Request for Capacity Calculation Region Hansa to be allowed to apply CNTC for capacity calculation methodology in accordance with Article 20(7) of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a Guideline on Capacity Allocation and Congestion Management

21st of September 2018

CCR Hansa TSOs request to be allowed to apply the coordinated net transmission capacity approach in CCR Hansa according to Commission Regulation (EU) 2015/1222 Article 20(7).

The CCR Hansa TSOs acknowledge the objectives of the Commission Regulation (EU) 2015/1222 on capacity allocation and congestion management which, among others, are:

- ensuring optimal use of the transmission infrastructure;
- ensuring operational security;
- optimising the calculation and allocation of cross-zonal capacity.

With this in mind, the CCR Hansa TSOs aim to implement an effective and efficient capacity calculation process, which allows for an optimal use of the transmission infrastructure while maintaining a high level of system security.

CCR Hansa consists of two DC-connected borders and one AC-connected border. To understand the capacity calculation methodology and the related methodologies for remedial actions, it is important to know the current topology of the AC border which is shown in Figure 1~~Figure 1~~. When the 220kV lines (green lines in map) are upgraded to 400kV, the one which connects to the Danish substation "Ensted" will instead connect to "Kassø", making the existing and new 400kV lines fully parallel.

At present, there are two phase-shifting transformers placed in Denmark at the substations where the 220kV lines connect. The aim of these is to equalise the distribution of flows between the 400kV and 220kV lines and therefore to ensure the 220kV lines are not overloaded in operation.

There is no synchronous interconnection from DK1 to DK2 or Scandinavia. DK1 is only connected with AC lines to the German grid. This means that all exchanges between DK1 and DE/LU have to flow from Kassø to Audorf. Only the grid between Kassø and Audorf is represented within the capacity calculation of CCR Hansa. The 150kV line from Ensted in Denmark and Flensburg in Germany is only a supply line, as there is no transfer capability between the bidding zones of DK1 and DE/LU on this line. Due to historic reasons, significant parts of Flensburg are supplied from Denmark and are a part of the market in DK1.

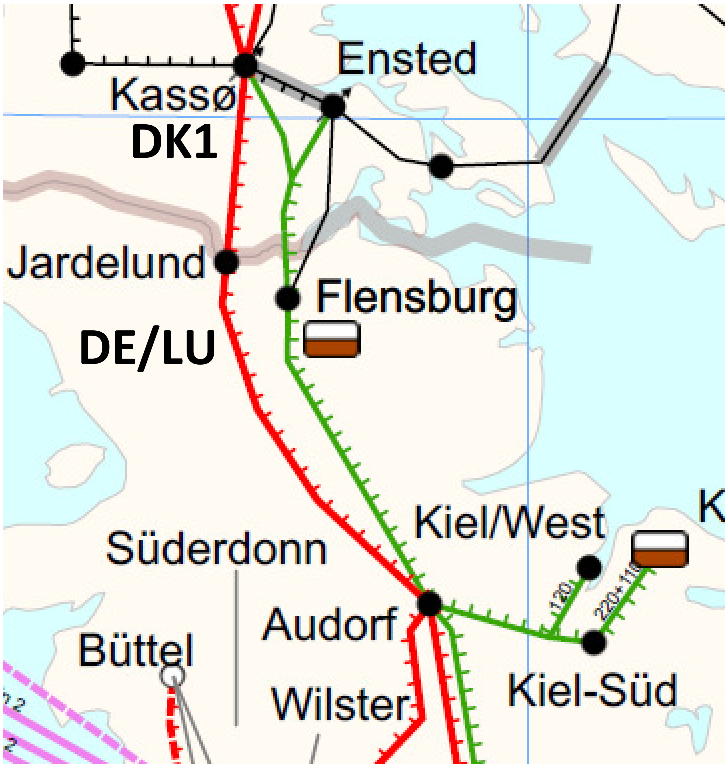

Figure 1: Topological overview of the Denmark West (DK1) - Germany (DE/LU) AC interconnection within CCR Hansa. The green lines are 220kV lines and the red lines are 400kV lines, and these are both double circuits across the border between Denmark (DK1) and Germany (DE/LU).

Since both cross-border connections are connected to the substations Kassø in Denmark and Audorf in Germany, the DK1-DE/LU bidding-zone border is considered radial, and no loop flows can occur.

All of the CCR Hansa interconnections, including the DK1-DE/LU AC border due to the topology, are radial[1] interconnections. This quite unique feature of CCR Hansa was kept in mind by the CCR Hansa TSOs when developing the capacity calculation methodology (CCM) for the CCR Hansa.

CACM Regulation Article 20 paragraph 1 in conjunction with paragraph 7 state that the approach used in the common capacity calculation methodology shall be a flow-based approach, unless the TSOs concerned are able to demonstrate that the application of the capacity calculation methodology using the flow-based approach would not yet be more efficient compared to the coordinated net transmission capacity (CNTC) approach and assuming the same level of operational security in the concerned region.

