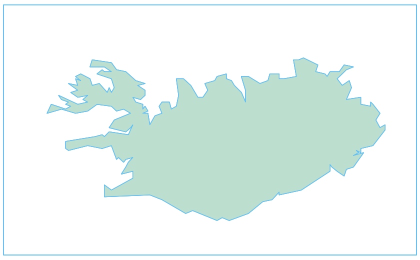
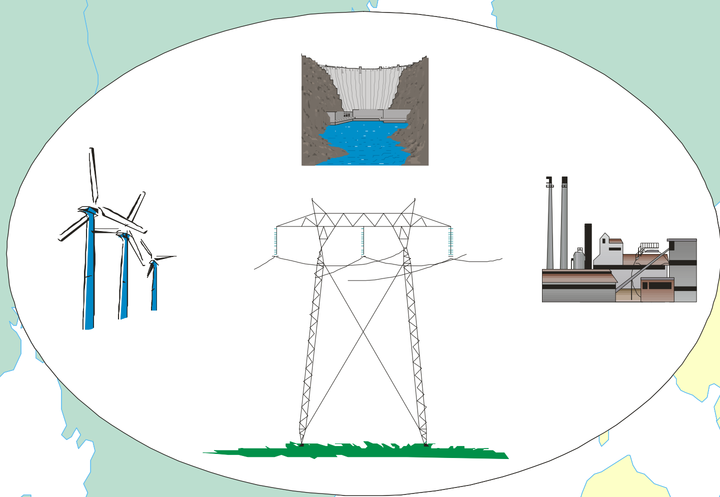
Nordel



Nordic Grid Code 2007

(Nordic collection of rules)



PREFACE

The transmission system operators (TSOs) in Denmark, Finland, Norway and Sweden have agreed to publish the Nordic Grid Code for the Nordic grid. The code is a collection of rules concerning the interconnected Nordic grids. It is the aim of the parties to develop the code. Future agreements concerning the interconnected Nordic grids should be incorporated.

The Nordic Grid Code must be updated when necessary, but in addition it must be reviewed at least once a year.

The Operational Code and the Data Exchange Code are binding agreements with specific dispute solutions. The Planning Code and the Connection Code are rules that should be observed. They correspond to Nordel's recommendations in these areas.

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CONTENTS

The Nordic Grid Code contains:

The present document is the English translation of Nordisk regelsamling 2004 and its updated parts, which have been written and published in the Swedish language. In case of possible discrepancies between the English and the Swedish version, the Swedish version shall prevail.

INTRODUCTION TO A COMMON NORDIC GRID CODE

1 Introduction

The formulation of this common code for the Nordic grid (the Nordic Grid Code) is a step towards the harmonisation of the rules that govern the various national grid companies. The purpose of the Nordic Grid Code is to achieve coherent and coordinated Nordic operation and planning between the companies responsible for operating the transmission systems, in order to establish the best possible conditions for development of a functioning and effectively integrated Nordic power market. A further objective is to develop a shared basis for satisfactory operational reliability and quality of delivery in the coherent Nordic electric power system.

The Nordic Grid Code concerns the transmission system operators (TSO's) the operation and planning of the electric power system and the market actors' access to the grid. The Code lays down fundamental common requirements and procedures that govern the operation and development of the electric power system.

The Nordic Grid Code is made up of:

- General provisions for cooperation
- Planning Code
- Operational Code (System Operation Agreement)
- Connection Code
- Data Exchange Code (Data Exchange Agreement between the Nordic transmission system operators (TSOs)

The Operational Code and the Data Exchange Code are binding agreements with specific dispute solutions. The Planning Code and the Connection Code are rules that should be observed. They correspond to Nordel's recommendations in these areas.

The Nordic Grid Code governs technical cooperation between the transmission system operators in the interconnected Nordel countries: Norway, Sweden, Finland and Denmark.

Ideally, the planning, expansion and operation of all the subsystems would be governed by identical rules. However, this is not yet the case, partly for historical reasons and partly because the different subsystems are subject to different legislation and to supervision by different official bodies. However, an objective is that the Nordic Grid Code should be a starting point for the harmonisation of national rules, with minimum requirements for technical properties that influence the operation of the interconnected Nordic electric power system. The Nordic Grid Code must, however, be subordinate to the national rules in the various Nordic countries, such as the provisions of legislation, decrees and the conditions imposed by official bodies.

The first edition of the Nordic Grid Code was based on Nordel's former rules (recommendations), the system operation agreement, the Data Exchange Agreement and national codes. Therefore the content of the Code still shows traces of being taken from numerous sources.

The new versions of the System Operation Agreement and the Data Exchange Agreement are reproduced in this edition in their entirety. As a new Nordel recommendation this document includes the Nordel Connection Code for Wind Turbines. It is included as an own chapter in the Connection Code. Other parts of the Connection Code have been updated according to the latest development in the national requirements and rules. Coordination between the Planning Code and the Operational Code has been improved by developing the formulation of the criteria scheme in planning to better correspond with the operational states.

The development of the Nordic Grid Code is a project that ought to continue also in the years ahead. The work on further development of Nordic cooperation to the Nordic electric power market thus continues.

2 Background

2.1 Nordic cooperation

The expansion of electric power supply in the Nordic countries began at the end of the 19th century and at the beginning of the 20th. To begin with, small local electrical companies were set up. Gradually these companies merged in order to become larger regional units. Eventually, the systems developed to the point where the power grids in the individual Nordic countries were linked via high-voltage interconnections.

From the outset, the supply of electric power in the Nordic countries was based on different sources of energy. In Norway and Sweden, hydro-electric power was the main energy source. Finland used a mix of hydro and thermal power, whilst Denmark's energy supply was based almost entirely on thermal power. Companies and official bodies in the Nordic countries soon realised that there were significant benefits to be gained from collaborating and utilising whichever energy source was the most advantageous at the time in the various countries. Furthermore cooperation resulted in improved security of supply.

Already in 1912 the first inter-Nordic interconnection operation agreement was signed. Sydkraft in Malmö and NESA in Copenhagen agreed that Sydkraft would supply surplus power from its power plants to Zealand in Denmark. On 15 November 1915 a 25,000 volt AC cable between Skåne and Zealand was ready to go into service. Cooperation on electric power between Sweden and Norway began much further north with the opening of the railway between Kiruna and Narvik in the early 1940s.

In 1929 a 60 kV AC interconnection was built between Jutland and Northern Germany. Over the years from 1930 to 1960, further opportunities for cooperation were investigated, however, without result until 1959, when an AC interconnection between Sweden and Finland went into service. In 1960, new interconnections between Sweden and Norway were completed and a joint power plant project was implemented on the Linnvass river (Linnvassälven). Five years later, in 1965, an HVDC cable was laid between Jutland and the west coast of Sweden. Electrical interconnections to the east were extended in 1961 with an AC transmission line across the eastern border of Finland to the Soviet Union. In 1976 an HVDC link was installed between Norway and Jutland; its capacity was increased in 1993. The Fenno-Skan HVDC link between Sweden and Finland was built in 1989.

The planning and construction of the joint interconnections led to greater contact between the electricity companies in the Nordic countries, and in 1963, Nordel, a Nordic cooperation program in the field of electric power supply, was established.

During the 1960s, electric power consumption increased considerably in all the Nordic countries. The opportunities for cooperation, for linking together different kinds of production resources and for creating shared production reserves also attracted greater attention. The members of Nordel were seeking benefits from coordinating the expansion and operation of the grids.

As the rapidly growing electric power system would be connected to relatively weak transmission links, Nordel had to solve problems of control and stability. The long-term solution was to make the transmission links stronger. Nordel's recommendations formed the basis of the technical regulations for production and grid operations in the Nordic countries. Admittedly, the recommendations were not formally binding, however, since they were accepted jointly and unanimously, the rules were complied with by all parties and came to provide the foundation for any formal regulations required in the individual countries.

A feature of cooperation within Nordel has been a common will to find solutions which create good preconditions for utilising the technical, environmental and economic advantages that result from an effective common system. From the outset, the sector and electricity users over the entire Nordel area has benefited from this basic idea.

In order to increase efficiency in the electrical sector, the Nordic countries chose, starting in 1991 in Norway, to expose electricity production and trading to competition and to separate these functions from the still regulated natural grid monopoly. Since the 1980s, there has been a trend towards free competition both in the EU and elsewhere in the world, but the trend has developed most rapidly in the Nordic countries. Among other things, the world's first international electric power exchange, Nord Pool, was launched here in 1996. Factors that contributed to the rapid development of the open common Nordic electric power market were a well-functioning electric power system and a good tradition of cooperation, partly within Nordel.

The changes in the electricity market also changed the preconditions for Nordic cooperation. Nordel took its first step towards adaptation to the changes in 1993, when, among other things, the organisation changed its statutes to correspond better to the structure that emerged when the grid operations of the companies were separated from the rest of their operations. The changes supposed that both the grid sector and the production sector still should be represented in Nordel. The importance of continued cooperation between the sectors on technical system issues, for example, was emphasised.

The starting point for a further change to the statutes in 1998 was that Nordel would be a cooperation organisation for the transmission system operators in the Nordic countries and should provide a platform for cooperation. At the same time, market actors with technical installations of significance for the electric power system would continue to collaborate within the organisation. Yet another change to the statutes in June 2000 transformed Nordel into an organisation for the transmission system operators in the Nordic countries, with the stated objective of creating the conditions for an efficient and harmonised Nordic electricity market, and of developing that market further. Once a body for cooperation between integrated power companies, Nordel was now a body for cooperation between transmission system operators.

The number of physical interconnections between the Nordel region and neighbouring countries is increasing. In 1982, an HVDC link was installed between Finland and the Soviet

Union. There are now HVDC links to Germany from both Sweden and Denmark and since 2000 an HVDC cable between Poland and Sweden. The AC interconnections between Western Denmark and Germany have been expanded continuously. Since 2000, a 450 MW Russian power plant in St. Petersburg has been connected directly to the Finnish subsystem. The increasing number of interconnections brings growing need for coordination. In its capacity of cooperation organisation for transmission system operators, Nordel is a natural forum for contacts between the Nordic electric power system as a whole and system operators elsewhere. In addition, as a forum for technical cooperation, Nordel offers a unique opportunity for utilising the expertise that is also needed in international work.

Nordel operates non-bureaucratically. The posts in the organisation rotate between the Nordic grid operating companies. The company represented by the chairperson is responsible for the secretariat and bears the associated costs; this makes it possible for Nordel to have no budget of its own. Nordel uses no interpreters. The member companies provide human resources; a key factor in Nordel's work is the core specialist expertise that the companies make available.

2.2 The Nordic electric power system

In the Nordic countries, production systems differ greatly from one country to another. Denmark uses conventional thermal power and an increasing proportion of wind power. Norway has hydropower, whilst Finland and Sweden have a mix of different systems, mostly hydro and nuclear power.

Today, the Nordic grid comprises the national electric power systems of Denmark, Sweden, Norway and Finland, as well as several interconnections between the countries which tie the national grids together into a coherent system. This system constitutes a single area with a common frequency, with the exception of Western Denmark, which is interconnected with the grid that falls within the area of the continental cooperation organisation UCTE.

The subsystems in Finland, Norway, Sweden and eastern Denmark are interconnected synchronously and form what is known as the "synchronised system". The subsystem in Western Denmark is connected to Norway and Sweden via HVDC links. Together, the synchronous system and the Western Denmark subsystem form the interconnected Nordic electric power system.

The interconnection of the individual subsystems into a common system means increased security and lower costs. The delivery capacity of the system as a whole is higher than the sum of the individual delivery capacities of the subsystems. As a result of the expansion of transmission capacity between the subsystems, the interconnected Nordic electric power system operates increasingly as a single entity.

The common system reduces the need for reserves and improves the potential for obtaining help in the event of serious disturbances or in other extreme situations such as years of exceptional drought or shortage of fuel.

A Nordic grid that works well is the technical prerequisite for a secure Nordic supply of high-quality electric power, and has been the foundation of a financially and environmentally efficient power supply.

2.3 The electrical characteristics of the Nordic electric power system

The following AC voltage levels are used in the Nordic grid (there are also interconnections at lower voltages across national borders):

- Denmark: 132/150/220/400 kV
- Finland: 110/220/400 kV
- Norway: 300/420 kV (and 132 kV in the north of Norway)
- Sweden: 220/400 kV

Between subsystems there are also HVDC links at 285-400 kV.

These transmission lines interconnect a number of generators:

- Hydro power production is concentrated in Norway and the north of Sweden and Finland.
- Thermal power production is concentrated in Denmark and the southern parts of Sweden and Finland.
- Wind power production and decentralised production are concentrated in Denmark. Particularly in the West of Denmark in, wind power accounts for a large part of total production.

The reactance of the AC transmission lines determines how strongly the system is coupled. Long transmission distances and relatively weak coupling between distant generators are typical features of the Nordel system.

Weak coupling between generators means that on some interconnecting links it is not possible to utilise the full thermal capacity. According to the Planning Code, it must be possible to maintain stable operation after the most common types of fault. This applies to transient, dynamic and static stability for both frequency and voltage conditions, and no consequential tripping shall take place due to overloading of components.

Because of long transmission distances and high reactances, it is usually insufficient voltage support and/or insufficient damping that sets limits on transmission between subsystems. With excessive power transmission, either voltage collapse would occur (voltage stability) or generators would lose synchronism (angle stability) because of a single fault condition. This may occur with significantly lower transmitted power than the grid components themselves could tolerate (thermal capacity).

Another feature of long transmission distances and separate generators is that the ability of certain interconnections to transmit power depends on the direction of the power flow, and varies over the year, depending, for instance, on which generators are connected to the grid and how much power is being transmitted on other parts of the grid. The technical transmission limit is determined by grid simulations in different operating modes. Naturally there must be a system safety margin in terms of calculation accuracy. In addition, some of the technical transmission capacity is reserved for control margin used for system services, for instance. The remaining part of the capacity is put at the disposal of the electricity market and is known as the commercial capacity.

The main cross-sections where experience has shown that physical limitations on the Nordic electricity market may arise are (see the Planning Code):

- Denmark: In Western Denmark there are interconnections to Norway, Sweden and Germany and two internal cross-sections (A and B), which may limit import from

Norway, and Sweden. In Eastern Denmark the link between Zealand and Sweden may impose a limit. Transmission lines in Sweden's internal cross-sections (cross-section 4 and the west coast cross-section) also have a major impact on capacity there.

- Finland: There is one internal cross-section, P1, and two cross-sections to Sweden, RAC and RDC. Depending on the operating situation, it is voltage stability, insufficient damping or thermal limits that limit transmission in these cross-sections.
- Norway: There are five internal cross-sections and the Hasle cross-section to Sweden. In particular the latter cross-section has proved in practice to be important for conditions on the Nordic electricity market. In this cross-section, transmission is limited by voltage and/or angle stability.
- Sweden: There are three important main cross-sections (1, 2 and 4) and the west coast cross-section. The capacity of the main cross-sections is limited by voltage and/or angle stability, whilst the west coast cross-section is limited by thermal capacity.

Where the limit is imposed by the stability conditions, it may be possible to boost the transmission capacity without building new transmission lines. To improve voltage stability, fast-response reactive power can be installed, for example series capacitors or controllable shunt capacitors. Controllable grid components, such as controlled series and shunt capacitors and HVDC links, may be used to improve damping. Another option is to install a system protection which disconnects some production units or loads after certain types of fault, thus reducing the power transmitted on critical interconnections.

Since stability issues are highly important for the Nordel network, it is essential for production units to be able to tolerate different types of fault on that network. Uncontrolled tripping of generators in the event of grid faults might make the instability even worse. Stability on the Nordel network can be improved and its transmission capacity can be increased by optimising the voltage regulators and power system stabilisers of the generators. For these reasons it is important for Nordel to have a common Connection Code that lays down minimum requirements for the technical characteristics of production units.

2.4 Transmission system operators (TSOs)

In Denmark, Finland, Norway and Sweden, transmission system operators (TSOs) have been appointed, with overall responsibility for ensuring that every subsystem works properly. These TSOs are Energinet.dk for the Danish subsystem, Fingrid Oyj for the Finnish subsystem, Statnett SF for the Norwegian subsystem and Affärsverket Svenska Kraftnät for the Swedish subsystem.

The TSOs in the Nordic countries are required to operate within the framework of the rules laid down in national and EU law. Some of the higher-level frames are the same for all countries, however these may be interpreted differently. The frames also change with political developments.

The first system operation agreement between two Nordic TSOs was made in 1996 between Statnett and Svenska Kraftnät. This agreement was followed by bilateral system operation agreements between all TSOs. The first Nordic system operation agreement between all Nordic TSOs, with the exception of the TSO on Iceland, was made in October 1999.

2.5 The Nordic electricity market[1]

The Nordic market is an international market. The electric power system and functions of the market influence each other. The market structure in Nordel's neighbouring countries differs from the structure in the Nordic countries; this, together with the development of their production and consumption, is also significant for the Nordic electric power system.

There is a physical market and as well a financial market. For the grid, the physical market is of interest and is outlined below.

2.5.1 Elspot

The Elspot market deals with power contracts for physical delivery daily within 24 hours. Elspot's price mechanism is used to regulate the flow of power where there are capacity limitations in the Norwegian grid and between the individual countries. Therefore Elspot may be regarded as a combined energy and capacity market.

The price calculation is based on purchase bids and sale bids from all market actors.

2.5.2 Elbas

Elbas is an organised balance market for Sweden, Finland,Eastern Denmark and Germany. The Elbas market comprises continuous power trading in hourly contracts up to two hours before physical delivery. The Elbas market complements Elspot and balance management by the TSOs.

2.5.3 The regulating power market

The TSOs in each area manage the unforeseen balance between production and consumption. The active actors who can create balance are consumers and producers, who can react quickly in situations with unexpected power deviation by rapidly adjusting their power take-off or by feeding in large amounts of power.

3 General provisions

3.1 Bilateral agreements

Where bilateral agreements or similar arrangements are agreed, the rules and principles in the code must be followed to the greatest possible extent.

3.2 Confidentiality

If the information exchanged between parties has not been published in the country to which the information relates, the parties undertake to keep the information confidential as far as the legislation allows in the respective country.

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[1] For a detailed description of the ways in which the Nordic electric power market works, see Nord Pool's website: www.nordpool.com

3.3 Deviations from the regulations

If a TSO chooses not to follow the recommendations of the Planning Code and the Connection Code, the other TSOs must, if this is considered possible and necessary, be informed before the deviation takes place. The System Operation Agreement and the Data Exchange Agreement are binding agreements between the parties, with specific dispute solutions.

3.4 Dealing with unclear provisions in the regulations

If there is disagreement about the validity, application or interpretation of the rules in this code, the issue shall be dealt with primarily in the respective Nordel committee. If agreement cannot be reached, the issue can be referred to Nordel's board for a ruling. Nordel's legal advisor group must always be consulted before an issue is referred in this way.

3.5 The development of the regulations

Nordel's Planning Committee is responsible, in consultation with Nordel's Operations Committee, for the continued work on and further development of the Nordic Grid Code. The Operations Committee is responsible for the Operational Code in particular.

The Nordic Grid Code must be updated regularly. Updating must take place when necessary, however the Code must be reviewed at least once a year. Nordel's legal advisor group must always be consulted before any decision is taken that involves significant changes to the Nordic Grid Code.

The following documents have been included in this chapter:

Document	*Status*
The Nordel Grid Master Plan 2002 (parts of)	*For information*
Prioritized cross sections	*For information*
Nordel's planning rules 1992	*Recommendations (desirable requirements)*
Planning Code 2004	*Recommendations*
Follow up on the Moberg report	*Approved in May 2006 by the Planning Committee and the Operations Committee*
Transmission capacities in the Nordel system – the 2005 stage, 1999	*Approved in 1998 by the Planning Committee and the Operations Committee*
Final report of Nordel's HVDC working group, 1998 and drafted recommendation	*For information*

The following national documents deal with the planning code:

Document	*Status*

PLANNING CODE

All parts of the power system shall be designed so that the electric power consumption will be met at the lowest cost. This means that the power system shall be planned, built and operated so that sufficient transmission capacity will be available for utilising the generation capacity and meeting the needs of the consumers in a way which is economically best. This also presupposes suitably balanced reliability.

The long-term economic design of the grid means to balance between investments and the cost of maintenance, operation and supply interruptions, taking into account the environmental demands and other limitations. Flexible solutions which take into account future uncertainties, e.g. generation limitations, uncertain load development, technical development, etc., should be selected. In this evaluation socioeconomics as well as market functioning shall be included.

The Nordic main grid should allow for well-performing joint operation. This demands co-ordination, both in the planning of the power system and at the operating stage.

1 Purpose and target groups

Nordic planning work shall contribute to coherent and coordinated Nordic planning between the TSOs. It must secure the infrastructure that gives the best possible preconditions for an integrated Nordic market that works well and efficiently, both in spot market terms and regulating-power market terms. This must be done with due regard to the reliability of supply and the environmental targets of the individual countries.

The Planning Code describes higher-level and common Nordic requirements, frames, processes and criteria for joint planning. It also specifies the information necessary for planning, information which grid owners and producers must be obliged to provide to the TSOs.

The purpose is to provide a basis to secure the following by planning:

- cohesion in the Nordic electric power system
- reliability in the Nordic electric power system, including system security and system adequacy
- a functioning Nordic market
- environmental considerations

The target group is:

- TSOs in the Nordic countries
- Market actors
- Grid owners
- The authorities

2 The work of planning

The work of planning is generally constructed around:

- preconditions
  - imposed preconditions
  - the existing electric power system
  - generation system changes
    - concrete expansions (investment decisions have been taken)
    - forecast expansion
  - consumption change
    - concrete expansions (investment decisions have been taken)
    - forecast expansion
- events analysed under the given preconditions
- acceptable consequences for the given events

The work of Nordic planning includes both the need to extend the grid and the need for system services. Planning takes place on a higher level and therefore does not include the distribution networks. It is concerned only with the part of the transmission networks that are important for the interconnected Nordic electric power system. The method used to analyse present and necessary grid strengthening measures includes:

- clarification of preconditions, including relevant development scenarios
- system engineering analyses, including power/energy balance analyses and network analyses
- technical/economic comparison and evaluation. The economic evaluation is based on socio-economic theories.

This process is illustrated in Figure 1 below. The system engineering analyses (network and power/energy balance analyses) are done as an interactive process in which the results of the power/energy balances constitute the "input" to the network analyses and vice versa.

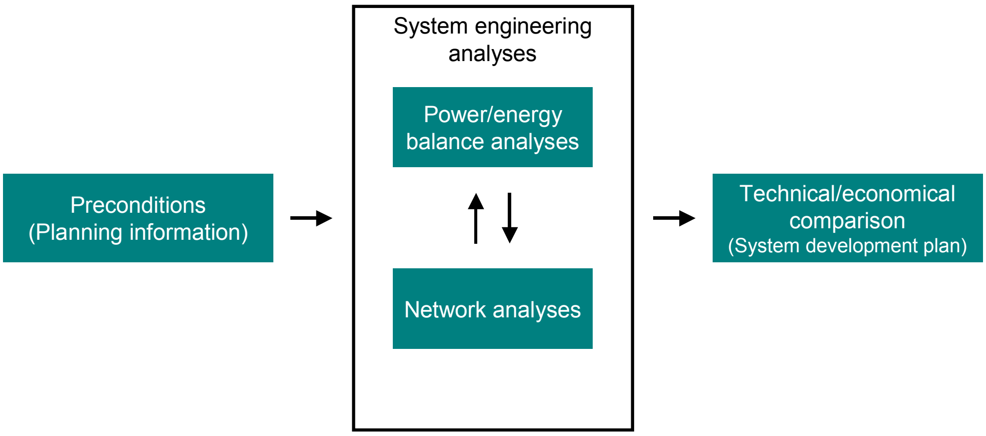

Figure 1 Sketch of the method for evaluation of the need for measures to reinforce the grid

Possible investments are evaluated on the basis of costs and benefit values. Socio-economic principles are used in the benefit evaluation. Important criteria for planning are:

1. Production optimisation and energy turnover
2. Less risk of energy rationing
3. Less risk of power shortage
4. Changes in active and reactive losses
5. Trading in regulating power and system services
6. The value of a better-functioning electric power market
7. Sufficient capacity

Examples of methods, models and tools are described in more detail in Appendix 1: Method, models and tools for system engineering studies.

3 Transmission capacity

3.1 Nominal transmission capacity for direct current

- The nominal transmission capacity is the maximum continuous power that can be allowed at an ambient temperature that is not exceeded for more than 4 weeks per year and without affecting the nominal availability.
- The nominal transmission capacity is measured on the AC side of the rectifier.

3.2 Nominal transmission capacity for alternating current

- The transmission capacity is the technical limit for active power that can be continuously transmitted over a grid section with a starting point in an intact network. The trading capacity is agreed between the TSOs and is lower, typically by 5-10 %.
- For the calculations, dimensioning transmissions, load situations and generation situations for the grid shall be selected; according to Nordel's grid planning rules.
- The transmission capacity is determined on the basis that the grid must withstand the dimensioning fault (n-1) both on the interconnection and in the connected grids; see Nordel's grid planning rules. This applies regardless of limitations due to thermal conditions, voltage stability, dynamic stability or conditions in the underlying grid.
- The transmission capacity is stated as the highest value achieved during the year. The number of hours for which the transmission capacity is available shall be stated for each section.
- The limiting factor must always be stated for the technical limit.
- The transmission capacity is measured on the receiving end.

3.3 Overloading of components

COMPONENT LOADING ABOVE NOMINAL				
Component	**Denmark**	**Finland**	**Norway**	**Sweden**
Overhead line /cables	"one hour's" current with a wind of 1.6 m/sec [1)] / 150 % with cables. In the future this will be assessed individually.	Uses temperature depending on area	120 % for 15 min	Conductor temperature +20^{o}C at 30^{o}C air and wind of 1 m/sec
Transformers	130 %	150 % briefly	130 % with 0^{o}C air	120 % for one hour.
End-point components	Does not normally limit the line	Nominal value	100 -> 120 % for up to 15 min	0

[1)] Operational possibility that is not brought into the calculation in the planning phase.
Series capacitors are dimensioned according to the IEC standard.

4 Grid planning for interconnections between the Nordel area and other areas

With the exception of West Denmark, the Nordel system is operated asynchronously with other electric power systems. Decisions on the establishment of new interconnections to and from the Nordel area have been formalised in the form of bilateral agreements. Such interconnections will nevertheless affect the entire Nordic electric power system, not just the TSOs that establish the new interconnection. It is therefore important that the planning of such interconnections is coordinated with the Nordic grid master plan. It is desirable that Nordel should take part in the planning work in a way that ensures that such expansion can be made clear to all of Nordel.

4.1 Planning new interconnections[2]

Appendix 2: Final report of Nordel's HVDC working group contains an approved overview report about new HVDC interconnections between Nordel and UCTE. A draft Nordel recommendation has been written on the basis of this report.

- The control systems for new HVDC interconnections should be adapted so that the risk of multiple commutation failures in the event of dimensioning fault, is minimised. It is assumed that the grid will be designed in accordance with the plans presented. There should be verification by means of simulator tests.

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[2] Written in the light of draft Nordel recommendation.

- Maximum frequency-controlled emergency-power activation in the direction away from the Nordel system should correspond to the dimensioning outage in the Nordel system. In direction towards the Nordel system a greater activation can be accepted. Frequency-controlled step or ramp variation of the power is permitted when the frequency is below 49.5 Hz. The basic rule is that the instantaneous disturbance reserve is divided up equally between the HVDC interconnections. However, transfer can occur subject to prior agreement between the owners of the HVDC interconnections.
- Emergency power control (EPC) with the HVDC interconnections should not be concentrated electrically, due to the risk of tripping several HVDC interconnections simultaneously.

5 Planning code for planning the Nordic transmission system

The criteria are still deterministic, although probabilistic considerations have been taken into account. In the criteria, demands are made on disturbance consequences that are acceptable for various combinations of operating conditions and fault types. In principle, more serious consequences are acceptable for less common combinations of faults and operating conditions. This principle is illustrated with the following figure.

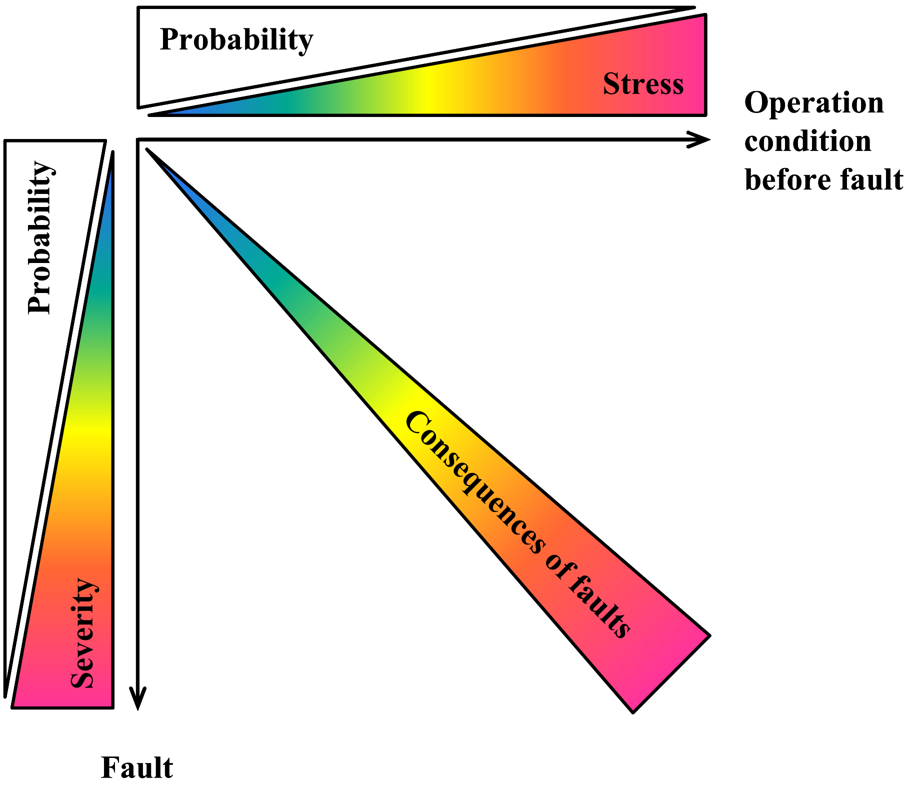

Figure **2.** *Illustration of the correlation between operation condition (including probability / stress of the condition), faults (including probability / severity of the faults) and acceptable consequences of faults.*

The main structure can be summarised in accordance with the table below.

