

Transitional solution for
calculation and allocation of
intraday cross-zonal capacities
for continuous trading in the
Intraday timeframe

29.11.2024



Abbreviations:

| | |
|---------|---|
| AAC | Already Allocated Capacity |
| AAF | Already Allocated Flow |
| ATC | Available Transfer Capacity |
| ATCE | ATC Extraction |
| BZ | Bidding Zone |
| CC | Capacity Calculation |
| CCM | Capacity Calculation Method |
| CNE | Critical Network Element |
| CNEC | Critical Network Element with Contingency |
| D-1 | 1 Day before delivery date |
| D-2 | 2 Days before delivery date |
| DA | Day-Ahead |
| FB | Flow-Based |
| ID | Intra-Day |
| MC | Market coupling |
| NEMO | Nominated Electricity Market Operator |
| NP | Net position |
| NTC | Net Transfer Capacity |
| PTDF | Power Transfer Distribution Factor |
| RAM | Remaining Available Margin |
| SDAC | Single Day-ahead Coupling |
| SE1-SE2 | Swedish border between bidding zone SE1 and bidding zone SE2, containing both directions of SE1→SE2 and SE2→SE1 |
| SE1→SE2 | Direction from bidding zone SE1 to bidding zone SE2 |
| TP | ENTSO-E Transparency Platform |
| TSO | Transmission System Operator |
| XBID | Intra-Day continuous trading platform |
| z2z | Zone-to-zone |
| z2s | Zone-to-slack |



| Version Control | | | |
|------------------------|------------------------------|-------------|---|
| Version | Author | Date | Changes |
| 0.1 | Nordic CCM project MET WG | 13.04.2022 | First version |
| 0.2 | Nordic CCM project MET WG | 29.02.2024 | Detailed explanation of relaxation parameters and various enhancements for better readability |
| 0.3 | Nordic CCM project MET WG | 24.04.2024 | Updated relaxation parameters |
| 0.4 | Nordic CCM project MET WG | 17/10/2024 | Improved explanation of delta compensation and more clarifications RAM relaxation on allocation constraints |
| 0.5 | Nordic CCM project MET WG | 29/11/2024 | Improved explanation on ID ATC extraction |



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1 Background and purpose

Article 20 of the Nordic DA CCM, approved on October 14, 2020, describes a transitional solution for the calculation and allocation of cross-zonal capacities for the intraday timeframe. Article 20(1) states the need of calculating ATC-values based on the FB domain for the intraday market until the single intraday



coupling is able to support FB parameters¹. Article 20(2) prescribes an optimization approach to facilitate this calculation. Article 20(3) requires the Nordic TSOs to publish the optimization approach and the parameters used, including their descriptions, purpose, and effect two months before the application of this transitional solution (i.e. two months before the Nordic DA FB go-live). The NRAs and stakeholders shall be informed along the development process of the optimization formulation, and they may provide comments duly to be taken into account in development work.

This document aims at fulfilling the article 20(2) and 20(3) by elaborating the optimization formulation that is currently being investigated in the Nordic CCR and is intended to be used at the start of the parallel runs. As such, this document is a living document that is aligned to the latest development of the ATC extraction (ATCE) along the Nordic CCM parallel runs.

Article 20 requires the calculation of 'ATC' values from the 'final DA FB domain'. The calculation is referred as the ATCE method. Because the final DA FB domain is used as input to the ATCE, the outcome of this calculation is 'ATC' values, corresponding to the ATC values that are calculated based on the remainder of the DA FB domain. Chapter 3 elaborates more on the terminology of the ATCE in the Nordic context.

2 High level comparison between FB and NTC

This chapter illustrates the relationship between the FB and NTC given the same grid topology and conditions for the two approaches. Considering the following example depicted in Figure 1, a power grid consisting of three bidding zones (BZs), and three identical lines with the physical capacity of 1000 MW each. Each line is considered a Critical Network Element (CNE).

The physical characteristics of this grid can be linearized and represented by a matrix of "zone to slack" PTDFs (z2sPTDFs) and Remaining Available Margins (RAMs). Each BZ has a specific z2sPTDF for each CNE that tells us how much of one MW injected in this BZ shows up on a particular CNE. Each RAM shows the maximum allowed flow on each CNE. In this simplified case, the capacity of each connecting line (or CNE)

¹ 'Until the single intraday coupling in accordance with Article 51 of the CACM Regulation is able to support the allocation of cross-zonal capacities based on FB parameters, the CCC shall transform the final FB parameters as referred to in Article 19 into available transmission capacity ('ATC') values on bidding zone borders of the Nordic CCR and bidding zone borders of neighbouring CCRs if the latter are included in capacity calculation pursuant to Article 18. For each market time unit, one set of ATC values shall be calculated.'



is the RAM for that CNE, and C is the chosen “slack zone”² in the system. The matrix of RAMs and z2sPTDFs are shown in figure 3 below³.

