



# **Principles for determining the transfer capacities in the Nordic power market**

**ENTSO-E System Operations Committee  
Regional Group Nordic**

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## 1. Definitions of transfer capacities

The principles for determining the capacities and margins are described in the System Operation Agreement between the Nordic TSOs. This is a part of the Nordic Grid Code, and can be found at [www.entsoe.eu](http://www.entsoe.eu). The Nordic TSOs use definitions, which are in line with the definitions used in the European Network of Transmission System Operators for Electricity ([www.entsoe.eu](http://www.entsoe.eu)).

### 1.1 Total Transfer Capacity - TTC

TTC is the maximum exchange between two areas compatible with operational security standards applicable at each system if future network conditions, generation and load patterns were perfectly known in advance.

### 1.2 Transmission Reliability Margin - TRM

TRM is a security margin that copes with uncertainties on the computed TTC values arising from:

- a) Unintended deviations of physical flows during operations due to physical functioning of load-frequency regulation,
- b) Emergency exchanges between TSOs to cope with unexpected unbalanced situations in real time,
- c) Inaccuracies, e.g. in data collection and measurements.

In practice, only the definition a) described above is used in the Nordic countries.

The present TRM values for each connection are agreed upon in the System Operation Agreement and given below.

|   |          |
|---|----------|
| Sweden - Southeastern Norway (NO1)                    | 150 MW   |
| Sweden – Central (NO3) and Northern Norway (NO4)      | 50 MW    |
| Sweden – Finland                                      | 100 MW   |
| Sweden - Eastern Denmark                              | 50 MW    |
| Sweden - Western Denmark                              | 0 *)     |
| Southwestern Norway (NO2) – Southeastern Norway (NO1) | 50 MW    |
| Southeastern Norway (NO1) - Central Norway (NO3)      | 0 MW **) |
| Southern Norway - Western Denmark                     | 0 *)     |

\*) HVDC-connection, no TRM is used.

\*\*\*) The capacity Southern Norway – Central Norway is a fixed value based on the expected flow on the connection the next day.

### 1.3 Net Transfer Capacity - NTC

The Net Transfer Capacity NTC (trading capacity) is defined as:

$$NTC = TTC - TRM$$

NTC is the maximum exchange program between two areas compatible with security standards applicable in both areas and taking into account the technical uncertainties on future network conditions.

## 2. Security standards

The criteria for system security are based on the N-1 criterion. N-1 is an expression of a level of system security entailing that a power system can handle loss of any single component

(production units, lines, transformers, bus bars, consumption etc.). For faults having the largest impact on the power system, the term dimensioning faults is used.

If the power system is not in normal state following an operational disturbance, the power system must have been restored to normal state within 15 minutes.

### **3. System protection**

System protection is used to limit the consequences of faults in the power system. System protection can have as its purpose to increase the system security, the transfer capacity, or a combination of these.

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 relieve the situation so that overloads do not arise.

### **4. Capacity calculation procedures**

The TTC between two subsystems is jointly determined by the TSOs on both sides of the interconnection.

When determining the capacity on the interconnection between two subsystems, the capacity is calculated by the TSOs on each side of the connection by using computer programs based on coordinated network models. If the values differ, the lowest value is used.

The objective is to give the market as high capacity for energy trade as possible taking into account outages and faults in the network.

The 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 corridor being defined, and static and dynamic simulations determine how much power can be transmitted in any direction through the corridor before thermal overloads, voltage collapse and/or instability arise following a dimensioning fault. In the corridor, an arbitrary number of lines on different levels of voltage can be included.

The TTC is the maximum transmission of active power, which is permitted in transmission corridors between the subsystems or individual installations. If the transfer capacity is exceeded, measures must be taken. The transfer capacity is set, using a certain safety margin (stability, voltage etc), at the transmission levels, which will entail network collapse in the event of dimensioning faults.

On the HVDC-connections, the thermal capacity (TTC) is normally used as NTC value in both directions and there is no need for any margin (TRM).

