CACM Annual Report 2023

ALL NEMO COMMITTEE

in coordination with entsoe

ALL

COMMITTEE

CACM
Annual Report 2023

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Letter to stakeholders

Dear Stakeholders, NRAs, ACER and Commission,

2023 was the year of recovery after the energy crisis caused by the still-ongoing war in Ukraine. The role of the NEMO Committee, and of the day-ahead and intraday market coupling operated by NEMOs, in safely overcoming an energy crisis of historical proportions was broadly acknowledged. Thanks to our expertise and to the robustness of our operations, NEMOs' position in the EU's electricity landscape has been consolidated during this crisis.

This recognition only encourages NEMOs to strive for excellence and to continue working on improvements for the benefit of the Internal Electricity Market.

It is of utmost importance for NEMOs to keep an open dialogue with all the stakeholders and to create a space where regulators, institutions, market participants, NEMOs and TSOs can freely exchange views and design the path to electrification and decarbonisation while safely operating SDAC and SIDC.

For this reason, the NEMO Committee launched in September 2023 its first Annual Conference where Catharina Sikow-Magny, Director of Green Transition and Energy System Integration of the European Commission, in her keynote speech highlighted that the "European electricity system is the most reliable in the world!" and also noted that "our market coupling project is unique; there is no other project of the same scale, of the same ambition anywhere in the world.... that is something we need to be proud of".

In the NEMO Committee, we are committed to bringing about and keeping a well-functioning and constantly improving single electricity day-ahead and intraday market coupling and therefore we actively engage with the market participants and TSOs. This cooperation has materialised in the creation of the Market Coupling Consultative Group that allows a closer look at technical details of the market coupling while implementing the regulatory requirements like Intraday Auctions (IDAs) and 15´ Market Time Unit in SDAC.

By the time of the publication of this report, the launch of the IDAs will be a reality. It is fair to acknowledge the effort made by NEMOs and TSOs on the implementation of the IDAs as well as the evolution of the day-ahead algorithm and systems in the past years. They are living proofs of how complex and challenging regulatory requirements are implemented thanks to the spirit of cooperation and resilience of NEMOs, which had to push the limits of existing technology to accommodate legal mandates.

IDAs have become part of the Single Intraday Coupling (SIDC) six years after the first go-live of the coupled intraday continuous market. Throughout these six years, the liquidity of SIDC has increased almost three-fold, exceeding expectations as it can be seen in this report. In 2024 we also celebrate ten years of the launch of the Single Day-Ahead Coupling (SDAC), which has become one of the essential components of the European electricity market. Indeed, at this stage, NEMOs can proudly state that their ambition to create a Pan-European single day-ahead market has proven to be a pivotal idea.

While SDAC and SIDC celebrated their anniversaries, the European Commission launched in 2023 a revision of the Electricity Market Design (EMD).

Although the achievements of the EU integrated electricity markets were acknowledged (in both timeframes SDAC and SIDC), where NEMOs have played and will continue to play a significant role, there was one aspect of the proposal for amendments to Regulation (EU) 2019/943 which raised serious concern not only among NEMOs but also among TSOs and EU industry associations.

This was the possibility for the introduction of a Single Legal Entity (SLE), referred to as a disruptive concept by NEMOs in their comments to the Commission's proposal.

NEMOs were pleased to witness that this initiative was finally dropped and that the risks associated with the potential introduction of a new entity to be entrusted with managing the integrated day-ahead and intraday markets were taken into account, since it would have jeopardised the very functioning of the single European electricity market.

The current integration of markets and coordinated management based on multilateral and decentralised cooperation has contributed to making short-term markets resilient and fit for operating in the context of various uncertainties.

This is evidenced by the completion of SDAC and SIDC integration last year and, on a more recent note, by the extension of the operational NEMOs family with ETPA's go-live in SIDC as a third NEMO in the Netherlands. We have also welcomed BRM as a newly designated NEMO in Romania, which started operating in SIDC in May 2024.

The next frontier for future expansion of the already integrated day-ahead and intraday markets could well be the integration of the Energy Community countries, once they adopt the EnC electricity package into their legislation which will bring their electricity market design elements and technical rules in line with those of EU Member States and therefore facilitate market integration. NEMOs have already drafted the MCO Integration Plan that will be a key piece for the integration of EnC NEMOs after it is officially submitted and approved by ACER.

Europe will continue to face a number of challenges against a complex backdrop of global instability and physical and cyber threats. For example, we cannot turn our back to the convulsive reality in the Middle East. Therefore, we need to be vigilant and anticipate possible new unprecedented crisis scenarios.

The NEMOs, with the close cooperation of the TSOs, are ready to focus our work going forward and to ensure the NEMO Committee continues to be a strong and reliable partner to European Institutions and decision-makers even in this ever-changing context.

In 2024 the European Union will welcome new Members of Parliament and a new Commission, who shall concentrate on the implementation of the EMD reform and on facilitating the achievement of Europe's energy and climate goals. The institutions can count on the NEMOs' expertise to discuss and shape the European internal electricity market and the evolution of SDAC and SIDC.

Let's keep it functioning, keep it coupled!

Rafael Gómez-Elvira González
Chairman of the All NEMO Committee

Regulatory framework

Annex I to the ACER Decision 04/2020 on the Algorithm Methodology of 30 January 2020 (hereinafter referred to as Algorithm Methodology) provides the regulatory framework for this CACM Annual Report.

It includes the methodology for the price coupling algorithm, the continuous trading matching and the intraday auction algorithm also incorporating a common set of requirements in accordance with Article 37(5) of the Commission Regulation (EU) 2015/1222 of 24 July 2015 establishing a guideline on capacity allocation and congestion management (CACM).

The reporting obligations to comply with CACM Annual Report are listed in the Algorithm Methodology. This report is elaborated in cooperation with TSOs and is structured in the following manner, for both SDAC and SIDC:

1. Operations report, consisting of:

a) Report on incidents

According to article 4(17) and 5(17) of the Algorithm Methodology, it provides a list of incidents in the operation of the relevant algorithm and the application of back-up and fall-back procedures. It includes an explanation for their occurrence, as well as remedies applied or anticipated to prevent their recurrence;

b) Report on the decisions on requests for change

According to article 19(11) of the Algorithm Methodology, it indicates the decision for each request for change, the criteria and the principles behind such decision as well as the assessment report as required under article 17(12) of the Algorithm Methodology; and

c) Report on the application of corrective measures

According to article 12(13) of the Algorithm Methodology, it indicates the corrective measure applied, the reasons for applying it and provides additional information on plans for future measures to address these problems.

2. Report on the outcome of the monitoring of the algorithm performance

According to article 8(3) of the Algorithm Methodology, it contains the items listed in Annex 3 and Annex 4 to the Algorithm Methodology, all cases of performance deterioration or non-compliance with an implemented functionality, an analysis on the usage of each product and its impact on algorithm performance (for SDAC only), a description of the reasons for these occurrences and remedies or future improvements (as referred to in article 5 of Annex 3 and article 5 of Annex 4 to the Algorithm Methodology) and a presentation of the conclusions made in cooperation with the relevant stakeholder fora.

3. Scalability report

According to article 9(4) of the Algorithm Methodology, it provides the outcome of the assessment of the estimated level of scalability for the coming years and an explanation as to whether this level meets adequate scalability requirements. This section also includes the assessment of the effective usage, anticipated usage and usage range. Finally, it provides the prospective projects scoped as part of research and development with estimated workloads.

4. Report on research and development activities

According to article 11(8) of the Algorithm Methodology, it provides the status of the research and development activity and the planning of the future research and development activity, including an estimation of the identified workload and the associated budget.

In addition, article 20(3) of the Algorithm Methodology sets the obligation to publish all the above-mentioned reports.

NEMOs & NEMO Committee

NEMOs are the Nominated Electricity Market Operators designated by the competent national authorities to run the Day Ahead and Intraday markets according to CACM. Currently there are 18 NEMOs designated for both DA and ID, with the exception of ETPA (designated only for the Intraday market) and NASDAQ* and EXAA (designated only for the Day Ahead market).

The All NEMO Committee is the body established by NEMOs to facilitate their cooperation in the delivery of common European tasks. It manages the delivery of the Terms, Conditions and Methodologies expected under CACM (the so called MCO Plan, and relevant Methodologies), the contractual framework among NEMOs and with TSOs and ensures NEMO representation, stakeholder's involvement and legal compliance.

*in late 2023 NASDAQ's designation was withdrawn, and an exit plan was prepared.

NEMO Committee Activities

Reporting

Publication of CACM Cost Report 2022, CACM Annual Report 2022.

Communication

On 20th September 2023 NEMO Committee held its 1st Annual Conference (in hybrid mode) in cooperation with ENTSO-E where the CACM Annual Report 2022 was presented.

NEMO representation

Preparation and representation of NEMO positions in public and institutional fora (including among others the Florence Forum, MESC, the Market Coupling Consultative Group (MCCG), the Pentalateral Coordination Group, EnC Market Coupling Workshop, together with European Commission, ACER and NRAs.

Methodologies

Following proposals submitted in 2022 by NEMOs for revision of the harmonised maximum and minimum clearing price methodologies for SDAC (SDAC HMMCP) and SIDC (SIDC HMMCP), ACER issued two decisions in early 2023 thereby amending SDAC HMMCP and SIDC HMMCP methodologies. The two methodologies set maximum and minimum price limits for the single day-ahead and intraday electricity markets in Europe. The adopted amendments allow for more gradual adjustment of the short-term electricity market price limits thus effectively limiting a cascading effect of increases in case of repeated extreme prices.

Further to that, the automatic adjustment mechanism is introduced for intraday markets, triggering price limits adjustments on the intraday auctions planned to be launched in June 2024.

In November 2023, following the corresponding public consultation, NEMOs submitted to ACER a proposal for amendments of the price coupling algorithm and the intraday auction algorithm methodology.

Consultations

- Public consultation on SDAC products opened in January 2023 and closed in February 2023. As a result of this consultation, the NEMO Committee did not propose an amendment at that stage.
- Public consultation on the potential removal of the so-called Second Auctions opened in November 2023 and closed in January 2024.
- Public consultation on the price coupling algorithm and the intraday auction algorithm methodology due to co-optimisation opened in July 2023 and closed in September 2023.

Further info about NEMOs and the NEMO Committee can be found at www.nemo-committee.eu.

Figure 01

Replied to:

- European Commission's public consultation on the reform of the EU's electricity market design.
- Commission consultation on the draft Commission Delegated Regulation establishing a Network Code for Cybersecurity Aspects of Cross-Border Electricity Flows (NC CS).

Recommedation

Joint Industry Statement: An Electricity Market Design Fit For Net Zero.

Further Tasks

- **IDA:** NEMOs in collaboration with all TSOs progressed with the testing and other preparatory activities required for the implementation of Intraday Auctions, complying with ACER's decision on Intraday Cross Zonal Capacity Pricing
- **SDAC 15-min MTU** preparations are ongoing for introduction of 15-min MTU in the Single Day-ahead Market Coupling in 2025 with a Big Bang Approach.

Newsletter

Since September 2021, All NEMO Committee has been publishing a newsletter on a quarterly basis, that provides the latest highlights of the NEMO activities in SDAC and SIDC and the relevant topics related to the European internal electricity market.

You can subscribe to the newsletter on All NEMO Committee website here.

NEMO Committee ANNUAL PROGRAMME 2024

In 2023 the NEMO Committee Annual Work Programme was published setting out the tasks and objectives to be fulfilled by the Committee and its taskforces for 2024.

LinkedIn account

As of April 2023, the NEMO Committee added yet another channel for sharing news and updates via the LinkedIn Professional network.

NEMO Committee 1st Annual Conference

In September 2023 the NEMO Committee held its first Annual Conference. NEMOs are committed to keeping an open dialogue with all the stakeholders and creating space where regulators, institutions, market participants, NEMOs and TSOs can freely exchange views and design the path to electrification and decarbonisation while safely operating SDAC and SIDC.

More details for the event can be found here.

Market Coupling Consultative Group (MCCG)

Launched in 2022, MCCG has established itself as an enduring forum to consult market participants on issues related to the design, development, implementation, and operation of the Single Day-Ahead and Intraday Coupling. The group aims at facilitating the exchange of views and information among NEMOs, TSOs and market participants on topics relevant for market integration.

In 2023 two MCCG meetings were held – on 19th June 2023 and 20th October 2023. Agendas, presentation materials and Minutes of meeting for each session are shared on the NEMO Committee website and ENTSO-E website.

MCCG all-day meetings share a common structure including two separate sessions with clear focus on MCSC, SDAC and SIDC topics. Progress on action points agreed is regularly monitored.

The topics covered in 2023 include: 15-min. Market Time Unit (MTU), operational timings and Fallback process, Non-Uniform Pricing (NUP) study in SDAC; 15-min. MTU and Intraday Auctions in SIDC. Additionally, update on the status of the projects' prioritisation exercise until 2026 and beyond was provided.

As an outcome of the discussions held among NEMOs, TSOs and market participants the NEMO Committee website has been enhanced with regards to the publication of information about the aggregated curves and block execution status.

Since MCCG are interactive sessions by design, participants' questions and answers to them are captured during the sessions and subsequently reflected in the meeting minutes document published.

ENTSO-E

40 TSOs operating one of the world's largest interconnected grids

- ENTSO-E is the association for the **cooperation** of the European transmission system operators (TSOs).
- 40 member TSOs, representing 36 countries and serving about 523 million citizens, responsible for the **secure and coordinated operation** of Europe's electricity system.
- ENTSO-E is also the c**ommon voice of TSOs in Europe.**
- ENTSO-E **serves the interests of society by optimising social welfare** in its dimensions of safety, economy, environment, and performance.