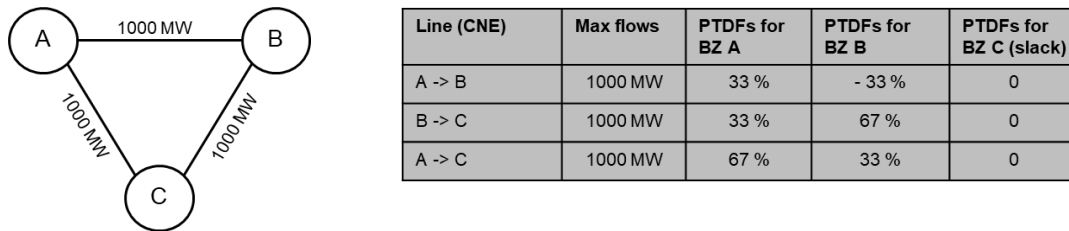


Figure 1. 3-bidding zone example and its z2sPTDFs

There are two approaches to calculate capacity for the market coupling based on this linearized modelling of the grids, NTC and FB. In FB, the capacity is provided to the market directly in the form of the z2sPTDF matrix above, in addition to the ‘Max flows’, being remaining available margin (RAM) in the FB terminology. The market algorithm determines prices and Net Positions (NPs) of the bidding zones as market coupling outcome. Essentially, the FB market coupling algorithm tries to increase NPs (with an objective/intention to maximize the socio-economic welfare of the market coupling bidding zones in Europe) until a limit on one (or several) of the CNEs are reached. The domain of all possible combinations of NPs allowed in the FB market complying to the matrix above, defines the "FB domain". The FB domain for the matrix above is illustrated in Figure 2 (in two dimensions only).

In NTC, capacities are provided as values for each direction for each individual bidding zone border. These values can be extracted from the linearized grid description above in such a way that the resulting NTC domain respects the linearized grid description and its limits. As for the FB domain, the NTC domain includes all possible combinations of NPs that are allowed in the NTC market, complying to the physical limits of the grid. The NTC domain is illustrated in Figure 2.

²The slack zone is the reference point in the z2sPTDF matrix in the sense that all power injections is extracted in this zone. Thus, all z2sPTDFs for the slack zone are zero (see Figure 1 and Footnote 3 for details). The slack zone is a necessary mathematical construct, but the choice of slack zone has no influence on the results.

³ The z2sPTDF of BZ A on the CNE (A->B) can be interpreted/computed by the following. First, run a load flow calculation, on the grid without any modification, to obtain the power flow on the CNE (A->B), denoted as ‘F_AB_original’. Second, modify the grid condition by injecting 100 MW power at A, and consuming the 100 MW power at C (i.e. being the slack). Run the load flow again in this modified setup to obtain the power flow on the CNE (A->B), denoted as ‘F_AB_new’. The z2sPTDF of BZ A is then computed by $(F_{AB_new} - F_{AB_original})/100$, where the 100 in the denominator refers to the 100 MW power injection. Similarly, to compute z2sPTDF of BZ B, the logic remains the same except that the modification in the second step injects 100 MW at BZ B. Finally, to compute z2sPTDF of BZ C, the injection and the consumption both happen at BZ C. Thus, the ‘F_AB_original’ and ‘F_AB_new’ in this case are the same, resulting z2sPTDF of BZ C on CNE (A->B) being 0.



In NTC, the physical limitation of CNE (A->C) being 1000 MW with a z2sPTDF of 67%, causing the export capacity of BZ A to be limited to 1500 MW (i.e. $1000 \text{ MW} / 0.67 = 1500 \text{ MW}$) (see Figure 2). The import capacity for BZ A, will equally have to be limited to 1500 MW due to the physical limitation of CNE (A->C) being 1000 MW as well with a z2sPTDF of -0.67 ($-1000/-0.67$). Similar arguments also hold for BZ B and bidding zone C, which also will face import- and export limits at 1500 MW. In this manner, NTC is a capacity calculation and market approach that limits the import- and export capacity for each bidding zone.

The way the limits are implemented, is by distributing the import/export limits to the different borders. However, the distribution itself can be done in a multitude of different ways, only requiring that the correct export and import limitations for each bidding zone are maintained. Returning to our 3-BZ example above, the 1500 MW limitations may for example cause the TSOs to ex-ante decide 750 MW in each direction for border A->B and A->C and B->C equally. A different, but equally valid distribution of NTCs, is to put NTCs for A->B at (1500,0), B->C at (1500,0) and A->C at (0, 1500). This capacity arrangement also provides 1500 MW as import and export limits for all 3 bidding zones. Thus, the two distributions are only two different representations of the same NTC domain. In fact, all distributions of NTCs resulting in the 1500 export/import limits are different representations of the same NTC domain.