Pre-fault operational conditions

Fault type		Grid intact	Maintenance	Spontaneously weakened (n-1)
	Common fault types	*Only local consequences*		
	Relatively common extreme faults	*Only regional consequences*		
	Other extreme faults	*Major breakdown acceptable*		

The rules are intended for use in the planning of the Nordic main grid. They should also be able to serve as support in the operation of the grid.

5.1 Principles of the planning code

The rules shall be used for the joint, synchronised Nordic transmission grid. This concerns principally the main grid, mainly 220-400[3] kV, and the interconnecting links between the various countries. The rules should be used in the planning of the power system. The aim is that the operation and planning work should be based on the same reliability philosophy, and that the rules should also be able to serve as a guide at the operating stage. The rules do not cover local supply reliability and other local conditions in the grid.

In order to safeguard a certain minimum reliability level for the interconnected Nordic power system, certain minimum demands on reliability for the required transmission capacity have been defined through the planning rules. The demands have been given concrete form by a number of criteria, which must be met in grid design. The criteria are based on a balance between the probability of faults and their consequences, i.e. more serious consequences may be acceptable for faults with lower probability.

The grid strength defined through the rules is such that it will be possible to maintain the required transmission level if the grid is intact under varying generation and load situations. If transmission lines are out of operation, lower capacity will normally be accepted.

The required transmission capacity can be achieved by a number of measures affecting the construction of primary equipment, system protections and auxiliary systems, as well as disturbance reserves and other operational measures. In the case of more severe disturbances than those directly taken into account in the criteria, it is assumed that operational facilities are available in the power system for restoring operation.

[3] In Norway nominal voltage is 420 kV

The rules are based on assessments, based on experience, of fault probabilities and availability of individual items of equipment. Future changes in the reliability of individual items of equipment or the introduction of new equipment may place special demands on grid design.

5.2 Planning criteria

5.2.1 Structure

Deterministic criteria are used in the planning of the grid. This means that a number of faults groups have been specified, against which the grid will be tested. The following are defined for every fault group

- prefault conditions, and
- acceptable post fault consequences

The criteria are summarised in the scheme in *Figure 3*, and in a list of fault groups, etc. in accordance with Chapter 5.5. The operating conditions before the fault, the fault types and consequences of various faults are described below.

5.2.2 Prefault operating conditions before the fault

The grid strength shall be studied for the following grid operating conditions.

Grid intact

All grid components that are of importance for the fault being studied are in operation.
For the grid studies, the dimensioning transmissions, load situations and generation situations for the grid shall be selected. As an example, for the surrounding grid it shall be possible to assume the transmission levels that correspond to the agreed capacities (normally in accordance with the Planning Code). Economically reasonable generation situations shall be assumed.

Grid not intact, scheduled work

A shunt or series component that is of importance for the studied fault shall be assumed to be out of operation for maintenance.
The point in time shall be selected on the basis of a suitable operating situation, e.g. with low transmission. The objective is to take into account in the planning the future need for maintenance, and to create sufficient flexibility for this purpose.

A shunt component is a component that belongs to fault group FG1, i.e. a generation unit or reactive shunt component (capacitor, etc.). A series component is a component that belongs to fault group FG2, i.e. transmission line, series capacitor, busbar, etc.

Grid not intact, unscheduled outage

A shunt or series component that is of importance for the studied fault shall be assumed to be out of operation due to a spontaneous fault event.

The point in time is assumed to be 15 minutes after the component failure. Generation and transmission have thus been adapted as far as possible with the disturbance reserves available. For the studied section of the grid, it is acceptable that the transmission has been reduced, provided that the needs of the consumers and other special transmission requirements can simultaneously be met.

5.2.3 Columns in the criteria scheme – Prefault conditions

In the criteria scheme (Chapter 5.4), five columns with different operating conditions have been defined as follows.

PC0 Grid intact
PC1 Grid not intact, scheduled maintenance
PC2 Grid not intact, spontaneous loss of a shunt component
PC3 Grid not intact, spontaneous loss of a series element
and three columns for even more serious conditions, with several components out of operation. Alternatively, the operating situation is not adapted, i.e. the time is less than 15 minutes after the initial fault.

5.2.4 Fault groups

The fault types for which the grid is to be tested are classified into five fault groups. The fault groups have been selected to ensure that the grid will have a certain strength. This will hopefully also cover other relatively common fault types that have not been specified. The individual fault types are described in more detail in Section 5.5. Fundamental comments are given below.

Primary relay protection is assumed to perform in the intended manner, unless a different function has been defined in the studied fault type.

The faults have been grouped with regard to their probability. Faults in FG1 and FG2 are the most frequent. Fault group FG3 comprises less probable single faults and special more common double faults. Fault groups FG4 and FG5 contain rare faults.

Three-phase busbar faults in FG3 shall principally be taken into account for stations, which are of significance to joint operation between countries.

The following shall apply to the fault combination of a line fault with loss of a thermal power unit in FG4. An economic assessment shall be made of whether it is justified to implement such measures in the unit and grid that the fault condition will be equivalent to those in fault group FG3.

5.2.5 Permissible consequences

Three levels of consequences are defined. The principal demands made are those that are of significance for the interconnected Nordic power system.

A. Stable operation, local consequences

Only local consequences are acceptable. Apart from the load shedding or tripping of generation that is necessary for eliminating the fault, limited amounts of loads and generation may be switched out by means of the system protections. After the fault, operational adaptation of the transmissions is acceptable.

It shall be possible to maintain stable operation as regards transient, dynamic and static stability for both frequency and voltage conditions, and no consequential tripping shall take place due to overloading of components. In addition, it is assumed that the voltages and frequency after the fault will be satisfactory for the consumers and power plants. Efforts shall be made to maintain joint operation also after the fault, and planned sectionalisation of the grid shall not normally be employed as a method for ensuring stability.

B. Controlled operation, regional consequences
The consequences shall be limited and further controlled operation shall be maintained for most of the system.

Controlled forced tripping of generation and load shedding may be carried out. Load shedding or forced generator tripping shall normally be confined to the region in which the fault has occurred. Minor grid breakdowns and grid sectionalisation are also acceptable provided that they are restricted to the region in which the fault has occurred. The term 'region' denotes parts of the national grid, which are confined by the main cross-sections in the national grid or by the interconnecting links (international tielines). In exceptional cases, major national disturbances may be permissible provided that they do not spread beyond the interconnecting links. However, subject to agreement, load shedding may be extended to other parts of the Nordic power system. This applies in particular to the use of system-wide system protections.

C. Instability and breakdown
Instability is acceptable. Grid sectionalisation and extensive breakdowns can take place in the Nordic system. However, the objective is to create a defined initial situation from which restoration can take place.

It is assumed that operational possibilities will be available for restoring operation to normal levels. It is also advisable to investigate at the planning stage whether simple measures can be applied to restrict the consequences in the event of very rare and difficult faults.

5.2.6 System protection scheme

The term system protection scheme denotes automatic control equipment that disconnects or otherwise controls generation, load or network components other than the faulty component. Disconnection may concern both individual components and a large number of components. The definition of system protection scheme is given in the System Operation Agreement appendix 1 and requirements for system protection in the System Operation Agreement appendix 2.

5.3 Other important aspects of system planning and design

5.3.1 Operational aspects

Future operational aspects shall be taken into account in the planning of the grid. Fundamental principles and criteria for planning and future operation must therefore be founded on the same basic ideas. The design includes both system design and the performance of individual objects.

The economic dimensioning of the grid means that consideration must be given to costs and need for flexibility at the operating stage.

It shall be possible to handle shutdowns of one or several system components in a manner, which is acceptable to operation.

At the operating stage, it shall be possible to distribute the disturbance reserves in an economical manner. The grid should therefore be designed so that transmission margins are available or that fault conditions will not lead to loss of necessary reserves.

Operating possibilities shall be available for handling major disturbances. This includes operating routines, equipment and training to enable both abnormal operation and restoration to normal operation to be handled.

5.3.2 Operational characteristics of generation plants

The units are assumed to have certain operational characteristics. These demands are i.e. regulated by the Connection Code.

The units shall have such tolerance to variations in voltage and frequency that it will be possible to handle the most common types of grid fault without the units being tripped or damaged. The units shall also have such control capability that they will be able to contribute towards the disturbance tolerance of the grid as active and reactive disturbance reserves.

5.3.3 Instructions

As a supplement to the planning criteria, instructions containing special national demands and 'user instructions' for the planners shall be drawn up. The instructions shall be prepared for each country, and shall then be co-ordinated between the countries.

The objective of the planning criteria is to achieve acceptable strength of the interconnected Nordic power system. Only a few demands are made on the supply security and local conditions. It is therefore natural to supplement the criteria with national planning requirements.

The structure of the criteria gives a large number of combinations of operating situations and faults that must be tested. In practice, only a few of them are dimensioning to the design of each individual section of the grid. Special comments should be made on these combinations, and instructions should be given on how calculations should be carried out.

Since several consequence levels have been introduced in the criteria, strict demands are made on knowledge of the nature of the power system and its behaviour in the event of disturbances. Experience and calculation methods must therefore be gathered and comments must be made on them.

5.4 Post fault performance table (Criteria Scheme)

<table>
<tr><td colspan="3" rowspan="4">Acceptable consequences
A Stable operation, local consequences and limited intervention of system protection
B Controlled operation, regional consequences
C Instability and breakdown
A/B Consequences in accordance with B for faults in previously weakened area, otherwise A.
B/C Aim should be to limit the consequences according to B but for all faults this cannot be fulfilled

[1] The operating situation has been adapted during 15 minutes after the fault by using the means available (disturbance reserves, etc.).</td><td colspan="7">Pre-Fault Conditions</td></tr>
<tr><td colspan="4">Normal operation</td><td>Alert-state operation</td><td>Disturbed operation</td><td>Emergency operation</td></tr>
<tr><td>Grid intact</td><td>Planned maintenance</td><td colspan="2">Spontaneous loss and adapted operation[1]</td><td rowspan="2">Exceeded transfer limits / insufficient reserves. Adapt operation by adjusting new transfer limits and / or activating reserves within max. 15 min.</td><td rowspan="2">Exceeded transfer limits and / or insufficient reserves</td><td rowspan="2">Exceeded transfer limits and / or insufficient reserves

Load shedding effected</td></tr>
<tr><td>No critical components out of operation

PC0</td><td>Shunt or series component out of operation

PC1</td><td>Shunt component out of operation

PC2</td><td>Series component out of operation

PC3</td></tr>
<tr><td rowspan="5">Fault groups</td><td rowspan="3">N-1 faults</td><td>Single fault that does not affect series components FG1</td><td rowspan="3">A</td><td rowspan="3">A</td><td rowspan="3">A</td><td>A</td><td rowspan="3">B/C</td><td rowspan="2">B/C</td><td>B/C</td></tr>
<tr><td>Single fault that affects series components FG2</td><td>A/B</td><td rowspan="4">C</td></tr>
<tr><td>Uncommon single faults and special combinations of two faults FG3</td><td>B</td><td rowspan="3">C</td></tr>
<tr><td rowspan="2">Serious faults</td><td>Other combinatios of two faults caused by the same event FG4</td><td>B</td><td>B</td><td>B</td><td rowspan="2">C</td><td rowspan="2">C</td></tr>
<tr><td>Other multiple faults FG5</td><td>C</td><td>C</td><td>C</td></tr>
</table>

Figure 3 Criteria Scheme to be used for grid planning

5.5 Fault groups

The faults for which the grid is to be tested are classified into five fault groups.

FG1 Common single faults that do not affect (transmission lines or other) series components

Definite loss of

1.1 Generation unit
1.2 Load block with associated transformer
1.3 Shunt component (capacitor, reactor)
1.4 DC pole (connected to adjacent system (e.g. Baltic Cable))

FG2 Common single faults that affect (transmission lines or other) series components

Definite loss, with or without initial single-phase permanent fault

2.1 Transmission line, one circuit
2.2 System transformer
2.3 Busbar
2.4 Other series component (series capacitor, etc.)
2.5 DC pole (Internal Nordic connection)

FG3 Less common single faults and special, more frequent combinations of two simultaneous faults

Definite loss with initial 2-phase or 3-phase fault

3.1 Transmission line, one circuit (without fast autoreclose)
3.2 Busbar[4]
3.3 Combination that includes equipment with unknown reliability.

FG4 Other combinations of two simultaneous faults with a common cause

Definite loss with initial 3-phase fault

4.1 Combination of line fault and loss of thermal power unit[5]
4.2 Double circuit transmission line
4.3 Stuck breaker pole or relay fault in the event of fault clearance
4.4 Two power station units
4.5 Station with sectionalising circuit breakers
4.6 DC bipole link
4.7 Two transmission lines along the same cleared path

FG5 Other multiple faults (two independent simultaneous faults, and three or more simultaneous faults)

5.1 Two independent simultaneous faults
5.2 Three or more simultaneous faults

[4] Considered principally for stations that are of importance to joint operation between countries

[5] Measures in the grid and on units assessed economically against grid consequences

APPENDIX 1: METHOD, MODELS AND TOOLS FOR SYSTEM ENGINEERING STUDIES

1 Methodology for system engineering studies

- Studies to evaluate the need to reinforce the grid
- The benefit values of alternative reinforcing measures
- Determining and describing preconditions
- Analysis of the technical properties with alternative solutions
- A technical/economic evaluation and prioritisation of these alternative solutions
- Choice of reinforcing measures

A method for this is shown in *Figure 4*. The method is described in more detail below.

1.1 Planning information and preconditions

The various preconditions that are fundamental for making analyses of the electric power system are described in *Figure 4*. Scenarios and basic assumptions are of particular importance (alternative developments that are important for the reinforcing need that is to be studied). This includes preconditions with regard to general load development, special load increases, production expansion, etc. When establishing models for carrying out the technical analyses it is important to consider operational situations that are of significance for the evaluation of limitations, capacity and reinforcing needs.

1.2 System reliability

The long-term planning of the electric power system must ensure the reliability of the system (security of supply). The international concepts for system reliability cover:

- system security, which covers necessary system services and grid capacity for the transport of these services.
- system adequacy, which covers sufficient production and grid capacity to meet demand.

The following concepts agree with the international definition of system sufficiency. The term “energy security” refers to the ability of the electric power system to deliver to consumers the desired amount of energy with a given quality. The term “power security” refers to the ability of the electric power system to deliver to consumers the desired amount of power with a given quality. A common expression for these two concepts is delivery security (or system sufficiency).

Internationally, security of supply is expressed with the concept of system reliability, where delivery security/system sufficiency is one part and system security is the other. System security is the ability of the electric power system to withstand sudden disturbances such as electrical short circuits or the unexpected disconnection of parts of the system. The concept includes dynamic conditions.

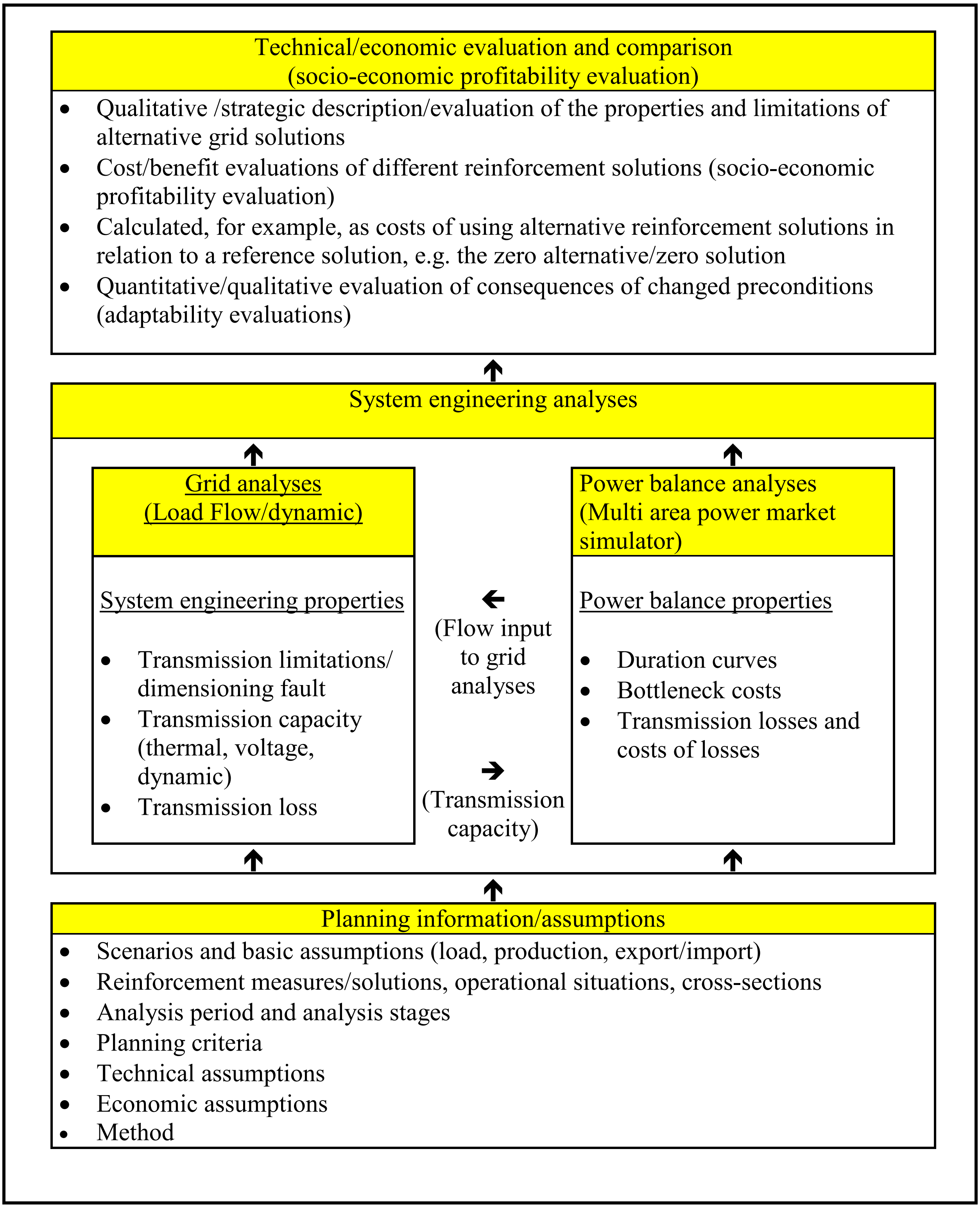

Figure 4 Procedure for carrying out a socio-economic profitability evaluation

1.3 System engineering analyses

System engineering analyses include grid analyses and power balance analyses:

- Grid analyses include the analysis of transmission limitations and transmission capacity (thermal, voltage and dynamic) for existing grids and alternative reinforcement solutions for relevant operational situations and scenarios. Information about energy flows in the grid, e.g. duration curves from power balance analyses will be important background regarding the need for transmission capacity in important cross-sections. The calculations are done with the load flow and dynamic simulation software and a relevant grid model.
- Power balance analyses include analysis of energy flows under the relevant scenarios. Among other things, duration curves are calculated for transmission between the individual joint load areas and bottleneck costs with limitations between these areas. The calculations are done with the multi-area power market simulator and a relevant grid model.

Duration curves are calculated without limitation between the relevant network areas, possibly without limitations between several/all areas.

Bottleneck costs are calculated with one fixed or several relevant capacity levels in the cross-section concerned, and without or with relevant capacities between the other areas. Relevant transmission capacities are obtained as a result of the grid analyses.

1.4 Technical/economic evaluation and comparison

Technical/economic comparison will include a summarising evaluation of the grid-related and power-balance-related properties of different grid reinforcement solutions in different scenarios.

Benefit value and cost evaluations (socio-economic profitability evaluations) will be important for evaluating alternative reinforcement measures, but more qualitative and strategic evaluations of alternative reinforcement solutions will have to be undertaken before a final decision to implement relevant reinforcement measures is made.

A socio-economic profitability evaluation can be done with various profitability evaluation methods. A method for calculating the net present value benefit of a reinforcement measure is described here.

The net present value is calculated as a capitalised and discounted value of all costs during the analysis period, stated as the benefit in relation to the reference solution (e.g. the zero solution[6]). For a measure to be socio-economically profitable, the following requirement must be met:

$$\text{Net present value benefit (NNN)} > 0$$

[6] The "zero solution" means the existing grid, i.e. with no measures taken to reinforce the grid (concrete reinforcement measures), or to utilise the grid more (e.g. system protection measures) in relation to existing grids and operational practice.

The net present value benefit is calculated on the basis of technical costs and system costs as follows:

$$NNN = \Delta I - \Delta D - \Delta M + \Delta F + \Delta T - \Delta A - \Delta S$$

(Δ means costs, cost/benefit effect of the measure compared with a reference solution, e.g. the zero solution.)

Cost components included are:

Technical costs

ΔI: Investment costs, possibly investment/reinvestment costs, etc. in relation to the corresponding costs of the reference solution.

ΔD: Operating and maintenance costs, i.e. o/m costs due to new measures or in relation to the corresponding costs of the reference solution.

ΔM: Environmental costs compared with the corresponding costs of the reference solution. Environmental costs are often difficult to quantify, and the environmental consequences are therefore often only evaluated qualitatively.

System costs

ΔF: Bottleneck costs, expressed as reduction (benefit) with respect to the bottleneck costs of the reference solution.

ΔT: Loss costs, expressed as the benefit compared with the costs of transmission losses for the reference solution.

ΔA: Outage costs compared with the corresponding costs of the reference solution.

ΔS: System costs compared with the corresponding costs of the reference solution.

Power/energy balance analyses and network analyses are carried out. The area subdivision used in the analyses is described.

2 Electrical engineering electric power system models

To carry out the analyses, a model of the Nordic electric power system is used which contains the transmission installations included in the system, e.g. transmission lines, transformers and generating plant. Underlying networks with corresponding components and connected consumption are also modelled. Analyses are done for relevant operational situations, i.e. with a relevant switching configuration in the grid and with correct production and consumption levels, so that transmissions and voltage levels are correct.

For this purpose the following load cases are created:
- High-load scenario with a five-year horizon.
- High-load scenario with a ten-year horizon.

2.1 Electrical engineering system analyses and tools

The practical analyses for determining, for example, the transmission capacity of the grid, are carried out by determining dimensioning operational situations and types of fault, limiting components (thermal) or limiting system properties (voltage collapse, dynamic instability), as well as loading of the grid until the limiting components are fully loaded or the limiting system properties are exceeded (voltage collapse, dynamic stability).

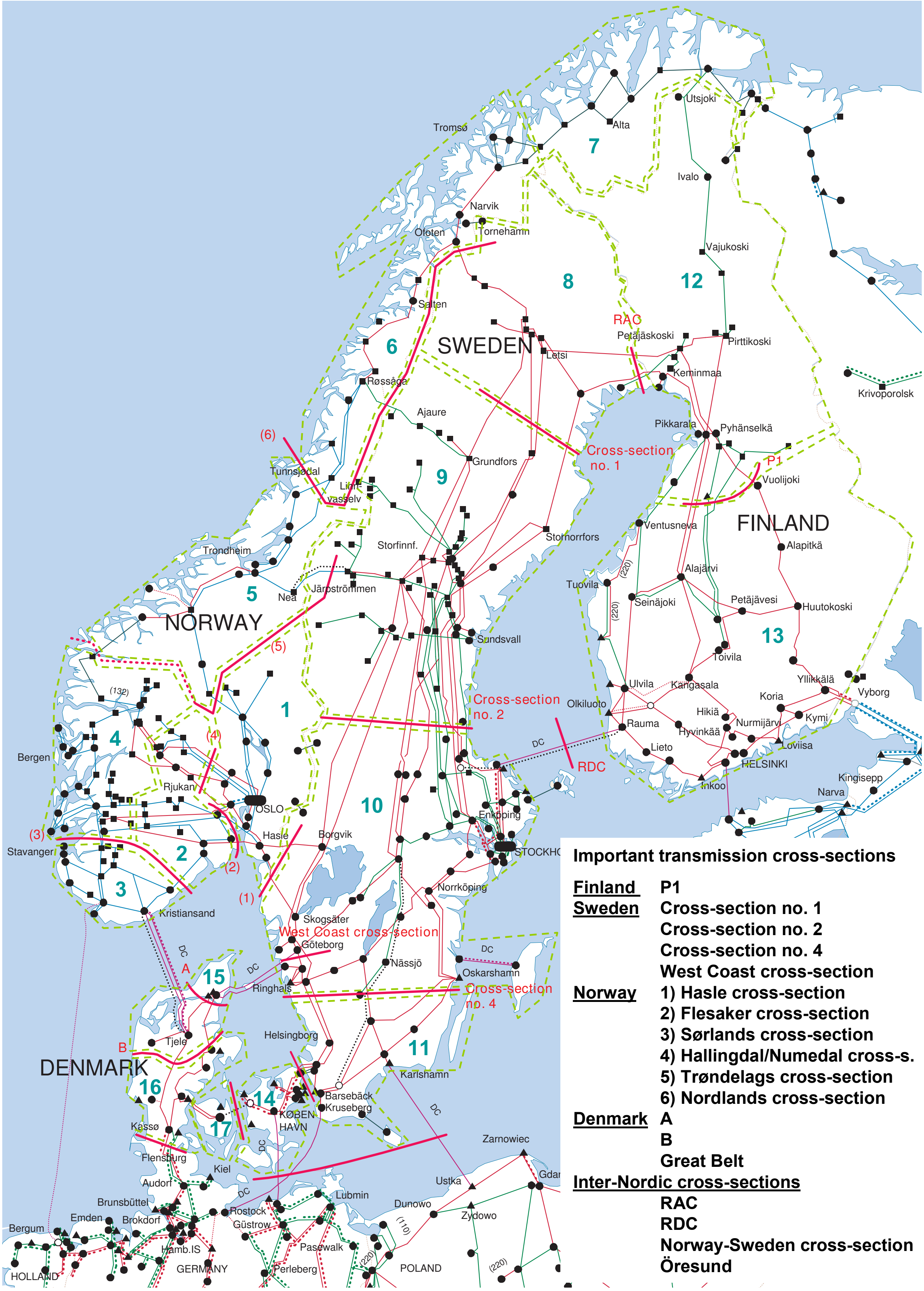

Figure 5 *Important transmission cross-sections in the Nordel area shown in relation to the area division (areas 1 – 17) for which power and energy analyses are made.*

2.2 Security of supply for energy and power

As well as analysing the capacity for transport on the market, it is important to determine whether there are sufficient resources in the generating plant to maintain security of supply in the Nordel area. This is done by analysing the probability of energy or power shortage. Where the energy supply is concerned, the focus is on dry years and extreme dry years for the hydropower system. Where power is concerned, the focus is on normal winter load and extreme winter load that occurs once every ten years.

There may be a need to develop a number of security-of-supply criteria, which determine the Nordel area's possible degree of self-supply in terms of power and energy.

APPENDIX 2: FINAL REPORT OF NORDEL'S HVDC WORKING GROUP FROM YEAR 1998

1 Background

The near future will see a rapid increase in the number of HVDC connections for transmission of power between the Nordel and UCTE systems. At present, total transmission capacity is almost 3000 MW, while current plans are for it to increase to about 5500 MW within the next few years.

The desire for such increase in the HVDC capacity springs primarily from commercial interests, powered by the idea within the EU of creating a single energy market, as well as the scope for joint operation of hydroelectric power generation in Nordel with thermal electricity production on the Continent. The prospect of an expansion of the existing main network is hampered by considerable public opposition to overhead lines.

The HVDC connections, having independent owners and representing uncoordinated interests, are in certain cases expected to draw so much from the Nordel system as to disrupt the stability of operations. With uncoordinated operation of the connections, there is a risk that a disturbance in the UCTE system could affect the dimensioning of the Nordel system.

The fast power control properties of the HVDC connections can contribute to improving the overall frequency quality of the system. Any production outage will affect system frequency. Depending on the extent of frequency deviations, various forms of emergency power will be activated. Current practice as regards emergency power in the Nordel system is described in Nordel's recommendation "Rekommandasjon for frekvens, tidsavvik, regulerstyrke og reserve", August 1996. The HVDC connections are included in both momentary operating disturbance reserve and in network protection control.

In consideration of the Nordel recommendation the power control properties of the HVDC connections may be used to improve the frequency quality in Nordel following disturbances of operation.

Nordel's HVDC working group has prepared two sub reports: "Sub report 1 prepared by Nordel's HVDC working group: Network disturbances" and "Sub report 2 prepared by Nordel's HVDC working group: System disturbances". This final report summarises the results from the two sub reports.

2 Objective

The objective of the work of the working group has been to illustrate:

- the impact of serious network disturbances on a system with several HVDC connections, which in electrical terms are close together.
- the importance of rapid power control response from the HVDC connections to frequency variation generated by disturbances during operation.

The studies have been undertaken for a future scenario, about 2002, assuming HVDC connections from Norway to both the Netherlands and Germany, as well as from Sweden to Poland. However, the plan is not for two of the Norwegian connections to be established until 2005.