For more Information, please check Member Companies

Figure 02

Executive summary

Single Day-Ahead Coupling

High level market data

The SDAC covered a large proportion of the EU, including 27 Countries. The average welfare increased by 10 % with respect to 2022 and was, on average, around 10.9 B € per session. The traded volumes remained stable at around 1 696 TWh with clearing prices heavily reduced with respect to the previous year, resulting between 90 €/MWh and 120 € / MWh for most of the countries, with the exception of a few bidding zones in Nordic Countries, which show annual average prices ranging from 30 and 70 € / MWh.

Operations report

In 2023, the SDAC operations continued to show great reliability and the number of incidents with respect to the past year remained stable, mainly concentrated on cases of low relevance mainly related to technical issues belonging to local NEMO or TSO systems. The most critical incident in SDAC led to a decoupling in October 2023. The incident was also due to a local IT issue. Many RfCs went live: among the others, several products extensions, two system releases which went live to support the changes related to the introduction of 15-min products and a new process for the decoupling of flow-based bidding areas. There has been no need to trigger corrective measures.

Performance Monitoring report

The SDAC algorithm continues to perform well. The usage of products shows a moderate increase with respect to 2022 (+13 %), the Time To First Solution (TTFS) remains, on average, well below the 17 minutes allowed for algorithm running, equal to 2.5 minutes. Optimality and Repeatability continued to perform well. The individual impact of products study indicates that no product on its own seems to have a disproportionate key impact on performance.

Scalability report

At the time of publication of the present Report, the scalability report data, scenarios and simulations execution were undergoing. The SDAC scalability report including the RfCs roadmap, scenarios and results is not available yet and will be included once the study is completed.

R&D report

Throughout 2023, key areas of focus included the implementation of the 15-minute Market Time Unit (MTU), scalability improvements, and exploratory research on future algorithmic adaptations. These efforts are crucial for ensuring the readiness and robustness of Euphemia to meet evolving market requirements and regulatory standards.

Single Intraday Coupling

High level market data

Through more than six years, since the go-live in 2018, trading in the SIDC continuous market has shown steady growth. 2023 shows increasing growth and another record year. The coupled SIDC volume continuously grew to 166.45 TWh traded – representing 150 million trades. Annual mean price per bidding-zone ranged from 22.06 €/MWh to 185.72 €/MWh. The SIDC market now included 25 countries. The SIDC continuous system handles orders and transmission capacity from 34 bidding zones and 56 borders where market participants are trading on platforms of 14 NEMOs.

Operations report

7 RfCs were implemented in 2023, most noticeable the successful go-live for ETPA's trading platform to operate within the SIDC. Through 2023, SIDC experienced 8 incidents in total, of which 3 incidents were not visible to market participants. The operation of the systems remained stable, and their performance was unaffected by the significant increase in orders and trades. There was one incident of Severity 1 on 27 February 2023 that led to a Market Halt; 52 minutes of unexpected outage of the XBID operation.

Performance Monitoring report

The analysis of monthly values regarding executed orders and matched trades shows steady increase through 2023. The daily values, in terms of processing time for orders/trades and order book update shows improvement and stability, much due to the deployment of the XBID version 3.3 in early 2023. The "Total matched – hours to delivery" indicator shows that still more than 50 % of the traded volume is matched in the last two hours before gate closure, which is set for cross-zonal trading one hour before delivery.

Scalability report

The scalability studies include assessments of the scalability of the SIDC IDAs as well as for the XBID Continuous. The SIDC Scalability Report will be included in a second release of the 2023 CACM Annual Report together with the SDAC Scalability Report.

R&D report

The biggest investment of R&D is in IDAs and execution of the Minimum viable product of Flow Based Allocation. A substantial focus was also given on the increase of performance to extend the system boundaries so that constant increase in trading can be accommodated. Also, in 2023, optimisation and improvements in the central functionalities of REMIT reporting were implemented.

Single Day-Ahead Coupling

SDAC main features

NEMO requirements

- Block products (simple, linked, exclusive)
- PUN & merit orders
- Complex Orders
- Aggregated MTUs orders (curves)

TSO requirements

- ATC and Flow based (PTDF constraints)
- Network constraints:
  Ramping, losses, minimum stable flows

CACM requirements

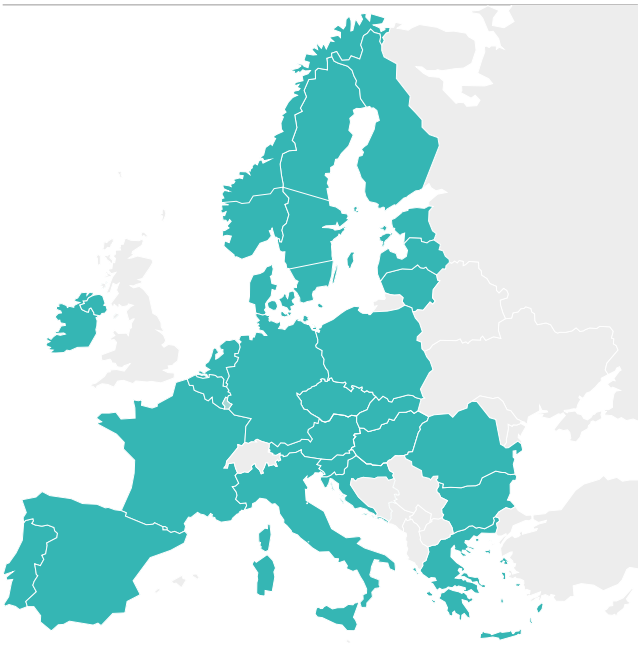
- Adequate optimality
- Adequate scalability
- Adequate repeatability
- MNA
- MTU: 60 min

Systems release(s)

- PMB12.0 and Euphemia 11.1 implemented from 23 March 2023 (first version to support 15 MTU)
- PMB12.1 and Euphemia 11.2 implemented from 14 November 2023 (fallback solution of Core region)

Geographical scope

PT, ES, FR, IT, DE, BE, NL, LUX, IE*, NI*, AT, SI, HR, BG, GR, PL, LT, LV, EE, FI, SE, DK, NO, HU, CZ, SK, RO



SDAC members (operational*)
* SEM bidding zone: operation in isolation

Figure 03

High level market data

In 2023, the SDAC covered most of the EU, in a fully integrated Pan-European day-ahead power market.

The «topology» of the coupling included 27 Countries, 61 bidding zones, 30 TSOs and 16 operational NEMOs.

- The welfare managed by the algorithm increased by 10 % with respect to 2022 and was, on average, around 10.9 B € per session. The traded volumes of the coupling remained stable compared to the previous year at around 1 696 TWh.
- After the increase experienced in 2022, the clearing prices decreased significantly compared to the previous year, with averages prices between 90 €/MWh and 120 €/MWh for the majority of the countries, with the exception of a few bidding zones in Nordic Countries, with an annual average price between 30 and 70 €/MWh.

Price indexes are computed excluding hourly prices in bidding zones with no traded volume on a daily basis. Yearly prices are computed as simple averages of hourly prices.

Traded volumes are computed based on selling and purchase volumes in each bidding zone.

Traded volumes (TWh)

Table 01

Annual	Daily average	Daily minimum	Daily maximum
1 696.14	4.66	3.69	5.64

Clearing prices – annual mean (€/MWh)

Table 02

Hourly minimum	Hourly maximum
-500	1 750

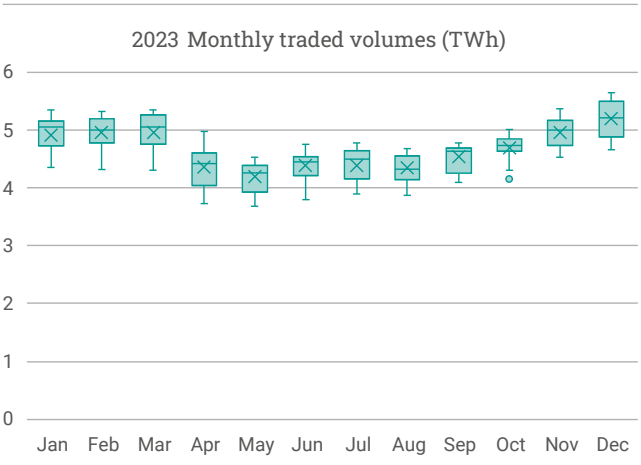


Figure 04

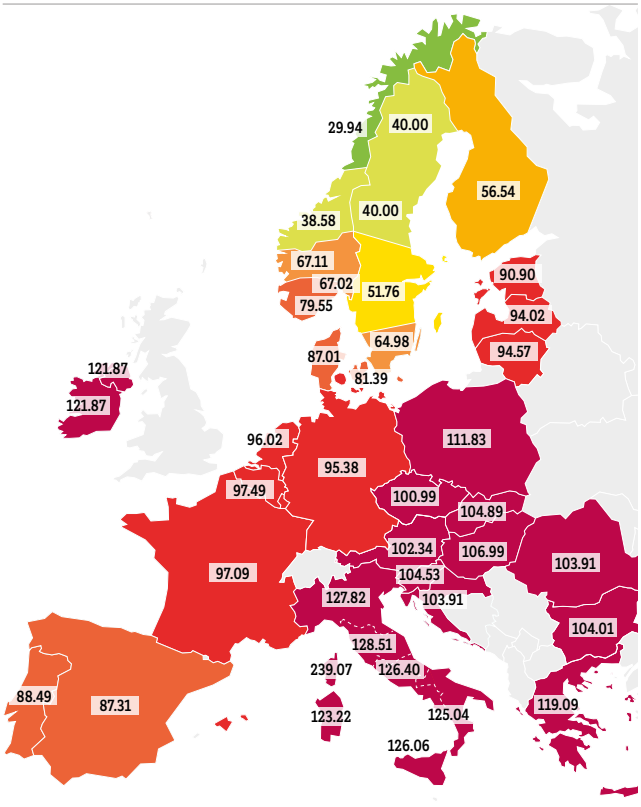


Figure 05

Operations report

In this section, 2020 – 2023 SDAC operational events are reported, including: the incidents, requests for changes and corrective measures.

"During 2023:
– product extensions went live
– a decoupling event occurred, due to local issues."

Incidents

As for the past year reports, incidents in SDAC are classified according to severity and causes, which is similar but not identical to the relevant classification applied for SIDC, given the differences in the two technical solutions.

The incidents in 2023, result in line with the ones registered in the previous years, mainly concentrated on cases of low severity.

- As regards severity, the most critical incident in SDAC was the one that lead to a partial decoupling, which occurred on 28/10/23. The incident was not caused by the SDAC algorithm or procedures, which performed as expected, but by an internal IT issue at HENEX. More details are provided in a dedicated paragraph on "Partial Decoupling incident 28 October 2023".
- The majority of the incidents were visible to market participants but only in one case the message of risk of decoupling was sent. A share of 18 % of incidents of low-severity was not even visible to market participants.
- All the incidents fell in the category "Non-MCO", mainly related to technical issues belonging to NEMO local trading.

Requests for change (RfC)

RfCs for SDAC are classified per type of requirement. The same classification is used in SDAC and SIDC, despite the differences of the two technical solutions.

- Many important RfCs went live in 2023, in particular: the product extensions on 25/01, 31/05 and 15/11/2023 related to the introduction of scalable complex orders in Ireland, the change of block parameter settings in Hungary, and the introduction of profile and linked blocks in Bulgaria. Two system releases for PMB and EUPHEMIA, on 23/03 and 15/11/2023, went live to support the changes related to the introduction of 15-min MTU products and a new process for the decoupling of flow-based bidding areas.
- After the high prices observed in the market in 2022, NEMOs and TSOs actively followed the evolution of the energy systems and reacted in order to preserve the market and to face the extreme volatility of prices, in particular:
  - in January 2023 a new version on HMMP Methodology went live, and;
  - the prices of the second auction thresholds were adjusted.

Corrective measure (CM)

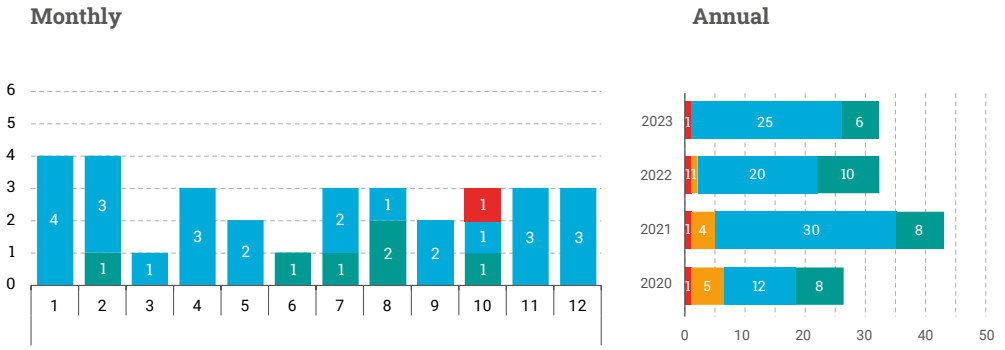
In 2023, no corrective measures were triggered.