The NTC values between all the subsystems are given to Nord Pool Spot for day-ahead trading (Elspot) in its entirety. The TSOs guarantee the NTC value given for Elspot trading.

The remaining cross-border transmission capacity available under actual operational conditions after the Elspot notification of planned trading flow is offered to the intra-day market Elbas. The Elbas capacity can be influenced by changes in prognosis, faults and changes in maintenance plans. This can both increase and decrease Elbas capacity. Capacities are updated automatically when market trades between parties across borders are made. Market splitting separates the Elbas market areas dynamically when congestion occurs. Changes in Elbas-capacity will be done without sending a UMM, the exception is if the capacity is set to zero because of a disturbance.

## 5. Practical implementation of NTC calculations

### Sweden

The main principle for managing potential congestion in internal transmission corridors in the planning phase is to limit when necessary the available capacity allocated for import and export between Sweden and other Elspot areas. The distribution of capacity per relevant interconnector is usually made in proportion to its rated capacity. However Cut 2 is treated differently in this respect (see below):

The relevant internal transmission corridors are:

- Cut 1, north part of grid
- Cut 2, middle part of grid
- Cut 4, south part of grid
- West-coast corridor in the Gothenburg area

During predicted high power flow in Cut 1 there may be a need to reduce NTC for imports from Norway and Finland to Sweden.

### Allocation principles in Elspot with regard to cut 2

#### General

The NTC for export on interconnectors in Elspot south of cut 2 (Hasle, Konti-Skan, Öresund, but not Fenno-Skan) is allocated with optimization with regard to price by NPS calculation.

The NTC for export on these interconnectors will be set to the same as maximum trade capacity if no other limitations exist e.g. cut 4. The optimization in the Elspot calculation is made on condition that the total trade on these interconnectors shall not exceed Elspot's total allocated share of cut 2.

The fact that Elspot is given a sum net export limit for all those interconnectors combined while the individual interconnectors are not constrained has the additional positive effect that import from any of those areas towards Sweden can be utilized for transit to any of the other areas in question. In cases when first the cut 2 net limit out of Sweden has been fully utilized (i.e. is congested) one outcome of such transits through Sweden is that it appears like the power flow goes from high to low price area, but the fact is that in those cases all imports from one of the Bid Areas south of cut 2 always represent a transit to one of the other Areas south of cut 2.

#### Strained situations

In critical power balance situations Svenska Kraftnät will, in order to maintain power system security, temporarily give up the Elspot optimization. In such situations the export capacity will be reduced in proportion to rated capacity for all interconnectors, Elspot and other, south of cut 2. When the temporary measure to give up the optimization is taken Svenska Kraftnät will send an UMM special information at the latest in the morning before delivery date and when procedures return to normal it will be notified by Svenska Kraftnät via a follow-up UMM.

When there is a need to limit cut 4 the export capacities to Poland, Germany and Eastern Denmark will be allocated as the sum of:

- Capacity allocated in proportion to the rated capacity on the interconnectors SwePol Link, Baltic Cable and Öresund
- and
- Capacity contribution of installed system protection on DC-links allocated to respective link in proportion to the system protection's impact on cut 4

Interconnectors affecting the load flow through the West-coast corridor are:

- Southern Norway-Sweden (Hasle)

- Western Denmark-Sweden (KontiSkand)
- Eastern Denmark-Sweden (Øresund)
- Germany-Sweden (Baltic Cable)
- Poland-Sweden (SwePol Link)

The West-coast corridor is different from other cuts in Sweden as it is not a cut across the whole country between national borders. When there is a need to limit the West-coast corridor import and export on all interconnectors affecting the load flow through the corridor will be reduced in proportion to their rated capacities.

Forecasts used when calculating NTC values in cuts:

- Physical capacity with regard to grid configuration and generation conditions.
- Demand south of cut with regard to temperature forecast.
- Export or import on interconnectors. The day before is used as reference.