3 Results and conclusion

The work of the group has resulted in recommendations, partly concerning the need for co-ordination of restart of HVDC connections following a network disturbance and partly concerning HVDC power control for frequency reserve.

The work has resulted in two sub reports, which have been considered by Nordel's System Committee; "Sub report 1 prepared by Nordel's HVDC working group: Network disturbances", Trapla 1997-10, 04.03.98 and "Sub report 2 prepared by Nordel's HVDC working group: System disturbances", Trapla 1997-42, 04.03.98.

3.1 Network disturbances

As far as network disturbances are concerned, the study focuses on power flow in the direction from UCTE to Nordel, since this is a "worst case" scenario, corresponding to inverter operation and low short-circuit power in Nordel. Only dimensioning network disturbances, for example busbar faults as described in Nordel's network dimensioning rules (1992 edition), are examined.

<u>Commutation failure</u>
Practical experience has shown that commutation failures caused by a network disturbance only occur concurrently on HVDC connections that in electrical terms are close together. For example, concurrent commutation failures have been seen on Kontek and Baltic Cable caused by an unsymmetrical network disturbance on Zealand, while other plants in Sweden and Norway continued operations as usual.

This study concentrates on the risk of repeated commutation failures, i.e. commutation failures during the restart of HVDC connections after a network disturbance. Only HVDC connections that are close together in electrical terms fail at the same time, e.g. Kontek, Baltic Cable and SwePol. This means that even with maximum power transmission to Nordel by all HVDC connections, the power that is lost immediately cannot exceed the sum of the connections affected.

There are no dimensioning faults that can cause commutation failure on all connections at the same time.

<u>Possible action</u>
The HVDC power that can be transmitted to a network area is highly dependent on the local short-circuit power Sk, e.g.:

- approx. 3000 MW at a short-circuit power of approx. 6 GVA, falling to
- approx. 2000 MW at a short-circuit power of approx. 4.5 GVA.

Increasing the short-circuit power by introducing various more or less expensive network measures could improve the situation, e.g.:

- increased network capacity,
- more production units in operation (rotating reserve) or
- synchronous condensers.

So far, work has shown that, as an alternative, it is highly advantageous to leave the control systems of the converter stations to handle the situation, e.g. through:

- gradual ramping-up from minimum power to the ordered level for a single connection in the affected area, or
- automatic shift-over from power control to current control on a single HVDC connection immediately after a network disturbance and in the case of commutation failure upon restart. This function is already available for some HVDC connections.

The expansion of the control systems on future HVDC connections to include such ”soft start” functionality presents a highly attractive solution, both technically and financially.

With a refined control system design, it will become feasible to increase the number of HVDC connections to an extent corresponding to the number of connections examined in the present study, trigging substantial reinforcements in the network.

<u>Damping</u>
Substantial improvements can be achieved in the damping of power oscillations in the network around known “bottlenecks”, e.g. the Hasle cross-section through Southern Norway and Central Sweden exploiting the damping function of the HVDC connections in the right way.

However, general guidelines for the setting of the HVDC connections' damping control function have not been determined.

3.2 System disturbances

Dimensioning outages and in a few cases outages larger than the dimensioning outage have been considered. As defined in Nordel's network dimensioning rules (1996 edition), the dimensioning outage is 1200 MW.

Focus is primarily on the first few seconds following the disturbance, a time when the conventional and slower power control of the generators is not particularly effective, but when the HVDC connections have their strength. Figure 6 shows the typical development in frequency following a production outage and illustrates the terms ”minimum temporary frequency” and “stationary frequency”.

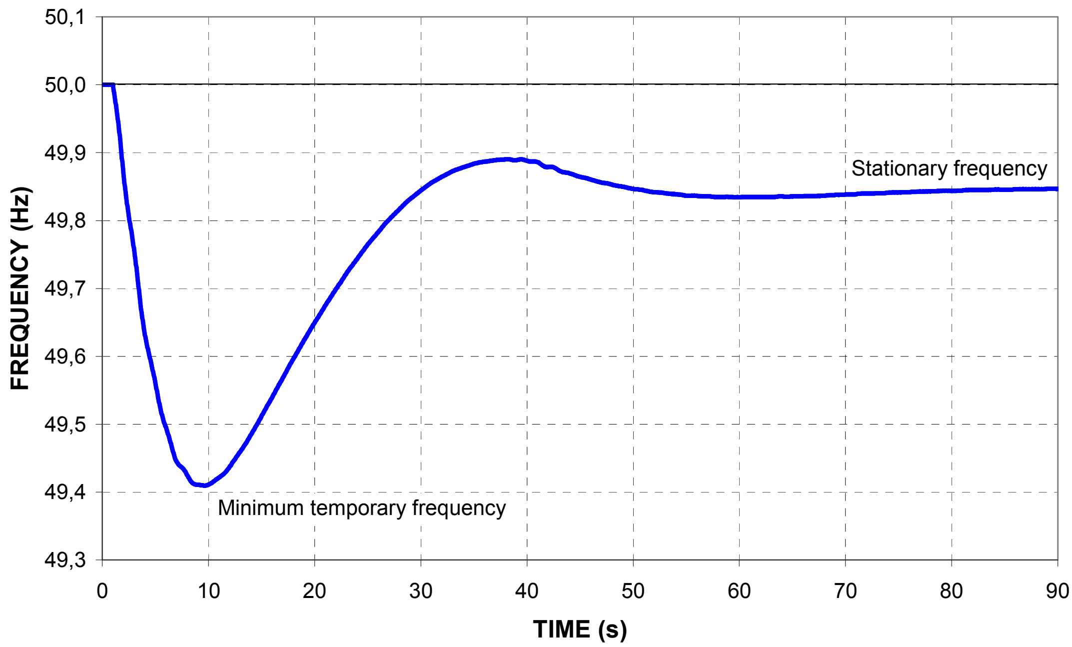

Figure 6 Development in frequency in Nordel following production outage

The power systems' frequency response within the first few seconds of the disturbance is improved markedly with HVDC emergency power control, reducing the minimum temporary frequency drop. The fast power control systems of the HVDC connections ensure efficient HVDC power control before regulation by the power control systems of the turbines.

The working group has identified the requirements that must be made to the power control of the HVDC connections with account being taken of Nordel's recommendations.

The following types of frequency-dependent emergency power control systems are recommended:

- HVDC droop control of up to, e.g., of 1000 MW/Hz in total as a momentary operating disturbance reserve (frequency control).
- HVDC emergency power in steps or ramps of up to 1200 MW in total as network protection control (EPC, Emergency Power Control).

<u>Momentary operating disturbance reserve</u>
HVDC frequency control (droop control) is activated in the frequency range between 49.9 and 49.5 Hz.

<u>Network protection control</u>
EPC, that is HVDC emergency power in steps or ramps, is activated when frequency drops below 49.5 Hz. It is recommended that a combination of frequency control and EPC should be used when the HVDC connections are used for network control, that is in the range below 49.5 Hz. During EPC, the frequency control should thus remain active. In this way, the ability of the EPC to quickly restore frequency to the desired level is used, while the frequency control ensures fast stabilisation of frequency.

Both the power response of the frequency control and the steps of the EPC should be determined on the basis of the current operating situation of the electricity system and with account being taken of the HVDC connections actually in operation.

The frequency response/droop of the HVDC connections within each local area can be set in relation to the currently phased-in MVA (S) and the load to ensure compliance with the minimum requirements for frequency control in the area.

The extent of EPC for each area can be set in relation to the current rotating reserve.

In situations where the Nordel HVDC connections are to supply emergency power to the UCTE system, the control parameters of the HVDC connections must be co-ordinated to ensure that the supplied emergency power does not exceed the dimensioning production outage of 1200 MW for Nordel.

In situations where the Nordel HVDC connections are to receive emergency power from the UCTE system, the control parameters of the HVDC connections do not need to be co-ordinated, if the recommended combination of static control and stepping-up or ramping-up of emergency power is used. This control principle ensures effective frequency control while preventing overcontrol.

4 Conclusion

The working group considers its task to be completed.

The following documents have been included in this chapter:

Document	*Status*
The System Operation Agreement 2006	*Binding agreement*

The following national documents deal with the Operational Code:

Document	*Status*

The TSOs in Scandinavia and Finland have entered into a System Operation Agreement. The System Operation Agreement contains rules for the operation of the interconnected Nordic electric power system, and is set out in this section. This is translation, the original one is in Swedish language.

AGREEMENT (TRANSLATION) REGARDING OPERATION OF THE INTERCONNECTED NORDIC POWER SYSTEM (SYSTEM OPERATION AGREEMENT)

§ 1 The Parties etc

- Energinet.dk (Energinet.dk) corporate registration no. 28 98 06 71
- Fingrid Oyj (Fingrid) Business Identity Code 1072894-3
- Statnett SF (Statnett) corporate registration no. 962 986 633
- Affärsverket svenska kraftnät (Svenska Kraftnät) corporate registration no. 202100-4284

The terms and concepts occurring in this System Operation Agreement (the Agreement) and its appendices are defined in Appendix 1.

§ 2 Background

The *subsystems* of Norway, Sweden, Finland and Eastern Denmark are synchronously interconnected, forming the so called *synchronous system*. The *subsystem* of Western Denmark is connected to Norway and Sweden using DC interconnectors. The *synchronous system* and the *subsystem* of Western Denmark jointly constitute the *interconnected Nordic power system*.

The supervisory authorities of Denmark, Finland, Norway and Sweden have appointed special *system operators* who are comprehensively responsible for the satisfactory operation of each *subsystem*. These *system operators* are Energinet.dk for the Danish *subsystem*, including Bornholm, Fingrid for the Finnish *subsystem*, Statnett for the Norwegian *subsystem* and Svenska Kraftnät for the Swedish *subsystem*. Åland is not covered by this Agreement.

The background to entering into this Agreement is that operation of the *interconnected Nordic power system* entails operational collaboration and co-ordination taking place between the *system operators*. Effective collaboration between these will provide the technical prerequisites for trading in power on an open electricity market.
The Agreement and its Appendices regulate the operational collaboration between the *Parties*. Several of the Agreement's provisions are based upon recommendations issued by Nordel.

§ 3 Objective

The objective of the Agreement is to make use of the advantages arising from the interconnected operation of the Nordic power system. The *Parties* shall thus jointly uphold the interconnected operation of the Nordic power system on a satisfactory level of reliability and quality.

The *Parties* shall jointly uphold a supply quality that is appropriate to joint system operation, e.g. frequency, *time deviation*, system oscillations etc.

The *Parties* shall jointly operate the *interconnected Nordic power system* in a manner which promotes the efficient utilization of existing resources and power trading on the Nordic electricity market, as well as on an additional potential international market. The Agreement specifies in detail the commitments that the *Parties* undertake to honour during their operational collaboration.

The *Parties* are agreed that agreements regarding the operation of the *interconnected Nordic power system* shall only be entered into between the *system operators* concerned.

It is the *Parties'* intention that, as long as *transmission facilities* between the *subsystems* are in operation, there shall exist an agreement between the *Parties* regulating their operational collaboration, rights and commitments vis-à-vis system operation issues

§ 4 Appendices

The following Appendices are attached to this Agreement.

Appendix	Content
1	Definitions
2	Operational security standards
3	Balance regulation standards
4	Exchanging information
5	System protection
6	System services
7.1	Joint operation between Norway - Sweden
7.2	Joint operation between Sweden - Finland
7.3	Joint operation between Norway - Finland - Sweden (Arctic Scandinavia)
7.4	Joint operation between Norway - Western Denmark
7.5	Joint operation between Sweden - Western Denmark
7.6	Joint operation between Sweden - Eastern Denmark
7.7	Joint triangular operation between the Norwegian, Swedish and Western Danish subsystems.
8	Management of transmission limitations between subsystems.
9	Power shortages
10	The Nordel system's joint operation with other systems

The Appendices constitute an integral part of the Agreement.

In the event of any variance between the contents of the Appendices and what is set forth in this, the main part of the Agreement, what is set forth in the main part shall take precedence.

§ 5 Decisions etc concerning own subsystems

The *Parties* will make their own decisions regarding the principles applicable to the *system security* of their own *subsystems*.

The *Parties* agree, however, when taking such decisions, to comply with the intentions and principles of the Agreement as far as is possible and appropriate.

The *Parties* are individually responsible for formulating their own agreements concerning system operation collaboration between their own *subsystems* and *subsystems* outside of the *interconnected Nordic power system*, with which there are physical transmission links, in such a way that these do not contravene the intentions of, or prevent compliance with, the Agreement.

It is the intention of the *Parties*, as far as is possible within the legal framework provided (terms and conditions of concessions etc) to co-ordinate the terms and conditions of such agreements with the provisions of this Agreement.

Each respective *Party* shall enter into such agreements with companies within its own *subsystem* as are necessary to comply with the Agreement.

Unless otherwise agreed, the *Parties* shall be responsible for ensuring that measures taken within their own *subsystems,* which impact upon the operation of the system, shall not burden the other *subsystems*.

§ 6 Operational security standards

The *Parties* shall, in the day-to-day operation of the system and in their operational collaboration with other *Parties*, comply with the standards set forth in Appendices 2 and 3.

§ 7 Operational terms and conditions for the links between the subsystems

7.1 Transmission facilities

The *transmission facilities* linking the *subsystems* are accounted for in the following Appendices.

Appendix 7.1 Norway - Sweden
Appendix 7.2 Sweden - Finland
Appendix 7.3 Norway - Finland - Sweden (Arctic Scandinavia)
Appendix 7.4 Norway - Western Denmark
Appendix 7.5 Sweden - Western Denmark
Appendix 7.6 Sweden - Eastern Denmark
Appendix 7.7 Norway - Sweden - Western Denmark
(subsystems in triangular operation)

The *Parties* are responsible, as and when required, for detailed *operating instructions* being drawn up for the links listed in the mentioned Appendices within their own *subsystems*. In parts where such *operating instructions* have a bearing upon the joint system operation, they are to be co-ordinated with the companies and *Parties* concerned.

7.2 Transmission capacity

The *transmission capacity* of the links between the *subsystems* shall be bilaterally determined on a routine basis by the *Parties* concerned. Decisions shall normally be based on the *operational security standards* set out in Appendix 2 and on such current technical and operative factors as are of significance to the *transmission capacity*. The *Parties* are individually responsible for assessing these circumstances within their own *subsystems* and will decide on the necessary measures.

The *Parties* agree to reserve a *regulating margin* between the *transmission* and *trading capacities* of the links. The *regulating margin* shall normally have the values specified in Appendices 7.1 -7.7.

7.3 Special operational terms and conditions

In certain cases, special rules are applied as regards using the *transmission capacity* of the links. Detailed terms and conditions, together with the companies concerned, are specified in the respective Appendices 7.1-7.7.

7.4 Transmission losses

Issues concerning transmission losses are governed by separate agreements – settlement agreements.

A *Party* shall not be responsible for transmission losses arising within another *Party's subsystem* in any operational situation, unless otherwise agreed.

The *settlement points* are specified in Appendices 7.1-7.6.

7.5 Voltage regulation

Voltage regulation in the *subsystems* shall be conducted in such a way that the *operational security standards* specified in 6 § are upheld and in such a way that the reactive flow of power between the *subsystems* does not entail operational problems. The *Parties'* rights and liabilities regarding reactive power flows on the AC interconnectors are limited to what corresponds, calculation-wise, to zero exchange at the national border, based on values measured at the terminals of the links.

7.6 System protection

System protection can be used to increase the *transmission capacity* and/or *system security* between and within the *subsystems*. The settings and operational status of *system protection* shall be decided upon and monitored by the respective *Party*. In cases when *system protection* has a bearing on two or more *subsystems*, co-ordination and communication of the operating status shall take place between the *Parties* concerned. The requirements relating to *system protection* are set out in Appendix 2. The forms of *system protection* used are set out in Appendix 5.

7.7 Relay protection and fault analysis

The *Parties* shall co-ordinate supportive data and plans for setting functional values for the relay protection of such *transmission facilities*. Following *operational disturbances*, information from registration equipment shall be exchanged between the *Parties* concerned to the extent necessary to enable investigation of the course of events.

§ 8 Operational planning

The *Parties* shall, as far as is possible, bilaterally co-ordinate operational outages and other measures which each and everyone of them has control over and which impact upon the joint system operation. In the event that *operational disturbances* and other measures occur during the *operational phase* and which have to be carried out at short notice, with no time for co-ordination, the *Parties* concerned shall be informed as quickly as possible.

Appendices 7.1- 7.6 contain certain rules regarding the co-ordination of operational outages on the respective links between the *subsystems*.

§ 9 System services

The *Parties* shall comply with the *operational security standards* specified in § 6 by ensuring the availability of *system services* within their own *subsystems*. When this is possible, the *Parties* can co-ordinate and exchange *system services* with each other. During the exchange of such *system services*, the pricing shall be based on the costs incurred by the respective *Party* when obtaining access to and utilizing the *system services* within its own *subsystem*.

The *Parties* shall work towards harmonisation of the terms and conditions in order to gain access to *system services* from companies within the respective *subsystem*.

System services are described in Appendix 6.

§ 10 Managing transmission limitations between the subsystems

The *Parties* shall be bilaterally responsible for transmissions on the respective links between the *subsystems* not exceeding the set *transmission capacity*. If a limit is exceeded, this shall be rectified within 15 minutes.

The *Parties* shall bilaterally co-ordinate terms and conditions and management routines in order to be able, as and when required, to restrict the commercial players' utilization of the links in cases when *transmission capacities* need to be reduced. The separate terms and conditions that apply, as and when appropriate, to each respective link are set out in Appendices 7.1 - 7.7. The *Parties* shall uphold the commercial players' planned trading, by means of *counter trading,* to the extent set out in Appendix 8.

It is incumbent upon the *Parties* to manage, within their own *subsystems*, such transmission problems that cannot be solved by restricting the commercial players' utilization of the links. The *Parties* are further responsible for implementing the necessary regulation on their own sides of the links, and for the costs thus arising, unless otherwise agreed between the *Parties* concerned.

§ 11 Managing operational disturbances

In the case of all *operational disturbances*, *normal state* shall be resumed without undue delay. The *Parties* shall assist one another in minimising the consequences of any *disturbances* that arise.

In the case of disturbances arising within its own *subsystem*, the affected *Party* will be responsible, at its own expense, for remedial measures. Whenever it is appropriate to carry out remedial measures in another *subsystem*, the affected *Party* shall be responsible for the costs of the agreed measures. For disturbances on a link between the *subsystems*, the *Parties* concerned shall, at their own expense, be responsible for the necessary measures on their own side of the link, unless otherwise agreed.

In the case of activation of the joint *frequency controlled disturbance reserve*, compensation shall normally be rendered via the settlement of *balance power*.

The *Parties* shall promptly inform one another of *system security* risks or disturbances arising.

§ 12 Balance regulation

Each *subsystem* is responsible for planning itself into balance hour by hour, as well as for upholding its own balance during the hour of operation.

The *Parties* shall collaborate towards minimising the cost of *balance regulation* by utilizing, to the greatest extent possible, one another's regulation resources when this is technically and financially appropriate.

The *balance regulation* of the Nordic system is divided up into two *balance areas*. One of these *balance areas* is the *synchronous system* while the other *balance area* is Western Denmark.

Energinet.dk manages the *balance regulation* of the Western Danish area, within its sphere of responsibility for the *UCTE* system, and in accordance with an agreement with EON Netz. Consequently, Energinet.dk has agreements with two *balance areas*; the *UCTE* system and the *synchronous system*.

The *balance regulation* of each *subsystem* within the *interconnected Nordic synchronous power system* shall be carried out in accordance with the principles set out in Appendix 3.

The basis of the *interconnected Nordic synchronous power system's balance regulation* is that regulation is carried out in respect of frequency. Regulation work is apportioned in accordance with the requirement for *frequency response* and a joint Nordic merit order *regulation list*. The entire Nordic power system shall constitute a single market for *regulation power*. In the event of *bottlenecks*, the *regulation market* can be split up.

The *Parties* shall pay attention to regulation problems within the hour of operation and especially at hour changes. Major changes to *exchange plans* should be managed via agreements concerning transitions.

§ 13 Power exchanges

13.1 Hourly exchange plans

Parties with adjacent *subsystems* shall jointly set routines for notifying hourly *exchange plans* and *trading plans* among the *subsystems*. Whenever transmission capacity is made available for other purposes than power trading, the relevant plans shall be bilaterally reported to each *player* individually. Trading must be reportable as a net trade between each *subsystem*.

13.2 Supportive power

Exchanges of *supportive power* between *Parties* with adjacent *subsystems* may be carried out in order to achieve efficient operation of the system. Such exchanges can come about as and when required during *normal state*, during *counter trading* or during *operational disturbances*. *Supportive power* can be agreed upon in advance, as well as commenced and terminated during the current hour of operation.

The principles for pricing *supportive power* are set out in Appendix 3.

13.3 Balance power

Balance power between the *subsystems* is calculated during settlement as the difference between the measured exchange of power and the sum of all forms of agreed exchange, including such exchanges as have been agreed between the *Parties*.

More detailed rules for managing and pricing *balance power* are set out in Appendix 3.

§ 14 Settlement

Settlement shall be based on the principles set out in § 12 - 13 for *balance regulation* and exchanges of power.

All settlement of exchanges of power between the *subsystems* shall take place at the *settlement points* specified in Appendices 7.1 - 7.6.

The settlement procedure is regulated bilaterally in separate agreements, settlement agreements, between the *Parties* concerned.

§ 15 Power shortages

When there is a risk of *power shortages*, the power trade within the power exchange area shall be given the opportunity, through price formation, to distribute risks and costs between the electricity market *players*. The *Parties* shall, as far as is possible and reasonable, work towards upholding such power trading and allocations of production capacity, which they do not contractually have the right to discontinue.

In the event of anticipated *power shortages* in one or more *subsystems*, the *Parties* shall collaborate in such a way that the resources available within the *interconnected Nordic power system* are utilized in order to minimise the extent of compulsory *load shedding*.

Acute situations such as general *power shortages* or *power shortages* resulting from *operational disturbances* on networks, or *bottleneck situations* when compulsory *load shedding* has to be carried out, are to be managed in accordance with Appendix 9.

System security shall be maintained on the level specified in Appendices 2 and 3 so that *dimensioning faults* do not lead to extensive follow-on disturbances in the *interconnected Nordic power system*.

§ 16 Exchanging information

Appendix 4 specifies the information that shall be exchanged between the *Parties* for system operation requirements.

If the information that the *Parties* are mutually exchanging has not been made public in the country the information relates to, the *Parties* pledge to keep this information confidential, as far as possible, in accordance with the legislation in force in the respective country.

§ 17 Liability

The *Parties* will only be liable to one another for damage resulting from gross negligence or malice aforethought.

None of the *Parties* will be able to hold any of the other *Parties* liable for lost revenues, consequential losses or other indirect losses, unless such damage has been caused by gross negligence or malice aforethought.

§ 18 Disputes

Should a dispute arise in connection with this Agreement, the *Parties* shall initially attempt to resolve their conflict through negotiation. If this does not succeed, the dispute shall, under Swedish law, conclusively be settled by arbitration in accordance with the Rules of the Arbitration Institute of the Stockholm Chamber of Commerce. The arbitration procedure shall take place in Stockholm.

§ 19 Alterations and supplements

Alterations and supplements to this Agreement shall, in order to be legally valid, be drawn up in writing and signed by all the *Parties*.

Appendices to this Agreement can be added to on a rolling basis. In doing so, Appendices which relate to all the *Parties* shall be updated jointly and approved by all the *Parties*. Appendices which deal with individual links shall be updated by the *Parties* that are affected by the Appendix in question. Any and all changes to Appendices shall be documented in writing and communicated to the *Parties*.

In the event of alterations to Appendices, the Appendices in question shall, by at the latest one month after the alteration has been made, be revised and sent out to all the *Parties*. An annual review of the Agreement shall be carried out in order to deal with any contractual revisions.

§ 20 Transfer

This Agreement may be transferred to another company which has been appointed as the *system operator* of a *subsystem* by the authorities of a country. Other transfers may not, wholly or in part, take place without the written consent of the other *Parties*.

In the event of the transfer of the *system responsibility* to another company, the *Parties* will be responsible for transferring their contractual commitments under this Agreement to the new *system operator*.

§ 21 Validity etc

This Agreement will come into force once it has been signed by all the *Parties* and will remain in force until further notice. The Agreement, which will apply from xx xx 2006, is conditional upon each respective *Party* receiving the necessary Board/Authority approvals.

If a *Party* deems the terms and conditions of this Agreement to entail unreasonable or inappropriate consequences, then this *Party* will be able to request, in writing, from the other *Parties* that negotiations be entered into as soon as possible with the aim of bringing about appropriate changes to the Agreement. Equivalent negotiations can also be entered into if the pre-conditions for the Agreement change significantly due to altered legislation or a decision made by an authority, or due to physical changes being made to the *interconnected Nordic power system*.

If a *Party* requests renegotiation, the other *Parties* will be obligated to actively take part in such negotiations within one month of receiving such a request.

If renegotiations do not, within six months of the request for renegotiation being made, lead to agreement being reached as regards such changes to the Agreement that the *Party* deems satisfactory, the *Party* shall have the right to terminate the Agreement. Termination, which must be in writing, shall occur by at the latest two weeks from the expiration of the renegotiation deadline. If such termination occurs, the Agreement shall be deemed to have ceased to be valid in respect of the terminating *Party*, once a period of six months has elapsed from the time when the notice of termination was communicated to all the other *Parties*.

This Agreement replaces the previous agreement dated 1 April 2004.
This Agreement has been drawn up and signed in four (4) identical copies, of which the *Parties* have received one copy each.

Fredericia 2006- -
Energinet.dk

Peder Ø. Andreasen

Helsinki 2006- -
Fingrid Oyj

Timo Toivonen

Oslo 2006- -
Statnett SF

Odd Håkon Hoelsæter

Stockholm 2006- -
Affärsverket Svenska Kraftnät

Jan Magnusson

DEFINITIONS

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

Most of the terms are Nordic and are not used in Continental Europe. Individual general terms correspond to terms used within UCTE. Terms concerning the capacity of the links between the subsystems are comparable to the corresponding terms within ETSO.

The **active reserve** is divided into *automatic active reserve* and *manual active reserve*.

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 cross-sections* in the national subsystems or by *cross-border links*.

Area prices are *Elspot prices* within an *Elspot 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*, *frequency controlled disturbance reserve* 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.

A **bottleneck** is a capacity limitation on the *transmission network*. On the Elspot market, attention is paid to *bottlenecks* between the *Elspot 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 *Elspot 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. For HVDC links, only the DC facility at stations on both sides of the link is included in the cross-border link.

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

A **deficit area** is a *subsystem* whose balance is negative, i.e. that power is physically flowing into the *subsystem* physically measured on the *cross-border links* between the *Parties*.

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 occur in Sweden, Finland and Eastern Denmark prior to and during the *day of operation* after *Elspot trading* has finished.

Elspot 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* in *Elspot areas*. In Finland, Sweden, Western Denmark and Eastern Denmark, the *Elspot areas* correspond to the *subsystems*.
In Norway, there are several *Elspot areas* within the *subsystem*.

Elspot prices are prices in *Elspot trading* within an *Elspot area*.

Elspot trading is power trading on the spot market of Nord Pool Spot. *Elspot trading* can occur 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.*

ETSO (European Transmission System Operators) 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* for carrying out *counter trading*.

The **fast active disturbance reserve** is the manual reserve 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* 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 or consumption. A fault causes an *operational disturbance* in the power system.

The **frequency controlled disturbance reserve** 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. Previously called the momentary disturbance reserve.

The **frequency controlled normal operation reserve** 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. Previously called the frequency regulation reserve.

The **frequency response** is the change ability in production dependent on the frequency of the network (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 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 an *Elspot area* which, due to *bottlenecks* towards another *Elspot 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.

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*. In Sweden, Finland, Western Denmark and Eastern Denmark, *regulation areas* normally correspond to the *subsystems*. In Norway, there are several *regulation areas* within the *subsystem*.

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.*

A **risk of power shortage** occurs when forecasts show that a *subsystem* is no longer capable of maintaining the demand for a *manual active reserve* which can be activated within 15 minutes, for the planning period.

Scaling means restricting changes in the *trading capacity* (NTC) between two *Elspot 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*. 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* like Finland-Russia, the SwePol Link, the Baltic Cable, Kontek and Western Denmark-Germany are not to be included in the calculation.)

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.

A **surplus area** is a *subsystem* whose *balance* is positive, i.e. that power is physically flowing out of the *subsystem* measured physically on the *cross-border links* between the *subsystems*.

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 *UCTE* system.

The **system operator** has the *system responsibility* for a defined *subsystem*.

The **system price** is an estimated price for the entire Elspot market. The s*ystem price* is estimated as if there are no capacity limitations on the *transmission network* between the *Elspot areas*.

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 or consumption.

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 *Elspot 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 *Elspot areas* (Elspot, Elbas, hourly trading).

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 cross-sections* between the *subsystems/areas* or individual installations.

A **transmission cross-section** is a cross-section on the *transmission network* between the *subsystems* or between *areas* within a *subsystem*. Also referred to solely as cross-sections.

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*.

UCTE (Union for the Co-ordination of Transmission of Electricity) is an association of *system operators* in continental Europe.

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*.