Detailed operation report

More information can be found in detailed Excel-file Operations Report reported on nemo-committee website at the publications section:

Incidents

Severity



Severity 1
Incidents that led to decoupling

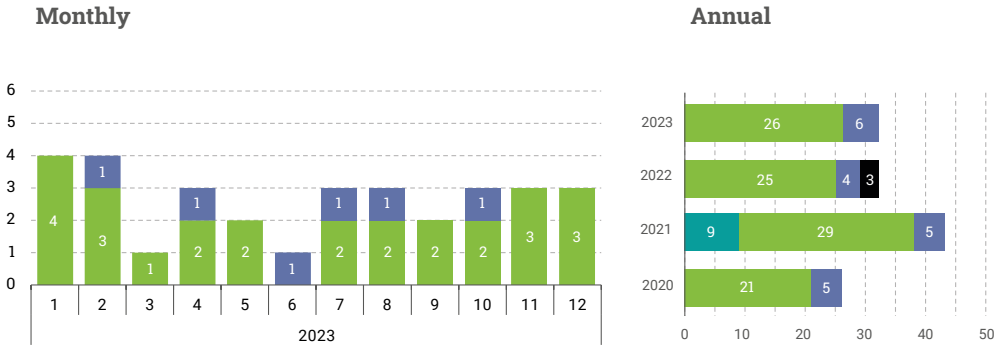
Severity 2
Incidents where message of risk of decoupling was sent

Severity 3
Incidents that were visible to market participants, but risk of partial decoupling message was not sent

Severity 4
Incidents that were not visible to market participants

Figure 06

Causes[1]



Other
Human error
Unusual process
Interface issue
System bug
Configuration
Non-MCO: local trading
Non-MCO: transmission of capacity
Non-MCO: Other

Figure 07

Partial Decoupling incident 28 October 2023

On Saturday, October 28th, 2023, an incident took place in the Single Day-Ahead Market Coupling process that led to a partial decoupling of HEnEx, affecting the day-ahead trades with delivery day Sunday, October 29th, 2023, in the Single Day-Ahead Coupling (SDAC).

The partial decoupling of HEnEx from SDAC was the consequence of HEnEx not being able to provide its order book until the partial decoupling deadline (13:05). This resulted in decoupling the Greek bidding zone and the following two interconnectors: GR-BG and GR-IT.

The delivery day of the incident corresponds to the Long Clock Change Day (25 hours).

The root cause was an incorrect implementation in the HEnEx Local Trading System impeding the validation of submitted orders concerning the Long Clock Change MTU (i.e., the additional hour). This prevented HEnEx from generating a correct order book, compliant with current regulatory requirements (i.e., validation of orders), on time. The problem was solved that very same day later in the afternoon by the implementation of a hotfix.

The impacted interconnectors were:

- GR-IT
- GR-BG

Following declaration of the partial decoupling and in line with the fallback procedures, shadow auctions were run by JAO for the above-listed interconnectors and the results were sent to the market participants.

The SDAC parties that remained coupled followed the normal procedures and the final results were published at 14:05.

The local auction was successfully completed by HEnEx around 16:05.

The MCSC initiated an in-depth investigation to identify lessons learned to mitigate the risk of similar incidents in the future.

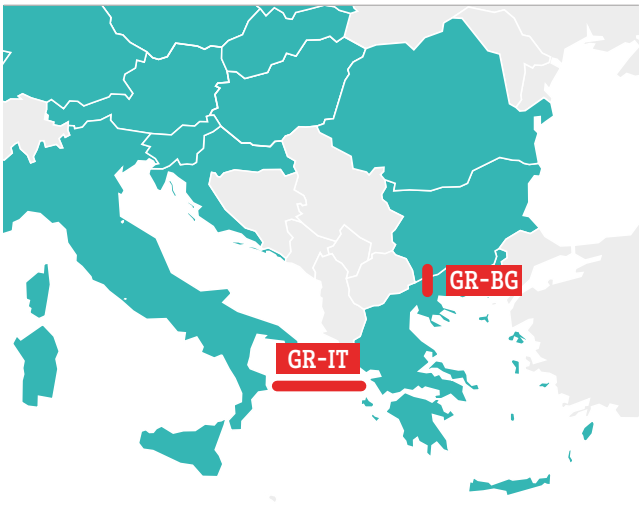


Figure 08

Lessons learned

- HEnEx successfully performed local and coupling operations during the 2021 and 2022 Long Clock Change Day in SDAC production. Such operational requirements also involve the execution of relevant dedicated tests, performed also for 2023, as done for every year. But even with the tests, the occurrence of this incident wasn't prevented.
- The common coupling system worked as expected and ensured the coupling of the remaining European market areas within SDAC.
- The SDAC procedures in place to manage a partial decoupling, have been properly applied and have proven to be successful in retaining the coupling among the bidding zones not involved in the issue.
- In addition, NEMOs and TSOs are continuing to investigate the generic robustness of the operational processes and procedures at different levels (European, regional, and local) and their consistency for specific types of incidents. This generic investigation is not specifically related to this incident.

Investigation report

The full investigation report was published on 24 November 2023.

Request for change (RfCs)[2]

Figure 09

Table 04

Require-ment	Name	Go-live Date*	Reason according to AM article 14.1	Initiator/ Owner	Details
Other	NEW HMMCP methodology implementation	11.01.2023	a	NEMOs	
Product Extension	Scalable Complex order introduction in Ireland	25.01.2023	d	NEMOs	
System release	PMB and Euphemia compatible with 15 MTU	23.03.2023	f	NEMOs/ TSOs	
Other	Increase in second auction threshold to 2400 €/Mwh In Slovakia	17.05.2023	NA	NEMOs	
Product Extension	Change of block parameter settings in Hungary	31.05.2023	d	NEMOs	
Other	Decrease of secondauction low threshold to -500	15.06.2023	NA	NEMOs	
Other	Activation of linear Inter Nemo Flow Calculation (INFC)	29.08.2023	a	NEMOs/ TSOs	Linear INFC is used replacing quadratic one
System release	PMB and Euphemia version	15.11.2023	e/f	NEMOs/ TSOs	Support fallback 6d for flow base Required changes for 15 MTU design update for LTA results
Flow based	Fallback 6d for flow-based areas	15.11.2023	e	NEMOs/ TSOs	New process for decoupling flow-based bidding areas
Product Extension	Introduction of profile blocks and linked blocks in Bulgaria	15.11.2023	d	NEMOs	
Network topology	Change of rounding of Flow on SI-IT border in SCF	15.11.2023	g	TSOs	
Network topology	Change of Italian topology	12.12.2023	g	TSOs	Change of Italian intercon-nector at the border with Greece

* Go-live Dates are reported as trading dates. Their corresponding delivery date is trading date plus 1 day

Performance monitoring report

During 2023 the performance of the SDAC continued to be positive, in which the performance has been better than previous years despite that the usage of products has increased in average.

- The usage of products, on average, shows an increase with respect to 2022 (+13 %).
- The usage of Scalable Complex Orders was activated in Ireland leading to a decrease in the overall usage of Complex Orders of around 30 %.
- The Time To First Solution (TTFS) kept reducing with respect to the previous year (- 3 %) – thus amounting to 2.5 minutes in average.
- Optimality and Repeatability continued to show good performances, as shown in previous years.

For performance monitoring, the indicators considered are listed in the draft annex 3 of the AM approved by ACER with decision 4/2020. The chapter addresses the past four years spanning from 2020 to 2024 in order to allow for a better appreciation of trends and seasonality.

The daily values for these indicators were considered as well as the maximum, minimum and average values observed throughout the year 2023. These are reported in tables in the following slides and compared with the average values of the past three years. When relevant, monthly values are also reported in separate graphs, with evidence of the main events which took place within the timeline of the graphs.

Notes on the calculation of these indicators are included at the end of the report as Annex 2 and further details are provided in the Monitoring Procedure published on the NC website.

"The performance of the SDAC algorithm continued to be highly reliable, ensuring yearly average TTFS of 2.5 mins, well below the maximum the 17 mins allowed."."

Usage indicators

- In 2023, we observe an increase in the average values for **product usage** for the majority of the products (pages 24 – 29) with respect to 2022, with the exception of the complex orders (–30 %), partially replaced by scalable complex orders and of supply merit orders (–6 %). For the other products the increase in 2023 with respect to 2022 is on average +13 %, mainly concentrated in the increase on the "total number of PUN orders" (+54 %), "total number of linked families" (+34 %) and total number of block orders exclusive groups" (+17 %).
- Among the indicators related to **network constraints** usage (page 29), the average value of the FB-PTDF constraints show an increase of +47 % with respect to 2022, due to the implementation of CORE flow based in June 2022. Nonetheless it is to be reminded that the 2021 baseline was low due to the implementation of the LTA, that allowed to significantly reduce the number of FB-PTDF constraints compared to 2020/ beginning 2021.
- The analysis of time series shows a seasonal effect in the usage of different kind of orders, with an increase during the winter period. This is particularly evident when observing the trend of the total number of blocks orders (page 25).

Performance data

- The analysis of TTFS (Time To First Solution) shows a reduction w.r.t. the previous year (–3 %) and the performance of the SDAC algorithm continued to show high reliability, with a yearly average of 2.5 mins for the TTFS. Also, in the most challenging sessions, the TTFS never exceeded 7 min. Such data shows that the algorithm was able to absorb the increase in the number of flow-based PTDF constraints that were a consequence of CORE FB implementation in 2022 as well as the usage increase of the majority of the products in 2023.
- The welfare indicators show good quality of solutions, negligible changes in the overall welfare for either first to final solution found in the standard 17 mins and for final solution to the one after extended calculation time. Increment of economic surplus with respect to the first OK solution is slightly decreasing than in previous years and as well as the economic surplus gain after increasing allowed calculation time by 10 minutes.
- The level of repeatability in 2023 increased, measured by the frequency indicator per delivery day, is always higher than 98.29 %, and the impact of differences over the relevant values, whenever present, proved to be negligible with an average annual value around 0.19 %. The level or repeatability with the deterministic time is, as expected, equal to 100 %.

Output indicators

- The average economic surplus shows an increase of about 10 % compared to 2022, amounting to an average economic surplus equal to 10.9 B €/MWh per session.
- Curve orders are responsible for the majority of the traded volumes, followed by merit orders, PUN orders, block orders and complex orders. We observe an increase in the number of matched orders for the majority of the products, while the value of traded volumes for most products is showing a slight decline, with the exception of curve orders, which show an increase in the matched volumes around +5 %.
- The time spent on the different phases of the algorithm calculation process was in line with the values from the previous year.

Usage indicators MRC/SDAC

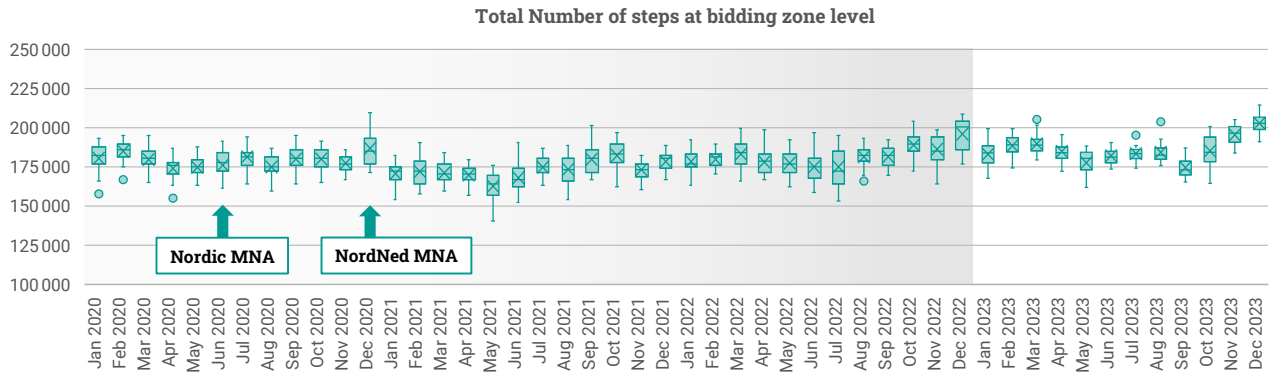
Table 03

Usage indicators Indicators to describe the Usage of SDAC products (Annex 3 of AM Article 10)	2020** MRC Avg	2021** MRC Avg	2022** MRC/SDAC Avg	2023** SDAC Avg	2023** SDAC Min	2023** SDAC Max
Total number of steps at bidding zone level*	179 746	173 392	182 216	186 818	162 646	215 446
Total number of block orders	4 498	3 745	4 076	4401	3 075	5 767
Total number of block order exclusive groups	146	114	135	158	118	210
Total number of linked families	59	35	43	57	21	129
Total number of complex orders	95	80	81	57	43	97
Total number of scalable complex orders	0	0	0	19	0	27
Total number of demand merit orders	985	651	687	832	571	1 207
Total number of supply merit orders	41 092	44 029	43 341	40 744	35 283	44 200
Total number of PUN orders	7 734	10 085	13 823	21 279	17 234	24 064

* This figure is the sum of number of points or steps of the aggregated bid curves or stepwise curves in all bidding zones in all 24 hours of the day respectively.

