European Network of
Transmission System Operators
for Electricity

entsoe

Amendment of the Methodology for Calculating Scheduled Exchanges resulting from single day-ahead coupling - Explanatory note

21 March 2024

Disclaimer
This explanatory document is submitted by all TSOs to the Agency for the Cooperation of Energy Regulators for information and clarification purposes only accompanying the "All TSOs' proposal for a Methodology for Calculating Scheduled Exchanges resulting from single day-ahead coupling in accordance with Article 43 of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management".

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I. Introduction

Article 43(1) of the Commission Regulation 2015/1222 establishing a Guideline on Capacity Allocation and Congestion Management (hereinafter referred to as 'CACM Regulation') requires that, by 16 months after the entry into force of CACM Regulation, all Transmission System Operators ("TSOs") which intend to calculate Scheduled Exchanges resulting from single day-ahead coupling shall develop a proposal for a common methodology for this calculation.

The common Methodology for Calculating Scheduled Exchanges resulting from single day-ahead coupling (hereinafter referred to as "DA SEC Methodology") developed by all TSOs in coordination with all NEMOs has been approved by all National Regulatory Authorities ("NRAs") on 14 February 2019 in line with Article 9.7(d) of the CACM Regulation.

On 20 December 2022 all TSOs proposed an amendment of the DA SEC Methodology in line with Art. 9(13) of the CACM Regulation. This amendment has been approved by ACER on 30 May 2023.

In Accordance with Article 9(13) of the CACM Regulation all TSOs propose an amendment to the DA SEC Methodology, which is described in more detail in this Explanatory Note. The proposal for amendment has been developed by all TSOs in close cooperation with all NEMOs.

Capitalised terms used in this document are understood as defined in CACM Regulation, Regulation (EC) No 2019/943of the European Parliament and of the Council of 13 July 2009 on conditions for access to the network for cross-border exchanges in electricity (hereafter referred to as "Regulation (EU) 2019/943"), Commission Regulation (EU) 543/2013, Article 3 of Regulation (EU) 2017/1485 and the DA SEC Proposal.

II. Main changes – DA SEC back-up calculation

Description of DA SEC

Day Ahead Schedule exchanges are calculated by solving an optimization problem. This optimization problem involves setting the cross-border flows between bidding zones with fixed net positions. Those net positions were established previously in the calculation sequence by maximizing the overall welfare of the market and optimizing traded volumes. This means for each bidding zone the sum of day-ahead scheduled exchanges equals the net position determined in the market coupling. The current DA SEC Methodology uses linear cost coefficients (LCCs) as well as quadratic cost coefficients (QCCs) to determine the flows between bidding zones (BZs) and scheduling areas (SAs) in situations with price convergence between two or more BZs. In all other situations when there is a price difference between BZs, flows between BZs are already given by the market outcome, i.e. flows that exhaust capacities on a given border. The QCCs ensure that flows are well balanced across the different borders while LCCs ensure that flows are prioritized to occur on the lines that are the cheapest to use and provides the shortest route.

When calculating scheduled exchanges using QCCs, the optimization problem can become quite complex and time-consuming in everyday operations. This turned out be an issue especially when switching the granularity of the Euphemia algorithm from 60 to 15 minutes. As the finer granularity increases the amount of data significantly, it also increases the complexity of the optimisation problem dealt within DA SEC. And as DA SEC is an integral part of the Euphemia algorithm, it influences its total computation time. Therefore, any improvements in the DA SEC process contribute to a reduction of the total computation time and in the end in extreme cases prevent a decoupling. To go live with the 15Min MTU in the day-ahead market coupling, the Euphemia algorithm needs to have its' performance improved to process the increased amount of data within the limited time available for calculation. The reason for proposing an amendment to the DA SEC

Methodology that introduces a back-up functionality for the calculation of the scheduled exchanges between the BZs is to increase the robustness of Euphemia.