Although the equal split of the 1500 MW export capacity on CNE (A->C) and CNE (A->B) is a valid NTC solution to facilitate the trades in the market, one may also observe that the FB method/domain can offer more capacities in terms of trading possibilities. With FB, one potential market outcome is 1000 MW export in BZ A and B at the same time, allowing C to import 2000 MW. This market outcome is at the 'edge/intersection' of the FB domain but still within FB. Consequently, by providing the FB domain to the market (i.e. asking the market allocation algorithm to find an optimal solution within the FB domain for the European market coupling), the market allocation outcome may end up at this market point. On the contrary, this 'FB feasible' market outcome is not within the previously described NTCs. Consequently, by providing the NTC domain to the NTC market allocation (i.e. asking the market allocation algorithm to find an optimal solution within the NTC domain for the European market coupling), the market allocation outcome can never find this 'FB feasible' market point as a market coupling solution.

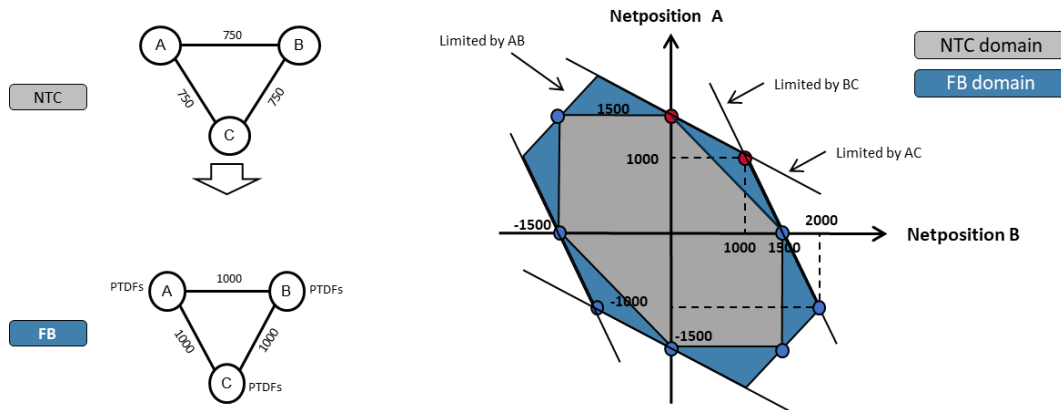


Figure 2 FB and NTC domain comparison

Note that BZ C is not explicitly shown in Figure 2. Because the 3-BZ example is considered a balanced and closed system, the sum of export of BZ A and B must equal to the import of BZ C.

3 ATCE in the Nordic context

3.1 Background

After the DA market clearing at 13:00 and before 14:00 D-1 (one day before the energy delivery date), the TSOs need to calculate ID capacities for the ID gate opening at 15:00 on D-1.

At the time of DA FB go-live in the CCR Nordic, XBID is technically not yet able to process the FB format (i.e. PTDFs and RAMs on the CNEC level), but the NTC/ATC-format (i.e. the capacities between bidding zones on the cross-zonal border level). The ATCE method is designed as a transitional solution to solve this compatibility issue⁴. Specifically, the required inputs of the XBID platform, foreseen at the DA FB go-live in the Nordic CCR, are DA NTC and DA AAC (AAC=Already Allocated Capacity), corresponding to the equation below.

$$ID\ ATC = DA\ NTC - DA\ AAC$$

To facilitate the ID trading activities, the TSOs shall provide the capacities corresponding to the DA NTC term and the DA AAC term, as inputs for the ID timeframe to the XBID platform, such that XBID automatically generates the ID ATC for the ID trading. In a nutshell, the ATCE optimization method computes the capacity that corresponds to the ID ATC values directly. To comply with the XBID input requirements, the TSOs need to further compute the DA NTC term, i.e. $DA\ NTC = DA\ AAC + ID\ ATC$. Together with the DA AAC (i.e. not computed by the ATCE optimization but computed by the TSOs based

⁴ Based on a given FB domain (PTDF and RAM on the CNEC level), the ATCE method provides an 'optimal' set of NTC values (capacities on the cross-zonal border level).



on DA MC results), the resulting DA NTC term is determined by the equation above, as input to the ID trading platform for the ID gate opening. For the sake of simplicity and explanation, from this point on the ID ATC in this document refers to the outcome of the ATCE (i.e. extracted ID ATC), if not specified otherwise.

3.2 DA AAC in ATCE

For the ID gate-opening capacity computations, the DA AAC refers to the DA market outcome of already allocated flows (i.e. DA AAF). In other words, the DA AAC is a more general terms being used within the current NTC world. In the ATCE method, the content of the DA AAC is (represented by) DA AAF.

On D-1 around 12:45, the EU market coupling algorithm (known as Euphemia) provides the market coupling outcome, in terms of price and net position per bidding zone. The DA AAF is computed using the formula⁵ below,

$$DA\ AAF = z2sPTDF \times NP$$

The z2sPTDF refers to the zone-to-slack PTDF, which forms the DA FB domain together with the RAM. The NP term is the balanced net positions of the Nordic bidding zones, as the market results from Euphemia⁶. In other words, the DA AAF is the physical flow on each CNEC that is induced by the DA market clearing point. In general, one can compute the DA AAF for every CNEC if their z2sPTDFs and the DA market clearing point are available.