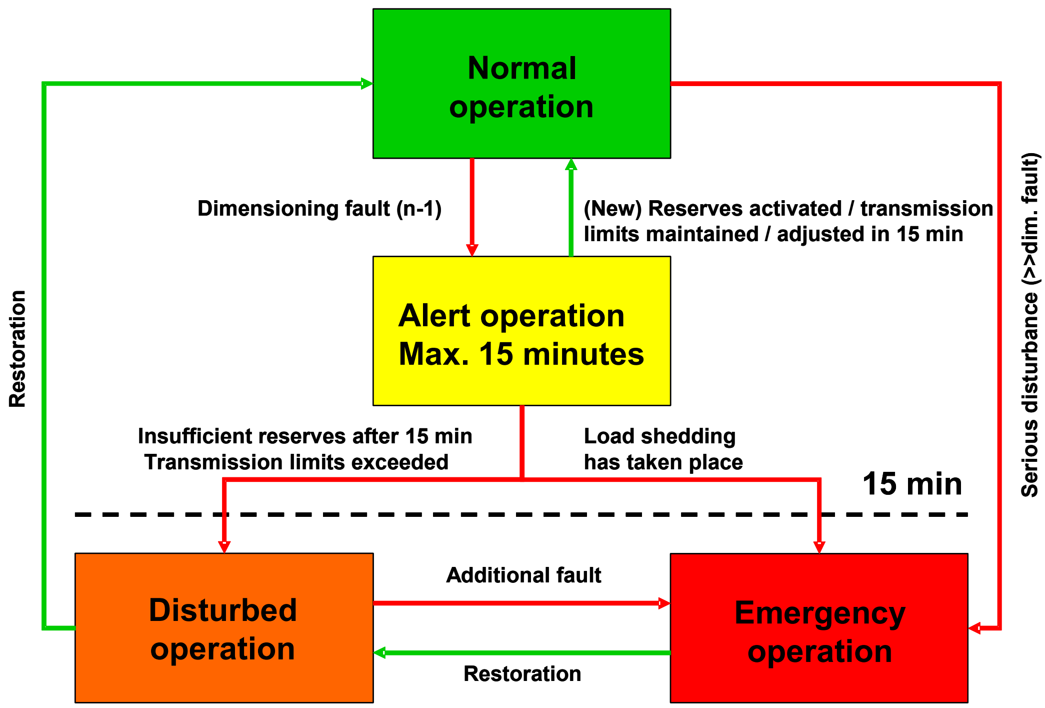

Figure 1 *Operational states (network collapse is not specified in the figure).*

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, unwanted and missing function hereby taking the interaction with other system protection schemes into account.

- In the event of a correct or unwanted 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, unwanted 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*.

4.1.1 Frequency controlled normal operation reserve

The *frequency controlled normal operation reserve* shall be at least 600 MW at 50.0 Hz for the synchronous system. It shall be completely activated at f = 49.9/50.1 Hz (Δf = +- 0.1 Hz).
In the event of a rapid change of frequency to 49.9/50.1 Hz, the reserve shall be regulated upwards/downwards within 2-3 minutes. The *frequency controlled normal operation reserve* is distributed between the *subsystems* of the *synchronous system* in accordance with the *annual consumption* (total consumption exclusive of power plant's own consumption) during the previous year.

The factual distribution of the *frequency-controlled normal operation reserve* between the *subsystems* shall be revised each year before 1 March on the basis of *annual consumption* in the previous year and rounded to the closest ten. *Annual consumption* shall be given in TWh with an accuracy of one decimal.

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

For 2006, the following distribution applies:

	Annual consumption 2005 (TWh)	Frequency controlled normal operation reserve (MW)
Eastern Denmark	*14.4*	*23*
Finland	*84.9*	*137*
Norway	*125.9*	*203*
Sweden	*147.3*	*237*
Synchronous system	*372.5*	*600*

4.1.2 Frequency controlled disturbance reserve

There shall be a *frequency controlled disturbance reserve* of such magnitude and composition that *dimensioning faults* will not entail a frequency of less than 49.5 Hz in the *synchronous system*.

Taking into account the frequency-dependence of consumption, the above requirements entail that the combined *frequency controlled disturbance reserve* shall amount to an output power equal to the *dimensioning faults* less 200 MW. The overall *frequency controlled disturbance reserve* must be able to be used until the *fast active disturbance reserve* has been activated.

Upward regulation of the *frequency controlled disturbance reserve* must not give rise to other problems in the power system. When setting the *transmission capacity*, localization of the *frequency controlled disturbance reserve* must be taken into account. Each *subsystem* shall have at least 2/3 of the *frequency controlled disturbance reserve* within its own system in the event of splitting up and island operation.

The *frequency controlled disturbance reserve* shall be activated at 49.9 Hz and be completely activated at 49.5 Hz. It must increase as good as linearly throughout the frequency range of 49.9-49.5 Hz.

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.

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 shows how distribution of the requirement for the *frequency controlled disturbance reserve* is achieved:

	Dimensioning faults (MW)	Frequency controlled disturbance res. (MW)	Frequency controlled disturbance res. (%)
Denmark	580	153	15.0
Finland	865	228	22.4
Norway	1,200	317	31.0
Sweden	1,220	322	31.6
Total		1,020	100

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

- Western Denmark 75 MW (7.4%)

- Eastern Denmark 78 MW (7.6%)

Energinet.dk accepts this requirement as long as E.ON Netz and UCTE 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 *UCTE* system entails that Energinet.dk is required to maintain the frequency and *frequency controlled disturbance reserve* in accordance with *UCTE* rules. This is described in section 5 "Special conditions for Energinet.dk as a member of UCTE".

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 1,200 MW, Energinet.dk 600 MW in Eastern Denmark (where 300 MW is *slow active disturbance reserve* which, on special occasions, can be made fast), Energinet.dk 620 MW in Western Denmark, and Statnett 1,600 MW.

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 a member of UCTE

N-1 security
The *n-1 criterion* also applies to the *UCTE* area. 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 *UCTE,* 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 2006, be able to deliver 32 MW as *frequency controlled disturbance reserve* in Western Denmark. This *frequency controlled disturbance reserve* shall be fully activated in the event of a momentary frequency change of ± 200 mHz.

Secondary reserve
Generally within *UCTE,* 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 cross-section* being defined, and static and dynamic simulations determine how much power can be transmitted in any direction through the cross-section before thermal overloads, voltage collapse and/or instability arise following a *dimensioning fault* (for the cross-section) being added. In the cross-section, 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 cross-section*, the maximum transmission capability through a cross-section, or for single lines following a simple fault, can be set at a given percentage over the nominal limit in cases when the cross-section/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 cross-section* 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 cross-sections and bilaterally between the *system operators* for cross-sections 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.

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 communicated 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.

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 $\Delta T = 15$ 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 UCTE 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 need only be in one direction.

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 *Elspot 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 *Elspot 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 *Elspot 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 cross-sections* or operational/trading rules which entail that it is not permitted to activate bids in the joint *regulation list*.

If the transmission between *Elspot areas* is greater than the *trading plan* and this creates *bottleneck problems* for other *Elspot 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 *Elspot area* which are caused by imbalances within an *Elspot area* are dealt with as *balance regulation* and give rise to a divided *regulation market*. *Bottlenecks* caused by a reduced *transmission capacity* to/from an *Elspot 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 cross-sections in an *Elspot 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 *Elspot 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 *Elspot 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 Western Denmark 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 triangular *supportive power exchanges* between Sweden, Norway and Western Denmark. This will not affect the individual *subsystem's* balance and the price of the exchange will be set at 0 SEK. *Supportive power* for balance regulation has priority over triangular transit.

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 West sends plans in advance for each operating hour for exchange between the *synchronous system* and Western Denmark. The plans are given per 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 *transmission capacity* between the *subsystems* shall be entered in the joint Nordic outage planning system NOPS (Nordic Outage Planning 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 cross-sections* 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 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 or downward regulation of production
- load shedding 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.

Frequency controlled actions in the NORDEL-system

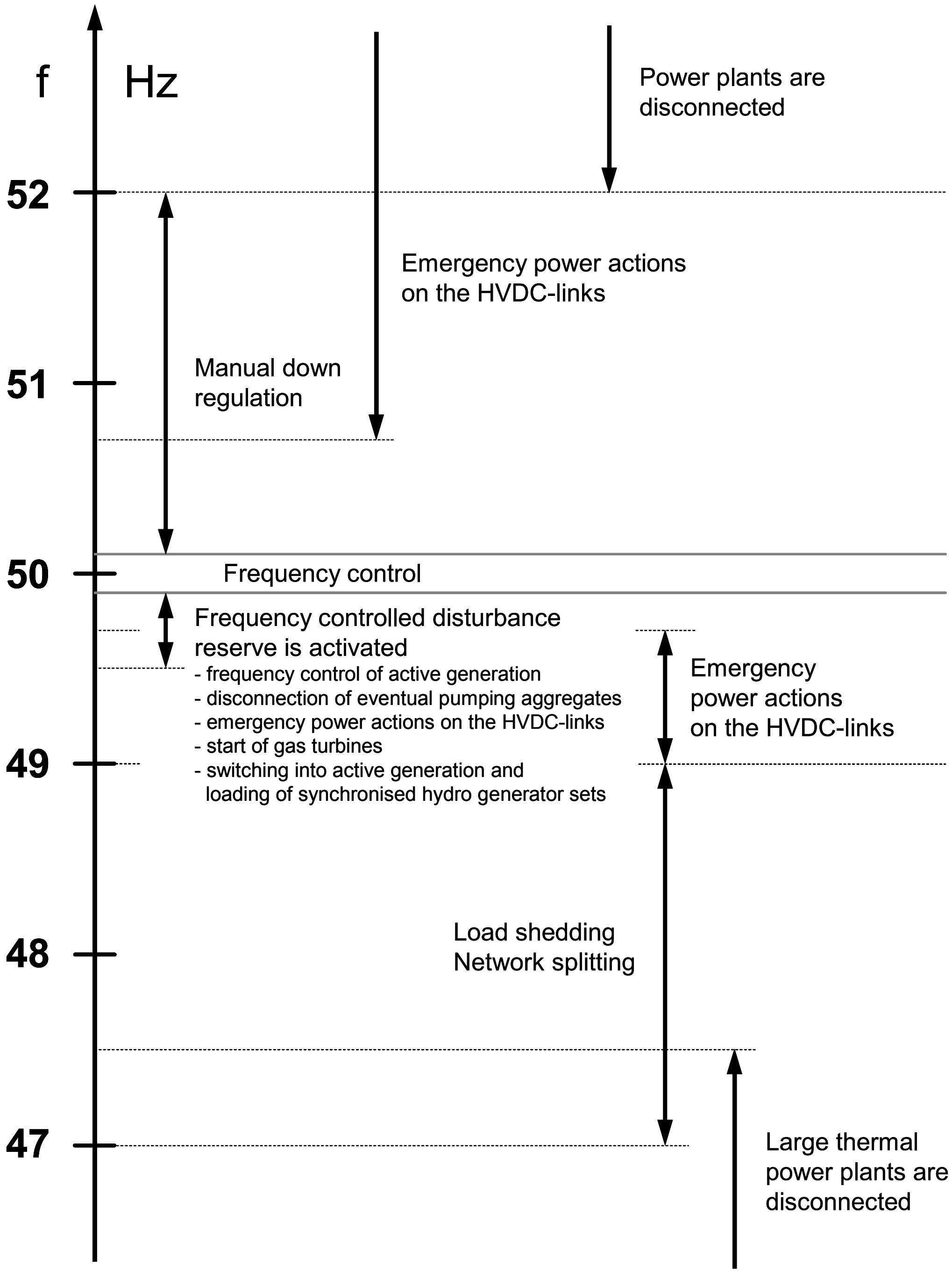

Figure 1 Frequency controlled actions in the Nordel-system

2 System protection activated by frequency deviations

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

- regulation of DC facilities, *emergency power*
- *production shedding* or downward regulation of production, PFK
- start-up of production
- *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 *emergency power*.

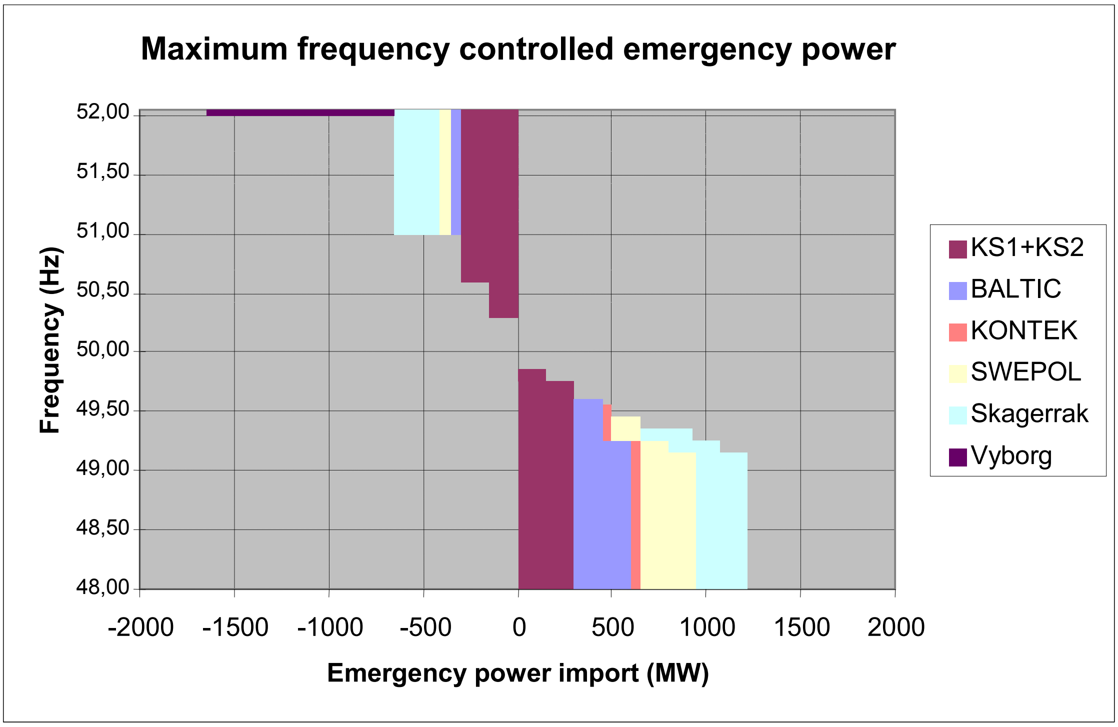

Figure 2 Maximum frequency controlled emergency power

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

2.2 Frequency controlled start-up of production

Automatic frequency controlled start-up of production is carried out in order to increase the number of production units in the power system during *operational disturbances*.

Hz	Denmark		Norway	Sweden	Finland
	East	West			
49.8		25 MW GT			
49.7-49.5				520 MW GT in three stages of 0.1 Hz	180 MW GT, 15 sec
49.5					

Schedule 1

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 Schedule 2:

Denmark	East	10 % of consump. f<48.5 Hz momentary, f<48.7 Hz 20 sec. 10 % of consump. f<48.3 Hz momentary, f<48.5 Hz 20 sec. 10 % of consump. f<48.1 Hz momentary, f<48.3 Hz 20 sec. 10 % of consump. f<47.9 Hz momentary, f<48.1 Hz 20 sec. 10 % of consump. f<47.7 Hz momentary, f<47.9 Hz 20 sec.
	West	15 % of consump. f<48.7 25 % of consump. f<47.7
Norway		7,000 MW* in stages from 49.0 Hz to 47.0 Hz
Sweden	South of cross-section 2	electrical boilers and heat pumps P ≥ 35 MW. f< 49.4 for 0.15 sec 35>P ≥ 25 MW. f< 49.3 for 0.15 sec 25>P ≥ 15 MW. f< 49.2 for 0.15 sec 15>P ≥ 5 MW. f< 49.1 for 0.15 sec 30 % of consump in 5 stages stage 1. f< 48.8 for 0.15 sec stage 2. f< 48.6 for 0.15 sec stage 3. f< 48.4 for 0.15 sec stage 4. f< 48.2 for 0.15 sec. f<48.6 for 15 sec stage 5. f< 48.0 for 0.15 sec. f>48.4 for 20 sec
Finland		10 % of consump. f<48.5 Hz 0.15 sec. f<48.7 Hz 20 sec 10 % of consump. f<48.3 Hz 0.15 sec. f<48.5 Hz 20 sec

Schedule 2

* For Norway, this refers to peak loads.

2.4 Frequency controlled disconnection of lines

Denmark	East	Disconnection of the Swedish link at f<47.0 Hz for 0.5 sec or f<47.5 for 9 sec
	West	-
Norway		-
Sweden		-
Finland		Disconnection of Vyborg DC link at a frequency in Finland of >52 Hz for 0.5 sec Disconnection of northern AC links to Sweden at a frequency of > 50.7 for 2 sec if imports from Sweden are > 900 MW and the voltage on the 400 kV network is < 380 kV.

3 System protection activated by voltage deviations

In Sweden, there are two important types of *system protection* which are controlled by voltage. Both types of *system protection* regulate 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 cross-section 2

The *System protection* that is to relieve cross-section 2 during *operational disturbances* measures the voltage at 4 stations north of cross-section 2; Storfinnforsen, Kilforsen, Stornorrfors, and Hjälta. When the voltage has been lower than 390 kV for 2 seconds, a signal will be sent to the *system protection*. If the voltage has been low in at least two of the stations, the *system protection* will send a signal to Fenno-Skan (*emergency power* 400 MW) and Konti-Skan 2 (*emergency power* 100 MW).

3.2 System protection in Sweden cross-section 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, cross-section 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 cross-section 4 (2/3 of the *emergency power* intervention). The increased capacity in cross-section 4 may only be used when consumption south of cross-section 4 is less than 4,500 MW.

System protection obtains measured values from 6 substations: Breared, Hallsberg, Hjälta, Kilanda, Tenhult and Sege. When *system protection* is in operation, a higher level of transmission will be allowed in cross-section 4. The increase will accrue on the respective overseas interconnector, Baltic Cable, the SwePol link and Öresund connection.

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 cross-section* 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.

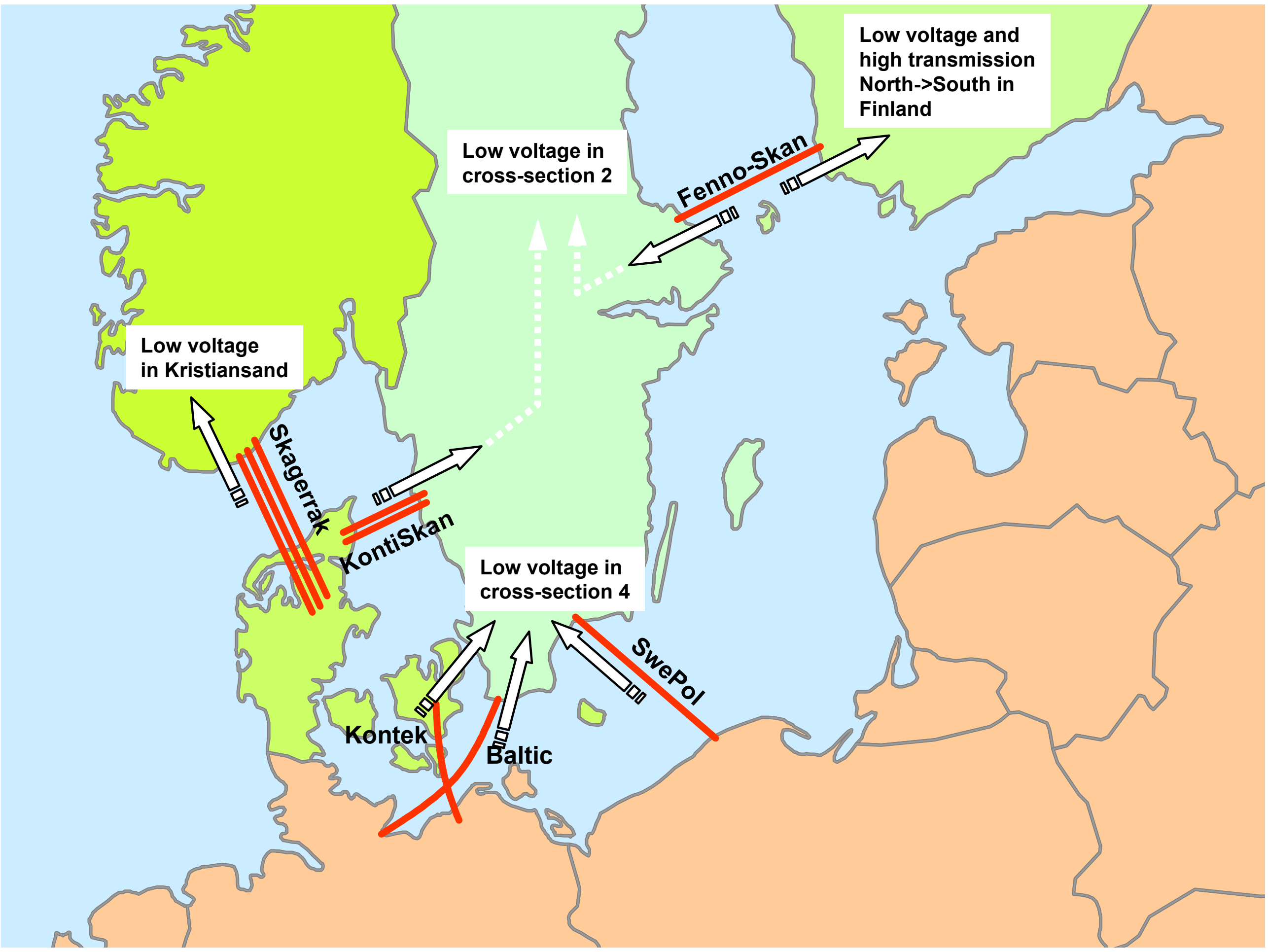

Figure 3 *Control of HVDC-links on low voltage*

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*.

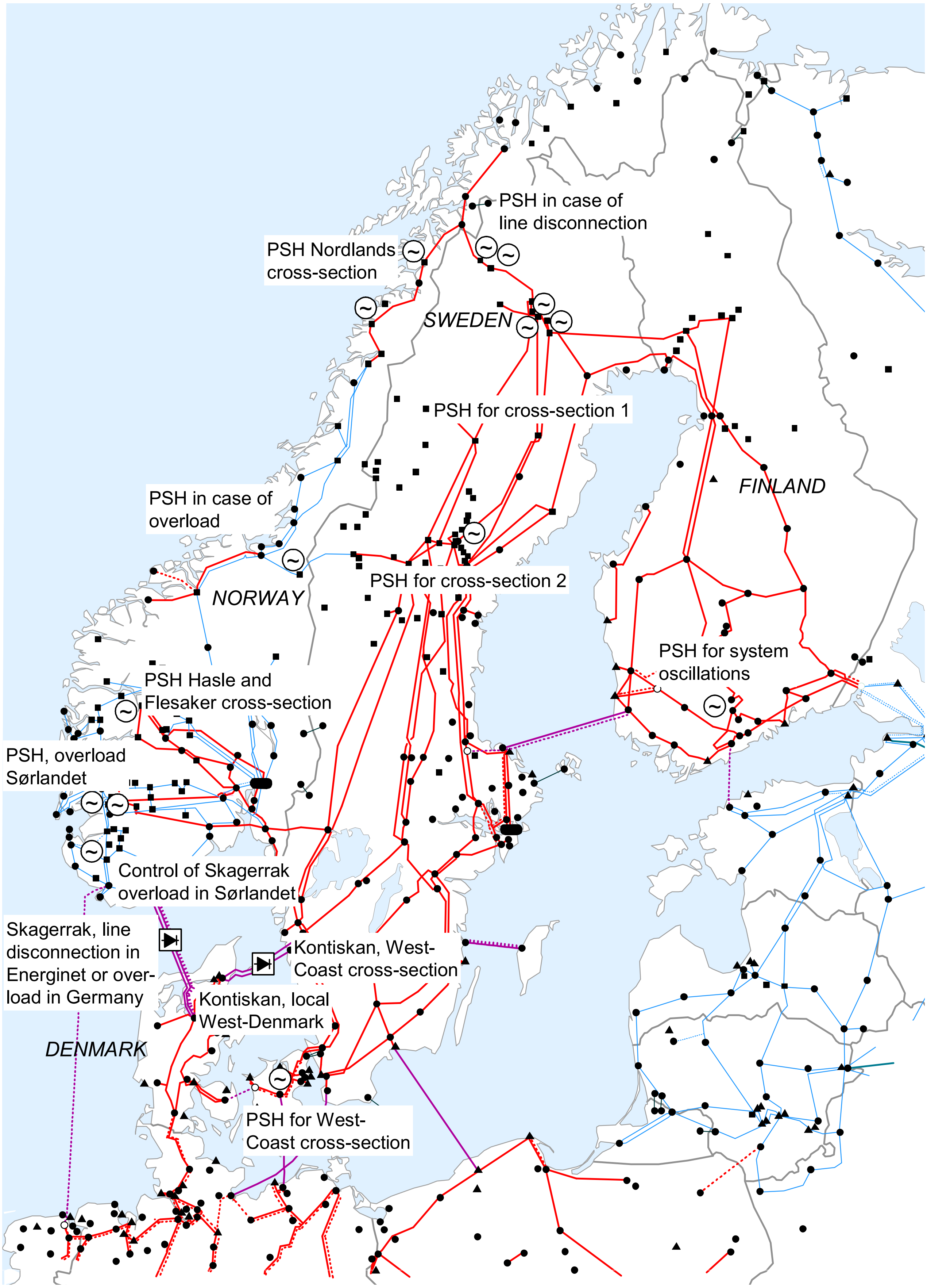

Figure 4 *System Protection based on Production Shedding (PSH) or Control of HVDC-links*

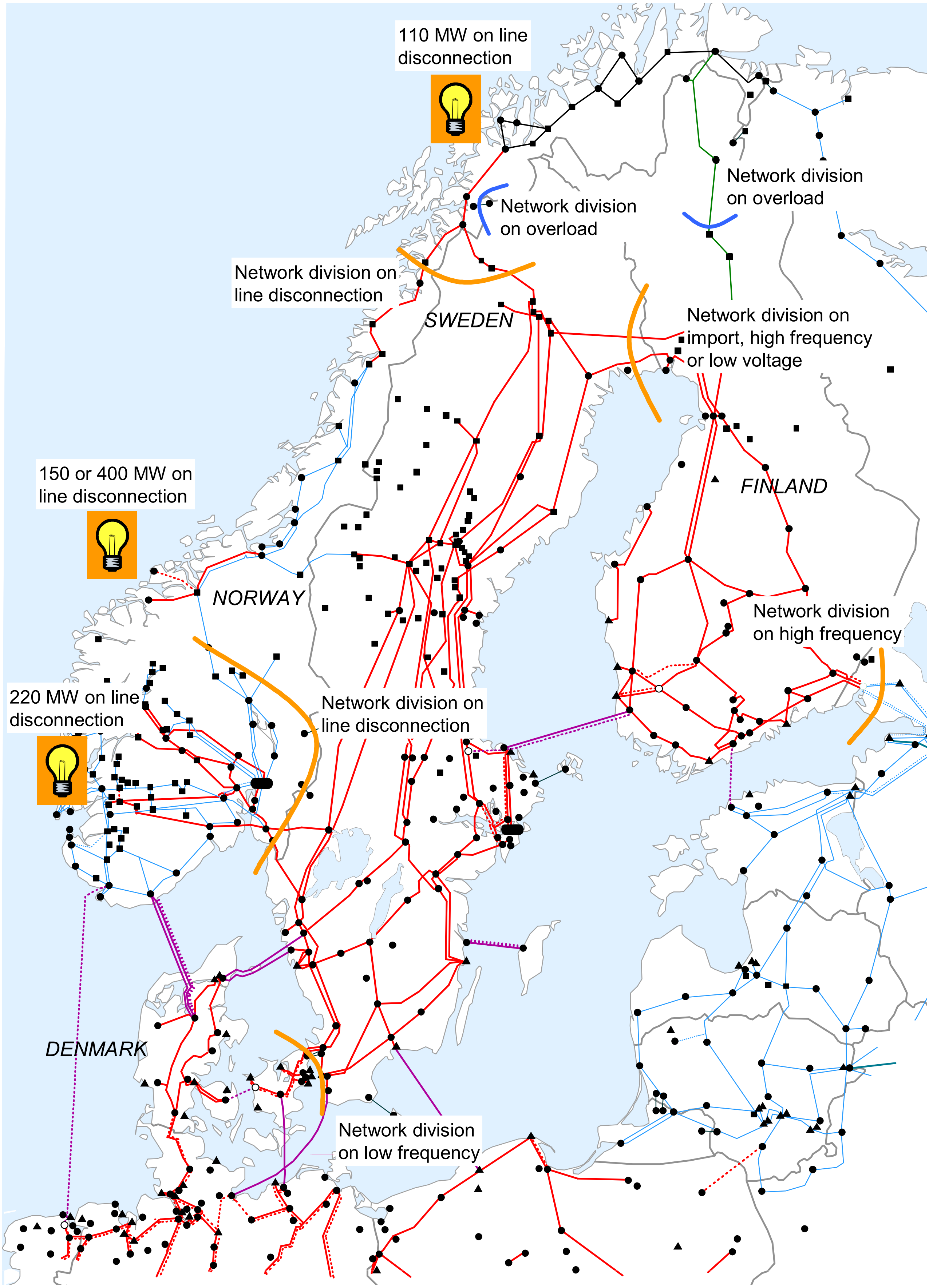

Figure 5 System Protection based on Load Shedding or Network Division

4.1 Eastern Denmark: System protection for stability in Eastern Denmark

Disconnection of gas turbines and downward regulation of the steam turbine at unit 2 of the Avedøre plant upon activation of certain breakers on the 400 kV network in Zealand. This *system protection* is only activated during operational situations when critical 400 kV network components are disconnected or during high export volumes towards Sweden.

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

Shedding of hydropower production in northern Sweden via remotely-transmitted signals from activated protection functions. Extent of approx. 1,600 MW of installed power. Upon disconnection of lines in cross-section 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 lead to *load shedding* in northern Norway.