This gives the prerequisites for calculation of NTC values on respective interconnector that will be given to Nord Pool Spot.

### Norway

The Norwegian power grid is divided into Elspot/Elbas areas in order to handle large and long-term congestions. New Elspot/Elbas areas can also be established in case of strained regional energy situation. Other congestions will under normal conditions be managed through the use of the Balancing Market as special regulations covered by Statnett. Large congestions in the grid may arise on short notice, for example due to a fault or a forced outage of a critical transmission line. The market will be informed about a new Elspot/Elbas area division at the latest on Monday one week before it comes into force (normally two weeks before).

From 11.01.2010, Norway is divided into four Elspot/Elbas areas:

- NO2, a southwestern Norway Elspot/Elbas area limited by the 420 kV line Rød-Hasle, the 420 kV line Rjukan-Syiling, the 300 kV line Vemork-Flesaker, the 300 kV line Tokke-Flesaker, the 300 kV line Hof-Flesaker, the 300 kV line Modalen-Refsdal, the 132 kV line Grønnvollfoss-Skollenborg, the 132 kV line Hof-Skollenborg and the 66 kV (50 kV) line Klyve-Sima, where the first node of each line are located in the southwestern area (NO2) and the second mentioned nodes are located in the southeastern area (NO1).
- NO1, a southeastern Norway Elspot/Elbas area limited to the southwest (NO2) by the nodes listed above, and to the north (NO3) by the 300 kV line Øvre Vinstra-Vågåmo (with node Ø.Vinstra in NO1), the 132 kV busbar at Litjfossen and the 132 kV double busbar at Åskåra, with one busbar in each area (NO1 and NO3)
- NO3, a middle Norway Elspot/Elbas area (NO3) limited to the south (NO1) by the nodes listed above and to the north (NO4) by the 300 kV line Verdalen-Tunnsjødal and the 300 kV line Namsos-Tunnsjødal, with node Tunnsjødal in NO4.
- NO4, a northern Norway Elspot/Elbas area, north of NO3.

The determination of the NTC value between two Elspot/Elbas areas is based on thermal restrictions, voltage or stability limits in the transmission system in order to maintain an agreed level of security of supply. The NTC value may also be affected by outages of major transmission lines in the Norwegian grid. This happens when the outage is close to cross-

border connections and/or when it is impossible to relieve the congestion through counter-trade in the Norwegian system.

### NO2-DK1

The capacity on the HVDC-cables between Norway and western Denmark is:

- 950 MW from Western Denmark to Norway
- 1,000 MW from Norway to Western Denmark

when Kristiansand is the exchange point (losses purchased in Western Denmark) and:

- 1000 MW from Western Denmark -> Norway
- 950 MW from Norway -> Western Denmark

when Tjele is the exchange point (losses purchased in Norway). Statnett and Energinet.dk agree weekly where the losses can be bought most economically.

During summer, in periods with high temperature, the NTC value may be reduced due to thermal restrictions on the HVDC-link.