DA AAF of border CNECs

Of all CNECs nominated to the FB CC and MC process, some CNECs are border CNECs, and others are 'internal' CNECs within the bidding zone. In the ATCE context, not all the computed DA AAFs of CNECs are relevant used. Instead, only the AAFs of border CNECs are of relevance. They are the physical flows flowing on the cross-border network elements. In other words, although the DA AAF term is on the CNEC level by default, the DA AAF in the ATCE context is a border level term.

Again, for the sake of simplicity and explanation, from this point on the DA AAC in this document refers to the DA AAF (of the borders) and is interchangeable, if not specified otherwise.

⁵ The AAF is also used in the Congestion Income Distribution Methodology in Article 4. link: https://documents.acer.europa.eu/Official_documents/Acts_of_the_Agency/Individual%20decisions%20Annexes/ACER%20Decision%20No%202016-2021_Annexes/ACER%20Decision%202016-2021%20on%20CIDM%20-%20Annex%20I.pdf

⁶ In terms of matrix multiplication, for a CNEC defined for a single border A→B, the dimension of its z2sPTDF is 1-by-n, where n is the number of the bidding zones, including the virtual bidding zones. The Nordic BZ NPs should be a n-by-1 vector, such that the dimension of the cross-product of the z2sPTDF and the BZ NPs is 1-by-1 (i.e. 1-by-n by n-by-1). This implies that the DA AAF for a border CNEC is a 1-by-1 value.



3.3 ID ATC in ATCE

The ID ATC is a direct outcome of the ATCE optimization process. At the ID gateopening, the ID ATC represents the remaining capacity of the DA FB domain after the DA market coupling. Determining the ID ATC through the ATCE optimization begins with identifying the remaining FB DA RAM after the market coupling, which is calculated as follows:

$$ID\ RAM = DA\ RAM - z2sPTDF * NP,$$

where the ID RAM refers to the DA 'leftover' RAM that is available for the ID timeframe after the DA market coupling. Please refer to Chapter 2 footnote 3 regarding the z2sPTDF computation. The NP term refers to the Nordic net position, being the outcome of the SDAC market allocation. The term PTDF*NP refers to the flow that is induced by the DA market allocation. The resulting ID RAM is the input for the ATCE optimization to extract the ID ATC. Consequently, the extracted ID ATC must be within the ID RAM as its boundary⁷.

The ID RAM, i.e. the remaining DA RAM after the DA MC, should always be larger or equal to zero. This property is ensured by the SDAC MC algorithm, i.e. Euphemia.

4 General implementation description of ATCE algorithm

This chapter describes the optimization formulation, including the description, purpose and effect of the parameter(s) used in the optimization. Mathematically, constrained optimization is the process of optimizing an objective function with respect to some variables in the presence of constraints on those variables.

Figure 3 show the schematic overview of the ATCE prototype tool. Essential building blocks are

- objective function (see section 4.1)
- constraints (see section 4.2)
- mathematical solver/problem overview (see section 4.3)
- threshold parameter (see section 4.4)

⁷ Suppose there is no further relaxation being applied in the ATCE optimization.

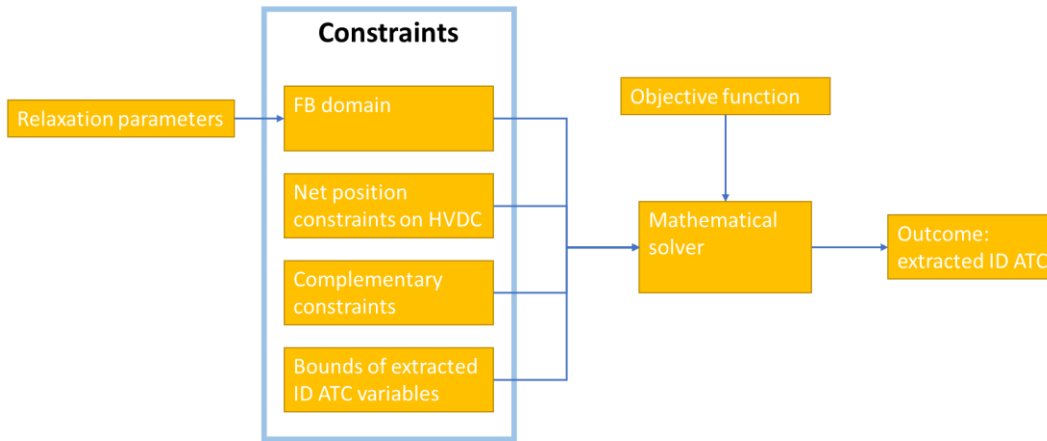


Figure 3 Overview of the ATCE

4.1 Objective function

In general, an optimization problem consists of an objective function that is a means to maximize or minimize something. In the Nordic ATCE context, the objective function maximizes the total Nordic bidding zone border capacities by multiplying all individual Nordic bidding zone border total capacity. The mathematical formulation is given in the equation below.