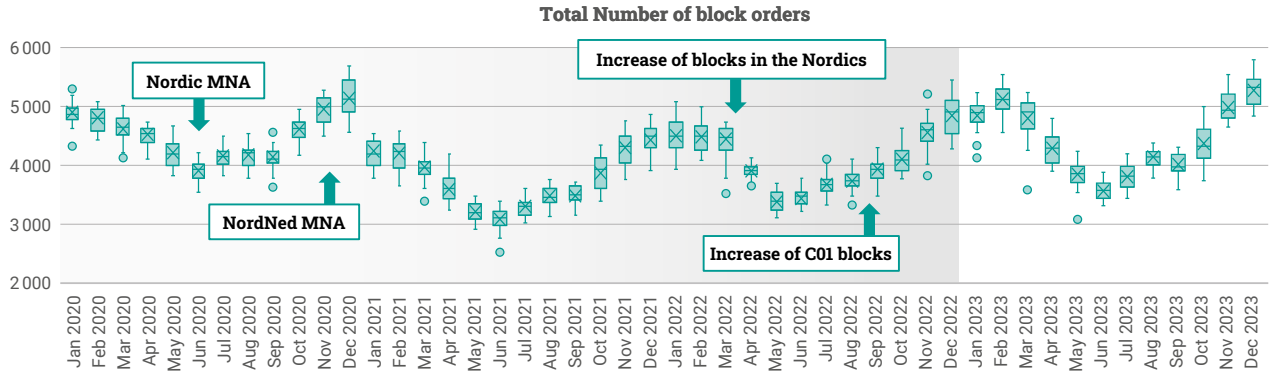
** The reported values are calculated excluding the days of Decoupling – one occurrence in each of the years 2020, 2021 and 2022.

MRC/SDAC[3]



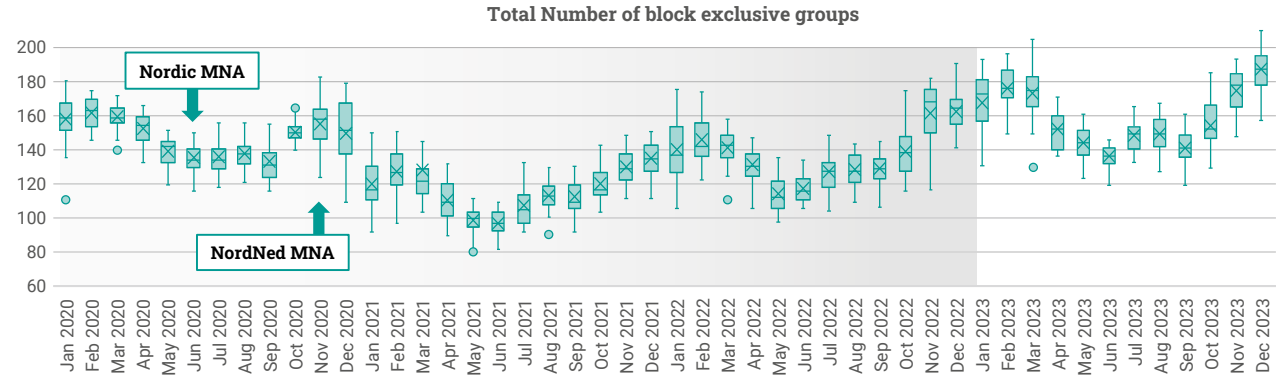
Weak seasonal variation, average increase w.r.t. 2022 around +2.5 %.

Figure 10



Marked seasonal variation, with an increase of the average annual level in 2023 w.r.t. 2022 (+8 %).

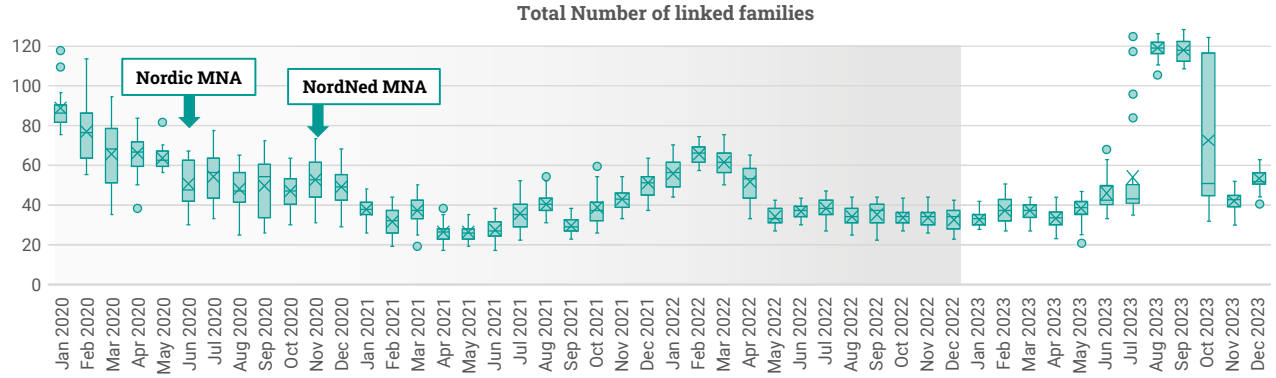
Figure 11



Average increase in 2023 w.r.t. 2022 around +17 %.

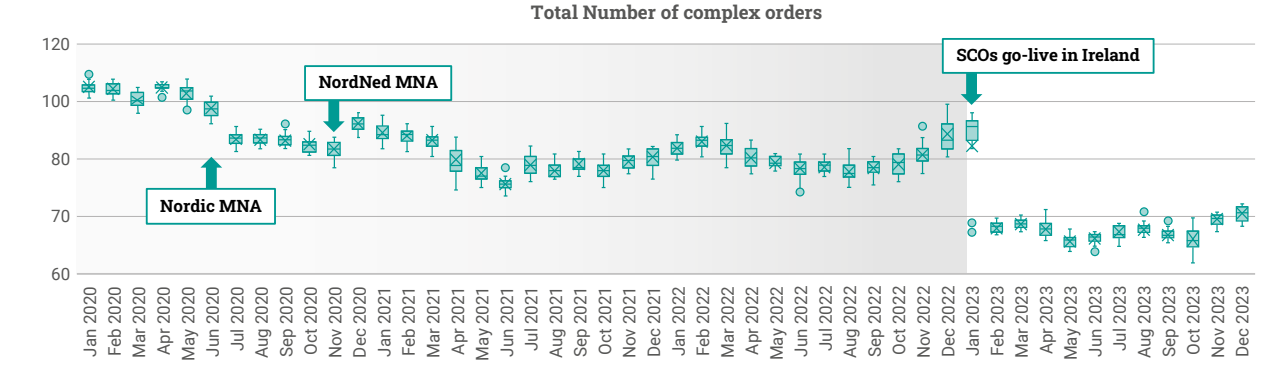
Figure 12

MRC/SDAC[3]



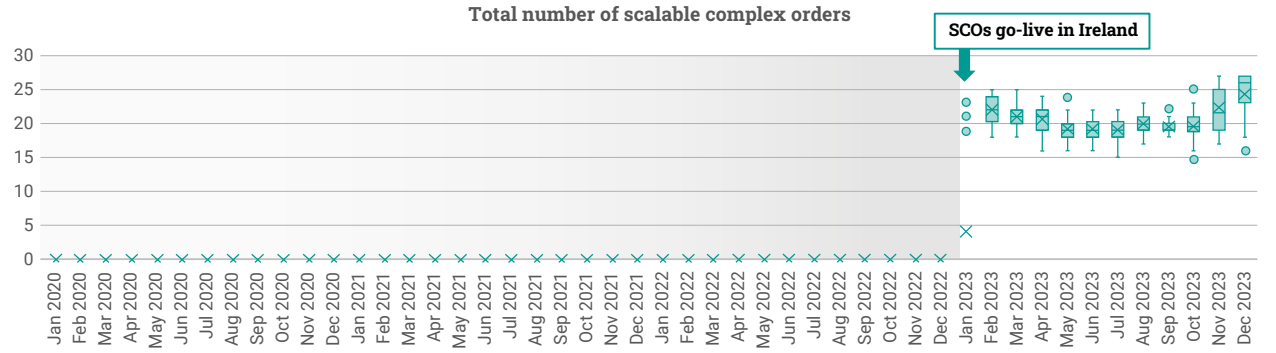
Significant increase in Summer 2023, to return later to previous levels in 2023 Q4.

Figure 13



Usage reduced –30 % in 2022 w.r.t 2021 due to the introduction of SCOs in Ireland

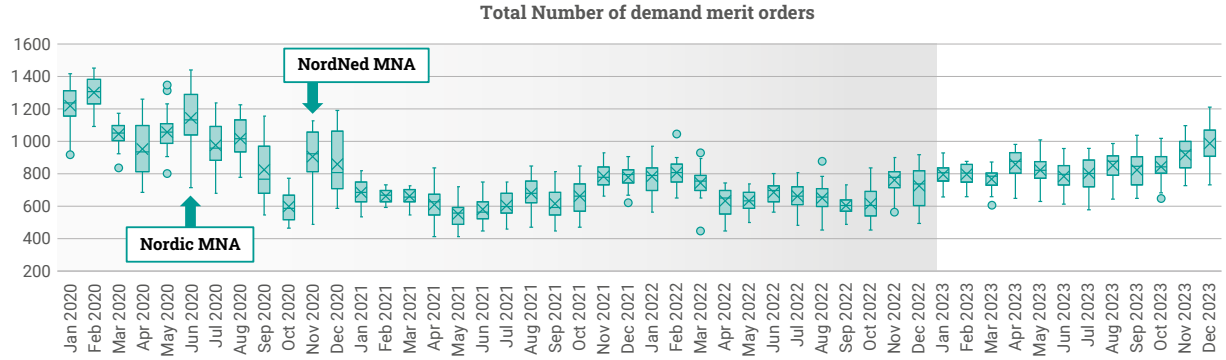
Figure 14



Usage started in January 2023

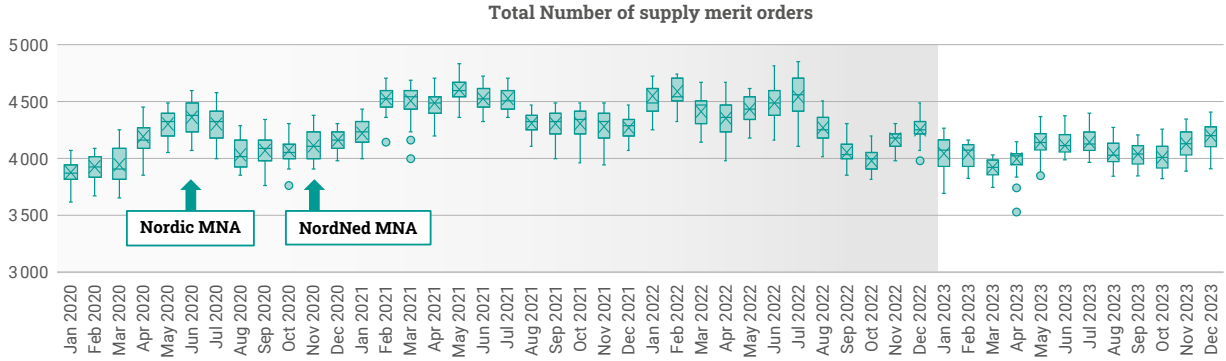
Figure 15

MRC/SDAC[3]



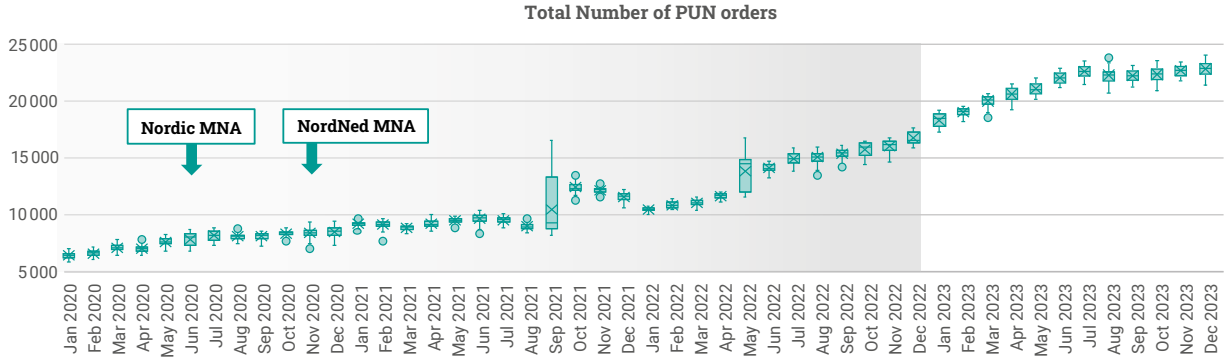
Significant increase of the average usage w.r.t. 2021 (+21 %).

Figure 16



Small reduction of the average usage w.r.t. 2021 (–6 %).

Figure 17



Significant increase of the average usage w.r.t 2022 (+54 %) partially due to an increase in PUN order with price indication (the price taking orders are instead aggregated by the algorithm). This led to an apparent additional increase in the number of PUN orders, while looking at the overall number of orders (not aggregating the price taking ones) the increment in PUN orders usage amounts up to +25 %.

Figure 18

MRC/SDAC

Table 05

Usage indicators	2020* MRC Avg	2021* MRC Avg	2022* MRC/ SDAC	2023* SDAC Avg	2023* SDAC Min	2023* SDAC Max
2) Indicators to describe geographical extension of the SDAC (Annex 3 of AM Article 11)						
Number of bidding zones	56.2	58.1	61.6	61	61	61
Total number of flow-based bidding zones	5.3	7	11	14	14	14
Number of scheduling areas	59.2	61.1	64.6	64	64	64
Number of NEMO Trading Hubs	80.8	95.9	99.4	97	97	97
3) Indicators to describe the network constraints (Annex 3 of AM Article 12)						
Total number of bidding zone lines	78.0	80.2	88.2	88	88	88
Total number of flow-based PTDF constraints	3 410.1	1 337.6	1 896.0	2 785.2	2079	3 531
Total number of scheduling area lines	88.0	90.2	98.8	99	99	99
Total number of NEMO Trading Hub lines	161.7	207.8	224.8	222	222	222

* The reported values are calculated excluding the days of Decoupling.