1. Why a CNTC capacity calculation is as efficient as a flow-based capacity calculation for CCR Hansa

The strength of the flow-based approach is its ability to model the simultaneous influences of cross-border trades over several bidding-zone borders on critical grid elements in the investigated CCR,

[1] A radial interconnection is a direct interconnection from A to B with no alternative paths. In an electricity system that means there are no unscheduled flows across other parts of the grid.

affected by several power flows. Particularly in highly-meshed grids, like the Continental European and Nordic AC grids, this approach offers a good model of the real power flows. On radial interconnections and HVDC links – the latter being fully controllable devices – however, the power flow has a predefined path across the bidding-zone border.

Here, the flow-based capacity calculation does not yield any additional benefit compared to the CNTC approach. This is demonstrated in Figure 2~~Figure 2~~.

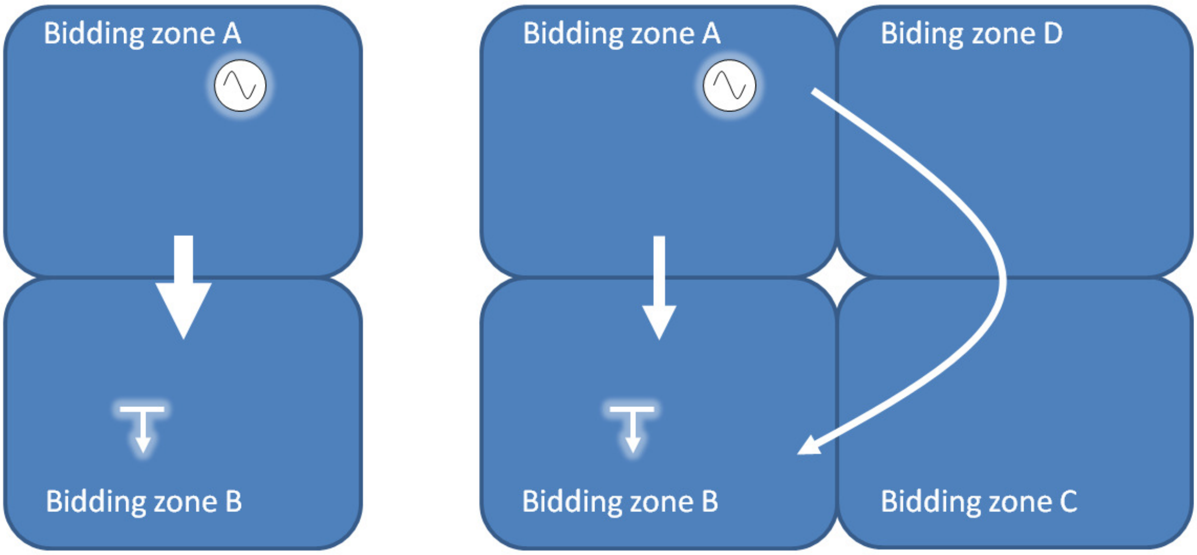

Figure 2: Radial (left) and meshed (right) bidding-zone configuration.

In Figure 2~~Figure 2~~ (left), the bidding zones A and B are interconnected in a radial way. Just like the substations Kassø and Audorf on the DK1-DE/LU AC bidding-zone border as shown in Figure 1~~Figure 1~~, there is a one-to-one translation from the commercial power exchange between those bidding zones into a physical cross-border flow on the lines. Translated into the flow-based parameters, this means the interconnection has a PTDF = 1. With the general flow-based equation being:

$$PTDF_{A \to B} \cdot NP_{A \to B} \leq RAM$$

The full change in net position (NP) between the bidding zones A and B fully manifests onto the capacity of the interconnection. In case there are several lines connecting the two radially connected substations, the individual PTDFs of these lines sum up to 1 in total. I. e. the same amount of power that enters the line also has to leave it again (not considering grid losses). In a setup as in Figure 2~~Figure 2~~ (left), there are no synchronous interconnections to other bidding zones. Therefore any exchanges between other bidding zones (not shown in the example of Figure 2~~Figure 2~~) have a PTDF = 0 onto this interconnection. Bidding-zone borders connected by HVDC lines also have no effect on the interconnection between A and B.

In case of an NTC calculation, the NTC value between the bidding zones A and B is equivalent to the full change in net position since the full flow has to pass through the interconnection between A and B. Therefore, both methods will lead to the same results.

This shows that the CNTC method is an efficient means to allocate the commercial exchanges in grids with radial interconnections.

In Figure 2~~Figure 2~~ (right), the situation in meshed grids – like the Continental European and Nordic power systems – is depicted. A commercial exchange between the two bidding zones A and B results in a physical flow fanning out through the meshed grid. It is exactly this behaviour that is captured by the flow-based methodology, which makes it the preferred solution in meshed grids.