4.3 Sweden: System protection in the West Coast cross-section (Kilanda-Horred + Stenkullen-Strömma)

During imports from 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 the event of a long-term fault on one of the lines.
The *system protection* will work as follows:
- In the event of losing Kilanda-Horred and transmission of more than 500 MW northbound on the line, this will result in a power change of 300 MW on Konti-Skan 2 towards Western Denmark.
- In the event of losing Stenkullen-Strömma and transmissions of more than 500 MW northbound on the line, this will result in a power change of 300 MW on Konti-Skan 2 towards Western Denmark.
These *system protections* do not provide increased capacity, rather they increase the *system security*.

During exports to Jutland, there is a risk that the regional network around Gothenburg will be overloaded in the event of a long–term fault on the Strömma-Lindome line. The sy*stem protection* will function as follows:
In the event of losing Strömma-Lindome, Konti-Skan 2 will be regulated down to 0 if there are exports on the link.

Extended *system protection*:
This protection disconnects ”production” in Zealand through *production shedding*. This will reduce the imports from Zealand which will relieve the West Coast cross-section and provide increased system security. The activation of ”production” in Zealand by the s*ystem protection* will be taken, following agreement between the *Parties* concerned, into and out of operation on the basis of the operational situation.

4.4 Sweden: System protection Forsmark

In the event of a stoppage on either of the lines Forsmark-Odensala (FL4) or Tuna-Hagby, the transformer at Tuna risks becoming overloaded if a fault arises on the remaining line.
The *system protection* will go into operation in the event of a stoppage on one of the mentioned lines. The *system protection* will regulate down the production at Forsmark to unload the transformer.
The *system protection* will work as follows:

- In the event of losing Forsmark-Odensala (FL4) or Tuna-Hagby, G12 will be regulated down if Forsmark G11, G12 and G21 or G22 are in operation, and:

- in the event of losing Forsmark-Odensala (FL4) or Tuna-Hagby, G22 will be regulated down if Forsmark G21, G22 and G11 or G12 are in operation.

4.5 Sweden: System protection Långbjörn

Production at Ångermanälven is fed out via transformations at Långbjörn and Betåsen. In the event of losing a transformation, there is a risk that the other will become overloaded. The *system protection* at Långbjörn will disconnect the Långbjörn-Korsselbränna-Stalon line with its connected production when the link between Kilforsen and Långbjörn is broken (400 kV line Kilforsen-Långbjörn + transformer T1 at Långbjörn).

4.6 Norway: System protection in the Hasle and Flesaker cross-section

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 cross-sections by means of automatic *production shedding* at Kvilldal, Sima, Aurland, Tonstad, Tokke and/or Vinje. 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-Skogssäter, Kvilldal-Sylling and Sylling-Tegneby. During these events, the *system protection* has redundancy when measuring high power levels on Hasle-Borgvik, Hasle-Halden, 300 kV Tegneby-Hasle, 300 kV Flesaker-Tegneby and 300 kV Flesaker-Sylling. The *system protection's* setting will depend on the operational situation.

4.7 Norway: System protection in the Nordland cross-section

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 cross-section 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-N.Røssåga.
- High levels of current on 300 kV Tunnsjødal-Verdal, 300 kV Tunnsjødal-Namsos or 300 kV Nea-Järpströmmen.

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 point 4.2.

4.8 Norway: Local system protection at Kvilldal

Automatic *load shedding* at Kvilldal when the loss of a line entails high levels of transmission westbound (towards Saurdal).

4.9 Norway: Network division in southern Norway

Automated systems that establish separate operation for the southern Norway area during simultaneous stoppages on both the links between southern Norway and Sweden.

4.10 Norway: System protection for load shedding

System protection which disconnects up to 220 MW of industrial load in the event of the loss of one or both 300 kV lines in the Sauda cross-section which supplies Bergen and important industrial centres in Vestlandet.
System protection which disconnects 150 MW or 400 MW of industrial load in the event of the loss of one or two 300 kV lines adjacent to Møre or in the event of loss of lines which entails a low voltage or overload on the Nea-Järpströmmen line. The network supplies general consumption and important industrial centres in Nord-Vestlandet.
System protection which disconnects up to 110 MW of industrial load in the event of losing the 420 kV lines north of Ofoten. The *system protection* will prevent overloads in the parallel 132 kV network which might otherwise lead to a collapse in the most northerly part of Norway.

4.11 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 cross-section through automatic downward regulation of the Skagerrak HVDC line. The *system protection* measures overload on the 300 kV lines at 4 stations. The *system protection* regulates 400 MW of exports down on Pole 3 during 1 sec.

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 cross-section through automatic downward regulation of the Skagerrak HVDC line or PFK at Tonstad. The *system protection* measures overload on the 300 kV lines at 3 stations. The *system protection* regulates 300 MW of imports down on Pole 3 during 1 sec and/or regulates production down at the Tonstad power plant (4 x 160 MW available).

4.12 Western Denmark: Konti-Skan pole 2

The *system protection* on Konti-Skan 2 will be activated at a load of over 80 % of the 400 kV transformer at the Nordjylland plant (NVV3+NNV5) (see point 1 in Figure 6). Transmissions on pole 2 will be reduced until the load is once again under 80 % of the transformer (30 MW per sec.).

The *system protection* is used to increase the import capacity from Sweden (load flow).

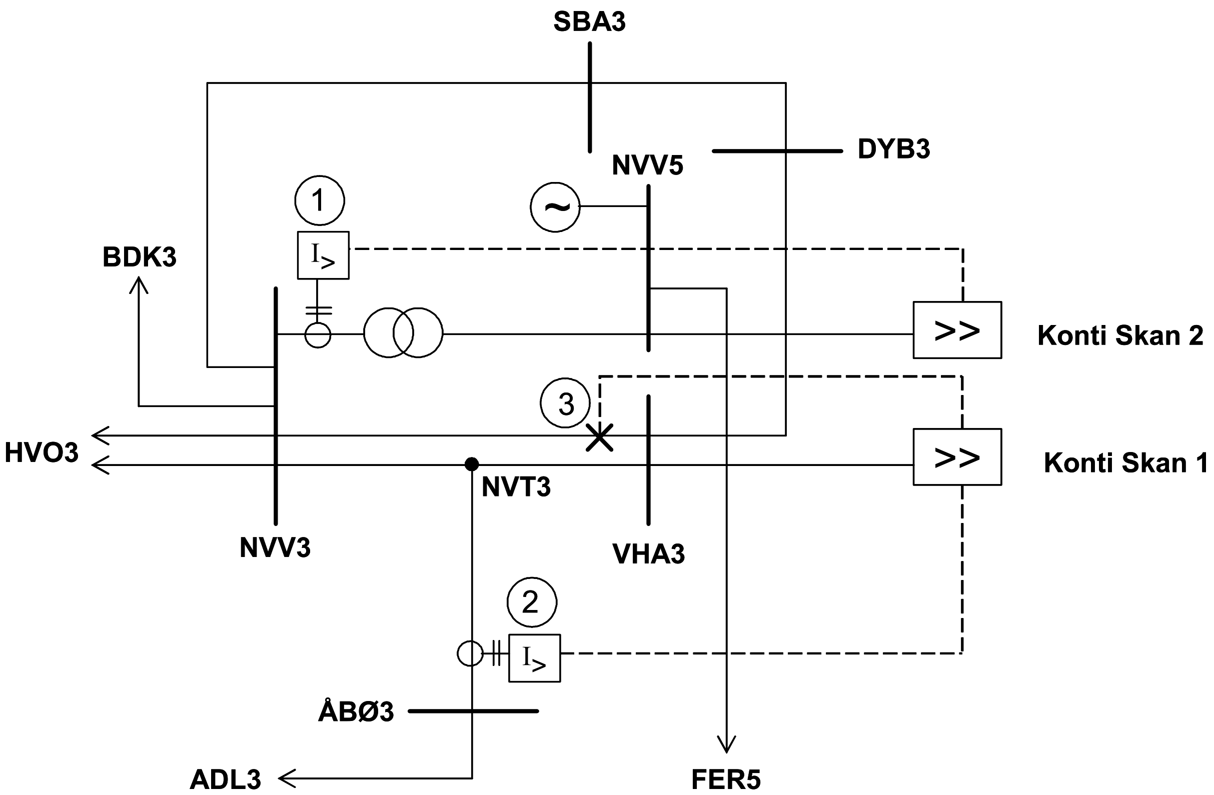

Figure 6 System Protection on Konti-Skan

4.13 Western Denmark: Konti-Skan pole 1 & 2

To safeguard the 150 kV link Ålborg Øst (ÅBØ3) – the Nordjylland plant (NVV3) from dangerous overloads, there is an overload protector at the Ålborg Øst (ÅBØ3) station which disconnects the T-branch (NVT3) - Ålborg Øst (ÅBØ3) during loads of over 150 % for 2-5 minutes. Additionally, the 150 kV line Ådalen (ADL3) - Ålborg Øst (ÅBØ3) is disconnected if the overload exceeds 174 %.

The *system protection* is used to increase the import capacity from Sweden (load flow).

4.14 Western Denmark: Skagerrak pole 3

In the event of a disconnection of the 400 kV line Tjele – Askaer and the 400 kV line Askaer - Revsing - Kassö, imports are reduced from Skagerrak pole 3 to 50 MW.

The *system protection* is not used to increase the import capacity from Norway, only to protect the HVDC station.

4.15 Western Denmark: the German link

In the event of loads on the links to Germany in excess of 120 % for more than 15 seconds, the remote control system will automatically commence downward regulation of the HVDC links.

Regulation will be terminated when transmissions are normal again or when maximum regulation has been reached. The function allows a maximum of 200 MW on Skagerrak poles 1, 2 and 3 as well as 150 MW on each of the Konti-Skan poles.

4.16 Finland: Frequency regulation (during island operation) with automated systems on the HVDC Fenno-Skan link

The *system protection* can be used when the northern AC network between Rauma and Dannebo is broken. This can control the frequency of the potential island network in Finland.

4.17 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.

4.18 Finland: Network division in northern Finland to protect the 110 kV network from overloads

The *system protection* sections the line Vajukoski-Meltaus 110kV when the power on the line is over 100 MW for 0.2 seconds.

4.19 Finland: System protection for avoiding system oscillations

The *system protection* is used to increase the capacity in the north towards Sweden. In certain fault scenarios, with large transmission levels, there is a risk of system oscillations. *System protection* relieves transmissions by means of *production shedding* in southern Finland. *Production shedding* is activated by means of remotely-transmitted signals from activated protection functions. Extent approx. 900 MW. The *system protection* is activated automatically depending on the operational situation. The Power System Centre in Helsinki can put *system protection* into/out of operation using the remote control system, depending on the transmission situation.

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 of the System Operation Agreement

1.1.1 Frequency controlled normal operation reserve

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 UCTE.	
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

Activated automatically at 49.9 Hz and fully activated at 49.5 Hz. At least 50 % shall be regulated out within 5 sec and 100 % within 30 sec. Joint requirement for the *interconnected Nordic power system* is approx 1,000 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 UCTE)
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 sec start-up delay.	Yes

1.1.3 Voltage controlled disturbance reserve

This service 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 DC links south of cross-section 4 in Sweden. SwePol Link, Baltic Cable and Kontek (Zealand).	Yes

1.1.4 Fast active disturbance reserve

This service 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 comes into force.

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. Russian DC link.	Yes Yes Yes
Statnett	Contracted regulating power: Options market for regulating power (production and consumption). Voluntary bids on regulation market.	Yes Yes
Svenska Kraftnät	Requirement for producers to report to SvK, gas turbines and hydropower.	Yes

1.1.5 Slow active disturbance reserve

Requirements 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 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 < 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.	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/under magnetization of production plants. Synchronous condenser operation in one generator. Connection/disconnection of capacitor batteries and reactors.	No
Energinet.dk West	Over/under magnetization of central production plants. Change of Mvar production at power plants. Synchronous condensers at Tjele and Vester Hassing. Connection/disconnection of capacitors. Connection/disconnection of reactors.	No
Fingrid	Over/under magnetization of production plants. Synchronous condenser operation at certain hydropower plants. Connection/disconnection of power lines. Connection/disconnection of capacitor batteries and reactor.	No No No No
Statnett	Over/under magnetization of production plants. Connection/disconnection of power lines. Connection/disconnection of capacitor batteries. Static phase compensation (SVC plants).	No
Svenska Kraftnät	Over/under magnetization of production plants. Connection/disconnection of power lines. Connection/disconnection of capacitor batteries, reactors. Static phase compensation (SVC plants).	No

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

1.2 System services not defined in Appendix 2 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*. This service can be exchanged between the *subsystems*.

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[1]
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[1] Yes[1]
Svenska Kraftnät	Players report production plans with a quarter-hourly resolution to SvK. SvK has the right to move production by at least a quarter of an hour.	Yes[1]

[1]) Quarter hourly regulation improves the quality of the frequency throughout the synchronous system.

1.2.2 System protection

The 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 and/or KONTEK, automatic upward regulation of KONTEK. Specified in App. 5.	No
Energinet.dk West	Emergency power on Kontiskan and Skagerrak. Downward regulation of Kontiskan in the event of an overload on transformers. Downward regulation of Skagerrak 3 upon the loss of some 400 kV lines (downward regulation in respect of voltage quality).	Yes
Fingrid	Automatic production shedding. Network division. Specified in App 5.	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.	Yes

1.2.3 Ramping

Ramping entails a *system operator* designating a facility for complete or partial regulation in step with the HVDC links, when it is being regulated on an HVDC link out from the *synchronous system*. This is a *system service* for improving the quality of the frequency and for allowing major load changes on the HVDC links. This service can be exchanged between the *subsystems*.

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Not used.	
Energinet.dk West	Not used.	
Fingrid	Not used.	
Statnett	Not used.	
Svenska Kraftnät	Not used.	

1.2.4 Black starts

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

TSO	Generation of system service	Exchange between subsystems
Energinet.dk East	Diesel generator and/or gas turbines.	No
Energinet.dk West	2 gas turbines.	No
Fingrid	Some hydropower plants and gas turbines.	No
Statnett	Some selected hydropower plants.	No
Svenska Kraftnät	Some selected hydropower plants.	No

1.2.5 Automatic load shedding

This service 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 App. 5.	No
Energinet.dk West	Load shedding. Link with Germany is not disconnected. Load shedding between 48.7 Hz and 47.7 Hz.	No
Fingrid	Automatic load shedding between 48.7 Hz – 48.3 Hz.	No
Statnett	Automatic load shedding between 49.0 Hz – 47.0 Hz.	No
Svenska Kraftnät	Automatic load shedding between 48.8Hz – 48.0 Hz.	No

1.2.6 Manual load shedding

This service is used during major *operational disturbances* and *power shortages* and cannot be exchanged between the *subsystems*. This is regulated by Appendix 9.

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 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 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.

1.2.7 Fast active forecast reserve

This service 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 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

1.2.8 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

1.2.9 Peak load resource

Requirements 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 will come into force.

TSO	**Generation of system service**	**Exchange between subsystems**
Energinet.dk East	Not used.	
Energinet.dk West	Not used.	
Fingrid	Not used.	
Statnett	Not used.	
Svenska Kraftnät	Being procured.	

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*.

During conversion between the *frequency response*, *frequency controlled normal operation reserve* and *frequency controlled disturbance reserve,* the following conversion table is to be used, unless otherwise agreed:

Frequency response	**Frequency controlled normal operation reserve**	**Frequency controlled disturbance reserve**
10 MW	1 MW	1.5 MW

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*.

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.

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 and Sweden 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	Misc.
Ofoten-Ritsem	400	Ritsem	
N.Rössåga-Gejmån-Ajaure	220	Gejmån, Ajaure	
Nea-Järpströmmen	300	Nea	
Hasle-Borgvik	400	Hasle	Incl. in Hasle cross-section
Halden-Skogssäter	400	Halden	Incl. in Hasle cross-section

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 *trading capacity* of the link is submitted to Nord Pool by Statnett on the Norwegian side and by Fortum on the Swedish side.

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 Nordel 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 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 (DCSO)
N.Rössåga-Gejmån-Ajaure	Regional Centre at Sunndalsöra	Operations Centre at Sollefteå (DCSO)
Nea-Järpströmmen	Regional Centre at Sunndalsöra	Operations Centre at Sollefteå (DCSO)
Hasle-Borgvik	Regional Centre in Oslo	Operations Centre at Råcksta (DCRÅ)
Halden-Skogssäter	Regional Centre in Oslo	Operations Centre at Råcksta (DCRÅ)

3.4 Operations monitoring and control in respect of electrical safety

Same *Parties* as under 3.3.

3.5 Switching schedule

Switchings on the links are carried out in accordance with a switching schedule drawn up by Svenska Kraftnät. Statnett's Regional Centres acknowledge reception.

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 2.1 and 2.2

4.1 Transmission capacity (TTC)

The *transmission capacity* of the links is as follows, in MW.

Line	-20 °C	-10°C	0°C	10°C	20°C	30°C	Total to Sweden	Total to Norway
Sildvik – Tornehamn (to Sweden)	120	120	120	120	120	100	Approx 900-1,300	Approx 700-1,100
Sildvik – Tornehamn (from Sweden)	70	70	70	70	70	70		
Ofoten – Ritsem	1,350	1,350	1,350	1,350	1,170	880		
N.Rössåga - Gejmån –Ajaure	536	496	451	398	334	250		
Nea - Järpströmmen	730	690	650	610	550	500		
Hasle -Borgvik	2,100	2,000	1,900	1,780	1,650	1,510	See below	See below
Halden – Skogssäter	3,070	2,900	2,700	2,490	2,260	2,000		

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

- To Norway in the Hasle cross-section: The *transmission capacity* is dependent on the temperature as follows (at temperatures below 0ºC, 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 cross-section: 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]	3,200	3,300	3,400	3,500	3,600	3,700	3,800	3,900	4,000	4,100
Capacity [MW]	2,200	2,175	2,090	2,000	1,900	1,785	1,700	1,600	1,450	1,250

Oslo load [MW]	4,200	4,300	4,400	4,500	4,600	4,700	4,800	4,900	5,000
Capacity [MW]	1,050	850	650	500	350	200	100	50	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 cross-section 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 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 cross-sections*, which can affect exchanges, are conducted in accordance with the below:

Line	Norway	Sweden
Sildvik-Tornehamn	National Centre in Oslo	Vattenfall Norrnät's Operations Centre at Luleå
Ofoten-Ritsem	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Råcksta
N.Rösssåga-Gejmån-Ajaure	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Råcksta
Nea-Järpströmmen	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Råcksta

Hasle-Borgvik	National Centre in Oslo	SvK's Operations Centre at Råcksta
Halden-Skogssäter	National Centre in Oslo	SvK's Grid Supervisor at Network Control at Råcksta

4.5 Voltage regulation

The basic principle for voltage regulation is governed by item 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 Rösståga	235	240-250	250
Nea	285	285-300	306
Hasle	380	410-415	430
Halden	380	410-415	430

4.5.2 Voltage regulation on the Swedish side

The Operations Centre in Sollefteå (DCSO) is responsible for voltage regulation in the northern parts of the grid, and the Operations Centre in Råcksta (DCRÅ) 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	280	285-295	305
Borgvik	395	400-415	420
Skogssäter	395	400-415	420

4.5.3 Co-ordination of voltage regulation

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

4.6 Outage planning

Svenska Kraftnät shall plan the following in consultation with Statnett:

- Outages or other measures on the Swedish network impacting upon the *transmission capacity* of the links between Sweden and Norway.
- Outages on one of the 400 kV lines between Porjus and Ritsem.
- Outages on the 400 kV line between Midskog and Järpströmmen or the 400/300 kV transformer at Järpströmmen.
- Outages on one of the 220 kV lines between Grundfors and Gejmån or the 400/220 kV transformer at Grundfors.
- Outages causing a major reduction of the *transmission capacity* in cross-sections 1 or 2, or the West Coast cross-section in Sweden.
- Control facility works at Skogssäter, Borgvik, Porjus, Ritsem 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*.

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 and Sweden using DC links. This Appendix describes the operation of the AC links and the Fenno-Skan DC link.

2 Transmission facilities linking the subsystems Sweden – Finland

2.1 Transmission facilities which are owned/held by system operators

Facility	**Voltage level**	**Settlement point:**
Petäjäskoski - Letsi	400 kV AC	Letsi 400 kV
Keminmaa - Svartbyn	400 kV AC	Svartbyn 400 kV
Fenno-Skan	400 kV DC	Dannebo 400 kV
Ossauskoski – Kalix*)	220 kV AC	Kalix 220 kV

*) SvK and Fingrid own the line, Vattenfall Norrnät and Fingrid are responsible for its electrical operation.
The transmissions depend on consumption in the Kalix region. The transmissions are taken into account when determining the trading capacity between Finland and Sweden.

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 Nordel 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, SvK 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 lies at the cable connection point in the terminal at Rihtniemi, Finland.

3.3 Switching responsible operator

Facility	Swedish side	Finnish side
Petäjäskoski – Letsi	Operations Centre at Sollefteå (DCSO)	Tavastehus Network Centre
Keminmaa - Svartbyn	Operations Centre at Sollefteå (DCSO)	Tavastehus Network Centre
Fenno-Skan	Operations Centre at Råcksta (DCRÅ)	Tavastehus Network Centre

3.4 Operations monitoring and control in respect of electrical safety

Operations monitoring and control in Finland are carried out from:

– Tavastehus Network Centre as regards the AC links and Fenno-Skan.

Operations monitoring and control in Sweden are carried out from:

– The Operations Centre at Sollefteå (DCSO) as regards the 400 kV AC links.

– The Operations Centre at Råcksta (DCRÅ) as regards Fenno-Skan.

3.5 Switching schedule

Switchings on the links are carried out 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, the Preparedness plan for fault clearance is used.

4 System operation for facilities under 2.1

4.1 Transmission capacity (TTC)

4.1.1 400 kV AC links

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

Temperature °C	< 20	> 20
Capacity	1,650 MW	1,600 MW

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

Cross-section 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	700 MW	500 MW
From Finland	400 MW	400 MW

4.1.2 Fenno-Skan

The *transmission capacity* of Fenno-Skan is transiently max. 600 MW. The *transmission capacity* of Fenno-Skan is temperature-dependent, the normal value being 550 MW. As the *trading capacity,* a temperature-dependent value is used continuously, normally 550 MW.

4.2 Routines for determining the transmission capacity

The *transmission capacity* between the *subsystems* is set on a daily basis in consultation between the System Operation Centre in Helsinki and SvK's Grid Supervisor at Network Control at Råcksta.

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. Consumption in the Kalix region is taken into account when determining the *trading capacity* between Finland and Sweden. The *trading* c*apacity* of Fenno-Skan is equal to its *transmission capacity*, normally 550 MW. For the *trading capacity,* a weekly forecast is set for the coming week. The forecast is sent to Nord Pool by at the latest the Tuesday of the week before.

4.4 Operations monitoring and control in respect of system operation

Operations monitoring and control in Finland are carried out from:

- The System Operation Centre in Helsinki as regards AC links and Fenno-Skan.

Operations monitoring and control in Sweden are carried out from:

- SvK's Grid Supervisor at Network Control at Råcksta concerning 400 kV AC links and Fenno-Skan.

Regulation of Fenno-Skan is carried out on an alternating basis per half calendar year: the first half by Svenska Kraftnät's Operations Centre at Råcksta and the second half by the System Operation Centre in Helsinki.

4.5 Voltage regulation

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

4.5.1 Voltage regulation on the Swedish side

The Operations Centre in Sollefteå (DCSO) 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
Svartbyn	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 System Operation 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 Svartbyn - 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 parties 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 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. This means that no compensation for loss minimization benefit will be paid out. The *Parties* will only pay for non-notified *balance power*.

During disturbance situations, both *Parties* have the right to regulate Fenno-Skan to support their networks. Fenno-Skan 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's *emergency power* regulation has been activated, this will also be deemed to be a disturbance situation. If the *emergency power* intervention entails *counter trading* requirements for a *Party* not being affected by a disturbance, then Fenno-Skan shall be regulated within 15 minutes to such a value that the *counter trading* requirement ceases.

5 Distribution of capacity utilization 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. 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.

5.1 Basic distribution

Basic distribution is used as a starting point for the distribution of electricity transmissions between northern and southern links. Basic distribution is determined by the proportion between the determined *trading capacity*, at any one given time, of the AC links and Fenno-Skan 1. Basic distribution shall be used if neither loss minimization nor the use of the other *Party's* idle capacity is relevant.

Basic distribution is applied as follows:

- For each hour, the planned cross-border power trade is totalled.
- The power trade is distributed between the northern AC links and Fenno-Skan in accordance with the above basic distribution.
- Elbas and *supportive power* trading across the border are not handled in basic distribution.

If either *Party* needs to limit the AC links or Fenno-Skan due to internal limitations, e.g. cross-sections 1, 2 or P1, the above trading capacity will nevertheless be used for the AC link and Fenno-Skan when calculating basic distribution.

5.2 Loss minimization (Fenno-Skan optimization)

In the event of loss minimization, Fenno-Skan will be regulated in such a way that the transmission losses on the Finnish and Swedish grids are minimized. The benefits thus gained are to be divided equally between Fingrid and SvK through financial reimbursement twice a year.

5.3 Loss minimization model

The model for loss minimization is based upon SvK and Fingrid calculating their network losses as a function of the transmissions on Fenno-Skan. The curves are calculated using the current operating situation and the constant net trade. The curves are sent to the other company and added in order to obtain the minimum point giving a reference value for Fenno-Skan.

The price of energy used in loss minimization shall be *area price* Sweden in Nord Pool Spot's Elspot market. The *Parties* shall specify the prices in SEK. As of the beginning of 2006, the prices shall be specified in EUR.

5.4 Distribution of benefit

The overall benefit to the system during a period of one hour is defined as the positive difference between the calculated overall loss overheads during basic distribution and during the real reference value. Normally, the minimum point is used as the reference value.

The overall benefit shall be distributed in accordance with the 50/50 principle; both *Parties* shall have equal benefit of loss minimization. The distribution of benefit will be as follows: firstly the overall benefit is calculated as set out above. Following this, Fingrid's benefit is calculated as the difference between its loss overheads during basic distribution and during the real reference value. SvK's benefit is calculated the same way. Subsequently, either of the *Parties* compensates the other *Party* to the extent that SvK's benefit increased/decreased by the compensation is the same as Fingrid's benefit increased/decreased by the compensation.

5.5 Utilizing the other party's idle capacity

Both countries have pledged to internally *counter trade* in the event of transmission limitations on their own networks during *normal state*, this applies during the *operational phase*. *Parties* experiencing problems on their networks due to loss minimization have the right to change, free of charge, the power distribution within the range [basic distribution, optimum]. If there are, nevertheless, bottlenecks in one of the networks, the System Operation Centre in Helsinki and SvK's Grid Supervisor at Network Control at Råcksta shall agree upon the redistribution as follows.

5.5.1 Bottlenecks in Fingrid's network

If there are *bottlenecks* in Fingrid's network and there is idle capacity in SvK's network, the System Operation Centre in Helsinki and SvK's Grid Supervisor at Network Control at Råcksta shall agree upon the utilization of SvK's network in order to relieve Fingrid's transmissions. The agreement must feature the following points:

– new reference values for the northern links and Fenno-Skan

– the transit amount=the volume outside the range [basic distribution, optimum].

Afterwards, Fingrid shall compensate SvK for utilizing SvK's capacity. This compensation will be calculated as the product of the transit price and the transit sum. The transit price is, until further notice, set at SEK 30/MWh unless otherwise agreed between the parties. The transit price shall, however, be adjusted by the parties for each commencing period of two (2) calendar years.

5.5.2 Bottlenecks in SvK's network

If there are *bottlenecks* in SvK's network and there is idle capacity in Fingrid's network, the System Operation Centre in Helsinki and SvK's Grid Supervisor at Network Control at Råcksta shall agree upon the utilization of Fingrid's network in order to relieve SvK's transmissions. The agreement must feature the following points:

– new reference values for the northern links and Fenno-Skan

– the transit amount=the volume outside the range [basic distribution, optimum].

Afterwards, SvK shall compensate Fingrid for utilizing Fingrid's capacity. This compensation will be calculated as the product of the transit price and the transit amount. The transit price is, until further notice, set at SEK 30/MWh unless otherwise agreed between the parties. The transit price shall, however, be adjusted by the parties for each commencing period of two (2) calendar years.

5.5.3 Bottlenecks in both parties' networks

If both parties are experiencing *bottleneck* situations simultaneously, the net trade shall be distributed between the links as in basic distribution. But if the *counter trading* overheads in the parties' networks differ greatly and the control rooms agree upon cost distribution, another type of power distribution can be used.

5.6 Settlement of loss minimization

The compensation of loss minimisation takes place twice a year, at the beginning of January and at the beginning of July, if the parties do not agree upon another procedure. Fingrid makes out the invoice if the parties do not agree otherwise.

The compensation of the use of the other party's idle capacity also takes place twice a year at the same time with loss minimisation compensation.

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 and Sweden 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's Elspot market 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 kV**	**Settlement point**
Ivalo-Varangerbotn	220 kV AC	Varangerbotn

3 Electrical safety for facilities under 2

3.1 General

The common ground for the electrical safety work of the *system operator* companies within Nordel 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	Tavastehus Network Centre

3.4 Operations monitoring and control in respect of electrical safety

In accordance with 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 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 2

4.1 Transmission capacity (TTC)

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

The exchange of *supportive power* is agreed upon on each separate occasion between Statnett and Svenska Kraftnät and between Fingrid and Svenska Kraftnät.

Statnett manages the transmissions on the *cross-border link* by redistributing production and sectioning in Norway so that the *transmission capacity* is not exceeded. Fingrid confirms the daily *transmission capacity*.

