Line Sets

NO2A

NO1A

DK1A

SE3 to (NO1+DK1)

Explanation document

Optimization of Day-Ahead Transmission Capacities

The transmission system operators (TSOs) determine the trading capacity between each bidding zone. The available trading capacities for the next day are published on Nord Pool's website at 10:00 CET.

To optimize the use of the transmission grid, Nord Pool uses both transmission capacities on individual interconnectors, and sum limitations for a group of interconnectors, so-called Line Sets, in the price calculation. The three bidding zones which before March 2022 have had Line Sets implemented are linked to DK1, NO1, and NO2. From delivery date 29th of March 2022 a Line Set is also applied for bidding zone SE3 as a sum towards DK1 plus NO1.

The NO2A Line Set consists of the following connections:

- NO2 ↔ TT NL
- NO2 ↔ TT DE

The NO1A Line Set consists of the following connections:

- NO1 ↔ NO5
- NO1 ↔ NO2

The DK1A Line Set consists of the following connections:

- DK1 ↔ SE3
- DK1 ↔ NO2

The SE3 Line Set consists of the following connections:

- SE3 ↔ DK1
- SE3 ↔ NO1

The solution applied in the Single Day Ahead Coupling (SDAC) algorithm, i.e., PCR Euphemia, is the same for Denmark, Norway, and Sweden even through the physical limitations and background for implementing the given Line Sets are different.

NO2A Line set

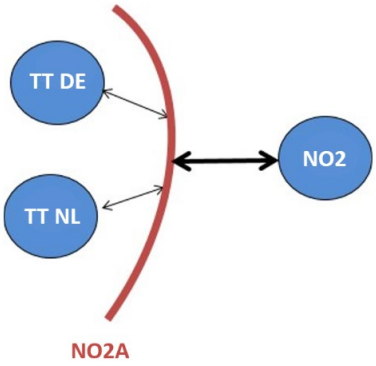

Figure 1: Line set NO2A WITH RELATED CONNECTIONS

With the implementation of the NordLink interconnector, the sum of capacity and ramping in/out of the Bidding Zone NO2 in southern Norway is increased. To maintain the operational security in southern Norway, the TSO Statnett needed to set limitations for both ramping and capacity for the two HVDC interconnectors NorNed (NO2-NL) and NordLink (NO2-DE) linked to the bidding zone NO2. NO2A was implemented to optimise the use of capacity and ramping in the most cost-efficient way.

A new virtual interconnector was implemented, including cost coefficients for NO2-NO2A (in both directions):

- NO2-NO2A interconnector includes capacity (both directions)
- NO2-NO2A interconnector includes ramping

The two interconnectors now have the new area NO2A on the Norwegian side:

- NordLink NO2-DE <-> NO2A-DE (both directions)
- NorNed NO2-NL <-> NO2A-NL (both directions)

Planned ramping limitations:

- NO2-NO2A virtual interconnector: 900 MW
- Skagerrak NO2-DK1A: 450 MW (changed from the previous limitation of 600 MW)
- NordLink NO2A-DE: 619 MW (changed from the previous limitation of 309 MW)
- NorNed NO2A-NL: 619 MW (no change)

Loss factor unchanged:

- Skagerrak: 2,9%
- NordLink: 3,1%
- NorNed: 3,2 %

The net flow on the individual interconnectors (NorNed + NordLink) cannot be higher than the NO2A-NO2 limitation.

NO1A Line set

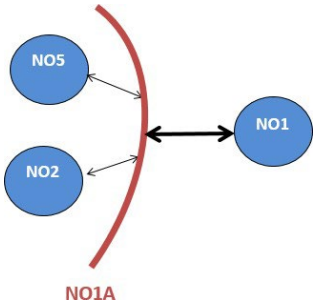

Figure 2: Line set NO1A WITH RELATED CONNECTIONS

The total sum of power into NO1 from Western and Southern Norway cannot be larger than the sum of thetransmission capacity from NO5 into NO1, and from NO2 into NO1. The additional constraint between NO5/NO2 and NO1, is referred to as NO1A, where the "A" indicates that a line set is implemented on the related connections.

Total sum of power flowing from NO2 and NO5 into NO1 = Max [(Power flow on (NO5-NO1) + Power flowon (NO2-NO1)]

The sum of import/export to/from NO1 equals the physical flow on the interconnectors NO5-NO1 and NO2-NO1. The import/export cannot be higher than the NO1A-NO1 limitation. Hence the flow out of/into NO1 on each of the interconnectors can be restricted by the NO1A-NO1 limit even though there is available capacity on each single interconnector.

Background on NO1A Line set

The Line Set NO1A represents an internal bottleneck in the South of Norway and reflects the sum of net export/import capacity available for the day-ahead calculation, east of the internal bottleneck from areas NO2 and NO5.

Example:
The NO2-NO1 and NO5-NO1 corridors have a total theoretical capacity of 6700 MW. The cut that constitutes most of these corridors has a dynamical stability limit of 5500 MW while the secondary cut has a thermal limit of approximately 800 MW, resulting in a maximum combined capacity in the range of6300 MW, which is represented by the Line Set NO1A.

Full utilization of both corridors at the same time is expected when consumption in the Oslo-area peaks at daytime in the winter months. Reductions aimed at managing the combined capacity is managed by the Line Setrestriction. For the remaining parts of the year the issue of full utilization of both corridors simultaneously is expected to be insignificant. This means that apart from the winter months the combined capacity can be higher to maximize the usage of one corridor at the time. The Line Set in Southern Norway was implemented in January 2015.