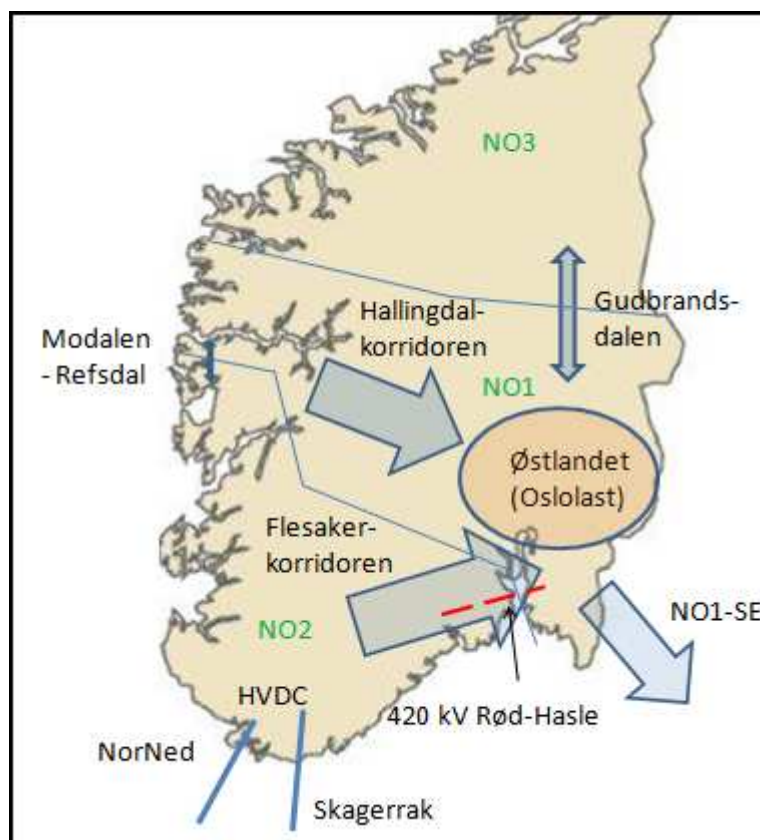


Figure 1, main corridors in the southern part of Norway.

### NO2-NO1

The thermal transmission capacity on the 420 kV line Rød-Hasle is, until further reinforcement, permanently reduced to 65% compared to the previous capacity (before April 2008). The load flow on this connection determines the NTC value between southwestern Norway (NO2) and southeastern Norway (NO1). When the Rød-Hasle connection is fully loaded, the flow on the connections from the southwest to the east (the Flesaker-corridor) may vary depending on the HVDC exchange and the distribution of production internally in the area. The load flow at the connection 300 kV Modalen-Refsdal may also vary due to load and production in the area close to this line. The expected load flow at the individual lines between NO2 and NO1, including the reduced 420 kV Rød-Hasle connection will in general affect the calculated NTC-value between NO1 and NO2. The calculated NTC value from NO2 to NO1 is thus expected to vary between 1700 MW to 2700 MW. The Rød-Hasle

connection is estimated to be fully loaded when the flow towards southwest through the Flesaker-corridor is about 1600 MW. The capacity band from NO1 to NO2 will correspondingly be in the interval 1300 MW to 1900 MW due to the varying load flow at 300 kV Modalen-Refsdal.

### NO1-SE

The Elspot/Elbas corridor between southeastern Norway (NO1) and Sweden (SE) consists of the Hasle-corridor and the transmission line Eidskog-Charlottenberg. The calculated NTC-value NO1-SE is the sum of these capacities.

The capacity in the Hasle-corridor is dependent on several factors. In the winter period, the export capacity is dependent on the consumption in the Oslo-area. When the Flesaker-corridor and the Hallingdal-corridor are fully loaded towards Oslo, the capacity in the Hasle-corridor is gradually reduced with increased consumption in the Oslo-area, figure 2.