$$O = \prod_n C_n, \quad \text{where } C_n = \hat{C}_n + \hat{C}_{n,o}$$

For each bidding zone border, there are two transfer capacities (i.e. NTCs to be extracted) representing the two opposite directions, denoted as \hat{C}_n and $\hat{C}_{n,o}$, where 'n' is the number of borders and 'o' refers to 'opposite'. Each of the directional capacities is a variable in the optimization formulation. The sum of the two opposite capacities of the same border forms the 'total' capacity of the border, denoted as C_n in the equation above, e.g. the SE1-SE2 total border capacity is $(NTC(SE1 \rightarrow SE2) + NTC(SE2 \rightarrow SE1))^8$, reflecting $\hat{C}_n + \hat{C}_{n,o}$ ⁹. Again, the objective function maximizes the total Nordic bidding zone border capacities by multiplying all individual Nordic bidding zone border total capacity. To write it more explicitly, the

⁸ $(NTC(SE1 \rightarrow SE2) + NTC(SE2 \rightarrow SE1))$ term can be further expanded to $(ID\ ATC(SE1 \rightarrow SE2) + AAF(SE1 \rightarrow SE2)) + (ID\ ATC(SE2 \rightarrow SE1) + AAF(SE2 \rightarrow SE1))$ and the ID ATC is the variable of the ATCE optimization.

⁹ One of the \hat{C}_n or $\hat{C}_{n,o}$ could be a negative number. However, the sum of the two is always a positive number. Conceptual example: DA AAF of the forward direction is 1000MW, i.e. the DA AAF of the opposite direction is -1000MW. Suppose that the extracted ID ATC of the forward direction 100MW. The \hat{C}_n term becomes $1000 + 100 = 1100$ MW. Meanwhile, the extracted ID ATC of the opposite direction must also be larger or equal to zero, e.g. 200MW. This implies that the capacity of the opposite direction $\hat{C}_{n,o}$ becomes $-1000 + 200 = -800$ MW. Although the opposite direction term is a negative number, the sum of these two terms, i.e. $\hat{C}_n + \hat{C}_{n,o}$, is always positive.



objective function looks like $\text{Maximize}[(\text{SE1-SE2 total capacity}) * (\text{NO1-NO5 total capacity}) * (\text{other AC borders total capacity...}) * (\text{FennoSkan total capacity}) * (\text{other DC borders total capacity...})]^{10}$.

The \hat{C}_n and $\hat{C}_{n,o}^{11}$, are the exogenous variables in the ATCE optimization. The ATCE optimization respects the FB constraints, which are on the CNEC level. The extracted ID ATCs are on the bidding zone border level. The formula $\text{z2zPTDF} * \text{capacity variable (i.e. extracted ID ATCs)} \leq \text{ID RAM}$ links the CNEC level z2zPTDF to the bidding zone border level exogenous capacities variables.

4.2 Constraints

A constraint in the optimization formulation is a condition that the solution must satisfy. In the context of the Nordic ATCE approach, the constraints can be classified as below,

- FB constraints: the physical flows on the CNECs and combined dynamic constraints induced by the resulting ID ATC must be less than or equal to the ID RAM of these elements. Please see more information in section 4.5.4.
- Net position constraints: If net position constraints are present on the HVDC links to limit the import and export of the HVDC links as part of the DA FB capacity calculation (CC) inputs to the DA FB market coupling (MC), they are also considered in the ATCE.
- Complementary constraint: The HVDC capacity at the sending end of an HVDC cable (i.e. the extracted ID ATC at the sending end of an HVDC cable) should be equal to the capacity at the receiving end of the cable (i.e. the extracted ID ATC at the receiving end of the cable) plus the losses¹². Also, to avoid polarity reversal that deteriorates the HVDC equipment, additional constraints are also included in the modelling.
- Bounds of ID ATC variables: The optimization variables contain ID ATC of AC borders and the DC borders.
 - AC border: Using the AC border SE1-SE2 as an example, the variables are $\text{ATC}(\text{SE1} \rightarrow \text{SE2})$ and $\text{ATC}(\text{SE2} \rightarrow \text{SE1})$. The upper bound of the variable $\text{ATC}(\text{SE1} \rightarrow \text{SE2})$ in the optimization formulation is infinity. 'Infinity' implies that the TSOs do not explicitly set the upper boundary to the ID ATC on this direction. The lower bound of $\text{ID ATC}(\text{SE1} \rightarrow \text{SE2})$ is zero.
 - DC border: Using FennoSkan as an example, the upper bound of ID ATC of $\text{FennoSkan}(\text{SE3} \rightarrow \text{FI})$ is not infinity, but the capacity defined by the TSOs, either as its

¹⁰ The Skagerrak HVDC connects NO2 and DK1. Suppose the power flows from NO2 to DK1 via Skagerrak, both $\text{NTC}(\text{NO2-NO2_SK})$ and $\text{NTC}(\text{DK1_SK - DK1})$ refer to the NTC of the same cable. To avoid both NTC terms in the objective function, i.e. adding advantage to this cable over other AC borders, only one NTC term is considered in the objective function. Similar modelling approach is applied to KontiSkan (i.e. SE3-DK1) and Storebælt (DK1-DK2).