DK1A Line set

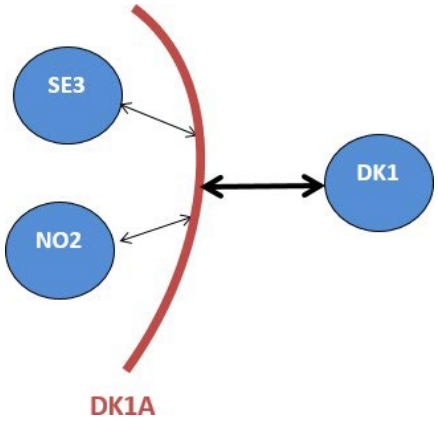

Figure 3: LINE SET DK1A WITH RELATED CONNECTIONS

The total sum of power into DK1 cannot be larger than the sum of the transmission capacity from SE3 into DK1, and from NO2 into DK1.

Total sum of power flowing into DK1 (or out of DK1) = Max [(Power flow on (NO2-DK1) + Power flow on (SE3-DK1)]

The Line Set configuration for DK1 towards (NO2+SE3) also allows for transit flows from (to) NO2 to (from) SE3 via DK1(A) on top of the set Line Set limit for DK1 export/import towards SE3+NO1.

Background information on DK1 Line set

Cut B in Denmark is an internal bottleneck in the north of Jutland. Cut B reflects the sum of net export/import capacity available for the Day-ahead calculation, north of Cut B towards areas NO2 and SE3.

The sum of import/export to/from DK1 equals the physical flow on the interconnectors DK1-

NO2 and DK1-SE3. In DK1 the import (export) cannot be higher than the Cut B limitation. Hence the flow out of/into Denmark on each ofthe interconnectors can be restricted by the Cut B limit even though there is available capacity on each single interconnector

The line set on Jutland was implemented in March of 2004

SE3 Line Set sum towards NO1 plus DK1

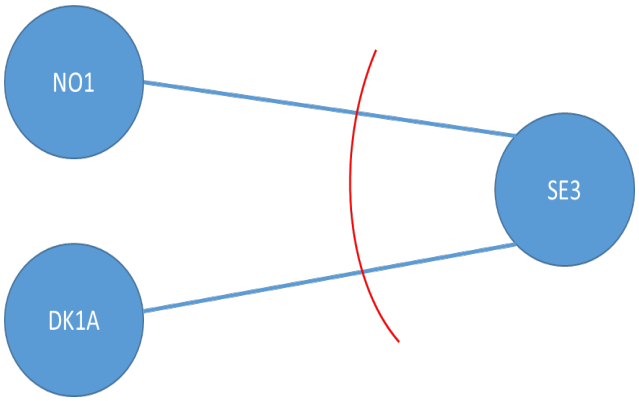

Figure 4: LINE SET SE3 TOWARDS NO1 AND DK1(A)

The total sum of power export from SE3 towards NO1 plus DK1(A) cannot be larger than the SE3 line set sum towards (DK1+NO1) depicted by the red curved line above. That sum limit of export power flow from SE3 (to NO1+DK1) is given by this formula:

Max [(Power flow on (SE3 to NO1) + Power flow on (SE3 to DK1)].

However, the SE3 line set also allows transit flows between DK1 and NO1 via SE3. This enables the export flow to either NO1 or DK1 to be higher than the sum export limit from SE3 because the total net export from SE3 to NO1+DK1 given by the line set will be assured never to be exceeded because of transits between DK1 and NO1 via SE3.

Background information on SE3 Line Set

The total sum power export from SE3 towards NO1 and DK1(A) cannot be larger than the from time-to-time varying physical constraint on East to West power flows across SE3 that is concluded by the Swedish TSO Svenska Kraftnät. Before implementation of the line set that physical sum limit has been managed by a distribution of reductions of the capacity on each of the two cross zonal interconnectors, while the sum of the export capacity from SE3 to NO1 and DK1 has equalled the concluded total constraint for Westward exports out of SE3. In that setup there are cases when only one cross zonal interconnector is utilized for export from SE3 and then the total net export from SE3 to NO1+DK1 will be less than what physically could have been managed. In addition, the positive effects of import from one cross zonal interconnector cannot be utilized for transit through SE3 to allow for more export on the other cross zonal interconnector. With the introduction of a SE3 Line Set sum to NO1 plus DK1 as an additional constraint, it is possible to set the individual line capacities, i.e. SE3-DK1 (A) and SE3-NO1, based on the limits the TSOs on both sides agree as being max ATC, typically equal to max NTC unless there are specific limits such as outages on the links themselves.

There is a significant difference in max NTC for SE3-DK1 (715 MW) vs. for SE3-NO1 (2095/2145 MW). If for example the SE3 line set limit is modest (for example 1500 MW export limit from SE3 to NO1+DK1) the SE3 Line Set will be above the max (NTC) export that is possible to DK1 while it towards NO1 will be lower than what is possible max (NTC) export. In that case import flows from DK1 to SE3 can be added as transit flows to NO1, until the max (NTC) limit is reached for SE3-NO1.

The SE3 line set to (NO1+DK1) is implemented in the Single Day Ahead Coupling (SDAC) from delivery date 30th of March 2022.