MRC/SDAC[3]

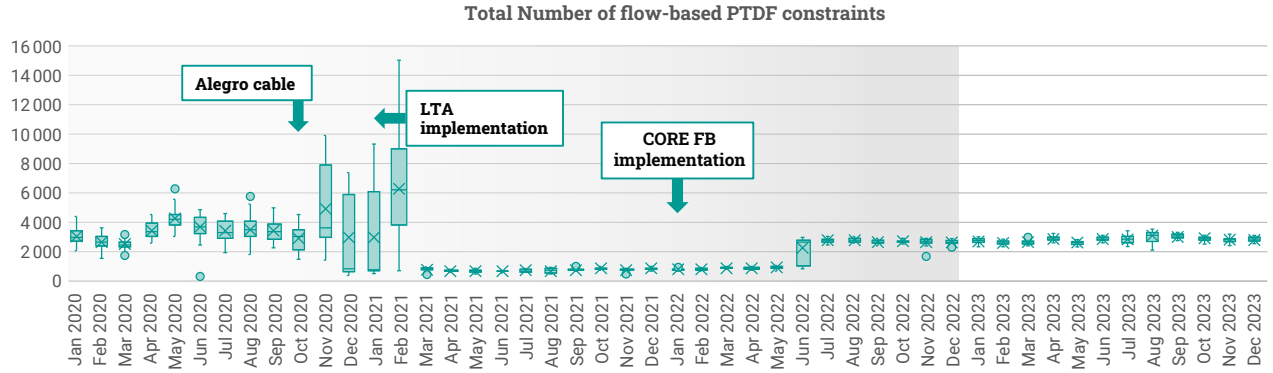


Figure 19

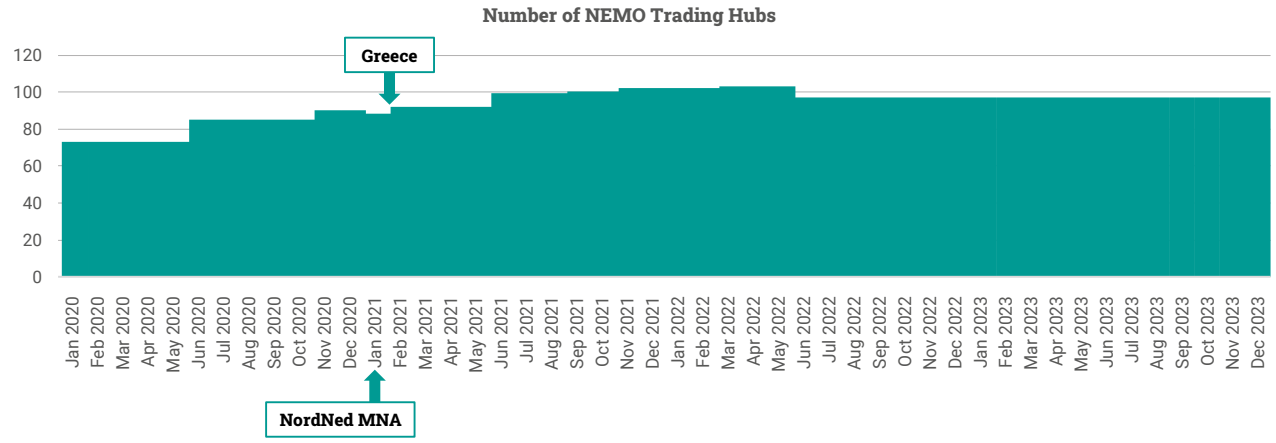


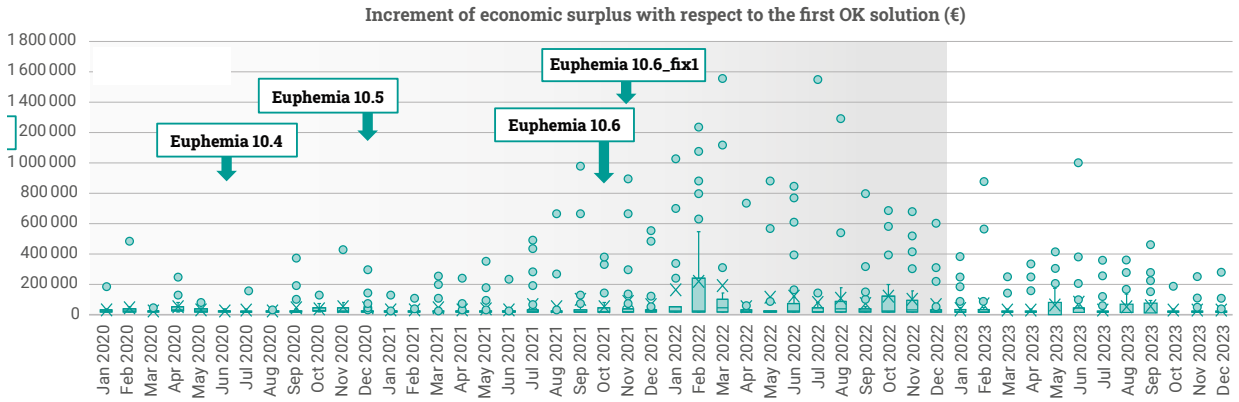
Figure 20

Performance indicators[4]

Table 06

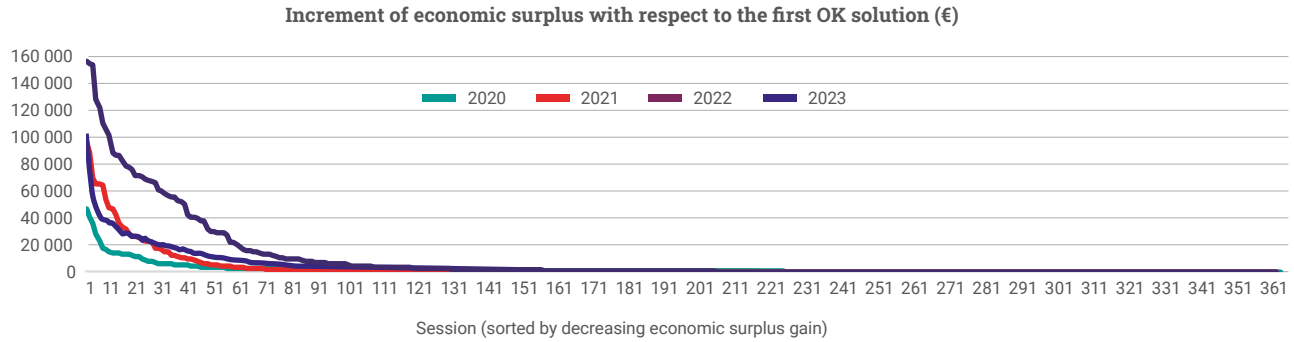
Performance	2020 MRC Avg	2021 MRC Avg	2022 MRC/SDAC	2023 SDAC Avg	2023 SDAC Min	2023 SDAC Max
1) Ability to maximise economic surplus (Annex 3 of AM Art. 7)						
(a) Increment of economic surplus with respect to the first OK solution (%)	0.000205 %	0.000407 %	0.001021 %	0.000351 %	0 %	0.009628 %
(b) Economic surplus gain after increasing allowed calculation time by 10 minutes (%)	0.000063 %	0.000092 %	0.000011 %	0.000007 %	–0.003643 %	0.004188 %
2. Algorithm repeatability without deterministic time						
(a) Algorithm repeatability without deterministic time. Repeatability frequency indicator, measured as number of equal values over total values for the relevant results (%) [bigger is better]	99.83 %	99.86 %	99.88 %	99.89 %	98.29 %	100 %
(b) Algorithm repeatability without deterministic time. Repeatability impact of differences indicator, measured as average of the contributions of the sums of absolute values of differences over the sum of the absolute values, for all the relevant results (%) [lower is better]	0.24 %	0.17 %	0.17 %	0.19 %	0 %	7.46 %
(b) Algorithm repeatability with deterministic time. Repeatability frequency indicator, measured as number of equal values over total values for the relevant results (%) [bigger is better]	100 %	100 %	100 %	100 %	100 %	100 %
(b) Algorithm repeatability with deterministic time. Repeatability impact of differences indicator measured as average of the contributions of the sums of absolute values of differences over the sum of the absolute values, for all the relevant results (%) [lower is better]	0 %	0 %	0 %	0 %	0 %	0 %
3) Algorithm scalability (Annex 3 of AM Art. 9) TTFS (min)	3.21	3.78	2.56	2.47	1.21	7.20

Ability to maximise the economic surplus [3,5]



Increment of economic surplus with respect to the first OK solution: maximum increase around 1 M € over 10 909 M € average daily welfare in 2023. Negative axis is not shown due to the absence of negative values.

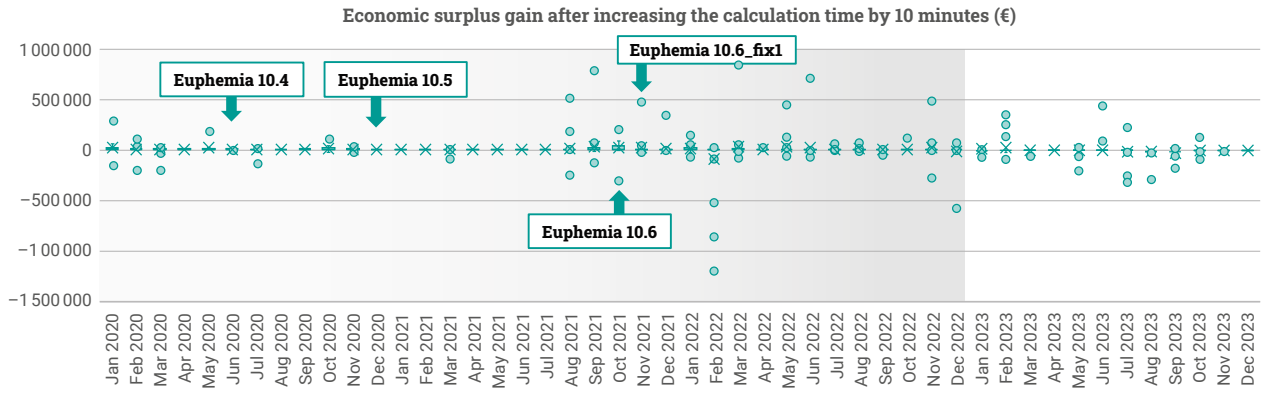
Figure 21



Duration curve shows the Increment of economic surplus with respect to the first OK ordered in descending order of magnitude, rather than chronologically.

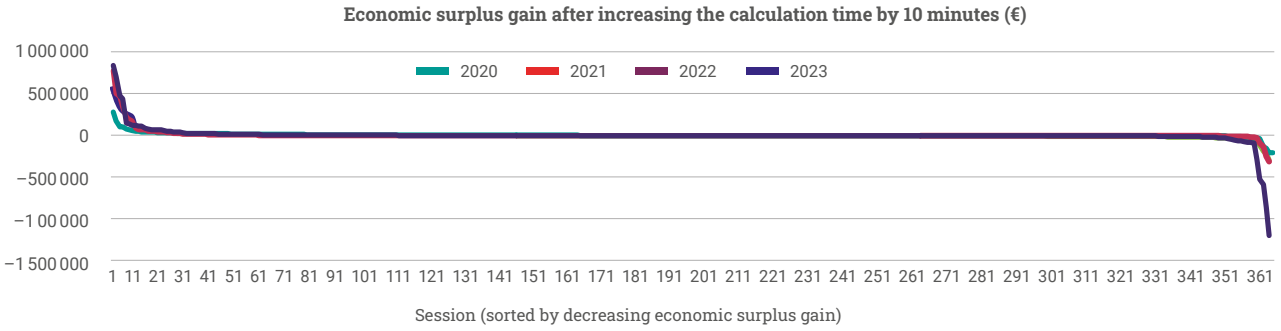
Figure 22

Ability to maximise the economic surplus [3,5]



Economic surplus gain after increasing the calculation time by 10 minutes: maximum/minimum gain ranges among +457 k € and −310 k € over 10 909 M € average daily welfare in 2023.

Figure 23



Duration curve shows the Economic surplus gain after increasing the calculation time by 10 minutes ordered in descending order of magnitude, rather than chronologically.

