacity permitting, Svenska kraftnät can conclude power transactions with PSE.

The NorNed HVDC link between Norway and the Netherlands was taken into commercial operation in May 2008. The cable links together 380 kV Eemshaven in the Netherlands and 300 kV Feda in Norway. Statnett SF owns the HVDC facility in Feda and TenneT TSO B.V. owns the HVDC facility in Eemshaven. The submarine cable is owned in equal proportions by the parties, with Statnett owning the northern part. The cable is 580 km long and has a capacity of 700 MW at the receiving end. At the moment, there is no overloading capacity on the cable.

2.4 Joint system operation with TenneT

Statnett and TenneT signed a System Operation Agreement on 10 December 2007. This agreement specifies the principles and relationships for system operation. There is a separate agreement for the exchange of system services and a settlement agreement. The Operation and Maintenance Agreement specifies how the HVDC link and communications systems between the AC/DC converter stations in Norway and the Netherlands must be operated and maintained.

Maintenance of the link is planned in co-operation between TenneT and Statnett. On the Nordic side, this is co-ordinated with other maintenance work in Southern Norway and other essential outages in the synchronous *interconnected Nordic power system*.

System protection for the link consists of busbar protection in Feda and of the overload protection of the 300 kV line Tonstad-Feda. The activation of protection reduces the transmissions to 200 MW or 300 MW, depending on the direction in which the power flows and what protection is activated. It is also possible to request emergency assistance from the other *party* when a critical situation has occurred or is anticipated.

In the event of *operational disturbances* where no other means are available and when there is no time to follow normal procedures, it is possible to quickly reduce the exports by 200 MW (offset regulation).

2.4.1 Commercial conditions

Since January 2011, the capacity (700 MW) has been made available to the day market hourly through implicit auctioning (day-ahead trading) as a result of market coupling (Interim Tight Volume Coupling) by Nord Pool Spot on one side and APX ENDEX and others on the other side. In November 2013 this volume coupling is replaced with price coupling through North West Europe (NWE). If the implicit auctioning or market coupling cannot be implemented, the capacity is allocated in explicit auctioning that is held applying the same principles as for implicit auctioning. Since March 2012 any unused capacity and potential overloading capacity have been transferred to the intraday market.

If the change in the specified programme is less than 300 MW from one hour to the next, *ramping* will begin 5 minutes before the change of hour and finish 5 minutes after the change of hour. If the change is greater than or equal to 300 MW, this is ramped at 30 MW/min symmetrically around the change of hour. If the change is greater than 600 MW, 600 MW will be ramped at 30 MW per minute symmetrically around the change of hour and the remainder of the change is placed in the step in the following hour.

Statnett and TenneT can temporarily restrict the available *trading capacity* in order to secure *operational security* if no other means are available.

3 The synchronous system's joint operation with Russia

3.1 System operation collaboration with Russian parties

The Finnish grid is connected with the Russian grid via three 400 kV lines from Vyborg (Russia) to Yllikkälä and Kymi (both Finland). The technical *transmission capacity* is 1,400 MW. Transmissions take place via the HVDC stations at Vyborg and from a 450 MW gas-fired power plant (North West Power Plant, NWPP) that works in an isolated operation, i.e. the plant is synchronised with the *synchronous system*. In addition to this, there are two 110 kV links, Ivalo – Kaitakoski (60 MW) and Imatra – Svetogorsk (100 MW), owned by private network companies.

Fingrid and the Russian parties have agreements that regulate operational, technical and market relations between the power systems. The agreements consist of four separate agreements between Finnish and Russian grid and system operators, i.e. Intersystem Agreement, Operation Agreement, Capacity Allocation Agreement and Agreement on electricity metering and accounting. The agreement parties are Federal Grid Company of the Unified Energy System (FGC), System Operator of the Unified Energy System (SO) and Fingrid. The System Service Agreement covering ancillary services is concluded between Fingrid and InterRAO.

The Norwegian network is linked to a Russian power plant in Boris Gleb. This plant supplies Kirkenes. The import capacity varies between 0 and 56 MW and is forecasted weekly, but the import capacity is established daily on an hourly basis by Statnett SF. The power plant is not connected to the Russian grid when it exports electricity to Norway.

3.2 Commercial conditions

The commercial transmission capacity, *trading capacity,* from Russia to Finland is 1,300 MW and 320 MW from Finland to Russia.

140 MW of the commercial capacity is used for so-called direct *trade* in both directions. The direct trade capacity is allocated through the Finnish-Russian exchange area of Nord Pool Spot. No reservation is necessary for the direct trade, but market players may bid to the exchange area. The exchange area divides the capacity among various players. However, in 2015 there is only one trader.

The rest of the capacity 1160 MW from Russia to Finland and 320 MW from Finland to Russia is reserved for the bilateral trade. The daily hourly transmission programme of the bilateral trade is agreed upon on a daily basis.

Pricing of the transmission services is based on the electricity price difference between the Finnish area price and the North West Russia area price. When the price difference is small, the tariff level is low.

Fingrid and Inter RAO UES have agreed that the link and the HVDC stations at Vyborg may also be used for ancillary services. 100 MW has been reserved for *frequency controlled normal operation reserve*. The link can also be used for *fast active disturbance reserve.*

4 The synchronous system's joint operation with Estonia

Estlink 1 is an HVDC VSC link between Finland and Estonia. The link was taken into commercial operation on 4 January 2007, and it runs between Espoo in Finland and Harku in Estonia. The *transmission capacity* is 350 MW in both directions. The link has a 15 MW temperature-related overload capacity.

EstLink 2 is the second HVDC link between Finland and Estonia. The link runs between Anttila in Finland and Püssi in Estonia. EstLink 2 was taken into commercial operation on 7 February 2014. The *transmission capacity* of the link is 650 MW in both directions. EstLink 2 also has a thermal overload capacity which can be used in accordance with valid instructions.

The owners of the Estlink 1 and EstLink 2 connections are OÜ Elering in Estonia and Fingrid in Finland.

4.1 System operation collaboration with Elering

Fingrid and Elering have signed an agreement of the operation and maintenance of the links. Fingrid operates the links during the first half of the year and Elering during the second half. Both parties are responsible for the loss purchases for the links in equal amounts, i.e. to the middle point of the connections.

The links are provided with *system services* such as power oscillation damping, *emergency power* control as well as automatic *frequency control* function and voltage control and reactive power capability on both sides depending on active transmissions on the links. Estlink 1 also has a black start capability on the Estonian side.

The links can also be used for manual regulation i.e. supportive power exchange or fast disturbance reserve transmission when separately agreed between the control centres.

4.2 Commercial conditions

All capacity of Estlink 1 and EstLink 2 is allocated to *Elspot* and *Elbas*.

5 The synchronous system’s joint operation with Lithuania

NordBalt is an HVDC VSC link between Sweden and Lithuania. The link was taken into operation on 18 February 2016, and it runs between Nybro in Sweden and Klaipeda in Lithuania. The transmission capacity is 700 MW in both directions. The owners of NordBalt are Svenska kraftnät in Sweden and Litgrid in Lithuania.

5.1 System operation collaboration with Litgrid

Svenska kraftnät and Litgrid have signed agreements for the operation and maintenance of the link. Losses are bought in the exporting country and the costs for losses are shared. The link has frequency control functions, black start function, emergency power control and voltage control and reactive power capability on both sides depending on active transmissions on the link. The links can also be used for manual regulation, i.e. agreed supportive power, when separately agreed between the control centres.

5.2 Commercial conditions

All capacity of NordBalt is allocated to *Elspot* and *Elbas*.