¹¹ To be specific, the $\hat{C}_n = \text{ID ATC}_n + \text{DA AAF}_n$. The ID ATC_n is an exogenous variable of the ATCE optimization and the DA AAF_n is the outcome of the DA FB MC.

¹² The Skagerrak HVDC has an implicit loss factor at 2.9% currently. The loss factor is aligned among TSOs, NRAs and NEMOs on a regular basis.



nominal capacity – DA AAF or explicitly defined in the net position constraints – DA AAF.
The lower bound of this directional capacity is zero.

4.3 Non-linear optimization problem

Given the objective function of the optimization formulation, being the product of the total cross-zonal transfer capacity of each bidding zone border, the optimization problem of the ATCE is a non-linear problem, which requires a non-linear solver to solve it.

4.4 Introduction to PTDF and filter

4.4.1 Forms of PTDF and FB domain

The FB parameters, or FB domain, in this document refer to the PTDFs and RAMs. PTDF, the power transfer distribution factor, has two forms, namely the zone-to-slack PTDF¹³ (z2sPTDF) and the zone-to-zone PTDF¹⁴ (z2zPTDF).

The translation between the two forms of PTDFs is straightforward, using the equation below.

$$z2zPTDF(A \rightarrow B) = z2sPTDF(A) - z2sPTDF(B)$$

z2zPTDF(A->B) denotes the z2zPTDF from bidding zone A to bidding zone B. Physically, it describes the impact of power flow on a CNE, when there is an exchange from bidding zone A to bidding zone B.

Example: Suppose that A, B, and C are three fictitious bidding zones connecting each other. Let's assume the z2sPTDFs of CNEC X are shown below.

| | z2sPTDF(A) | z2sPTDF(B) | z2sPTDF(C) |
|--------|------------|------------|------------|
| CNEC X | 0.3 | 0.28 | -0.2 |

Correspondingly, the z2zPTDFs of CNEC X are shown below, applying the equation above,

| | z2zPTDF(A->B) | z2zPTDF(B->A) | z2zPTDF(A->C) | z2zPTDF(C->A) | z2zPTDF(B->C) | z2zPTDF(C->B) |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| CNEC X | 0.02 | -0.02 | 0.5 | -0.5 | 0.48 | -0.48 |

Because of the two forms of PTDFs, a FB domain can also be described in two different equations/forms, namely,

$$z2sPTDF \times NP \leq RAM, \text{ and}$$

¹³ 'zone-to-slack PTDF' means the PTDF of a commercial exchange between a bidding zone and the slack

¹⁴ 'zone-to-zone PTDF' means the PTDF of a commercial exchange between two bidding zones



$$z2zPTDF \times Exchange \leq RAM$$

These equations/forms reflect the PTFD definition in the footnotes 13 and 14. Again, the FB domain is the same, but with two forms of expression and application. Specifically, the single day-ahead coupling (SDAC) algorithm, commonly known as Euphemia, takes the form of z2sPTDF and RAM as inputs to perform the DA market coupling. For the ATCE purposes, the form of z2zPTDF and RAM, transformed from z2sPTDFs, is needed.

4.4.2 Positive z2zPTDF filter

From the example above, the z2zPTDFs of the CNEC X appear to be both positive and negative with the same magnitude.

The same z2zPTDFs are shown below,

| | z2zPTDF(A->B) | z2zPTDF(B->A) | z2zPTDF(A->C) | z2zPTDF(C->A) | z2zPTDF(B->C) | z2zPTDF(C->B) |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| CNEC X | 0.02 | -0.02 | 0.5 | -0.5 | 0.48 | -0.48 |

Suppose a trade A->B is 100MW and the z2zPTDF of A->B is 0.02, the impact of this trade on the CNEC X is computed by $0.02 * 100 \text{ MW} = 2 \text{ MW}$.

Because the direction is A->B with 100MW, this also implies that the opposite direction of the same trade (i.e. B->A) is -100MW, i.e. the same magnitude with an opposite sign. The impact of the opposite direction but the same trade, i.e. B->A, is $-0.02 * -100 = 2 \text{ MW}$

Because these 'two' directions are the same trade and its actual impact on the CNEC X is only 2MW, it would be double counting, if we consider the two directions separately.

Numerically, to avoid the double counting, this positive z2zPTDF filter is applied by identifying 'z2zPTDFs with a negative sign' and setting them to 0. Physically, keeping the positive z2zPTDFs indicates that the optimization only considers the loading effect of the CNECs, given that the resulting ID ATC and the ID RAM are both larger or equal to zero.