Figure 24

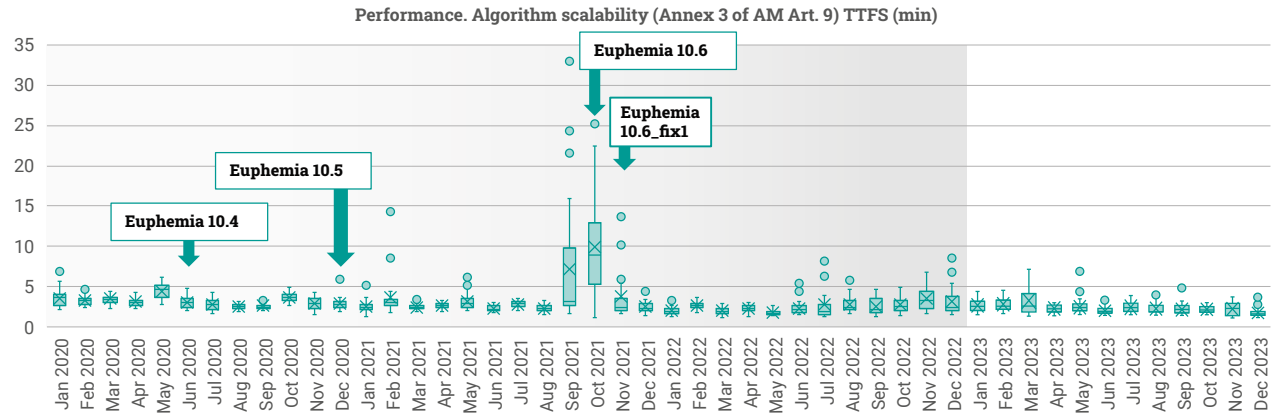


Figure 25

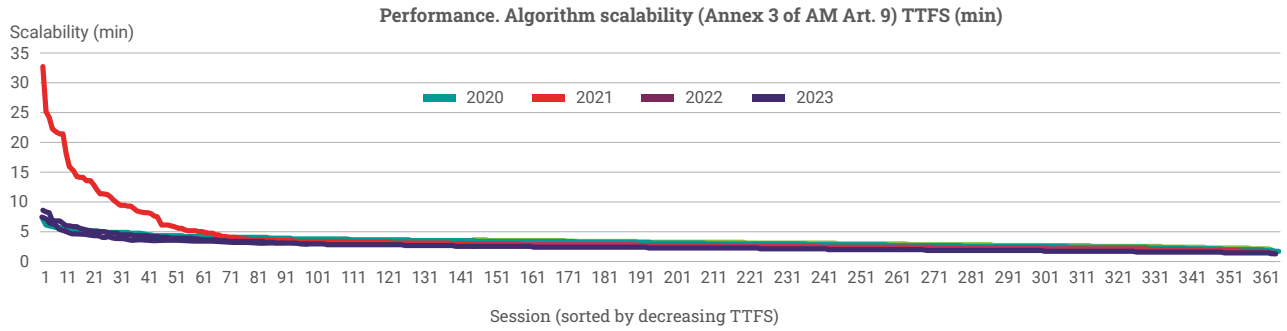


Figure 26

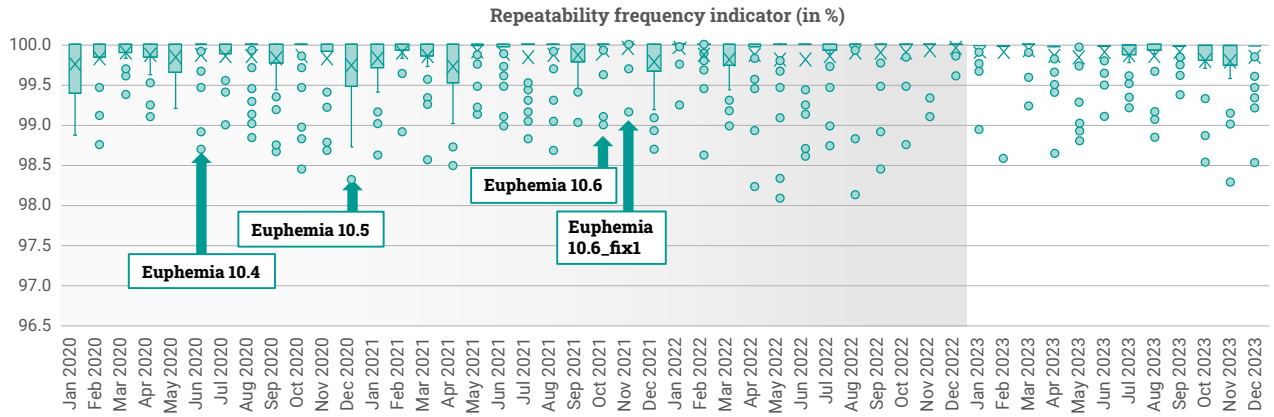
In September-early October 2021 we observed an increase in the TTFS due to the increase of PUN links.

PUN links are not PUN orders, but data that are created by the Algorithm to solve the problem. In particular, PUN links are caused by more orders at the same level of price: the more orders that are present at the same price, the more links are created for solving Euphemia. **Price level of the orders depends on the offers of Market Participants.**

In order to solve the issue, **a change in Euphemia (fix version)**, consisting in removing the PUN links constraints, was implemented and the TTFS was reduced again.

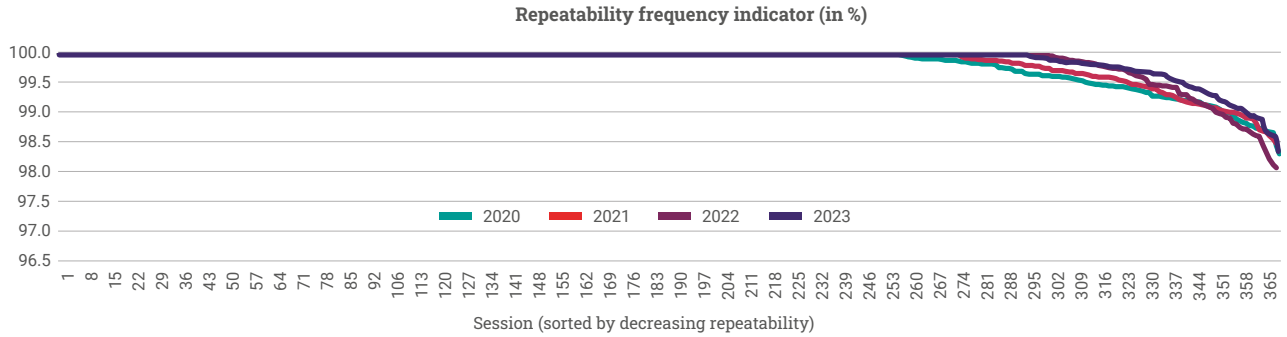
In 2023, the behavior is similar to 2022 and aligned with the values observed in 2019 and 2020.

Algorithm repeatability without deterministic time [3,4]



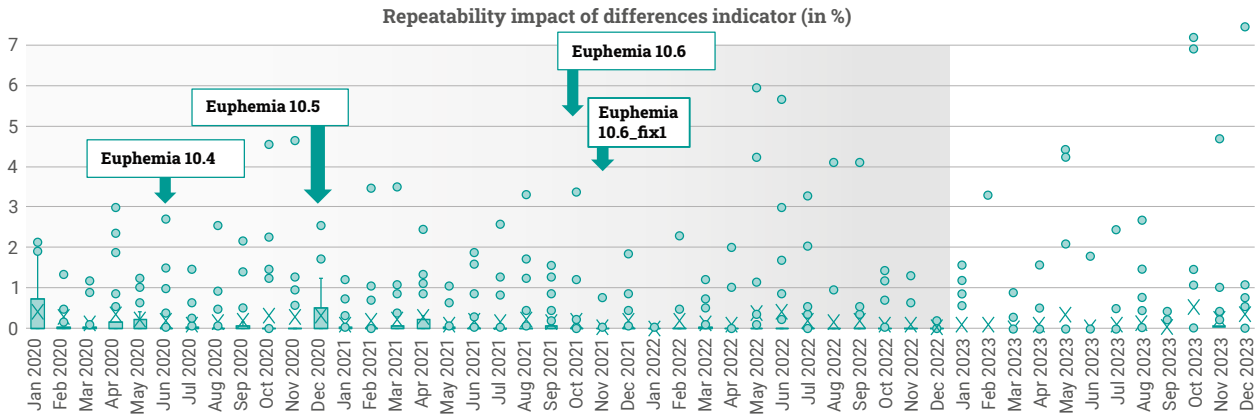
Repeatability frequency indicator: ellipses underlines the high level of repeatability, which, in 2023, is always higher than 98.29 %.

Figure 27



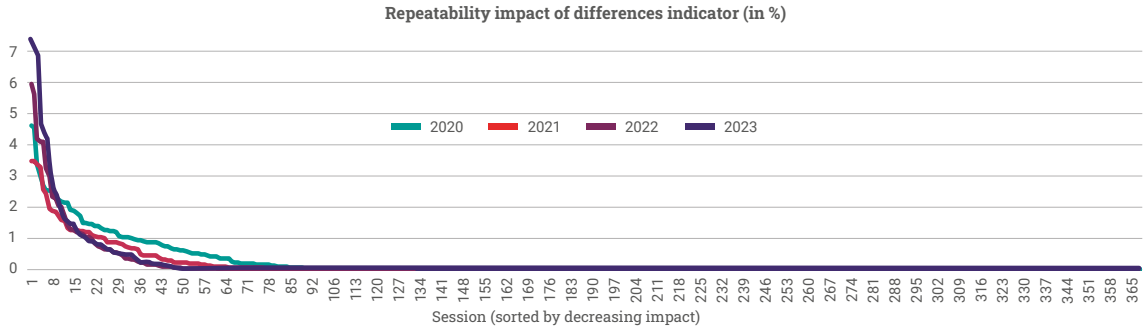
Duration curve shows the Repeatability frequency indicator ordered in descending order of magnitude, rather than chronologically. The number of sessions reaching 100 % value for repeatability frequency in 2023 is close to the value obtained in 2022.

Figure 28



Repeatability impact of differences indicator: the impact of differences over the relevant values, whenever present, proved to be negligible. In 2023 behaviour is similar to 2022.

Figure 29



Duration curve shows the Repeatability impact of differences indicator ordered in descending order of magnitude, rather than chronologically.

Figure 30

Output indicators

MRC/SDAC

Table 07

Output indicators	2020* MRC	2021* MRC	2022* MRC/ SDAC	2023* SDAC		
	Avg	Avg	Avg	Avg	Min	Max
1) Indicators on the maximisation of economic surplus (Annex 3 of AM art 13						
Maximisation of the first economic surplus						
Economic surplus of first OK solution (M €)	8 923.448	8 528.200	9 904.509	10 908.781	8 513.339	13 700.467
Economic surplus of the final solution (M €)	8 923.467	8 528.234	9 904.607	10 908.819	8 513.339	13 700.469
2) Indicators to describe the status of orders (Annex 3 of AM art 14)						
Evolution of number of matched orders						
Total number of matched blocks	692	742	808	875	528	1 467
Total number of matched complex orders	25	31	42	13	0	39
Total number of matched scalable complex orders	0	0	0	6	0	14
Total number of matched non-PUN merit orders	31 270	33 421	32 883	32 542	27 408	36 808
Total number of matched PUN orders	5 190	7 184	11 354	16 936	13 831	20 656
Total matched volume from curves (MWh)	6 020 578	5 917 323	5 707 128	6 001 375	4 995 751	7 693 256
Total matched volume from blocks (MWh)	383 456	343 177	398 544	363 438	139 913	702 363
Total matched volume from complex orders (MWh)	128 051	114 367	210 601	62 762	0	238 562
Total matched volume from scalable complex orders (MWh)	0	0	0	36 600	0	89 345
Total matched volume from (non-PUN) merit orders (MWh)	732 547	733 778	730 972	691 978	455 557	971 355
Total matched volume from PUN orders (MWh)	741 481	783 501	776 821	751 039	504 677	1 019 992
Paradoxically rejected orders						
Number of PRBs in the final solution	16.3	11.4	13.0	7.5	0	54
Number of PRMICs in the final solution	0.9	1.0	2.1	1.5	0	11
Maximum Delta P in the final solution	3.3	10.2	41.7	14.9	0	480
Maximum Delta MIC in the final solution	1	2.2	6.1	3.3	0	42
PRB utility loss in the final solution (k €)	18.363	50.687	129.859	46.123	0	539.976
PRMIC utility loss in the final solution (k €)	5.701	11.542	50.669	23.610	0	315.628
Volume of PRBs in the final solution (MWh)	21 941	13 021	12 704	10 127	0	55 589
Volume of PRMICs in the final solution (MWh)	4 628	5 143	10 955	6 897.64	0	45 454

Table 07

Output indicators	2020* MRC Avg	2021* MRC Avg	2022* MRC/ SDAC Avg	2023* SDAC Avg	2023* SDAC Min	2023* SDAC Max
Indicators on the evolution of the use of network constraints along the time						
Number of periods for ATC/DC lines with flows at full capacity	869	856	1 059	1 127	939	1 272
3) IT calculation process (Annex 3 of AM Article 15)						
Time spent in every phase of the algorithm calculation process						
TTFS (s)	192.8	227.2	153.6	148.3	72.706	431.894
Input data reading time (s)*	10.6	11.9	10.4	9.3	5	24
Input data delivery day creation (s)*	12.5	12.8	23.1	30.0	9	167
Time to solve the root node for the master computer (s)*	19.5	50.4	15.0	17.2	8.3	167.0
Time to solve the root node for the job that found first solution (s)*	17.2	45.2	3.49	5.6	0	114
Number of successive improvements of the solution in the given timeframe *This indicator measures the number of OK solutions that improve a previously found solution during the optimisation process limited by the amount of time available for running the SDAC algorithm******	3.4	2.6	2.4	3.1	1	12
Total number of nodes in the master branch and bound tree**	911	444	405	565.2	45	4 409

* The reported values are calculated excluding the days of Decoupling
** Some time measurements in the calculation are overlapping (parallel processes).
*** Zero nodes in the master branch can happen when the root node directly resolves to an optimal solution.
**** This number includes the first solution

Performance monitoring report: analysis on the usage of each product and its impact on algorithm performance

In this section, the individual impact on performance of each product is assessed, as stated in article 8.3.a) of the Algorithm methodology approved by ACER in January 2020.