4.3 Trading capacity (NTC)

The *trading capacity* is included in the trading scope of Nord Pool's Elspot market 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 item 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 conjunction with Fingrid's System Operation Centre in Helsinki/Uleåborg Regional Centre and Statnett's National Centre in Oslo/Operation 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

Settlement of power exchanges between Norway and Finland shall be carried out in accordance wit the following principles:

- Power exchanges via the Ivalo - Varangerbotn line shall, for Statnett's part, be included in the total exchanges between Statnett and Svenska Kraftnät.
- Power exchanges via the Ivalo - Varangerbotn line shall, for Fingrid's part, be included in the total exchanges between Fingrid and Svenska Kraftnät.

Settlement is carried out in accordance with separate bilateral agreements between Statnett and Svenska Kraftnät, and between Fingrid and Svenska Kraftnät.

5.2 Information exchange

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

JOINT OPERATION BETWEEN THE NORWEGIAN AND WESTERN DANISH SUBSYSTEMS ON THE DC LINKS SKAGERRAK POLES 1, 2 AND 3

1 Background

The *subsystems* of Norway, Sweden, Finland and Eastern Denmark are synchronously interconnected. The *subsystem* of Western Denmark is connected to Norway and Sweden 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	Kristiansand 300 kV DC
SK3	350 kV DC	Kristiansand 300 kV DC

Together, SK1, SK2 and SK3 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 Nordel 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.

The *power operation responsibility boundaries* for the links lie on the Danish side of the submarine cable at Bulbjerg in Jutland.

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 despatched, between Statnett's Regional 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 room at Skærbæk, 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 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 room at Skærbæk and from Statnett's Regional 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 rooms at Skærbæk or Tjele.

Operation monitoring and control in Norway is carried out from:

- Statnett's Regional Centre in Oslo.
- The three poles 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 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 (TTC)

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

SK1, SK2:	Techn. min 10 MW/pole	Nominal (500 + 40) MW
SK3:	Techn. min 13 MW	Nominal 500 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 room at Skærbæk 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* in "bipolar operation":
950 MW from Western Denmark to Norway
1,000 MW from Norway to Western Denmark
The above applies when Kristiansand is the exchange point (50 MW of losses).

The following calendar day's *trading capacity* is decided each 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 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 room at Skærbæk.

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

The three poles can be operated individually.

4.4.1 The power flow and distribution between the poles

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.

To minimize losses and electrode currents, the following shall be aimed at during resulting exchanges:

> ≥ 75 MW for > 2 hours, the power is distributed at 42 % on SK1, 2 and 58 % on SK3. Also applies during ”monopole operation”.
>
> < 75 MW, SK3 is used alone.

During special operational circumstances, other types of operation can be agreed upon.

4.4.2 Regulating the link

Regulation of the Skagerrak link in accordance with agreed *exchange plans* will be carried out, until further notice, from the Danish side. Energinet.dk’s control room at Skærbæk is responsible for its own *balance regulation* towards Norway. Regulation is carried out, 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 value. 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.

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 room at Skærbæk 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 System services

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

The *regulation margin* is maintained following the agreement between the *Parties* taking into account the exchange of system services. 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.

5.2 Settlement

Energinet.dk manages balance settlement.

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 and Sweden 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 under 2

3.1 General

The common ground for the electrical safety work of the *system operator* companies within Nordel 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

During work between Lindome and XL1-F at Läsö Öst or Lindome and XL2-F at Läsö Öst, the Operations Centre at Råcksta (DCRÅ) 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 Operations Centre at Skærbæk or Vester Hassing and the Operation Centres at Råcksta (DCRÅ).

- 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

Switchings on the links are carried out in accordance with switching schedules drawn up by Svenska Kraftnät. Energinet.dk’s Operations Centre at Skærbæk acknowledges receipt.

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 Operations Centre at Skærbæk 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 under 2

4.1 Transmission capacity (TTC)

The *transmission capacity* 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 Operations Centre at Skærbæk 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* after the modernisation of the 400 kV line Nordjyllandsværket - Vester Hassing, scheduled to be commissioned in 2007, is:

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

Until then, the normal trading capacity is:

500 MW from Western Denmark → Sweden
620 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 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 Operations Centre at Skærbæk and Svenska Kraftnät's Grid Supervisor at Network Control at Råcksta.

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 Operations Centre at Skærbæk 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 energy and power plan agreements which form the basis for utilizing the Konti-Skan link.

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 Operations Centre at Skærbæk.

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 Operations Centre at Skærbæk 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*. Svenska Kraftnät can give Vattenfall Regionnät AB the right to initiate the *operational reserve* during disturbances on the regional network in western Sweden.

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 occur between the control room staff of Energinet.dk's Operations Centre at Skærbæk and Svenska Kraftnät's Grid Supervisor at Network Control at Råcksta.

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 *regulation margin* is maintained following the agreement between the *Parties* taking into account the exchange of *system services*. 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.

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 and Sweden 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
Gørløse - Söderåsen (FL23)	400 kV	Gørløse

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 Sydkraft and Østkraft.

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 Nordel 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

The *power operation manager* for the 400 kV Öresund links on the Swedish side is Svenska Kraftnät’s Operations Centre at Råcksta (DCRÅ), and the switching leader on the Danish side is Energinet.dk’s Control Centre at Ballerup.

Switchings on the links take place after agreement between Svenska Kraftnät's Operations Centre at Råcksta (DCRÅ) and Energinet.dk's Control Centre at Ballerup.

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 Ballerup and on the Swedish side by Svenska Kraftnät's Operations Centre at Råcksta (DCRÅ).

Both *parties'* switching responsible operators/switching leaders have access to status indications and electronic measured values via remote control from each others' 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's Outage Planning at Råcksta. Energinet.dk's Control Centre at Ballerup shall acknowledge the receipt of order.

The *parties* shall exchange switching confirmations in accordance with the operational orders/switching schedule before the work begins and after the work is complete.

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 Room at Ballerup and Svenska Kraftnät's Operations Centre at Råcksta (DCRÅ) 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 Råcksta (DCRÅ).

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

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. A special preparedness plan has been drawn up for fault finding and repair for submarine cables.

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 (TTC)

4.1.1 Transmission capacity in MW per cable bundle

Line	5 °C	15-20 °C	30 °C
Hovegaard – Söderåsen	830	830	830
Gørløse – Söderåsen	830	830	830
Teglstrupgaard 1 – Mörarp	182	182	154
Teglstrupgaard 2 – Mörarp	173	173	157
Hasle, Bornholm - Borrby,	51	51	51

4.1.2 Transmission capacity in MW per link

– To Eastern Denmark

Link	Capacity
Öresund (Zealand)	1,350
Bornholm	51

– To Sweden (thermal limitation)

Link	Capacity
Öresund (Zealand)	1,750
Bornholm	51

The *transmission capacities* 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 (NTC)

Determination of the capacity is based on the combined *transmission capacity* of the 400, 130, and 60 kV *transmission facilities*. When determining the *trading capacity* 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 cross-sections, which can affect exchanges, is managed on the Danish side by Energinet.dk's Control Centre at Ballerup and on the Swedish side by Svenska Kraftnät's Network Control Centre at Råcksta (SvK-vhi).

4.5 Voltage regulation

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

4.5.1 Voltage regulation on the Swedish side

The Operations Centre in Råcksta (DCRÅ) 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 Ballerup 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
Gørløse	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 Ballerup and Svenska Kraftnät's Outage Planning at Råcksta.

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 cross-section 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 Ballerup 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 Ballerup 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 cross-section 4

Own fault = largest fault in own area south of cross-section 4

Counterparty fault = largest fault in counterparty's area south of cross-section 4

In Sweden, south of cross-section 4, the largest fault is typically the result of:

- Network part of cross-section 4
- Baltic Cable
- SwePol Link.

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

- Unit at the Avedøre or Asnæs plants
- KONTEK.

5.4 Counter trading

Energinet.dk's Control Centre at Ballerup can agree with Svenska Kraftnät on *counter trade* in Sweden to increase the *trading capacity* between Sweden and Eastern Denmark. Energinet.dk shall in this context compensate all of Svenska Kraftnät's costs in respect of this *counter trading*.

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
Hasle-Borgvik	400 kV AC	Included in Hasle cross-section
Halden-Skogssäter	400 kV AC	Included in Hasle cross-section
Stenkullen-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 utilizes the *trading capacity* which the *system operators* have set in order to try to avoid price differences between the *Elspot areas*.

Energinet.dk's Control Centre at Skærbæk sets a *trading capacity* to and from the *Elspot area* in Western Denmark which can entail a limitation of the *trading capacity* between the *Elspot areas* Western Denmark - Norway and Western Denmark - Sweden. 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 and the rest of the Nordic *subsystem* will not be changed more than 600 MW from one hour to the next (this applies to the overall net regulation between Western Denmark and Sweden/Norway as well as per single 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 Skærbæk 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 and minimising network losses in the triangular link. Energinet.dk's Control Centre at Skærbæk is responsible for the plans meeting the stipulated requirements.

The *UCTE* 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 *UCTE* 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 (triangular trading) 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 cross-section. Statnett has a co-ordinating function. Triangular trading requires the approval of all three *Parties*.

Energinet.dk's Control Centre at Skærbæk 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*.

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*.

For the *transmission capacity* of the *cross-border links* between *Elspot areas*, the same prioritization rules are to be applied by all *system operators* in the *subsystems*. See table below.

Priority		Sweden	Finland	Norway	Eastern Denmark	Western Denmark
1	Elspot	X	X	X	X	X
2	Elbas	X	X		X	
3	Balance power/ Supportive power	X	X	X	X	X

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

2.1 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*.

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

2.3 In the event of transmission limitations within an *Elspot 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

3.1 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 trade on Elspot 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.

3.2 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 *sybsystems*.

3.3 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*.

3.4 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.

4 Step by step of the trading capacity

During major changes to the *transmission capacity* between two *Elspot areas,* this can entail major changes in power flows from one hour to the next. These major changes can be difficult to manage regulation-wise. Thus, restrictions are placed on changes to *trading capacities*, MWh/h, from one hour to the next. This change may be a maximum of 600 MWh/h, unless otherwise agreed.

RULES FOR MANAGING POWER SHORTAGES DURING HIGH CONSUMPTION, BOTTLENECKS OR DISTURBANCES

Introduction

These rules describe how the *system operators* of the *interconnected Nordic power system* shall jointly manage possible *power shortages.* This shall be carried out with a level of *system security* which is as high as possible.

Extracts from Appendix 1 Definitions:

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*. 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* like Finland-Russia, Norway-Russia, the SwePol Link, Baltic Cable, Kontek and Western Denmark-Germany are not to be included in the calculation.)

A risk of power shortage defines the state when forecasts show that a *subsystem* is no longer capable of maintaining the demand for a *manual active reserve,* which can be activated within 15 minutes, for the planning period.

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

Prerequisites

- Each *subsystem* is responsible for its own balance and for the requirements for automatic and manual reserves being fulfilled.

- All regulation resources shall exist as *regulation bids* on the joint Nordic *regulation list*. This concerns both market-based bids and *manual active reserve* (15 min).

- *System operators* inform each other on a continuous basis.

- A *subsystem* with a physical surplus does not need to carry out *load shedding* to the benefit of *subsystems* with a deficit.

- The need for *manual active reserve* (15 min) in each *subsystem* shall normally be equal to or greater than the *dimensioning faults* in each *subsystem.*

- When *power shortages* or *critical power shortages* exist, the *manual active reserve* (15 min) is reduced to less than the normal level.
  The *manual active reserve* (15 min), however, must not fall short of 600 MW, in total, in the *synchronous system.*

- The physical *transmission capacities* of the network shall be maintained and a frequency which does not drop below 50.0 Hz shall be aimed at.

- Each *system operator* formulates instructions which comply with this set of rules. The content of the instructions is co-ordinated between the *system operators*.

1 General power shortages without bottlenecks in the network

1.1 Maintenance of manual active reserve (15 min)

- When a *subsystem* in normal *balance regulation* is approaching the limit of keeping the *manual active reserve* (15 min) in its own *subsystem* for its *dimensioning faults*, the control centres of the other *system operators* shall be informed. This shall also be done even if there is a surplus in the *subsystem*. This information shall be delivered by e-mail and by telephone as early as possible.

- The *system operators* concerned assess whether the *manual active reserve* (15 min) in their own *subsystem* can also be used for upward regulation purposes in normal balance regulation. This means that the *subsystem* will not have sufficient own reserves to cover the need for *manual active reserve* (15 min).

- If further *upward regulation* is needed, 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* (15 min). “Available” means that resources can be activated for this purpose and that there is sufficient *transmission capacity*.

- If there are available market-based upward regulation bids, the parties can agree on maintaining part of the need for *manual active reserve* (15 min) in another *subsystem*. In this case, upward regulation can take place in price order in the joint Nordic *regulation list*.

- In further upward regulation in price order, the *subsystem* can maintain parts of its *manual active reserve* (15 min) continuously. The *system operator* of the *subsystem* shall specify the volume and composition of this reserve on the basis of the current operational situation.

- If there are not available market-based upward regulation bids in the neighbouring systems to cover the *subsystem*'s deficit of *manual active reserve* (15 min), a *power shortage* generally takes place in accordance with item 1.3.

1.2 Risk of power shortages

- The *system operator* shall inform the other *Parties* as quickly as possible. The measures in question will be taken in order to avoid an unacceptable reduction of the *system security*.

- Whenever required, the market *players* shall be informed via UMM as soon as possible. The information shall also be delivered directly from the *system operators* to the other P*arties*.

- At least 600 MW of the most expensive *manual active reserve* (15 min) *in the regulation list* will be earmarked for each hour. Unavailable *regulation bids* will be marked on the joint *regulation list*. When there is a potential risk of *bottlenecks* arising, the reserve is to be distributed in consultation between the *Parties*.

- The starting of *slow active disturbance reserve* and *peak load reserve* will be assessed. The other *system operators* will be informed on plans to start the reserve. The costs of starting the reserve in order to keep it in readiness are considered as *special regulation*.

1.3 Power shortages

- When a *subsystem* is no longer capable of meeting the requirement for *manual active reserve* (15 min) and there are not sufficient available market-based *regulation bids* in the neighbouring systems, the other *system operators* are to be informed as quickly as possible

- Prearranged trading between *players* is fixed and cannot be changed.

- Svenska Kraftnät and/or Fingrid can demand that cross-border trading on Elbas between Sweden and Finland ceases, and Svenska Kraftnät and/or Energinet.dk can demand that cross-border trading on Elbas between Sweden and Eastern Denmark ceases.

- When there is a requirement for upward regulation, bids on the *regulation list* are to be used in the order of price unless the *regulating power* will lead to *bottlenecks* in the *transmission network* or will be unavailable for other reasons. Market-based bids are used before *fast active disturbance reserve.* The earmarked *manual active reserve* will not, however, be activated until all of the remaining *regulation list* has been activated. When unexpected *bottlenecks* arise, the earmarked reserve can be redistributed.

1.4 Critical power shortages

- When a *critical power shortage* is approaching, preparations for manual *load shedding* (15 min) will be ordered in the *deficit areas*. The *Parties* will agree on the *subsystem(s)* where the *load shedding* will take place and where in the *subsystem(s)* the *load shedding* will take place. The consequences for load shift must be assessed.

- If no network problems arise, bids in the *regulation list* will be used until only 600 MW of *manual active reserve* (15 min) remains in the *synchronous system*. The activation of *regulation bids* shall take place in price order, and if frequency regulation so requires, all market-based bids shall be activated before the *fast disturbance reserve*.

- When only 600 MW of *manual active reserve* (15 min) remains in the *synchronous system*, it will be activated and retained as increased *frequency controlled normal operation reserve*. The activated reserve of at least 600 MW will be redistributed among rapidly regulating hydropower production in consultation between the *Parties.* The most expensive available upward regulation bid in hydropower production shall be deactivated. Bids with a low volume can be skipped in order to facilitate their handling. If there are no upward regulation bids, the downward regulations will be activated in price order. SvK and Statnett are responsible for and co-ordinate this.

- At the same time, *load shedding* will be ordered without a commercial agreement. The expected activation time for *load shedding* has to be weighed into the decision. *Load shedding* occurs in the *subsystem* with the greatest physical deficit in its balance. Shedding occurs in stages until the requirement for 600 MW of *manual active reserve* (15 min) in the *synchronous system* is met. When *load shedding* has taken place until two or more *subsystems* have an equally large deficit, *load shedding* is distributed thereafter between these *subsystems*. Attention must be paid to the practical handling; *load shedding* in stages of 200 – 300 MW at a time is considered a suitable level.

- When assessing a *subsystem's* balance, the *manual active reserve* (15 min) that is not activated must be taken into account. A *subsystem* with a physical deficit which can regulate itself into balance does not need to implement *load shedding.*

- The *system operator* that carries out *load shedding* shall inform the market and the other *system operators* of *critical power shortage*.

2 Regional power shortages caused by bottlenecks or network disturbances

- The relevant *subsystem* is responsible for measures as long as regulation resources are available.

- If time allows, preparations for *manual load shedding* (15 min) will be ordered in the *deficit areas*.

- If a *bottleneck* arises within a *subsystem* towards a area with a deficit and all available bids in the merit order *regulation list* that are without sufficient *manual active reserve* (15 min) within the area are activated, then *load shedding* will be ordered outside the merit order *regulation list*. *Load shedding* will be carried out in the *subsystem* with the greatest physical deficit in its balance and which remedies the *bottleneck.*

- When assessing a *subsystem's* balance, the *manual active reserve* (15 min) which is not activated must be taken into account. A *subsystem* with a physical deficit which can regulate itself into balance does not need to implement *load shedding.*

- If there are stable consumption conditions, the need for *manual active reserve* (15 min) within the *deficit area* will be less than if consumption had been rising. However, *manual active reserve* (15 min) must not fall short of 600 MW in the *synchronous system*.

3 Connection of consumption following load shedding

- When the power balance within the *deficit area* improves, consumption will be reconnected in small steps. The potential for increased consumption as a consequence of shedding must be taken into account.

4 Pricing

The pricing of *supportive power* and *balance power* shall be set in accordance with normal principles. Normally, no *supportive power* shall be agreed upon, instead the power will be exchanged as *balance power*. In the event of price disputes, the setting of prices shall take place afterwards. The correction of irregularities in the pricing can be achieved by means of subsequently reaching agreement about *supportive power*.

THE INTERCONNECTED NORDIC POWER SYSTEM'S JOINT OPERATION WITH OTHER SYSTEMS

1 Western Denmark's joint operation with the UCTE 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 *UCTE* system. Energinet.dk has been a part of E.ON Netz' *balance area*, thus meeting the formal *UCTE* requirements. Irrespective of this, Energinet.dk shall comply with all the requirements set by *UCTE*. Effective 25 October 2001, Energinet.dk is formally an associated member of *UCTE*.

Energinet.dk's relationship with E.ON Netz is such that it does not have a formal system operation agreement with E.ON Netz, 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 E.ON Netz

Energinet.dk is connected to E.ON Netz via the following links:

- 220 kV Kassø – Flensborg, *settlement point* Kassø
- 220 kV Ensted – Flensborg, *settlement point* Ensted
- 2 st 400 kV Kassø – Audorf, *settlement point* Kassø.

The *transmission capacity* is normally 1,200 MW in both directions. Taking into account faults at major production facilities, the *transmission capacity* northbound is 800 MW, in relation to planning.

Energinet.dk and E.ON Netz are discussing a system operation agreement. Irrespective of this agreement, Energinet.dk must comply with the following *UCTE* requirements:

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

- The network-regulating function on the Danish-German border

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

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

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

- The *load shedding* is co-ordinated.

The ramping requirement for exchanges with E.ON Netz 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 the Energinet.dk and E.ON Netz 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.

- Every day, the remaining part 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 day before the day of operation. Utilization of the capacity is not compulsory.

There are formal requirements for the traders to comply with in order to be able to take part in the auction.

1.2 Western Denmark's joint operation with Flensborg

Since the beginning of the 1920's, Stadtwerke Flensborg (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 Flensborg 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 SWG

Stadtwerke Flensborg is connected to Energinet.dk via the following links:
- 150 kV Ensted – Flensborg, settlement point Ensted
- 60 kV links between Kruså and Flensborg.

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

SWF has the opportunity to carry out exchanges with Slesvig via the 60kV 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 Flensborg 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 E.ON Netz today.

2 The synchronous system's joint operation with the UCTE 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. Co-owners are E.ON Sverige and Statkraft Europa.

The capacity is 600 MW.

2.1.1 System operation collaboration with E.ON Netz

There is no system operation agreement. The *system services* that exist have been produced vis-à-vis E.ON Sverige. 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

The link is used today for *Elspot trading*. The utilization fees are regulated by means of a tariff. Idle capacity permitting, there are opportunities for Svenska Kraftnät to do *supportive power* deals via E.ON Sverige.

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. Vattenfall Europe Transmission 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:
550 MW is made available to Nord Pool Spot for *Elspot trading* until the middle of 2006.
50 MW is utilized for the *frequency controlled disturbance reserve*.

Northbound:
550 MW is made available to Nord Pool Spot for *Elspot trading* until the middle of 2006.
50 MW is utilized for the *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. SwePol Link AB owns the cable link. The owners are:

Svenska Kraftnät
Vattenfall AB
Polish Power Grid Company (PPGC)

The capacity is 600 MW.
The *system operator* on the Polish side is Polskie Sieci Elektroenergetyczne (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
- *Emergency power functions*
- Exchanges of *trading plans*.

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

2.3.2 Commercial conditions

SwePol Link AB is a transmission company that sells *transmission capacity* on the link. The utilization fees are regulated by means of a tariff. Today, the bulk of the link's capacity is being utilized via a long-term agreement. A minor part of the capacity remains unutilized. Idle capacity permitting, there are opportunities for the respective *system operator* to do *supportive power* deals.

3 The synchronous system's joint operation with Russia

Electricity imports from Russia began in 1960. There was a significant increase in imports at the beginning of the 1980's, when the HVDC stations at Viborg and the double 400 kV lines were commissioned. The third 400 kV line went into commercial operation at the beginning of 2003.

3.1 System operation collaboration with RAO UES of Russia

The Finnish grid is connected with Russia via three 400 kV lines from Viborg (Russia) to Yllikkälä and Kymi (both Finland). The technical *transmission capacity* is 1,400 MW. Transmissions take place via the HVDC stations at Viborg and from a 450 MW gas-fired power plant which is in isolated operation, i.e. synchronised with the *synchronous system*. In addition to this, there are two 110 kV links owned by private regional network companies.

Fingrid and RAO UES of Russia signed a system operation agreement on 6 February 2003, which regulates operational and technical relations between the power systems. Nordel's recommendations and requirements have been taken into account.

3.2 Commercial conditions

For technical and commercial reasons, trading via the link only occurs from Russia to Finland. The *trading capacity* is 1,300 MW.

The transmission service is based upon a firm fixed-period transmission. The minimum period for a transmission reservation is one year while the longest is three years. The smallest volume for individual *players* is 50 MW.

The daily hourly transmission programme is agreed upon on a daily basis and imports are managed as a firm delivery in the balance settlement. Fingrid carries the balance responsibility for the delivery.

Fingrid and RAO UES of Russia have agreed that the link and the HVDC stations at Viborg may also be used for technical requirements. 100 MW has been reserved for this purpose. The link is used for frequency regulation and can also be used for *fast active disturbance reserve*.

The following documents have been included in this chapter:

Document	*Status*
Nordel's connection requirements to be met by thermal production plants (Operational performance specifications for thermal power units larger than 100 MW and Operational performance specifications for thermal power units smaller than 100 MW), 1995	*Recommendations*
Dimensioning practice in the Nordic countries, Nordel's system committee, 1998	*Descriptive*
Nordel Connection Code Wind Turbines, November 2006, Edited by the ad-hoc group Jan Havsager Energinet.dk, Inge Vognild Statnett, Matti Lahtinen Fingrid, Erik Thunberg Svenska Kraftnät and Fredrik Norlund Svenska Kraftnät	*Recommendations*

The following national documents deal with the Connection Code:

Document	*Status*
Electrical quality: The working group has attempted to bring together the regulations of the different countries. Not complete.	*Varying: Guidelines (Sweden, Finland, Norway)*
Production: The working group has attempted to upgrade Nordel's recommendation for thermal power plants to apply to all types of power plant, on the basis of national regulations:	
Sweden: Technical design of power plants regarding reliability (SvKFS 2005:2 Affärsverket svenska kraftnäts föreskrifter och almänna råd om driftsäkerhetsteknisk utformning av produktionsanläggningar)	*Binding regulation (according to delegation in law)*
Norway: Regulations for hydro power	*Guidelines*
Finland: General Connection Terms of Fingrid Oyj's Grid, Specifications for the Operational Performance of Power Plants, Power Quality in Fingrid's 110 kV grid	*Binding requirements and recommendations*
Denmark: *Technical Regulations of Thermal Power Station Units of 1,5 MW or above (July 2006)* *Technical Regulations of Thermal Power Station Units below 1,5 MW (work in progress)* *Requirements to be met by wind power installations connected above 100 kV (December 2004)* *Rules for regulation units (work in progress)*	*Binding requirements*
Upgrading not complete.	

CONNECTION CODE

1 Introduction

The purpose is to lay down certain basic rules for connection to the transmission system on non-discriminating terms. There are national requirements which shall be taken into account in the first place.

The connection conditions specify requirements for minimum technical requirements to ensure security of operation in the Nordic electric power system. The connection conditions lay down the lowest technical requirements that a plant must satisfy to have access to the grid, and the lowest technical requirements to be met by a plant that may be important to the operational reliability of the Nordic electric power system. The respective TSOs lay down national requirements. They should be based on minimum requirements laid down in this Connection Code, but may be stricter.

The Connection Code applies to new installations or to the reconstruction of existing installations. Existing installations must retain the properties they had when they were connected to the grid.

2 Connection to the grid

2.1 Electrical quality (in systems of 110 kV and above)

This section has been written with national requirements in mind.

2.1.1 Frequency

The nominal frequency is 50 Hz. Under normal operating conditions (synchronous operation of the Nordic grid) the frequency will typically remain within the range 49.9 to 50.1 Hz. However, larger frequency deviations may occur during operational disturbances. See Section 4.1.2 of the System Operation Agreement, appendix 2.

2.1.2 Voltages and slow voltage variations

The nominal voltages between the phases (UN) and the corresponding minimum insulation levels for the equipment (the insulation levels are normally lower for power lines) are shown in the table below:

Nominal voltage or rated voltage	Used for transmission in	Highest operating voltage on equipment	Withstand voltage for lightning surge (LIWL)	Withstand voltage for switching surge (SIWL)	50 Hz, 1 min withstand voltage
110	Finland	123	550	-	230
132	Denmark, Norway	145 [1)]	650	-	275
150	Denmark	170	750	-	325
220	Denmark, Finland, Sweden	245	950	-	395
300	Norway	300	1050	850	-
400	Denmark, Finland, Norway, Sweden	420	1425 1350 (DEN West)	1050	-

[1)] Isolation level. Highest operating voltage is 138 kV according to thermal dimensioning of transformer core, 105% of rated voltage due to induction.

The lowest operating voltages at each voltage level are highly dependent on the local conditions. The lowest values are reached during operational disturbances and are usually not lower than 90 % of the nominal voltage.

2.1.3 Rapid voltage variations

During normal operating conditions, a rapid voltage variation does not typically exceed 5 % of the nominal voltage.

A rapid voltage variation due to a single regulation or switching action must not generally exceed 3 % of the nominal voltage. However, the value must be lower if the action is constantly repeated, e.g. several times a day (the exact requirement depends on the local conditions).

Comment: A rapid voltage variation that causes a voltage, which falls below 90 % of the pre-existing voltage, is regarded as a voltage dip.

Rapid periodic voltage variations are known as flicker and the severity of these must be measured with special instruments. The aim is to keep the measured value for short-term flicker (Pst) below 1.0 and the measured value for long-term flicker (Plt) below 0.8. The limit values apply to 95 % of all measured values during a period of one week. Permitted flicker due to only one connecting party is usually lower than these values but is highly dependent on local conditions.

2.1.4 Voltage dips

A voltage reduction with duration of 10 ms to 1 minute and a voltage drop of more than 10 % of the existing value is known as a voltage dip. There are no standard requirements for the severity or extent of voltage dips since they are highly dependent on the grid structure, weather conditions, etc. Most voltage dips are caused by earthing faults. Whether or not such voltage dips are transferred to lower voltages depends on which earthing methods are used and on the transformer connections. The voltage dips may often become deeper and may also spread to larger parts of the grid if faults occur in more than one phase, but this is relatively rare. The duration of a voltage dip is highly dependent on the type of fault concerned and on which relay protection methods are used locally.

2.1.5 Outages

At outages, the voltage at the customer's connection point is below 1 % of the nominal voltage. Outages can be divided into planned outages (customers are informed beforehand) and outages due to operational disturbances. The negative effects of outages differ greatly between the two cases. There are no standards with defined limit values for outages.

2.1.6 Overvoltages

Temporary overvoltages

Earth faults are the most common cause of temporary overvoltages. During the fault, the voltage in normal phases rises. The voltage may rise up to 1.8 times the rated voltage, depending on the earthing method used in the grid. In practice, however, the voltage is usually kept to a lower level.

Switching and lightning overvoltages

Switching-in of shunt capacitors and auto-reclosure of lines are the most common causes of switching overvoltages. During switching of a capacitor, the voltages between phase and earth may, depending on the earthing method used, reach values up to 1.8 times the peak value of the phase voltage (1.8 p.u.). Switching of lines, especially rapid automatic reclosure of lines, may cause high over voltages, up to 3 p.u. However, the probability of such high values is low. Overvoltages on the overhead lines of the grid due to atmospheric phenomena are largely limited by the dielectric strength of the lines and the overvoltage protection of the transformer stations. Because of these factors, it may largely be assumed that the over voltages will be limited to a level of 5-6 p.u.