The back-up functionality of DA SEC will only be activated if the Euphemia algorithm takes too long to find a first solution. Since the quadratic part of the objective function of SEC can make the calculation slow, the back-up functionality will use an objective function where the quadradic part is replaced by a first-order Taylor expansion, making it linear. According to simulations performed by N-SIDE the probability that this back-up functionality will be used on a given day is very low. Latest simulations indicate a frequency less than once a year. Nevertheless, it is highly recommended to introduce this back-up functionality as in certain cases it will help to prevent a decoupling.

Impact of DA SEC amendment

TSOs have investigated the dependencies of DA SEC and potential impacts of changes in case of usage of the back-up functionality. It was concluded that there will be no impact on congestion income distribution and no impact on unintended exchanges. In flow-based CCRs the CID calculation does not take DA SEC values as inputs.

In radially connected NTC-based CCRs such as SWE, the back-up SEC values will even be identical to the current ones. In NTC-areas in general there can be changes in SEC values in case the back-up functionality is activated, but only if several routes are possible, but responses from CCRs show these discrepancies will either have no impact or they will be acceptable.

In Core CCR there are processes dependent on DA SEC values today. The DA SEC result is used to compute leftover capacities for ID in a temporary transitional period, described in Annex 3 and Annex 4 of the Core ID CCM. In Q2 2024 Core ID CCM will no longer use this transitional solution to compute leftover capacities and hence DA SEC results will no longer be used in the Core ID CC. After the leftover capacities are found, there will be an entire recalculation of the FB domain using only the net positions from DA result. To sum it up: DA SEC results won't be used in Core ID CC at the introduction of the DA SEC back-up functionality in 2025, which means from Core ID CC perspective the proposed changes to the DA SEC Methodology are acceptable.

In the Nordic FB CCM, DA SEC values are not used for the extraction of capacities for intraday. In other words, both DA CCM and ID CCM in CCR Nordic will be independent of the SEC result at FB go-live of Nordic DA CCM.

Additionally, the Core ROSC Project Team informed that they assessed the impact of the DA SEC back-up functionality and found no impact/issues on the ROSC process.

Next to this, it was confirmed by the remaining CCRs, that the introduction of the DA SEC back-up functionality would be acceptable and would not affect their processes in any critical way.

ANNEX 1 – Technical description of the DA SEC back-up calculation

The SEC problem is a subproblem of the post-processing problems of Euphemia. This problem aims at assigning values to the different cross-zonal borders.
Through diagnosis on 15 minutes MTU performance, it was observed in the Euphemia Lab program that the time spent by the Algorithm in the SEC problem can increase disproportionally in some cases, which can increase the risk to find a first solution (TTFS) after the initial operational time limit and, as a consequence, the risk of a decoupling scenario. To mitigate this risk, a back-up functionality has been developed for this challenging problem.
This Annex describes the resolving of the issue of indeterminacy surrounding DA SECs (Schedule Exchange Calculation), also known within Euphemia as cross-zonal flow indeterminacy problem. This particular problem proved to be numerically demanding, especially when dealing with sessions involving significant market growth and a mix of 60 and 15-minute orders.

A back-up method was already used for another volume sub-problem, the Inter Nemo Flow Calculation. For this problem, a back-up is triggered if the sub-problem is numerical infeasible. It leads to a "different", but still acceptable outcome of the problem creating results by which the market coupling process is not blocked and thus the risk of a decoupling is mitigated.

The **default** approach makes use of the "normal" calculation, which is currently done based on quadratic and linear cost coefficients.
The **back-up** functionality makes use of the Taylor method to linearize the calculation. The calculation becomes simpler, allowing Euphemia to find a solution timely which still generates acceptable outcomes for the DA SEC results (scheduled exchanges respecting calculated prices, net positions and network constraints).

Trigger of the back-up functionality, new parameters and configuration
The primary objective is to minimise the use of the back-up functionality. This back-up is triggered only in situations where no solution is available and too much computation time is already spent in Euphemia or in the DA SEC calculation specifically.