Methodology

The analysis is performed for all the products included in the DA product methodology, apart from Stepwise Curves and Simple Blocks (which are deemed being the least impacting way to implement requirement explicitly mentioned in CACM) and merit orders (which are considered basically equivalent to stepwise curves in terms of performance impact). The analysis is performed against a historical dataset from Q4 2023.

Conversion of products

In order to assess the individual impact on performance, the remaining products have been replaced by the most similar alternative product, following specific conversion rules.

- **Piecewise curves:** converted into stepwise curves. For each non-vertical piecewise curve segment, one stepwise curve segment is created with price at the middle of min and max price of the given source piecewise segment. In case of source segment is stepwise (e.g. having STEPWISE or HYBRID source curve) it is kept as it is. Vertical segments needed for the construction of the stepwise curve may be added or amended.
- **Smart Blocks:** converted into simple blocks.
  - Linked families where all members have same sign (all buy or sell) are converted into a single block that aggregates all their energy at the price of the family parent block. Linked families with mixed members (buy and sell) are discarded.
  - Exclusive groups are converted by picking the most promising block of the blocks forming the exclusive group, maintaining its MAR and price.
  - Flexible blocks are removed. Their usage in production sessions is minimal.
- **MIC/MP and load gradient orders (BO + curves):** converted into Simple Blocks plus Stepwise curves.
  - All suborders' steps below the variable term are converted into profile block orders with minimum acceptance ratio equal to 1 and whose price will be the variable term plus the contribution of the fixed term over the sum of all offered volume.
  - **Remaining steps shall be integrated into the single curve.**
- **MIC/MP and load gradient orders (Scalable MIC/MP):** converted into Scalable Complex Orders. The variable term from the complex order and their impact on the acceptance of the order is incorporated to the fixed term of the Scalable Complex Order.
- **PUN orders:** converted into Demand Merit Orders by changing their type.
- **PUN and merit orders:** converted into stepwise curves. All PUN and merit orders offered at the same price are merged in a single step in the stepwise curve

Conversion of products drawbacks

Due to the nature of the requirements these conversion rules are not able to convert all the requirements from the original product into requirements from remaining products.

The conversions done in this study may not reflect a realistic behaviour of market participants in case one product is replaced by another one. For instance, one stepwise order may be split in several stepwise orders by a market participant in order to reflect their needs.

It should be noted that such approach is overestimating the impact on performance, as the conversion eliminates not only the individual impact of each product but also the combined effect linked to the interaction with the remaining products. For such a reason, it should also be noted that the estimated impact of the different scenarios cannot be accumulated.

Results

First, the gains of a product replacement measured in seconds are in the order of few tens of seconds. Furthermore, repeated runs of the same input data may return small differences values for the time to first solution (TTFS), in the order of few seconds, even when the same machine and configuration is used.

Second, the impact on individual sessions is not evenly distributed. It has been observed that although the average behaviour may be negative, there may exist a few sessions that are not single outliers and their value has a different sign.

Third, it has been observed that the impact on TTFS may depend on the internal parameters of the simulation. The selection of values for internal parameters of CPLEX and heuristics in EUPHEMIA is done pursuing a good behaviour in a wide variety of cases, covering adequate performance in average and being able to deal with problematic cases too. If one kind of product is removed, then the values of parameters should be reassessed against the full set of data scenarios used for the acceptance of new EUPHEMIA releases.

Fourth, the Q4 of 2023 has been selected, which contain many of the most challenging sessions of the year. Although the size of the sample used for input data has been extended from 1 month for 2019 study to 3 months for 2020, 2021, 2022 and 2023 studies, data still show counter intuitive behaviours in some scenarios when using normal configuration. We observed opposite counter intuitive behaviours such as in piecewise conversion into stepwise when using normal configuration (+58.8 % in TTFS).

Fifth, the comparison of impact from this study with the outcome from R&D activities may be indicating that the size of the input data for the sessions used in an impact of products on algorithm performance study is more relevant than the size of the sample (in number of sessions) used for the study.

Sixth, it should be reminded also the drawbacks due to the conversions of products applied that have been already explained on a previous page.

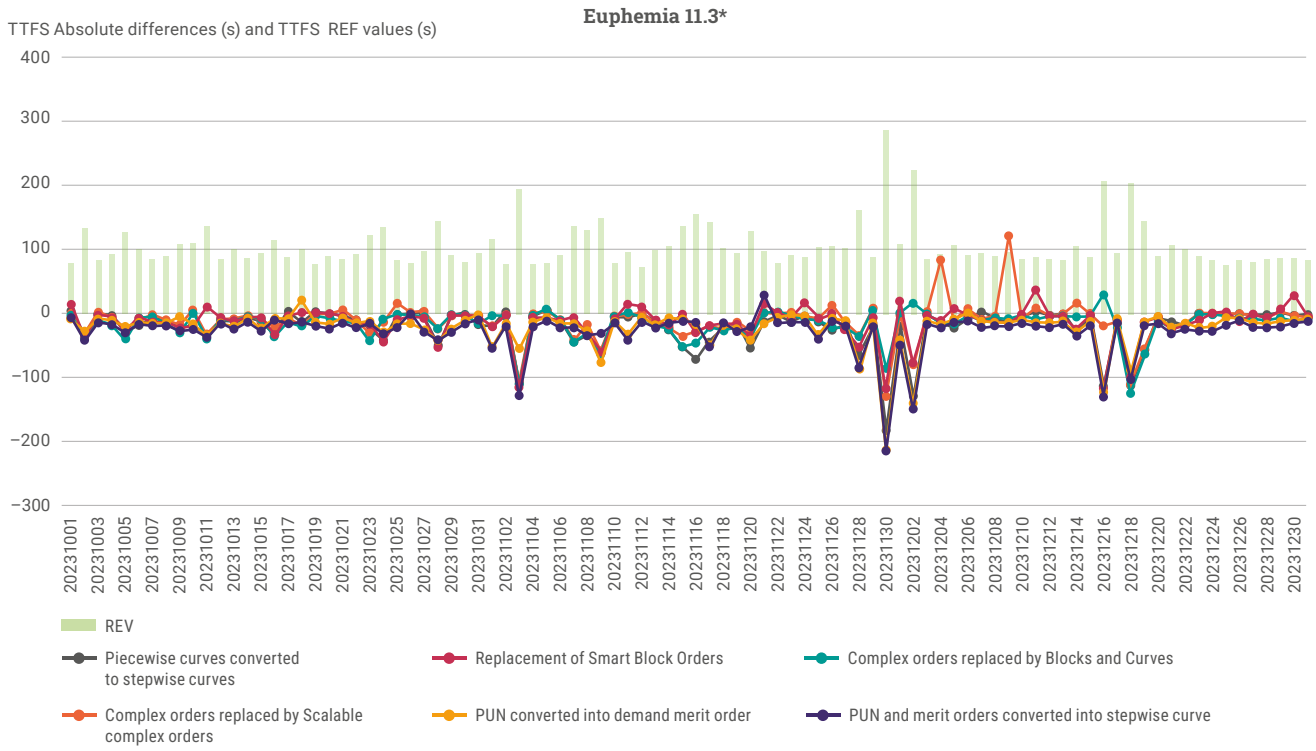
In conclusion, the main findings of the study seems to be:

- The outcome heavily depends on the methodology used [replacement of products, length in number of sessions of the batch, selection of internal parameters of the algorithm, size of the input data for each one of the sessions contained in the batch, ...]
- Given the chosen methodology, no product seems to have a standalone key impact on performance.

As a **final remark,** all these observations suggest reconsidering the approach to be followed to assess the impact of each product on algorithm performance. It should be noted than in the scope of this study only products were taken into account, while other requirements, such as flow-based has also a significant impact, as shall be reflected in scalability report. NEMOs defend that in case corrective measures need to be applied, the decision should be accompanied with a study analysing the impact on prices.

		Reference Scenario											
		Actual values		Impact on performance*			Assumptions for the simulation						
	Products	Orders submitted(#)	Traded volumes(GWh)	AVG TTFS(s) E11.3	ΔTTFS (s) E11.3	ΔTTFS (%)E11.3	# of steps at BZ level	# of Block orders	# of Smart Block Orders	# of MIC/MP and load gradient orders	# of Scalable MIC/MP and load gradient orders	# PUN and Merit Orders	# of PUN Orders
Reference	Reference scenario			105.0	–	–	195 177	4 854	2 847	57	22	42 088	22 539
Scenarios in which products are replaced	Stepwise Curves	195 177	6 553	Not estimated				–	–	–		–	–
	Piecewise Curves			82.5	–22.5	–21.4 %	182 152	4 854	2 847	57	22	42 088	22 539
	Merit orders	42 088	673	Not estimated			–	–	–	–	–	–	–
	Block Orders	4 854	355	Not estimated			–	–	–	–	–	–	–
	Smart Block Orders (exclusive groups + linked blocks)	42 088	673	89.0	–15.9	–15.2 %	195 177	2 198	0	57	22	42 088	22 539
	MIC/MP and load gradient orders (BO+Curves)	4 854	355	87.1	–17.9	–17.0 %	197 282	4 910	2 847	0	22	42 088	22 539
	MIC/MP and load gradient orders (Scalable MIC/MP and load gradient)	42 088	673	92.7	–12.3	–11.7 %	195 177	4 854	2 847	0	79	42 088	22 539
	PUN Orders	4 854	355	80.6	–24.3	–23.2 %	195 177	4 854	2 847	57	22	64 387	0
	PUN and Merit Orders	42 088	673	75.5	–29.5	–28.1 %	213 237	4 854	2 847	57	22	0	0

Figure 31



* Calculated with respect the reference scenario. The values of the impact (ΔTTFS) report AVG(TTFS from scenario replacing the product X) compared against AVG(TTFS from REF scenario). A negative value means that when the product is replaced, the TTFS is shorter than in the reference scenario.
All the scenarios, except for the one in which piecewise curves are converted in stepwise curves, are calculated using default configuration (the one used in production).
For the scenario in which piecewise curves are converted in stepwise curves, different internal parameters have been used, as suggested by the algorithm provider (these are different than the default configuration).

Figure 32

R&D report

The SDAC R&D program within Euphemia Lab continues to drive significant advancements in market coupling algorithm development. Since the beginning of Euphemia Lab in 2019, the program has been pivotal in developing and integrating several innovative solutions into Euphemia releases. Throughout 2023, key areas of focus included the implementation of the 15-minute Market Time Unit (MTU), scalability improvements, and exploratory research on future algorithmic adaptations. These efforts are crucial for ensuring the readiness and robustness of Euphemia to meet evolving market requirements and regulatory standards.

Key Developments and Achievements

The development and finalisation of 15-minute MTU support have been at the forefront of this year's R&D activities with extensive simulations and performance assessments being conducted. Key activities included performance assessments with new 15' MTU batches, finalisation of fallback procedures, and SIDC IDAs simulations using the latest Euphemia Prototype Features. These initiatives have resulted in performance improvements, particularly through the new bidirectional flow avoidance mechanism and other enhancements such as outer approximation in the master computer. These improvements are expected to be included in Euphemia 11.3 and subsequent releases.

Significant efforts were also dedicated to the exploration and integration of core software improvements. This involved finalising prototype integration and conducting tests to confirm results obtained with beta versions. The successful integration of these changes into the Euphemia prototype marks a substantial milestone, with possible recommendations to industrialise support for this changes. Concurrently, hardware studies assessing performance improvements with new machine types from cloud providers were conducted. Optimised DisCo (Distributed Computing) configurations and recommendations on the number of jobs per machine have been explored, enhancing the performance and robustness of the algorithm.

"The development and finalisation of 15-minute MTU support have been at the forefront of this year's R&D activities."

In the realm of generic improvements, the focus was on finalising volume problem solutions and outer approximation in the master computer. This included tuning the outer approximation for volume problems, adapting fallback procedures, and implementing performance enhancements. These efforts have led to substantial improvements in performance and robustness, especially with the latest 15' MTU data batches. Additionally, analyses of alternative methods to efficiently perform specific price condition checks using primal problems were conducted, providing valuable insights for future work.

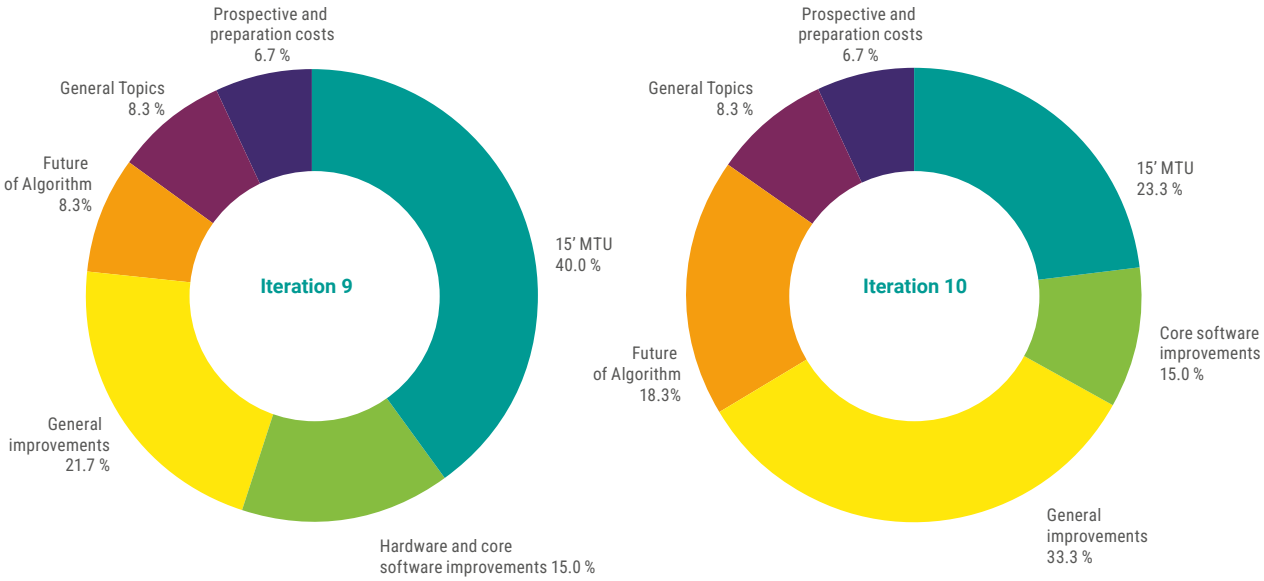
The 15-minute MTU project remains a critical aspect of the upcoming changes. It involves simulations to validate the system's performance under the new configuration. 31.67% of the total combined R&D budget was allocated for this project, reflecting its importance in meeting CACM compliance requirements. Performance enhancements achieved through this project are expected to be incorporated in Euphemia 11.3 and subsequent releases.