Note that the application of the positive z2zPTDF filter is a methodological implementation in the ATCE algorithm and is not adjustable by the TSOs.

After applying the positive z2zPTDF filter, the z2zPTDFs are shown below,

| | z2zPTDF(A->B) | z2zPTDF(B->A) | z2zPTDF(A->C) | z2zPTDF(C->A) | z2zPTDF(B->C) | z2zPTDF(C->B) |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| CNEC X | 0.02 | 0 | 0.5 | 0 | 0.48 | 0 |



4.5 Introduction to Relaxation parameters

4.5.1 Background

The primary purpose of the ID market is to allow market participants to balance supply and demand close to the time of energy delivery, considering the variability and unpredictability in production and consumption. Furthermore, having sufficient ID capacities allows the market participants to manage their risks and optimize their portfolios, contributing to the overall efficiency of the electricity market more effectively.

Process-wise, the ID market opens after the closure of the DA market. The capacity available in the ID market can be seen as the 'leftover' or remaining capacity after the DA market clears. In other words, after the DA market allocations, the remaining transmission capacity is made available for ID trading. It is often presumed that because the Single Day-Ahead Coupling (SDAC) algorithm allocates transmission capacities optimally, there would be limited capacity left for the ID market.

The TSOs implement two types of mathematical relaxations to expand the FB domain, aiming to meet market needs for substantial ID capacities. However, as with most things, there is another layer to consider. In this scenario, these mathematical relaxations bring along operational implications.

According to the DA CCM Article 20(3), the Nordic TSOs will publish the relaxation parameters used in the optimization approach including their descriptions, purpose and effect, two months before the Nordic FB go-live.

The following sections elaborate the so-called 'RAM relaxation' and the 'PTDF relaxation' and the TSO choice of the relaxation setting associated operational implications.

4.5.2 RAM relaxation parameter

The DA FB domain serves as a key input for the ATCE engine to compute the ID ATCs. This DA FB domain is formed by PTDFs and RAMs. In this context, the RAM relaxation specifically refers to the addition of a certain number of megawatts (MW) to the existing ID RAM of CNECs only (not to allocation constraints), while maintaining their PTDFs unchanged.

The RAM relaxation is a manageable setting. For example, by adding an extra 10 MW of RAM as to the existing RAM on a CNEC, we create a larger FB domain for the ATCE engine to work with. This expansion allows for the computation of a 'larger' set of ID ATCs. However, it is important to note that if this enhanced ID ATC is fully utilized in the ID market, it could potentially lead to an overload of the same magnitude – in this case, an additional 10 MW on the relaxed CNEC.

The TSOs agreed to manage the overload caused by the RAM relaxation using available measures, such that the application of the RAM relaxation does not compromise the operational security of the transmission grids (after applying the security measures).



4.5.3 z2zPTDF relaxation parameter

Next to the RAM relaxation parameter, the ATCE method also introduces another parameter, namely the z2zPTDF relaxation parameter. In other words, any 'small' z2zPTDF value less than or equal to the parameter are set to zero. Using the PTDF example above, suppose the z2zPTDF relaxation parameter = 0.05 or 5%. Before applying the z2zPTDF parameter, the z2zPTDFs are shown below,

| | z2zPTDF(A->B) | z2zPTDF(B->A) | z2zPTDF(A->C) | z2zPTDF(C->A) | z2zPTDF(B->C) | z2zPTDF(C->B) |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| CNEC X | 0.02 | -0.02 | 0.5 | -0.5 | 0.48 | -0.48 |

After applying the positive z2zPTDF filter, the z2zPTDFs are shown below¹⁵,

| | z2zPTDF(A->B) | z2zPTDF(B->A) | z2zPTDF(A->C) | z2zPTDF(C->A) | z2zPTDF(B->C) | z2zPTDF(C->B) |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| CNEC X | 0.02 | 0 | 0.5 | 0 | 0.48 | 0 |

After applying the z2zPTDF relaxation parameter, the filtered z2zPTDFs are shown below.

| | z2zPTDF(A->B) | z2zPTDF(B->A) | z2zPTDF(A->C) | z2zPTDF(C->A) | z2zPTDF(B->C) | z2zPTDF(C->B) |
|--------|---------------|---------------|---------------|---------------|---------------|---------------|
| CNEC X | 0 | 0 | 0.5 | 0 | 0.48 | 0 |

The z2zPTDF relaxation parameter is introduced to filter out the following two scenarios:

- The z2sPTDF and z2zPTDF are computed by power system analysis tools and contain decimal numbers by nature. Due to rounding or computational accuracy, it may happen that 'on paper' the z2zPTDF is 1 % and 'in reality' the effect of such 1 % z2zPTDF is not observed by the TSOs. Such small z2zPTDFs should not limit the cross-border exchanges. By applying the z2zPTDF threshold, the effect of such small z2zPTDFs is eliminated from the ATCE.
- The TSOs may have sufficient remedial actions to alleviate certain overloads, without limiting the cross-border exchanges. Thus, the TSOs decide not to consider these 'minor overloads' being potential reasons to limit the cross-border capacities. By applying the z2zPTDF threshold, such 'minor overloads' become acceptable in the ATCE.