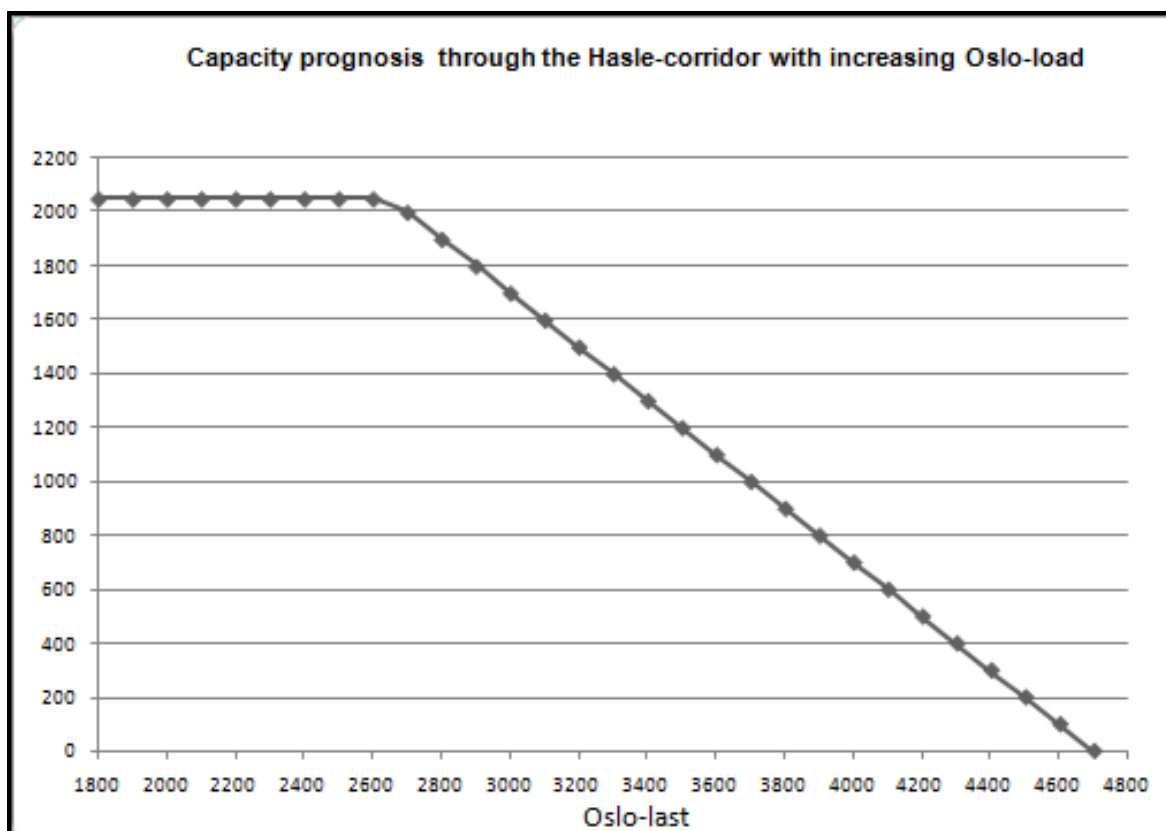


Figure 2, prognosis of the capacity between southern Norway and Sweden through the Hasle-corridor, dependent on load in the Oslo area. The TRM is subtracted in the figure.

During summer, in periods with high temperature, the capacity may be reduced due to thermal restrictions on the lines in the Hasle-corridor. The condition for maximum capacity through the Hasle-corridor, is a balanced load flow between the Flesaker-corridor and the Hallingdal-corridor towards the Oslo-region. The capacity may therefore also be reduced in situations of biased load flow between the Hallingdal- and Flesaker corridor.

In addition to the capacity in the Hasle-corridor, the capacity on the transmission line Eidskog-Charlottenberg is included in the NTC-value NO1-SE and SE-NO1. The maximum physical capacity on Eidskog-Charlottenberg is 95 MW in both directions. In heavy load situations (winter period), the capacity is reduced to about 50 MW due to constrains in the transmission grid close to the Eidskog-Charlottenberg connection.

The maximum NTC NO1-SE is 2145 MW, and SE-NO1 is 2095 MW.

### NO1-NO3

The NTC value given to the market between southern and middle Norway is a fixed value based on the expected flow on the connection the next day. The direction may deviate from normal direction of the flow between low and high price area. This is due to physical laws in the power system: A variation in the traded balance in South-Norway will hardly influence the physical flow between South- and Middle-Norway while the impedance through this corridor is high compared with the impedances in parallel grid in Sweden and between South-Norway and Sweden. Power may thus flow south from NO3 to NO1 even when there is full export from South-Norway (to Sweden), and vice versa.

### NO3

The import capacity to middle Norway will vary, depending on production in NO3, and the volume and distribution of production in NO1, NO4 and Sweden. The lowest capacity to middle Norway occurs in cases of low production in southern and northern Norway. Low production in southern and northern Norway could cause low transmission to middle Norway from these areas. This will cause high transmission from Sweden to middle Norway, and the connection SE-NO3 could reach its thermal limit. During high transmission to NO3 from NO1 and Sweden or from NO4 and SE, the congestion can appear as a sum of these two transmissions.