Given the physical layout of CCR Hansa, the situation of Figure 2~~Figure 2~~ (right) cannot happen on the CCR Hansa bidding-zone borders. In fact, in radially-connected systems, the flow-based methodology does not provide different results and therefore has not any added value compared to CNTC, as there are no alternative routes from bidding zone A to bidding zone B.

CNTC in CCR Hansa is therefore the preferred solution for the CCM in CCR Hansa, as it is more proportionate to introduce compared to a flow-based approach.

2. Simple Simulation Assessment

Below is a calculation of the PTDF based on a 2025 grid model from the TYNDP2018 project considering the planning models of Denmark and Germany. In comparison to the map shown in Figure 1~~Figure 1~~, then the 220 kV lines have been upgraded to 400 kV lines, as they will be in reality in 2020.

400 kV Endrup-Klixbüll 1 and 2 (West coast line) are disconnected for the purpose of this calculation, leaving 4 x 400 kV tie lines in service, which are subsequently also the 4 CNEs that are monitored:

- 400 kV Flensburg-Kassø 1
- 400 kV Flensburg-Kassø 2
- 400 kV Jardelund-Kassø 1
- 400 kV Jardelund-Kassø 2

Experience shows that an outage of a given circuit will give a higher loading on a remaining parallel circuit, than an outage of a line on another tower.

The example below assumes that all four lines are in service. Flow Reliability Margin is not considered.

Two Area-to-Area PTDF transactions (GSK strategies) are considered:

a) DK1->DE/LU: Covering a situation where all generators in DK1 and DE/LU are used in the GSK. GSKs are set according to the active power generation of all units in Denmark (excluding DK2) and Germany (excluding windfarms Baltic1 and Baltic2).
b) DK1(NO2)->DE/LU(DK2): GSK is arbitrarily based on power injection at Tjele in Denmark (where DK1-NO2 connects) and Bentwisch in Germany (where DE/LU-DK2 connects)

Option b is included to demonstrate that the results are invariant to the GSK strategy.

The 4 CNECs (Critical Network Element and Contingencies) consist of each line with the parallel line out of service. The result of the simulation is shown in Table 1~~Table 1~~.

Name	Fmax MW]	PTDF DK1->DE/LU (option a)	PTDF DK1(NO2)->DE/LU(DK2) (option b)
CNE:FLEN-KAS1 C:FLEN-KAS2	2500	38.50%	38.50%
CNE:FLEN-KAS2 C:FLEN-KAS1	2500	38.50%	38.50%
CNE:JARD-KAS1 C:JARD-KAS2	1500	33.90%	33.90%

CNE:JARD-KAS2 C:JARD-KAS1	1500	33.90%	33.90%

Table 1: PTDF matrix for CNEs on DK1-DE/LU bidding-zone border with two different GSK strategies applied. The PTDF value shows the share of the total cross-border flow that the critical branch will carry when the critical outage is its parallel circuit as this will be the most critical outage.

When considering one of the 4 Contingencies (e.g. C:FLEN-KAS2) of Table 1~~Table 1~~, it can then be shown how the flow distributes on the rest of the bidding-zone border elements, which is done in Table 2~~Table 2~~.

Name	Fmax MW]	PTDF DK1->DE/LU (option a)	PTDF DK1(NO2)->DE/LU(DK2) (option b)
CNE:FLEN-KAS1 C:FLEN-KAS2	2500	38.50%	38.50%
CNE:FLEN-KAS2 C:FLEN-KAS2	2500	0%	0%
CNE:JARD-KAS1 C:FLEN-KAS2	1500	30.75%	30.75%
CNE:JARD-KAS2 C:FLEN-KAS2	1500	30.75%	30.75%

Table 2: The N-1 security principle sets an outage on FLEN-KAS2, thus loading FLEN-KAS1 to 38.5% of the total cross border flow. The resulting flow on the other two circuits will be 30.75% each. In total this sums to 100%.

From Table 2~~Table 2~~ it can be deducted that the flow across the remaining three available cross-border elements sums up to 100% thus showing that all direct exchange between the bidding zones of DK1 and DE/LU will cross this bidding-zone border and subsequently leads to the conclusion that a CNTC methodology is suitable to be applied for the bidding-zone border as there are no power flows to be taken into account which are not crossing the bidding-zone border.

3. Conclusion

In the paper it has been shown graphically that power exchanges between the bidding zones of DK1 and DE/LU have to pass through the substations Kassø in Denmark and Audorf in Germany. Also it has been shown that in a simulation, the GSK strategy is of no consequence to the power flows on the AC border and that all power that is exchanged between DK1 and DE/LU does indeed flow on the radial lines crossing the border, with the PTDF of the lines across the border summing to 100%.

Based on this, the CCR Hansa TSOs, in accordance with Article 20(7) of the CACM Regulation, request to apply CNTC as we believe we have demonstrated that a flow-based approach is not more efficient in terms of capacity calculation and allocation taking into account market perspective and operational security.