The introduction of certain new parameters within Euphemia ensures triggering the back-up functionality based on specific conditions. Hence, the following new internal application parameters will be implemented:

1. **Computation time already spent in Euphemia**: Integer value.
   The number of seconds spent since the start of Euphemia.
2. **Computation time already spent in DA SEC calculation**: Integer value.
   The number of seconds spent since the start of the DA SEC calculation.
3. **Backup mode:** "yes" or "no".
   Determines if the back-up functionality is allowed to be triggered at all. The main purpose is to develop, test and implement it in the Euphemia algorithm but prevent its use before the DA SEC Methodology is approved.

Desired default values for triggering the back-up functionality.
Only for a certain combination of the above parameters the back-up functionality is triggered. The relevant values will be found through testing and industrialisation of the Euphemia release including the DA SEC back-up functionality.
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Description of the back-up functionality

The aim of implementing the DA SEC back-up functionality is to modify the objective function of the cross-zonal flow indeterminacy problem to simplify its resolution while maintaining a solution close to that of the original problem. No constraints are modified during this process, ensuring the feasibility of the solutions. The objective function of the SEC flow indeterminacy problem can be expressed as follows:

$$\min\left(\sum_{i=1}^{n} lc_i * flow\_bzb_{i,h} + \sum_{i=1}^{n} qc_i * flow\_bzb_{i,h}^2\right)$$

With:

- lc_i = linear cost coefficient associated to bidding zone border i
- qc_i = quadratic cost coefficient associated to bidding zone border i
- $flow\_bzb_{i,h}$ = Scheduled Exchange on bidding zone border i for market time unit h
- n = total number of bidding zone borders and individual HVDC interconnectors considered in the optimization

To address the quadratic costs the Taylor expansion is used. To approximate each quadratic term, a first-order Taylor approximation is employed. This method utilises the concept of tangent lines, where the slope of the quadratic function at a specific point of interest is considered. By constructing a straight line that closely follows the behaviour of the quadratic function in a local neighbourhood, a linear approximation can be derived. The first-order Taylor approximation of a quadratic term x^2 around a reference point x^{ref} can be expressed as $x_{ref}^2 + 2x_{ref} * (x - x_{ref})$.

It is crucial to carefully select the reference point as the approximation remains valid only within a nearby region: In Euphemia's scenario, we choose the flow values obtained from the volume indeterminacy problem solved earlier in the computation. Those values are guaranteed to be feasible for the SEC problem. The objective function is then rewritten:

$$\min\left(\sum_{i=1}^{n} lc_i * flow\_bzb_{i,h} + \sum_{i=1}^{n} 2qc_i * flow\_bzb_{i,h}^{ref} * (flow\_bzb_{i,h} - flow\_bzb_{i,h}^{ref})\right)$$

With:

- lc_i = linear cost coefficient associated to bidding zone border i
- qc_i = quadratic cost coefficient associated to bidding zone border i
- $flow\_bzb_{i,h}$ = Scheduled Exchange on bidding zone border i for market time unit h
- $flow\_bzb_{i,h}^{ref}$ = Reference Scheduled Exchange on bidding zone border i for market time unit h, around which the first order Taylor approximation is computed.
- n = total number of bidding zone borders and individual HVDC interconnectors considered in the optimization

By applying the Taylor expansion and thereby linearising the objective function, the complexity of the SEC flow indeterminacy problem can be reduced while still maintaining a solution within the feasible domain of the original problem. These modifications alleviate the numerical challenges posed by the quadratic terms, facilitating the resolution process.