4.5.4 Implementation

Referring to the implementation, the FB domain in the ATCE is modelled as follow,

$$z2zPTDF_relaxation+ * capacity\ variable\ (i.e.\ extracted\ ID\ ATC) \leq ID_RAM + RAM_relaxation$$

¹⁵ The sequence of applying the positive z2zPTDF filter and applying the z2zPTDF threshold does not impact the results.



On the left-hand side (i.e. the left-hand side of the \leq sign), $z2zPTDF_relaxation+$ refers to the $z2zPTDF$ applying the positive PTFD filter and the PTFD relaxation parameter. The capacity variable for the ATCE optimization refers to the extracted ID ATCs.

On the right-hand side, the two terms refer to the original DA RAM and the RAM relaxation parameter.

In the mathematical terms, the inequality constraints are modelled as $A * x \leq b$.

A is a matrix containing $z2zPTDF+$

x is a vector containing to-be-extracted ID ATCs

b is a vector containing ID RAM and the RAM relaxation together

Corresponding to the matrix implementation, the $z2zPTDF_thres+$ is a m-by-n matrix, m is the number of constraints, e.g. the number of presolved¹⁶ CNECs, n is the number of directional borders. Thus, the ID ATCs is an n-by-1 vector, and the ID RAM and the RAM relaxation are both also n-by-1 vectors.

In a more explicit form, the above equations can be written out, using the 3-node example, as

$$\begin{aligned} & z2zPTDF_relaxation+(A \rightarrow B) * tobeextracted(A \rightarrow B) + z2zPTDF_relaxation+(B \rightarrow A) * tobeextracted(B \rightarrow A) + \\ & z2zPTDF_relaxation+(A \rightarrow C) * tobeextracted(A \rightarrow C) + z2zPTDF_relaxation+(C \rightarrow A) * tobeextracted(C \rightarrow A) + \\ & z2zPTDF_relaxation+(B \rightarrow C) * tobeextracted(B \rightarrow C) + z2zPTDF_relaxation+(C \rightarrow B) * tobeextracted(C \rightarrow B) \\ & \leq ID_RAM + RAM_relaxation \end{aligned}$$

5 ATCE settings during EPR and after go-live

The PTFD relaxation parameter has been set to 2% since week 13 2024. The RAM relaxation parameter is set to 10 MW on CNECs, excluding allocation constraints¹⁷. These allocation constraints are comprised of both combined dynamic constraints¹⁸ and HVDCs. In this context, the RAM relaxation is applied exclusively to the thermal limits of the transmission grid elements. It is not applied to the combined dynamic constraints as these are computed by the TSOs to ensure dynamic stability of the grids. The dynamic constraints are harder limits than the thermal limits. In other words, the thermal overloads may be manageable if remedial actions exist, but the dynamic stability limits must never be exceeded.

¹⁶ 'Presolved' refers to the mathematical step to remove the redundant constraints from the optimization problem without affecting the mathematical optimal solution. Conceptual example: suppose the solver looks for an optimal solution that must fulfil constraint 1, being $x \leq 5$ and constraint 2, being $x \leq 10$. The presolve, mathematically, removes the constraint 2 before performing the optimization, given the consideration that if a solution is less than 5, it must be less than 10.

¹⁷ A 0.01 MW relaxation is strategically implemented on the allocation constraints. This deliberate margin allows the optimization solver to discover feasible solutions, without compromising the quality of the outcome.

¹⁸ Combined dynamic constraint is modelled as 'Power Transfer Corridors' (PTCs) limitations in the FB world.



Furthermore, HVDCs are excluded from the RAM relaxation because they are controllable devices that adhere to specific allocation schedules.

Initially, the TSOs set the PTDF relaxation parameter to 0.05 and the RAM relaxation to 0 at the start of the external parallel run (EPR). During the EPR, the TSOs observed large potential overloads resulting from this combination of parameters. Such potential overloads, in terms of magnitude and frequency of occurrence, impose heavy operational risks that the TSOs are not able to manage. To address the operational risks, the TSOs decided to use a more controlled and balanced relaxation combination, opting for increased RAM relaxation and a carefully chosen PTDF relaxation to ensure that operational risks remain manageable.

6 Summary

This document describes the ATCE method planned for the implementation in January 2025, as a transitional solution for ID capacity calculation until XBID supports FB parameters. It reflects the latest development of the ATCE implementation during the Nordic CCM parallel run and post go-live and incorporated feedback from NRAs and stakeholders.

The document fulfils the requirement of publishing the exact values and parameters of the ATCE method two months before introducing changes in accordance with approved CCM methodology.