The expected congestions imply an import capacity in the range of 1100-1500 MW, depending on the distribution of production, consumption and the load flow towards the area. The NTC value is based on the expected physical congestions.

### NO4

Where NO3 in general is a deficit area, NO4 is a surplus area with export to NO3 and Sweden. The NTC value NO4-NO3 and NO4-SE is based on the expected physical congestions. The total export capacity from NO4 is normally in the range 1500-1700 MW. The highest export capacity will occur in situations with high load flow from NO4 to NO3. Low production and high consumption in the northern part of NO4 could cause a lower export capacity.

The import capacity SE-NO4 is normally 600 MW and NO3-NO4 is normally 0 MW, but could be up to 200 MW in periods with high production and low consumption in NO3.

## **Finland**

When defining the NTC value between Finland and Sweden the forecasted regional power balance in southern and northern Finland is taken into consideration as well as the predicted connection of power plants having influence on the system stability. Typically due to winter temperatures the deficit in northern Finland increases and this will be taken into account when defining NTC from Finland to Sweden. During night time the NTC may be reduced according to the forecasted deficit volume to manage system stability during heavy transmission from south to north Finland.

The flow on radial 220 kV line from Ossauskoski Finland to Kalix Sweden as well as transit flow to/from northern Norway through Sweden and Finland may affect the NTC values up to 150 MW. The allocation of these transit flows are the reason why published max NTC values seem sometimes to be exceeded or the NTC may be slightly reduced without any other reason,

The transfer capacity on Fenno-Skan will be reduced in cases with high temperature. Typically during summer the NTC of Fenno-Skan is 50 MW lower than during winter.

The Russian connection can only be used for import to Finland due to technical reasons in the HVDC system in Vyborg. In June 2009 one of four 350 MVA HVDC units was technically tested in bidirectional operation. The results were positive, but some additional tests may be needed and capacity allocation rules have to be agreed before bidirectional operation is allowed to be used.

Estlink HVDC connection between Estonia and Finland has the capacity of 350 MW to both directions. During winter 15 MW temperature dependent overloading capacity can be used. The connection is a merchant line owned by Nordic Energy Link AS.

### **Denmark**

The NTC on the HVDC-connection between Eastern Denmark and Germany (Kontek) is the TTC deducted by 50 MW frequency controlled disturbance reserve in both directions.

In special situations the calculated NTC value between Western Denmark and southern Norway+ Sweden depends on the power production in the northern part of Jutland. In periods with high wind production the import capacity can be reduced. To handle these special situations a optimization limit is in place in Elspot for the so called cut B in Western Denmark. It works as a limit both for the sum export allowed from Western Denmark to Sweden and Southern Norway and for the opposite i.e. the sum import.

The capacity on the HVDC-cables between Sweden and Western Denmark refers to the measurement in Vester Hassing in Denmark. This means that because of the losses in the connection the NTC value is 680 MW to Denmark and 740 MW to Sweden.

The day-ahead NTC capacities on the connections between Denmark and Germany (AC from Western Denmark (price area DK1) and HVDC from Eastern Denmark (price area DK2, Kontek)) are made available to the European Market Coupling Company (EMCC) for market coupling between Denmark and Germany. The intra-day trading (Elbas) between Eastern Denmark (price area DK2) is handled by Nord Pool Spot.

### **Constraint reasons and locations**

To ensure a higher level of transparency of how capacities between the Elspot areas are determined, Nordel has decided to extend its information to the marked by using codes for capacity reduction. Each Elspot capacity will have one code every hour. The codes consist of four numbers, where the two first numbers informs about what type of capacity reduction it is, and the two last numbers informs about location of the constraint. The Capacity Reduction Codes can be studied at: <http://www.nordpoolspot.com>