ANNEX 2 – Public consultation responses

TSOs comments to public consultation responses for DA SEC amendment

Organisation	Dedagroup	TSO comment
	In my opinion, it could be useful to run as the first step the linearized DA SEC. In this way, a feasible solution is always available in a reasonable amount of time. Further, this solution can be used as a starting point for the quadratic DA SEC or to provide other kinds of algorithmic hints, possibly improving the total execution time.	The SEC problem is not the final hurdle in validating a solution through EUPHEMIA. An additional challenge involves addressing the inter-SCHEDULING and inter-NEMO flow calculations, which may encounter numerical difficulties. Therefore, it is preferable to find a solution to the SEC problem as quickly as possible. The methodology you propose, on average, would take more time to solve the SEC problem. In practice, the objective functions of the fallback and the initial SEC problem are significantly different. The former is a Linear Programming (LP), while the latter is a Quadratic Programming (QP). Sharing information from the solution of the first to the second can prove complicated and sometimes lead to numerical difficulties, even if they share the same solution space.
Organisation	Market participant (requested anonymity)	TSO comment
	Confidential comment	Confidential comment

Organisation	All NEMO committee	TSO comments
	- NEMOs support this amendment proposal, since it facilitates the reduction of risk of full decoupling in case the SEC takes too long to conclude or even gets stuck. Even though with the recent improvements in the performance of EUPHEMIA the likelihood of triggering this backup tool, which in practice linearizes the quadratic term in the objective function of cross-zonal scheduled exchange calculation, is expected to be very limited/small, it is still considered a positive back-up tool in place.	
	- Addition of a configurable parameter, based on the time limit of the algorithm, would be a valuable trigger for this backup (when/if needed): Whereas, par(7): "A back-up mode of DA Scheduled Exchanges Calculation will be activated if the price coupling algorithm takes too long to find a solution."	TSOs agree. Clarification included in the methodology.
	- Considering that the need to have a back-up for cross zonal SEC in SEC methodology is not necessarily limited to the change in ISP and DA MTU, maybe the following sentence can be dropped (or moved to an explanatory note if deemed needed): Whereas, par(7): "Before aligning the DA MTU with the respective imbalance settlement period, the price coupling algorithm needs to have its' performance improved to cope with the increased amount of data in the limited time available for calculation. Further the performance needs improvements in the DA Scheduled Exchanges calculation process help to reduce the total computation time needed by the price coupling algorithm."	TSOs consider it best to keep the section in the whereas section for context.
	- Moreover, it would be great to know if it is guaranteed that the backup solution will certainly end-up with results (highlighted sentence):	Text has been adjusted to accommodate comments: - "more easy" replaced by "easier". - "from previous solution" replaced by "based on reference flows".

	Whereas, par(7):: “the back-up will use an objective function that is a Taylor expansion on the quadratic part from previous solutions, making it linear and ~~more easy~~ easier to solve” Also, in the above sentence, it is not clear what is meant by “from previous solutions”. If it is related to reference flows (question raised above) it can be clarified.	
	- The amendment proposal can be improved by further elaborating the methodology to derive reference flows: Article 4, par(5): “These reference flows are derived from the solutions to previously addressed volume indeterminacy problems.” In case the intention is not to describe the technical details of Taylor approximation, the alternative can be to drop the reference to “reference flows”.	The term ´Reference flows´ describes an important parameter in the equation and needs to be defined.
	- Another aspect is that currently there is also a fallback for inter NEMO SEC which is not explained in SEC methodology, but in section “3.5.3 SEC Backup calculation process (degraded mode)” of the following explanatory note document for the SEC methodology: https://www.entsoe.eu/assets/docs/180221_DA_Scheduled_Exchanges_Calc_Methodology_Explanatory_Note_for_submission.pdf The question is whether in principle all potential fallbacks (cross zonal SEC, inter NEMO SEC) should be explained in the main SEC methodology (topic of the current consultation).	Since introducing the previous 2023 DA SEC amendment the degraded mode is no longer needed.
	- It seems that Statnett is missing from the list of TSOs (Annex 1). Quadratic term is used on the borders under their control as well.	Statnett was added to the list of TSOs in Annex 1.