2.1.7 Voltage imbalance

Depending on local conditions, the average measured values for 10 minutes for the phase component of a three-phase system with negative sequence must be below 1-2 % of the phase component with positive sequence for 95 % of the time over a measuring period of one week. In Sweden and Norway a limit value of 1 % is used. 2 % is used on the Finnish 110 kV grid.

2.1.8 Voltage harmonics

The figures in Table 1 must not be exceeded for voltages with harmonics. This means that 99 % of the average values for a period of 10 minutes over a measuring period of one week must be below the limit values. NOTE: The limit values differ between the countries.

PLANNING LEVELS FOR HARMONIC VOLTAGES As a percentage of the nominal voltage											
Odd				Odd				Even			
Multiples other than 3				Multiples of 3							
n	F	N	S	n	F	N	S	n	F	N	S
	%	%	%		%	%	%		%	%	%
5	3.0	2.0	2.5	3	3.0	2.0	2.0	2	1.0	1.5	1.0
7	2.5	2.0	2.5	9	1.5	1.0	1.0	4	0.7	1.0	1.0
11	1.7	1.5	1.5	15	0.5	0.3	0.6	6	0.5	0.5	0.5
13	1.7	1.5	1.5	21	0.5	0.2	0.4	8	0.3	0.2	0.5
17	1.5	1.0	1.0	>21	0.3	0.2	0.4	10		0.2	0.4
19	1.5	1.0	1.0					12		0.2	0.4
23	0.8	0.7	0.7					>12		0.2	0.2
25	0.8	0.7	0.7								
>25	0.5	0.2+ 0.5* 25/n	0.2+ 0.5* 25/n								
Total harmonic distortion (THD) for the voltage < 3% (F and N), < 4% (S)											

Table 1 (F = Finland, N = Norway, S = Sweden)

2.1.9 Voltages with intermediate harmonics

Voltages that contain intermediate harmonics are usually far lower than voltages with full harmonics. So far, there are no standards that lay down limit values for systems above 110 kV, but 0.2 % (of the nominal voltage) is used in Norway and 0.5 % in Sweden. Voltages and intermediate harmonics are generated by arc furnaces, welding equipment and fast frequency converters.

2.2 HVDC[1]

- Every new HVDC link should be designed so that it has no negative effect on existing equipment connected to the grid. Examples of negative effects are SSR (sub-synchronous resonance), rapid voltage variations, harmonic voltages and interference with telecommunications. In addition, the link should not have a negative effect on system operation. Examples of possible system operation problems are insufficient ability to tolerate voltage dips or exaggerated input/output of reactive power. A bipolar link should also be designed so that the risk of losing both poles for the same reason is as low as possible.
- It should be possible within the frequency range 49.9-49.5 Hz for the HVDC interconnections to have frequency-dependent regulation with droop. Frequency-controlled step or ramp variation of the power is not permitted in this frequency range when it is used in droop regulation.
- Any other regulation of emergency power must be based on the conditions that apply at the site. The question also concerns the affected TSOs.
- The owners of new HVDC interconnections are to notify the Operations Committee of the setting parameters for the regulating energy, ramps and emergency power in relation to existing HVDC links according to agreements with the TSOs in Nordel.

2.3 Connecting grids

The connection must be set up in such a way that the quality of the Nordic electric power system is not affected.

2.3.1 Take-out and surplus of reactive power

TAKE-OUT AND SURPLUS OF REACTIVE POWER					
Subject	**Denmark**	**Finland**	**Iceland**	**Norway**	**Sweden**
Tapping from the grid	Balance per voltage level. MVAr transport is minimised.	Balance per voltage level. Transport is minimised with the aid of a "window" (tan φ = 0.04-0.16). MW loss is minimised.	PF (cos φ) = 0.90 at 132 - 220 kV. PF (cos φ) = 0.85 < 132 kV. + "fine" 1)	There must be no transport of MVAr, which has a negative effect on the voltage.	Balance per voltage level. Not measured.
Reactive surplus	Reactors etc. ~ intact grid after 50 % load shedding 2)	Reactors etc. ~ intact grid with three in reserve		Reactors etc. ~ Grid intact	

1) From 1998, the limits are changed to 0.95 and 0.9 respectively.
2) The eastern part synchronous to the Nordel grid. The western part has own rules corresponding to the demands from the synchronous UCTE grid.

[1] Written in the light of draft for Nordel recommendation.

3 Production

3.1 Terms

3.1.1 Types of production plant

Definitions:

Gas turbine unit	Production plant powered by air and combustion gases to generate electric power. One generator with one or more gas turbines. There are two types: jet and industrial.
Combined plant	Steam turbines and gas turbines that use the same fuel cycle, in which exhaust heat from gas turbines is used to produce steam for steam turbines.
Condensing power plant	One or more thermal power units in the same production plant, which produce only electricity.
Combined heating and power (CHP) plant	One or more thermal power units in the same production plant, powered by fossil and/or bio fuel and which combine the production of electricity and heat, which is used for district heating or for an industrial process.
Nuclear power plant	One or more thermal power units in the same production plant, which produce only electricity and which are powered by nuclear fission in a reactor. There are two types: the pressurised water reactor (PWR) and the boiling water reactor (BWR).
Hydropower unit	Turbine and generator coupled together and powered by water.
Hydropower station	One or more hydropower units in the same production plant.
Wind power unit	Turbine and generator coupled together and powered by wind.
Wind power farm	One or more wind power units with a common connection to the power grid.
Thermal power unit	Production plant powered by uranium, fossil and/or bio fuels to generate electric power. Turbine and generator coupled together, powered by steam from a boiler or a reactor.
Thermal power block	One or more thermal power units powered from a common boiler or reactor. Combined heating and power plants are included in thermal power blocks.

3.1.2 Other terms

Definitions:

House load operation	Operation of a unit with its own auxiliary machinery as its only load, when the unit is disconnected from the external power grid.
Rated field voltage	The field voltage of a generator at rated load and nominal operating voltage.
Rated load	Simultaneous nominal active and reactive production.
Nominal active power	Nominal design power for electricity production.
Nominal operating voltage	The operating voltage of the connecting grid, which is used as a design precondition when planning the unit.
Nominal generator voltage	The design voltage of the generator.
p.u.	"Per unit": a term which states the size relative to a nominal value which must have been defined in each individual case.

Frequency response	The ratio between power change and frequency deviation when automatic frequency control is used.
Droop	The inverse of frequency response, i.e. the ratio between frequency deviation and power change.
Synchronous generator	A generator whose rotation speed follows the frequency of the connecting grid.

3.2 General requirements to be met by thermal power and hydropower

Requirements:

- Thermal power plants (Norway, Sweden and Denmark > 100 MW, Finland > 50 MW)
- Hydro power plants (Norway > 10 MW, Sweden and Finland > 50 MW)

The national requirements may be stricter than the requirements stated below.

3.2.1 Automatic frequency control

The production plants must be capable of automatically contributing to frequency regulation of the electric power system with a frequency response in the range 0.25-1 p.u. power/Hz, which corresponds to a droop of 8-2 %, at a frequency variation of 50 ± 0.1 Hz. The locally measured grid frequency or the rotation speed of the plant is used as a control signal.

3.2.2 Turbine regulator, set point

The unit controller shall have an adjustable frequency set point in the range from 49,9 Hz to 50,1 Hz. The set point resolution shall be 0,05 Hz or better. For large thermal power plants an adjustable frequency dead band of the unit controller within the setting range of 0-50 mHz is acceptable.

3.2.3 Tolerance to frequency variations

<u>Frequency Range 49 Hz to 51 Hz</u>

It shall be possible to operate the unit continuously at full output power within the grid voltage range of 90- 105% of the normal voltage, and at any frequency between 49 and 51 Hz. A maximum operating time of 10 hours/year and duration of 30 minutes maximum per case can be assumed within the frequency range of 50.3-51 Hz. At a frequency above 50.3 Hz a small power reduction is accepted, if stable operation at full power can be re-established when the frequency again drops below this value. See Figure 1.

<u>Frequency Range 49 Hz to 47.5 Hz</u>

It shall be possible to operate the unit under disturbance conditions for 30 min within the grid voltage range of 95-105 % of the normal voltage, at any frequency down to 47.5 Hz. The output power may then be reduced by 0 % at 49 Hz and a maximum of 15 % at 47.5 Hz, and by a value found by linear interpolation at frequencies between these two limits. Efforts should be made to lower this reduction in output power, if this can be achieved without high additional costs.

<u>Transitory Frequency Variations 51 Hz to 52 Hz</u>

It shall be possible to operate the unit for 5 sec during transitory conditions of the network in connection with exceptional disturbances within the grid voltage range of 95-105 % of normal voltage at any frequency between 51 and 52 Hz. During such transients the power may be reduced, if stable operation at full power can be re-established when the frequency again drops below 50.3 Hz.

Frequency Range 51 Hz to 53 Hz
On a separate electrical network it shall be possible to operate the unit at strongly reduced output power within the grid voltage range of 95-105 % of normal voltage, at any frequency between 51 and 53 Hz for 3 min.

Frequency Below 47.5 Hz
The unit may be tripped from the network at frequencies below 47.5 Hz. The unit shall then be capable of changing over to house load operation. However, this should not take place instantaneously, the time delay being determined by the design limits of the unit and so that reliable changeover to house load operation will be obtained.

Frequency Gradients
The control system shall be designed so that the unit will not trip because of the transient frequency gradients occurring in case of short-circuit on the high voltage network to which the unit is connected.

3.2.4 Tolerance to voltage variations

Grid Voltage Range 90 % to 105 % of Normal Voltage
It shall be possible to operate the unit continuously at full load within the frequency range of 49-51 Hz and at a grid voltage between 90 and 105 % of normal voltage. At a frequency above 50.3 Hz, a small power reduction is accepted, if stable operation at full power can be re-established when the frequency again drops below this value. A maximum operating time of 10 hours/year and a duration of 30 minutes maximum per case can be assumed within the frequency range of 50.3-51 Hz. (Same requirements as in Section 3.2.3 (Frequency range 49 Hz to 51 Hz). See Figure 1.

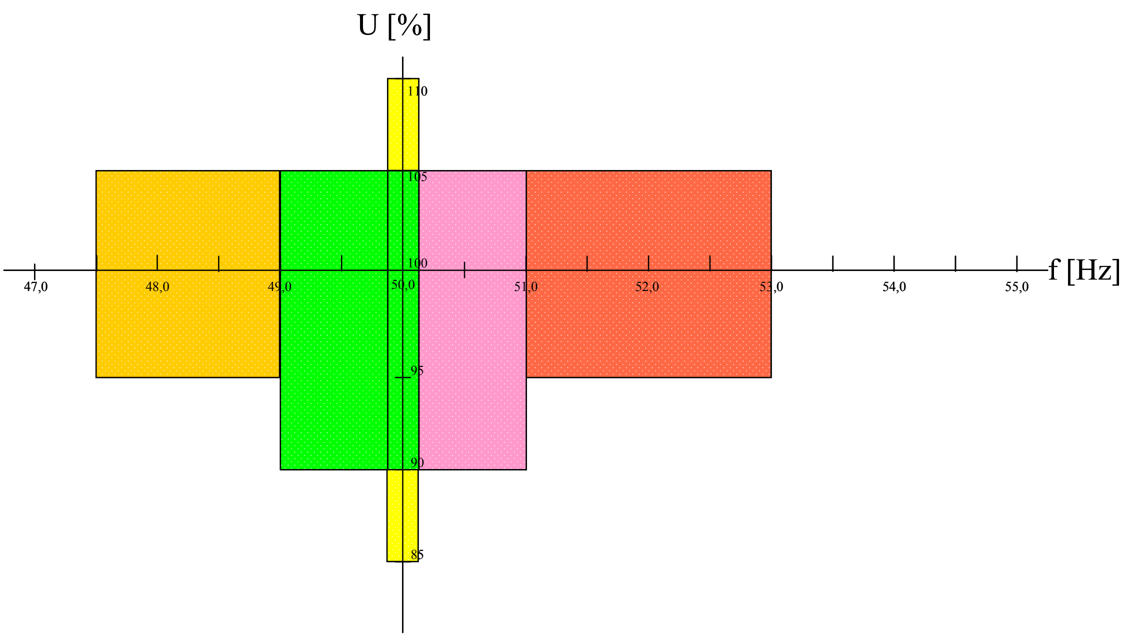

Figure 1 Performance requirements for power production in relation to frequency and voltage

Grid Voltage Range 85 % to 90 % of Normal Voltage
It shall be possible to operate the unit for 1 hour within the frequency range of 49.7-50.3 Hz at a grid voltage between 85 and 90% of the normal voltage, and an output power reduction of up to 10 % of full output may then be acceptable.

Grid Voltage Range 105 % to 110 % of Normal Voltage
It shall be possible to operate the unit for 1 hour at a frequency within the range of 49.7-50.3 Hz and at a grid voltage between 105 and 110 % of normal voltage. A small output power reduction may then be acceptable (approximately 10%).

Consequences of Nearby Grid Faults
a) Ability to Withstand Mechanical Stresses Due to Line Side Faults
Thermal power units shall be designed so that the turbine generator set can withstand the mechanical stresses associated with any kind of single-, two- and three-phase earth or short circuit fault occurring on the grid on the high voltage side of the step-up transformer. The fault can be assumed to be cleared within 0.25 sec. Neither damage nor need for immediate stoppage for study of the possible consequences are allowed.

b) Line Side Faults of Clearing Time up to 0.25 Sec
The unit shall be designed so that it remains connected to the grid and continues its operation after isolation of line side fault within 0.25 sec.

Thermal power plants > 100 MW in Denmark East (synchronous to the Nordel grid) shall fulfill the above demands. Thermal power plants > 100 MW in Denmark West (synchronous to the UCTE grid) shall fulfill UCTE demands. (Clearing time 0.15 Sec and the demands are to the line side of the generator transformer.) For smaller thermal power plants and wind power plants the demands are weaker see detailed specifications. (Chapter 6 of TF 3.2.3 will be changed at next revision.)

c) Deep Voltage Transient
The units shall be designed so that they can withstand the following line side voltage variation resulting from faults in the grid, without disconnection from the grid:

- step reduction to 0 % of the line side voltage lasting for 0.25 sec,
- followed by linear increase from 25 % to 90 % in 0.5 sec,
- followed by constant line side voltage 90 %.

Consequently, only a small power reduction can be accepted.

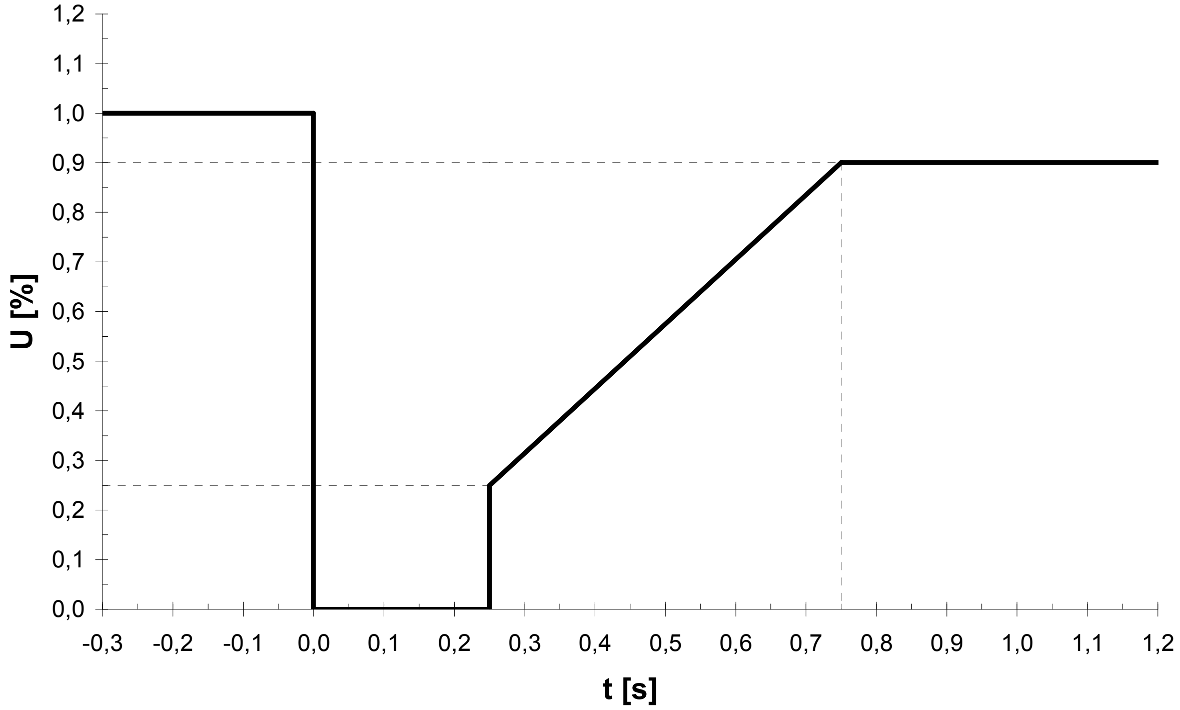

Figure 2 Deep voltage transient in line side voltage caused by a network fault

It shall be noted that the design criteria for the voltage protection may deviate, as the unit must manage several kinds of other faults that may occur in the generators/power grid.

Large Voltage Disturbances

The unit may be disconnected from the power system, if larger voltage variations or longer durations than those for which the unit has been designed occur, and shall, in each case, be disconnected if the unit falls out-of-step.

The unit and its auxiliary power system shall be designed for such voltage variations that a safe changeover to house load operation can take place after disconnection from the network.

Reactive Power Output at Low Voltages

Thermal power units shall be equipped with such excitation systems and shall be designed for such a power factor that the generator will be capable of providing a reactive power output of about the same magnitude as the rated active power output for 10 sec, in conjunction with network disturbances and at a generator busbar voltage of 70 % of the rated generator voltage.

Reactive Power Capability

The thermal power units shall be able to generate and to consume reactive power in adequate amounts within their capabilities for the voltage control of the power system. At normal grid voltage the generators shall be designed to operate within the limits of reactive power output and input defined by the capability diagrams of the generators or by stable reactive droop.

At grid voltages higher than the normal voltage the under-excited capability of the generators shall be fully available according to the capability diagram or static stable reactive droop, whichever is more limiting.

The countries' MVAr requirements for the power plants			
	MVAr requirements for new building 1)		Operating voltage range
	Production	Consumption	
Danish thermal power	tg φ = 0.4 at 420 kV	tg φ = - 0.2 at 400 kV	380 - 420 kV
Swedish thermal power	1/3 at U>90% Ugen 3)	0 3)	395 - 420 kV
Finnish thermal power	cos φ = 0.9 at 360…420 kV 2)	cos φ = 0.95 at 400…420 kV 2)	380 - 420 kV
Swedish hydro power	1/3 at U>90% Ugen 3)	-1/6 3)	395 - 420 kV
Finnish hydro power	cos φ = 0.9 at 360…420 kV 2)	cos φ = 0.95 at 400…420 kV 2)	380 - 420 kV
Norwegian hydro power	cos φ = 0.86 2)	cos φ = 0.95 2)	390 - 420 kV
Icelandic hydro power			

1) The countries combine the MVAr requirements and associated voltages at the generator terminals and busbar in different ways.
2) Power factor (cos φ) is measured at the generator terminals.
3) MVAr measured at the busbar and Ugen as nominal generator voltage transformed to busbar side of transformer.

The information above illustrates how the MVAr requirements affect the most costly component (the generator). Any supplementary requirements that the MVAr requirements should be met at set voltages for the busbar affect the systems properties of the power plants and the design of the plant, but have only a marginal effect on the price of the plant, provided that this is specified during the project phase. This may, for instance, apply to the ratio of the machine transformer and the winding connections for the internal consumption transformer. The actual operating point is determined depending on the actual operating situation in the transmission network.

3.2.5 Generator and voltage regulator characteristics

Generators

The generator reactance shall be as low as technically and economically possible in order to support the stable droop and reactive power control.

Each generator shall be capable of operating on the rated active power continuously at power factor down to at least 0.95 under-excited, and 0.9 over-excited. This shall be possible in connection with voltage and frequency conditions as described in Tolerance to voltage variations (90-105 % of normal voltage). At under-excited conditions normal grid voltage is applied instead of 90 % voltage.

Voltage Control

The preferred dynamic characteristics for steady state are defined in a measurable way as follows:

The 10 % step response of generator voltage is recorded in no-load conditions, disconnected from the grid. The set value of the voltage is changed by plus and minus stepwise changes causing change of generator terminal voltage from 95 to 105 %, and from 105 to 95 %. In both cases the step response of the generator terminal voltage shall be as follows:

- response is non-oscillating,
- rise time from 0 to 90 % of the change is 0.2-0.3 s in case of static exciter, or in case of brush less exciter: 0.2-0.5 s at a step upwards, 0.2-0.8 s at a step downwards,
- overshoot is less than 15 % of the change.

PSS, Power System Stabiliser

PSS shall be included in each generator. The PSS shall be tuned to improve the damping of the oscillations of generator and power system, especially the damping of low frequency (0.2-1.0 Hz) inter-area oscillations.

Additional Voltage Control Equipment

Current limiters (for generator rotor and stator) shall have invert time characteristics to utilise the generator over current capability to a good extent for various network conditions.

Voltage Control Priority

The normal way of operation is automatic control of generator voltage with the effects of reactive current droop. In case of needs for different type control, like control according to power factor or reactive output, these additional controls shall affect at lower priority than the regulation of voltage.

Island Operation

In case of very serious (and exceptional) disturbances, where the power system is separated into smaller grids, the units shall also initially be capable of performing the above-mentioned power changes (upwards or downwards), and then achieving stable operation and normal power control capability according to Section 3.3.3.

3.2.6 Verification

To the largest possible extent the specifications should be verified by full-scale test. This test should be made by the owner at commissioning and upon request from the TSO. Recordings of data from actual operation should be reviewed regularly in order to prove compliance with the specification.

Verification during Commissioning

This verification shall include:

- Full output power
- Minimum load
- Overload capacity
- Starting time
- Load following
- Power response rate including range
- Power step change
- Deep voltage transients by short circuit (if possible)
- Changeover to house load operation
- House load operation for 1 h
- Step response of generator voltage
- PSS test

3.3 Operational performance specifications for thermal power units > 100 MW

3.3.1 Operational characteristics

Minimum Output
The minimum output power shall be as low as possible. As a practical guideline, the minimum output power should be 40 % of full output power in coal-fired units, 20 % of full output power in oil-fired units, and 20 % of full output power in nuclear units.

Overload Capacity
Fossil-fired units should be prepared for overload capacities only to the extent that it is intrinsically available. For a steam turbine unit this could be the bypassing of high-pressure preheaters.

The overload capacities should only be utilised to a certain limit only, because of reductions in the efficiency and/or the lifetime of the unit.

The unit including auxiliary equipment should be designed to utilise these overload capacities up to 2 h/day and up to 500 h/year. No overload capacity is specified for nuclear power units.

Starting Time
For all types of thermal power units, the starting time shall be defined according to planned utilisation. In addition, the following guidelines shall apply to gas turbines for emergency and peak load generation, from rolling-up to full output power:

- gas turbines of jet engine type 3 to 3.5 minutes
- industrial gas turbines 10 to 15 minutes.

House Load Operation
House load operation is the unit operating with its own auxiliary supply as the only load.

3.3.2 Power control equipment characteristics

Operational Modes
The change of output power of a thermal power unit at the rates and within the ranges specified, during normal control and during disturbances control, is normally activated as follows:

- By manual operation
- By the unit controller

The unit controller shall have an adjustable frequency set point in the range from 49.9 Hz to 50.1 Hz. The set point resolution shall be 50 mHz or better.

The droop set point shall be adjustable in the range from 2 % to 8 %. The normal operation is generally with setting in the range from 4 % to 6 %.

An adjustable frequency dead band of the unit controller within the setting range of 0-50 mHz is acceptable. It shall be possible to disengage this dead band.

Power Step Change Limiter
The units shall be equipped with adjustable devices for limiting the magnitude and rate of the power change, so that it will be possible to set these set points at any values from zero up to the maximum specified, both for normal conditions and for disturbance conditions.

Power Control - Normal Operation and Disturbances
The required power output during normal operation is the manually preset power output, modified by a frequency-sensing unit controller (or turbine governor) and this power output shall meet the specifications in Section 3.3.3(Power response capability during normal operation of the power system).

The need for disturbance control shall be governed by frequency-sensing equipment (e.g. consisting of a frequency relay set at a certain value below normal frequency). The power output shall meet the specification in 3.3.4 (Power response capability during power system disturbances) when the unit is operated under these conditions.

3.3.3 Power response capability during normal operation of the power system

Load Following
All condensing units shall be designed so that they can be used for daily and weekly load following during certain periods of the year, using the rates of load change specified in the following.

The units shall also be designed so that, if necessary, they can participate in following the occasionally varying loads that cause frequency variations on the interconnected power system. This implies that the units shall be capable of accommodating power changes without intervals by plus or minus 2 % of full output within periods of 30 sec. The units shall be capable of performing these changes within the ranges specified. Power changes for nuclear units may be agreed with the grid operator to be less than plus or minus 2 %.

Power Response Rate and Range - Oil and Gas
Oil-fired and gas-fired units shall be designed for a power response rate of at least 8 % of full power per minute. The above power response rate of change shall be applicable to any range of 30 % between 40 % and 100 % of full power according to the load schedule. The power response rate may be limited to the maximum power response rate permissible for the turbines or the steam boilers in the range below 40 % and above 90 %.

Power Response Rate and Range - Coal
Coal-fired units shall be designed for a power response rate of at least plus or minus 4 % of full power per minute. The above power response rate of change shall be applicable to any range of 30 % between 40 % and 100 % of full power according to the load schedule. This range may be restricted to 20 % in certain cases. The power response rate may be limited to the maximum power response rate permissible for the turbines or the steam boilers in the range below 60 % and above 90 %.

Power Response Rate and Range - PWR Nuclear
PWR nuclear power units shall be designed for a power response rate of at least plus or minus 5 % of full power per minute within the output range of 60 % to 100 % of full power. At outputs below 60 %, the power response rate may be limited to the maximum power response rate permissible for the turbines.

Power Response Rate and Range - BWR Nuclear
BWR nuclear power units shall be designed for a power response rate per minute of at least plus or minus 10 % of the initial output value. This shall be maintained throughout all the output range within which the power can be controlled by the speed of the main circulation pumps. This output range shall be at least 30 % of the initial output power. In the remainder of the power range between minimum load and full load, the power response rate shall be at least 1 % of full power per minute.

Comment on requirements for nuclear power units: The power response rates of the units equipped with standard versions of light water reactors are usually sufficient. However, it should be noted that the power response rate is subject to some restrictions at the present time, due to the current design of fuel elements. It is expected that these problems will be solved, and the units should therefore be designed to conform to the recommended power response rates. However, in order to limit the stresses imposed, the power changes during normal daily and weekly load following should be carried out gradually over a period of about two hours.

3.3.4 Power response capability during power system disturbances

Instantaneous Power Response
The demand from the power system is that the instantaneous power response shall be available within 30 sec after a sudden frequency drop to 49.5 Hz. Half of that power response shall be available within 5 sec after the frequency drop.

Power Step Change - Fossil Fuel
Fossil-filed thermal units shall be designed with an operating mode allowing an instantaneous step change in output power of at least 5 % of full output within the range of 50-90 % when requested. Half of that power shall be available within 5 sec after the frequency drop. Units without or with only one reheater shall be designed in such a manner that this power step will be accommodated within 30 sec. If a unit includes more than one reheater, a further delay corresponding to the time constants of such additional reheaters is acceptable.

Power Step Change - Nuclear
PWR nuclear power units to which the power change signal is applied directly to adjust the turbine control valve shall be designed so that a power step of 10 % of full power can be accommodated within 30 % of the power range. BWR nuclear power units operating on pressure control shall be designed so that, within the range of pump control, they will be capable of accommodating a power change of 10 % of the initial value within 30 sec.

Subsequent Power Response Rate
After the power step changes specified above, thermal power units shall also be capable of accommodating a load change at the rates specified in 3.3.3 (Power response capability during normal operation of the power system). However, the total change in load may then be limited to the values also specified in 3.3.3.

Spinning Disturbance Reserve
All units of the condensing type shall be made so that they at times can be used as spinning disturbance reserves and then perform the above mentioned power variations, if serious disturbances occur on the grid.

3.3.5 House load operation

Design Characteristics

All power units shall be designed to change over safely to house load operation from conditions as specified in 3.2.3 (Frequency range 51 Hz to 53 Hz and Frequency below 47.5 Hz), and in 3.2.4 (Large voltage disturbances).

Operating Time

Thermal power units shall be designed so that they can operate in house load operation for at least 1 h. Nuclear power units shall be capable of operating in house load operation for a duration determined by the nuclear safety conditions.

3.4 Specifications for thermal power units < 100 MW

Below 100 MW and above 25MW

Minimum output: All the small power stations shall fulfil the regulation given in 3.3.1 irrespective of the type of primary fuel.

Overload capacity: Efforts should be made to observe this regulation, but observance is not demanded.

Starting time: Regulation given in 3.3.1 shall be fulfilled.

Operational modes and Power step change limiter: Regulation given in 3.3.2 shall be fulfilled.

Power control - normal operation and disturbances: Is not required to observe according to the abovementioned considerations.

Load following and Power response rate and range: Regulation given in 3.3.3 shall be fulfilled.

Instantaneous power response and Power step change for fossil fuel: Regulation given in 3.3.4 shall be fulfilled.

Power step change for nuclear, subsequent power response rate, Spinning disturbance reserve and Island operation: Are not relevant to small power stations.

Tolerance to frequency variations: A voltage profile as shown in Figure 2, in the transmission network or in the regional distribution network should not cause tripping of power stations.

Deviations of frequency and voltage within the hatched area on Figure 1 should not cause tripping of power stations. A reduction of the active production by up to 20 % is acceptable. The power stations should be able to tolerate frequencies up to 53 Hz.

Tolerance to voltage variations: Is not required to observe according to the above mentioned considerations. A quick start-up after tripping is desirable but is not demanded generally. Regarding the starting times the following directions can be given:

After release	30 min
After an outage time of 10 h	90 min
After an outage time of 30 to 50 h	120 min

As for unmanned plants another 120 minutes may pass before the personnel can arrive at the power station. It should be possible to start up and fully load gas turbine plants within 30 minutes even after a long outage time. It should be mentioned that the power that is at disposal after 15 minutes in the national systems can be calculated as part of the fast reserve.

Generator and voltage regulator characteristics, House load operation and Verification: Are not required

Below 25 MW
To these plants it applies that the requirements that it is reasonable to demand complied with depend on the mode of operation, manning and type of fuel.

Plants in the range 1 MW-25 MW
Minimum output: All the power stations shall fufill the regulation given in 3.3.1 irrespective of the type of fuel.

Overload capacity: Efforts should be made to observe this regulation, but observance is not demanded.

Starting time: Regulation given in 3.3.1 shall be fulfilled..

Operational modes and Power step change limiter: Regulation given in 3.3.2 shall be fulfilled. for power plants in the range 10-25 MW (In case of solid fuel fired plants observance may be difficult. No demands on plants in the range 1-10 MW.)

Power control - normal operation and disturbances: Is not required observed.

Load following and Power response rate and range: Regulation given in 3.3.3 shall be fulfilled. for power plants in the range 10-25 MW. (No demands on plants in the range 1-10 MW)

Instantaneous power response and Power step change for fossil fuel: Regulation given in 3.3.4 shall be fulfilled.

Power step change for nuclear, subsequent power response rate, Spinning disturbance reserve and Island operation: Are not relevant to small power stations.

Tolerance to frequency variations: A voltage profile as shown in Figure 2, in the transmission network or in the regional distribution network should not be allowed to cause tripping of power stations.

Deviations of frequency and voltage within the hatched area on Figure 1 should not be allowed to cause tripping of power stations. A reduction of the active production by up to 20 % is acceptable. For solid fuel fired plants of the 2nd category it may be difficult to comply with the requirement in the range from 47.5-49 Hz. The power stations should be able to tolerate frequencies up to 53 Hz.

Tolerance to voltage variations: Is not required observed. But a quick start-up after tripping is desirable. Gas turbine plants should be able to start automatically with the alternative of remote operation when the voltage is stable after a network fault causing tripping of the plant. For solid fuel fired plants of the 2nd category no requirements are made.

Generator and voltage regulator characteristics, House load operation and Verification: Are not required.

Plants < 1 MW
Local conditioned requirements are usually made. However, the power stations should be capable for short periods of time of tolerating frequencies in the range from 47.5 Hz to 53 Hz.

3.5 Special requirements for hydropower

National rules apply to hydropower plants that are not covered by the Connection Code. In Norway there are national requirements for hydro power plants. In Finland General requirements to be met by thermal power and hydropower are used.

NORDEL CONNECTION CODE WIND TURBINES

1 Introduction

The Nordic Connection Code for wind turbines is a part of the Nordic Grid Code. The Nordic Grid Code shall provide the common framework for the TSO's (Transmission System Operator) and the actors, who are operating facilities connected to the Nordic electricity system.

The Nordic Connection Code outlines the minimum technical requirements that new wind turbines together with their supplemental installations have to fulfil at the connection point to the transmission network in order to provide for adequate safe operation and reliability of the interconnected Nordic Power System. The Nordic TSO's may publish connection codes for the electricity system within their responsibility having additional requirements.

It must also be emphasized, that all capabilities will not be exploited in all wind turbines at all times. Connection codes shall provide the capabilities and characteristics of system components are available when ever needed for safe and reliable system operation. The exploitation of the different system components and their capabilities is regulated by system operation codes.

2 Definitions

Connection point: Point in the transmission network, to which the **wind turbine** or **wind plant** is to be connected. This point is defined by the TSO.

Wind turbine: Complete system to transform wind energy into electricity and to transmit the electricity to the **connection point**.

Wind plant[1] : More than one **wind turbine** connected to the same **connection point**, possible sharing connection cable/line and other equipment.

All other definitions are according to IEC standard.

3 Scope of the connection code

The requirements must be met by all **wind plants** connected to the Nordic Power system[2]. All requirements are to be met at the **connection point**.

4 Active power control

It must be possible to control the active power production from the **wind plant**. The following control functions must be available

[1] Wind Plant is a synonym to the commonly used Wind Farm.

[2] The TSO decides in each case whether wind plants smaller than 100 MW has to fulfil all requirements or they may be released to some extent according to the related impact to the interconnected Nordic system operation and security.

- An adjustable upper limit to the active power production from the wind plant shall be available whenever the wind plant is in operation. The upper limit shall control that the active power production, measured as a 10 minute average value, does not exceed a specified level and the limit shall be adjustable by remote signals. It must be possible to set the limit to any value with an accuracy of ±5%, in the range from 20% to 100% of the wind plant rated power.
- Ramping control of active power production must be possible. It must be possible to limit the ramping speed of active power production from the **wind turbine** in upwards direction (increased production due to increased wind speed or due to changed maximum power output limit) to 10% of rated power per minute. There is no requirement to down ramping due to fast wind speed decays, but it must be possible to limit the down ramping speed to 10% of rated power per minute, when the maximum power output limit is reduced by a control action.
- Fast down regulation. It must be possible to regulate the active power from the **wind turbine** down from 100% to 20% of rated power in less than 5 seconds. This functionality is required for system protection schemes. Some system protection schemes implemented for stability purposes require the active power to be restored within short time after down regulation. For that reason disconnection of a number of wind turbines within a wind plant cannot be used to fulfil this requirement[3] .
- Frequency control. Automatic control of the **wind turbine** active production as a function of the system frequency must be possible. The control function must be proportional to frequency deviations and must be provided with a dead-band. The detailed settings will be provided by the TSO.

5 Reactive power capacity

The **wind plant** must have adequate reactive capacity[4] to be able to be operated with zero reactive exchange with the network measured at the connection point, when the voltage and the frequency are within normal operation limits. See area A in figure 1, chapter 7.

6 Reactive power control

The reactive output of the **wind plant** must be controllable in one of the two following control modes according to TSO specifications:

1 . The **wind plant** shall be able to control the reactive exchange with the system. The control shall operate automatically and on a continuous basis. The wind plant shall be able to maintain acceptable small[5] exchange of reactive power at all active power production levels.

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[3] In a system having a limited number of wind turbines this is not a vital problem. But wind turbines are designed to stay in operation for 20 years or more, and the international trend is, that wind turbines in some periods will produce an increasing part of the total power production. It will eventual be a problem if not addressed in proper time.

[4] The reactive capability need not to be installed inside each wind turbine, but may be installed in one or more separate devices connected to the system at the same connection point as the wind turbines.

[5] The TSO defines the acceptable limit according to local system conditions

2 . The **wind plant** must be able to automatically control its reactive power output as a function of the voltage in the connection point with the purpose of controlling the voltage.

The detailed settings of the reactive power control system will be provided by the responsible TSO

7 Dimensioning voltage and frequency

The system operating conditions that the **wind plant** must be able to meet are outlined in the following figure:

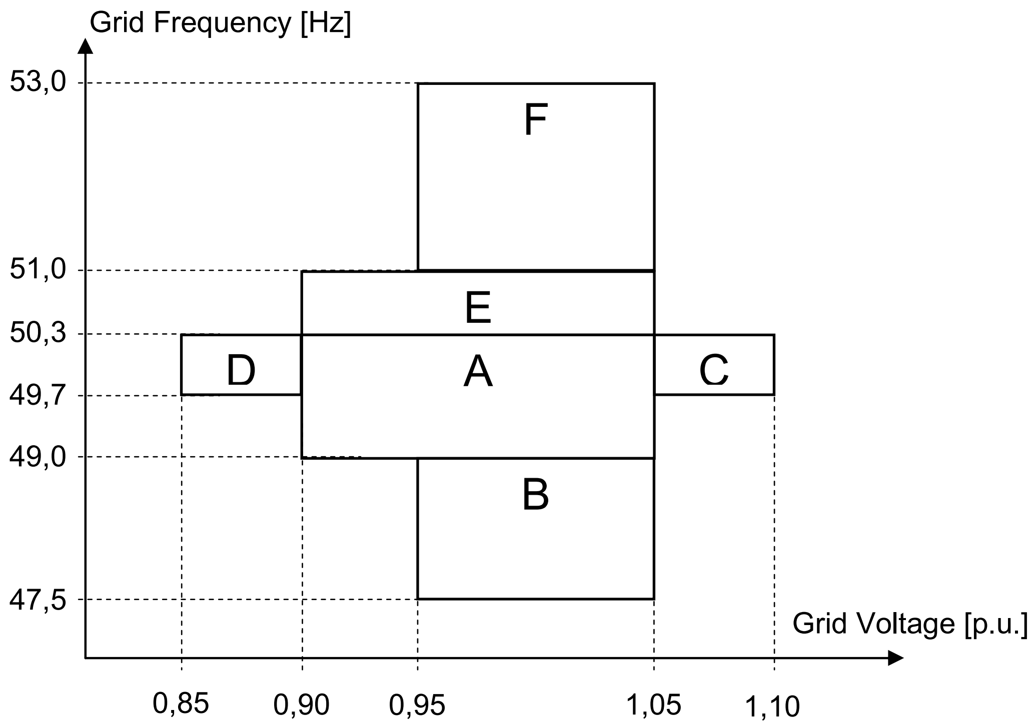

Figure 1. Performance requirements in relation to voltage and frequency. The reference for p.u.value shall be defined by TSO.

When the voltages and frequencies are within the rectangular areas shown in the figure, the following requirements applies:

A: Normal continuously operation. No reduction in active or reactive capability is allowed due to system voltage and frequency.

B: Uninterrupted operation in minimum 30 minutes shall be possible. The active output is allowed decreased as a linear function of the frequency from zero reduction at 49.0 Hz to 15% reduction at 47.5 Hz.

C: Uninterrupted operation in minimum 60 minutes shall be possible. The active output may be reduced 10%.

D: Uninterrupted operation in minimum 60 minutes shall be possible. The active output may be reduced 10%.

E: Uninterrupted operation in minimum 30 minutes shall be possible. The possible active output is allowed to be slightly reduced. (The total duration of these operating conditions is normally not more than 10 hours per year).
F: Uninterrupted operation in minimum 3 minutes shall be possible. The active output may be reduced to any level, but the turbines must stay connected to the system.

8 Operational characteristics during grid disturbances

The **wind plant** must be able to continue operation during and after disturbances in the transmission network. This requirement applies under the following conditions:

- The **wind plant** and the **wind turbines** in the **wind plant** must be able to stay connected to the system and to maintain operation during and after dimensioning faults in the common Nordic transmission system. In each area, the TSO defines which parts of his system are included in the Nordic transmission system. (It is normally defined by voltage level and depends on parallel operation with the highest voltage levels. It is always above 100 kV)
- The **wind plant** may disconnect from the system, if the voltage in the connection point during or after a system disturbance do fall below the levels shown in the following figure 2[6].

The fault duration, where the voltage in the connection point may be zero, is 250 milliseconds. The voltage at the wind turbine generator terminals will be higher due to transformer and network impedance.

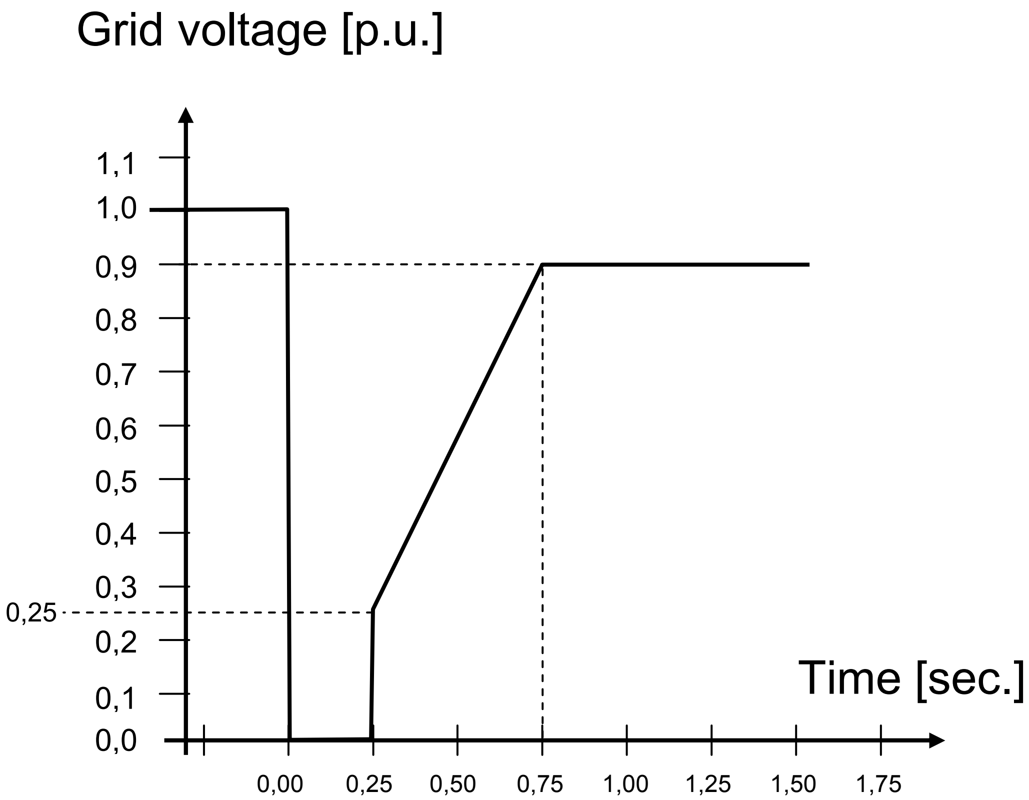

Figure 2. Voltage dip profile due to fault in the high voltage connection point which the wind plant must tolerate without disconnecting from the grid. The 1 p.u. value is the voltage before the disturbance.

[6] The rise-time of the voltage is highly dependent on the local system characteristics, i.e. short circuit capacity. The TSO may decide to use a different curve in his own area to ensure adequate system security.

9 Start and stop

It is recommended, that the **wind plant** is designed so that the **wind turbines** within the **wind plant** does not stop simultaneously due to high wind speeds.

10 Remote control and measurements

Wind plants must be controllable from remote locations by telecommunication. Control functions and operational measurements must be made available to the TSO on request.

The TSO in each area specifies the required measurements and other necessary information to be transmitted from the wind plant.

11 Test requirements

Prior to the installation of a **wind turbine** or a **wind plant**, a specific test programme must be agreed with the TSO in the area. The test programme shall be the documentation of the capability of the **wind turbine** or **wind plant** to meet the requirements in this connection code.

As a part of the test programme, a simulation model of the **wind turbine** or **wind plant** must be provided to the TSO. The model shall be provided in a format given by the TSO, and the model shall show the characteristics of the **wind turbine** or **wind plant** in both static simulations (load flow) and dynamic simulations (time simulations). The model shall be used in feasibility studies prior to the installation of the **wind turbine** or **wind plant** and the commissioning tests for the **wind turbine** or the **wind plant** shall include a verification of the model.

The following documents have been included in this chapter:

Document	*Status*
Data exchange agreement between the Nordic transmission system operators (TSOs) 2006	*Binding agreement*

The following national documents deal with the Data Code:

Document	*Status*

The TSOs in the Nordic countries have entered into a data exchange agreement, Data exchange agreement between the Nordic TSOs. The data exchange agreement contains a basis and data for a grid model and joint operation model, which was drawn up jointly by the TSOs. The agreement is reproduced in this section.

DATA EXCHANGE AGREEMENT BETWEEN THE NORDIC TRANSMISSION SYSTEM OPERATORS (TSOS)

Framework for the exchange, use and distribution of power system data

1 Introduction

The liberalisation of the energy sector in Europe has made it necessary to re-evaluate a number of old co-operative relationships. However, operational reliability for an individual country is still dependent on the reliability of the composite system.

The primary purpose of formalised Nordic co-operation in the field of power system data is to create the best possible basis for system analyses of the interconnected Nordic power system for dealing with balance and capacity problems and for secure exploitation of the advantages of interconnected systems, as well as to achieve
savings in terms of time and resources.

A further important aim is to control the distribution of the models that are used to analyse the Nordic power system, i.e. the complete Nordic grid model and the multi area power market simulator.

Certain data are subject to preparedness-related restrictions in the individual countries or are of commercial interest. Data concerning production plants should be considered commercial, and must therefore be treated as confidential; for further information see § 4.

This document sets out the framework that shall control future activity, primarily the exchange, use and distribution of power system data for and in the form of the grid model and the multi area power market simulator, as well as access to analysis results.

2 Parties

The parties to the agreement are the Nordic TSOs, Energinet.dk (cvr no 28980671, Denmark)., Fingrid Oyj (Business ID 1072894-3, Finland), Statnett SF (NO 962 986 633 MVA, Norway), Affärsverket svenska kraftnät (Org. no.: 202100-4284, Sweden) and Landsnet (Registration no. 580804-2410, Iceland).

It is a precondition that the parties take part in the co-operation by virtue of their function as TSOs. The Planning Committee of Nordel administers the agreements.

3 Scope

The data exchange agreement applies to the basis of and data for the grid model and multi area power market simulator established jointly between the TSOs in Nordel.

Grid model
The term **grid model** refers to the power system data that are needed in order to carry out load flow and dynamic studies on all or parts of the Nordic power system including the non-synchronised power system on Jutland. If the need arises, data for an equivalent of the complete Nordic grid model and fault current studies can be included in the work of the working group.

The scope of the term "complete Nordic grid model" is specified in Appendix 1.

Multi area power market simulator
The term **multi area power market simulator** refers to the power system data needed to calculate the power and energy balances of the entire Nordic power system, including assessment of the plants' expected operation in the market.

The scope of the term "complete Nordic multi area power market simulator" is specified in Appendix 2.

Procedure
The procedure for the use and maintenance of the Nordel dataset is described in Appendix 4.

The procedure can be altered by unanimous decision of the Planning Committee.

4 Rules of confidentiality

If the data that the parties exchange with each other has not been published in the country to which it refers, the parties are obliged to treat the data confidentially as far as possible in accordance with the legislation in force in the respective country.

5 Internal use and use within Nordel

The grid model and the multi area power market simulator may be freely used for studies by the parties to the agreements or for studies that exclusively involve the parties to the agreements, either bilaterally or with several parties involved.

All results from internal use of the models are regarded as the property of the parties participating in the study. In the case of analyses whose results are of significance for another party to the agreement, that party will be kept regularly informed.

The grid model and the multi area power market simulator may be freely used in Nordel's studies.

6 Use of consultants

In cases where one of the parties to this agreement uses a consultant for advice on a study or to carry it out, and the consultant represents a party to this agreement in his name, the grid model or the multi area power market simulator or the anonymised model may be passed to the consultant subject to his signature to the agreement that governs the relationship, confirming that the consultant will treat the information in strict confidence, and will obey the same rules of confidentiality as apply to the relationship between the parties for the particular data in the country where this data was produced; see Appendix 3.

The consultancy agreement is entered into solely by the parties of that assignment. Results and background material are the property of the client (the party/ies). The other parties of this data exchange agreement are to be informed of such consultant agreements. The information is governed by the procedure in Appendix 4.

Agreements for consultant assistance may only be entered into with consultants who are accepted by the parties to this agreement. The consultant's name and a presentation of the consultant must be sent to the other parties for approval within two weeks. Accepted consultants can only use the models for studies carried out for one or more of the parties of this data exchange agreement.

Agreements with consultants must state that they do not obtain rights of use or ownership of results produced with the aid of data in accordance with this agreement; see Appendix 3.

7 Equivalents

Equivalents of the Nordic power system can be supplied to and used by third parties for their studies. In such cases, studies may be done by a third party. The complete grid model or the complete multi area power market simulator may be used by the parties to the agreement to create such equivalents.

An equivalent is a simplified version of the complete Nordic models (see Appendix 1 and Appendix 2). The aim is that the characteristics of the equivalent at the connection points should be the same as those of the complete model (in terms of load distribution, impedances and dynamic response, for example). It must not be possible to identify in the equivalent the internal relationships in the model.

8 Anonymised complete model

An anonymised complete model of the Nordic power system can be supplied to and used by third parties for their studies. In such cases, studies may be done by a third party. An anonymised complete model is a special case of an equivalent. An anonymised complete model may only be supplied after specific processing and consensus in the Planning Committee (see Appendix 3).

Results of studies (see definition in Appendix 3) are to be given to all parties in accordance with procedure.

9 Transfer and renegotiation of agreement

If restructuring takes place in one of the countries involved in the collaboration, agreements and information concerning this matter may be transferred to the organisation that is given responsibility for the system in the country in question.

If one of the above-mentioned parties wishes to renegotiate the agreement, this process must start not later than six months from the request to do so. Once entered into, an agreement remains valid until a new agreement comes into force.

10 The agreement is accessible to market actors

To create confidence that the TSOs are fulfilling their obligations, this agreement will be made accessible to the market actors, who are required to supply data. This can be done, for example, by placing the agreements on Nordel's website, and by the parties to the agreement placing links to Nordel's website on their own websites.

11 Breach

In so far as a party is in breach of the provisions of the agreement, that party is obliged, within one month of being required to do so in writing by the other parties to the agreement, to cease using data, and the agreement is thereafter terminated as regards the party in breach. During that month, no data may be copied or distributed.

12 Validity period and notice of termination of the agreement

By signing of this agreement the previous data exchange agreement of 27. June 2002 will expire.

The agreement is valid until further notice and ceases after unanimous agreement between the parties. Three months' notice of termination of the agreement may be given in writing by one of the parties to the agreement, with the effect that the party who gave notice withdraws from the agreement. The party giving notice undertakes to cease using all data, models and information about the systems of the other parties to the agreement that, through the agreement, is in the possession of that party within one week of notice to terminate the agreement.

After notice of termination of the agreement has been given, no data may be copied or otherwise transferred or distributed.

13 Filing of the agreement

The agreement is drawn up in one copy, which is filed by the active secretariat of Nordel. Each party must be provided with a duplicate of the agreement.

Helsinki 7.th. March 2006

<signature>

Statnett, Øivind Rue

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Svenska Kraftnät, Bo Krantz

<signature>

Fingrid Oyj, Pertti Kuronen

<signature>

Fingrid Oyj, Jussi Jyrinsalo

<signature>

Energinet.dk, Peter Jørgensen

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Landsnet, Eymundur Sigurdsson,

SCOPE OF DATA FOR THE COMPLETE NORDIC GRID MODEL

The Nordic grid model is data for the Nordic power system formatted on the format of the analysis software used in the model in accordance with the procedure, but the term also applies to the same data formatted for the
format of other analysis softwares.

The term "power system data" comprises:

- All information stated in the definition of the data format of the analysis software used for studies with synchronous (positive-sequence), inverse (negative-sequence) and zero (zero-sequence) system data for 400 kV to 70 kV, possibly including equivalents for the connection of production and compensation installations at a lower voltage level and for the dynamic studies below:
    - Data for existing and future production, transmission and compensation installations including dynamic models.
    - Recorded or forecast data for active and reactive consumption in different operating situations, for instance high load and low load.
    - Production data for existing and future production plants in different operating situations.
    - Information about operational connection in different operating situations.
- Models and utility softwares developed and/or owned by the parties to the agreement and used in the studies
- Map material and drawing data that describe, or are used to describe, the geographical or electrical characteristics of the power system
- Written and electronic background material for creating and documenting the grid model

SCOPE OF DATA FOR THE MULTI AREA POWER MARKET SIMULATOR

The Nordic multi area power market simulator comprises data for analysis of the power balance, e.g. the power and energy balance for the Nordic power system. There are three main types of data:

Production data:
Production data is stated for the different types of production plant. These types may, for example, be subdivided into

- Hydro power
- Thermal power - condensing
- Thermal power withdrawal
- Thermal power, back-pressure – district heating
- Thermal power, back-pressure – industry
- Wind power

In addition, the plants are distributed geographically in accordance with the subdivisions in the transmission models; see below.

Technical data includes:

- Efficiencies
- Capacities
- Fuel type
- Availability
- Environmental conditions
- In addition, for wind power the energy conditions are stated in the form of time series suitable broken down by time; see below.
- For hydro power, the reservoir volume, draw-down limitations, and for certain analyses the relevant wind conditions, should be stated.

Financial data includes:

- Operating and maintenance costs

Further data: may include reserves (instantaneous, rapid), etc.

Consumption data:

- Annual consumption for electric power and for heating, when connected to a CHP plant
- Distribution of the consumption over the year – broken down by time, for example weeks and within the week into 3 to 8 load sections
- Additional material describing the maximum load situation
- Geographically distributed in accordance with the breakdowns in the grid models; see below

Grid and transmission data:

Transmission data is maintained on two levels of detail:

- For basic energy balances: here a DC approximation is needed, with the Nordel area subdivided into a modest number of areas with transmission between them. Data comprises transmission capacities, losses, availability, grid tariffs.

- For further assessments, e.g. to be able to assess the plausibility of the subdivision in the DC approximation, there must be a more detailed description. Subdivision into areas and design of the grid model must be coordinated with the Nordel Grid Group.

DRAFT AGREEMENT – POWER SYSTEM DATA – USE OF CONSULTANT ASSISTANCE

Agreement on the handling of power system data from TSO(s) to consultancy companies for use in the study "Study"

The consultancy company is referred to below as the recipient.

The transfer of power system data is subject to the following provisions:

1. All power system data received must be treated as confidential information, and the recipient must sign a declaration of confidentiality which contains, among others, the same clause as in § 4 of the agreement.
2. All power system data supplied by TSOs may only be used for the above-mentioned study.
3. When the recipient has completed the above-mentioned study, the received power system data must be deleted from the media on which it was stored (paper, magnetic tape, hard disk, backup etc). This must be confirmed not later than two months after completion of the study. Power system data must not be stored on media, where backup routines make the said deletion impossible.
4. The recipient will appoint one person who is responsible for the received information / power system data and who will ensure that the content of this agreement is respected and complied with.
5. Individuals at the recipient's company who are given access to the supplied power system data in order to carry out the study must be informed of the content of this agreement.
6. The recipient shall ensure that their computer and network security is sufficient (i.e. conforms to the de facto standard of the sector).
7. Parties to the agreement may approach the software supplier about software-related and model-related questions and in connection with this attach a data model. In this context, the software supplier has the status of a consultant. If the answer is of general interest, the parties to the agreement must be informed.
8. Results and background material from the study are the property of the client.
9. The content and scope of the term "power system data" are defined in Appendix 1.
10. The parties to the data exchange agreement between the TSOs are entitled to information about the content and results of the abovementioned study.

Sections 1 to 10 of this appendix apply to studies carried out with the complete model (see Appendices 1 and 2) and with the anonymised model (see § 8 of the agreement). Sections 2 and 4 to 10 apply to studies carried out with an equivalent (see § 7 of the agreement).

PROCEDURE FOR THE MAINTENANCE AND USE OF THE NORDEL DATA SET

This appendix described the procedure for the maintenance and use of the grid model and multi area power market simulator at the date of signing of the agreement.

A distinction is made between operational studies and planning studies.

Operational studies are carried out by the parties when necessary.

At the start of a planning study, if the result concerns more than two parties, the parties to the agreement are informed of the aims and timetable of the study not later than the first meeting of the Planning Committee of Nordel. The results of such a jointly carried-out planning study will be given to all parties to the agreement.

The chairman of the Planning Committee or the Operations Committee (as appropriate) must stress to any new members of the committees that everyone who is given access to the data must be aware of the content of the data exchange agreement.

Use of consultants
Each TSO chooses its own consultants.

The Nordic TSOs agree only to use consultants whose strategic interests are beyond question.

Any doubts must be raised with the TSO concerned before the data set is handed over.

Grid model data set
The grid model data set includes a data set for expansion planning to be used by, among others, the Grid Group, and a data set for operational planning, to be used by, among others, the Analysis Group of the Operations Committee.

Data sets must be established and supplied in the format for the latest version of a jointly chosen analysis software. At the signing of the agreement this is the analysis software PSS/E version 30 (from the company Siemens PTI).

A company is responsible for the functionality and updating of the Nordic dynamic grid model for a period of three years. The grid model must be a model for performing load-flow and dynamic analyses for the Nordic interconnected-operation power system. Since the major part of the model, namely the dynamic data, is common to operations and planning, the model is common to the Grid Group and the Analysis Group.

Svenska Kraftnät is responsible from 2005 to 2007 inclusive.

The parties to the data exchange agreement undertake to provide the best possible basis available for the work on the common grid model.

In addition to the necessary data it includes resources for making the multiarea power market simulator work and reflect the physical situation and to ensure that the content of the model is documented both technically and clearly.

Any revision of the grid model and the preconditions for a new model will be decided on by the Grid Group. The need for revision or for the creation of a new model is normally assessed yearly. In addition, all the parties to the agreement must provide information about important changes that may be significant for the multi area power market simulator, as quickly as possible.

Multi area power market simulator data set
The members of the Balance Group must regularly gather and maintain data on production systems, transmission systems and electricity consumption in the respective country, for the work of the group.

Data sets must be established and supplied in the format for the latest version of a jointly chosen analysis software. At the signing of the agreement this is the analysis softwares "Samkjøringsmodel" (*multi area power market simulator*) (from SINTEF of Norway) and "Samlastmodel" (multi area power market simulator) (from Powel of Norway).

Updating and filing procedure
The procedure is updated as necessary in accordance with § 3 of the agreement, and is approved by unanimous decision of the Planning Committee.

The chairman of the Planning Committee is responsible for ensuring that the currently valid procedure is filed at the Nordel secretariat.