Another crucial area of research is the exploration of core software improvements for the Euphemia algorithm. This project aims to test the integration and potential performance benefits. 10 % of total combined R&D budget was dedicated to this effort, demonstrating improvements suggested by the successful integration of these changes into the prototype Euphemia.

In addition to these targeted projects, there are ongoing generic improvements aimed at enhancing overall system performance. These efforts encompass a variety of minor enhancements that collectively result in significant performance gains. Both iterations allocated substantial resources to these improvements, with ongoing efforts expected to optimise the system.

The "Future of the Algorithm" research stream focuses on future requirements for the algorithm, including the integration of offshore wind resources and other advanced features. Significant resources were dedicated to this research, ensuring that future iterations will address development needs, keeping the algorithm adaptive to evolving market conditions.

R&D programme for the price coupling algorithm: budget share per topic



For both iterations 9 and 10, the largest share of the budget was dedicated to the 15-minute MTU implementation, similar to previous iterations. The diagnosis cost varies, reflecting the continuous need to measure improvements and simulate different scenarios for the 15-minute MTU implementation. The total cost for both iterations is 814 200 €, plus added costs for cloud testing of 94 405 €.

Figure 33

R&D programme for the price coupling algorithm – ITERATION 9 (1/2)

R&D topic	Description	Iteration #*	Share of Iteration workload and budget	Share of both iterations worklwoad and budget
15´MTU	15MTU support for the go-live: • SIDC simulations with the last Euphemia Prototype Features from the EL needed for the GL-Performance assessment with new 15' MTU batches (e.g., with different mixes of 15'/60' products) • Finalisation of fallback procedures (design + triggers) in case of risks of decoupling • Other topics to be defined in collaboration with MSD (10 MDs)	9	40.00 %	20.00 %
Hardware and core software improvements	Software improvements exploration in Euphemia. • Finalisation of the prototype integration • Tests to confirm results obtained with beta versions.	9	10.00 %	5.00 %
	Hardware study assessing and reporting on: • Perf. Improvements with new machine types available from cloud providers • New recommended configurations (number of machines, number of jobs/threads per machine) • CPU vs RAM usage	9	5.00 %	2.50 %

* The Iteration 8 is presented in the 2022 CACM Annual report; Iteration 9 and 10 took place from April 2023 until March 2024.

Table 08

	CACM compliance	Outcome and impact on CACM compliance	Implementation in production (forecast)
	15' MTU implementation	Performance improvements resulting from the new bidirectional flow avoidance mechanism and other improvements coming from the other tracks (e. g., outer approximation in the master computer).	E11.3 and following releases
	Scalability improvement	Core software improvements successfully integrated into proto-type Euphemia. Simulations and optimisation performed. Possible recommendation to industrialise the support for these changes in Euphemia.	To be further investigated
	Scalability improvement	Analysis and testing performed. New optimised DisCo configurations explored with focus on setup architecture and calculation work-load distribution regarding resources usage. Recommendations on the number of jobs per machine to optimise the performance and robustness of the algorithm.	E 11.3 and following releases

R&D programme for the price coupling algorithm – ITERATION 9 (2/2)

R&D topic	Description	Iteration #*	Share of Iteration workload and budget	Share of both iterations worklwoad and budget
Generic Improvements	Follow-ups (finalisation) on volume problems & OA in the master computer For volume problems: (a) tuning OA in volume problems, (b) tuning the reimplementation of It.8, (c) follow-up on the PTDF-based approach if deemed relevant	9	20.00 %	10.00 %
	Adapt price problems, leveraging "primal price checkers" (primal-like continuous problems to check the no PAB/no PASCO conditions)	9	1.67 %	0.83 %
Future of Algorithm	2030 Future of the Algorithm –→ General Support + Finalisation of the study on linked block orders for storage	9	6.67 %	3.33 %
	2030 Future of the Algorithm –→ It. 9 Topics / support for the proposal for amendment of the SDAC algorithm? (ref. to the MESC Meeting doc. of December 2022)	9	1.67 %	0.83 %
General Topics	Flow-based improvements (topics to be defined in collaboration with FB experts)	9	1.67 %	0.83 %
	Diagnosis updates	9	6.67 %	3.33 %
Prospective and preparation costs	Wrap up prototype iteration 9	9	6.67 %	3.33 %

* The Iteration 8 is presented in the 2022 CACM Annual report; Iteration 9 and 10 took place from April 2023 until March 2024.

Table 08

	CACM compliance	Outcome and impact on CACM compliance	Implementation in production (forecast)
	Scalability improvement	Further analysis of new fallback procedures for volume problems, adaptations in the implementation of volume problems, and implementation of the outer-approximation approach in the master computer. Performances and robustness have been substantially improved thanks to these improvements, especially with the latest 15' MTU data batches.	E 11.3 and following releases
	Scalability improvement	Analysis of alternative ways to efficiently perform specific price condition checks using primal problems. Insights in preparation of further work on the topic.	To be further investigated
	NA	Preliminary overview on the performance impacts of the introduction of storage orders in SDAC.	NA
	NA	Anticipation of the work on PST modeling in the Iteration 10 of the Euphemia Lab.	NA
	Scalability improvement	Recommendations on flow-based model adaptations to mitigate circular flows passing through HVDC interconnectors.	To be further investigated
	NA	Large scale simulations with new representative 15' MTU SDAC & SIDC data batches to provide a clear status on performances.	NA
	NA	Code integration of all the successful adaptations during the iteration. Euphemia prototype.	NA

R&D programme for the price coupling algorithm – ITERATION 10 (1/2)

R&D topic	Description	Iteration #*	Share of Iteration workload and budget	Share of both iterations workload and budget
15 minutes MTU	15' MTU • Last fine tuning • Extra perf. assessments • Support for the stakeholder management	10	13.33 %	6.67 %
	Core Advanced Hybrid Coupling Simulations	10	5.00 %	2.50 %
	MCO Integration Plan Simulations	10	5.00 %	2.50 %
Core software improvements	Core software improvements R&D continuation (further leveraging new features + extra tests) Oct. 2024 to Dec. 2024	10	10.00 %	5.00 %
Generic Improvements	Java code profiling update	10	6.67 %	3.33 %
	Java code improvements	10	6.67 %	3.33 %
	Follow-up on primal price checks in callbacks	10	6.67 %	3.33 %
	Follow-ups on fallbacks for volume problems	10	6.67 %	3.33 %
	Feasopt Refactoring	10	6.67 %	3.33 %

R&D programme for the price coupling algorithm – ITERATION 10 (2/2)

R&D topic	Description	Iteration #*	Share of Iteration workload and budget	Share of both iterations workload and budget
Future of the algorithm	• Continuation of It. 9 → storage orders • PST/HVDC modelling and simulations • Second Study on OBZ Wind	10	18.33 %	9.17 %
General Topics	Diagnosis updates	10	8.33 %	4.17 %
Prospective and preparation costs	Wrap up prototype iteration 10	10	6.67 %	3.33 %

* The Iteration 8 is presented in the 2022 CACM Annual report; Iteration 9 and 10 took place from April 2023 until March 2024.

Table 09

	CACM compliance	Outcome and impact on CACM compliance	Implementation in production (forecast)
	15' MTU implementation	Performance improvements finalised with additional fine-tuning. Enhanced support provided for stakeholder management for the go-live phase.	E 11.4 and following releases
	Scalability improvement	Successful simulations completed for core advanced hybrid coupling, with significant performance optimisations noted.	E 11.4 and following releases
	Scalability improvement	MCO integration plan simulations yielded favorable results, indicating better integration and performance of MCO within the system.	To be further investigated
	Scalability improvement	Core software improvements R&D efforts continued, leveraging new features and conducting extra tests, resulting in improved scalability and performance.	To be further investigated
	Scalability improvement	Updates to Java code profiling identified and addressed key bottle-necks, enhancing overall code performance and efficiency.	E 11.4 and following releases
	Scalability improvement	Implemented improvements based on Java code profiling updates, resulting in better system performance.	E 11.4 and following releases
	Scalability improvement	Primal price check follow-ups improved validation processes, reducing computational overhead and improving scalability.	To be further investigated
	Scalability improvement	Developed and implemented comprehensive fallback strategies for volume problems, preventing decoupling risks.	E 11.4 and following releases
	Scalability improvement	Refactored Feasopt mechanism to improve numerical stability and performance in resolving volume problems.	To be further investigated

Table 09

	CACM compliance	Outcome and impact on CACM compliance	Implementation in production (forecast)
	NA	Continued support for storage order implementations, PST and HVDC modeling, and initiated second study on OBZ Wind, leading to better future readiness.	To be further investigated
	NA	Simulations run and analysis performed. Recent production and forward-looking batches helped to identify specific challenges to be addressed.	NA
	NA	Integrated successful adaptations from the iteration into the Euphemia prototype, ensuring readiness for future tests and implementations.	NA

Future Plans

For 2024, the focus will remain on fine-tuning the 15-minute MTU implementation, supporting stakeholder management for the go-live phase, and enhancing scalability through various initiatives. Continued work on core advanced hybrid coupling simulations, MCO integration plan simulations, and continuing core software improvements R&D are planned. Updates to Java code profiling and improvements will address key bottlenecks, further enhancing overall code performance and efficiency. Follow-ups on primal price checks and fallback strategies for volume problems will ensure robustness and prevent decoupling risks.

Within the "2030 Future of the Algorithm" framework, support for storage order implementations, PST and HVDC modeling, and the second study on OBZ Wind will continue, aiming to ensure the algorithm's future readiness. Diagnosis updates will remain a priority, helping to identify and address specific challenges through detailed simulations and analysis.

Overall, the continuous development and implementation efforts within Euphemia Lab have significantly progressed the SDAC R&D program. Key advancements in the 15-minute MTU implementation and various scalability improvements ensure readiness for future market requirements.

With ongoing risk management and further investigation into specific areas, the SDAC market coupling systems are well-prepared to handle upcoming challenges and opportunities. The combined budget for these efforts in iterations 9 and 10 was 814 200 €, together with cloud testing makes total of 908 605 €, reflecting the program's commitment to robust and scalable market coupling solutions.

The continuous evolution of the R&D program at Euphemia Lab underscores its dedication to innovation and excellence. The upcoming 15-minute MTU implementation is a testament to these efforts, representing a significant milestone in the ongoing enhancement of the SDAC algorithm. Looking ahead, Euphemia Lab will continue to pioneer advancements, ensuring the algorithm remains at the forefront of market coupling systems. Through ongoing research and development, the program aims to maintain high performance levels, adapt to new market demands, and support the transition to a high-renewables energy system, ensuring robust and efficient market operations for the future.

The R&D plan in a nutshell: How it works

With the approval of CACM and the related methodologies, further challenging requirements have been introduced in terms of dimension (a wider geographical scope, going together with a higher usage of products, more complex network topology), market design (MNA, new demanding network constraints, 15 minutes MTU) and algorithm performance (optimality, scalability and repeatability).

To be ahead of the change and keep on ensuring the best level of performance even in the new demanding environments, NEMOs and TSOs launched in 2019 a forward-looking R&D program "Euphemia Lab", aimed at increasing both the scalability of Euphemia and the quality of the solutions in terms of economic surplus.

Proposals within Euphemia Lab address three areas: hardware, software and market design. The proposals might have a different impact on the algorithm: from non-disruptive, through moderately disruptive, until highly disruptive concepts. The lead time from research start until the implementation and usage in production is also variable: short-medium-long term.

The outcomes of the research and development are assessed against different criteria, among which the estimated impact on scalability (TTFS decrease), optimality (optimality gap measurement, number of PRB), repeatability. Additional aspects may be taken in account depending on concrete topics: need for an update of related methodologies, outcome of a cost-benefit analysis, impact on the market participants behavior, etc.

From the overall timeline perspective, at least 6 to 12 months are needed between the end of the R&D cycle called iteration, and the implementation of a feature into the algorithm and its actual usage in production. This time is due to the finalisation of developments and a comprehensive testing.


Single Intraday Coupling

SIDC main features

NEMO requirements

- MTU: 15, 30, 60 mins without cross-matching
- Regular orders
- Linked orders
- Iceberg Orders

TSO requirements

- ATC (including possibility to set a global constraint for set of cross-zonal interconnectors)
- Ramping constraints
- Explicit capacity requests

CACM requirements

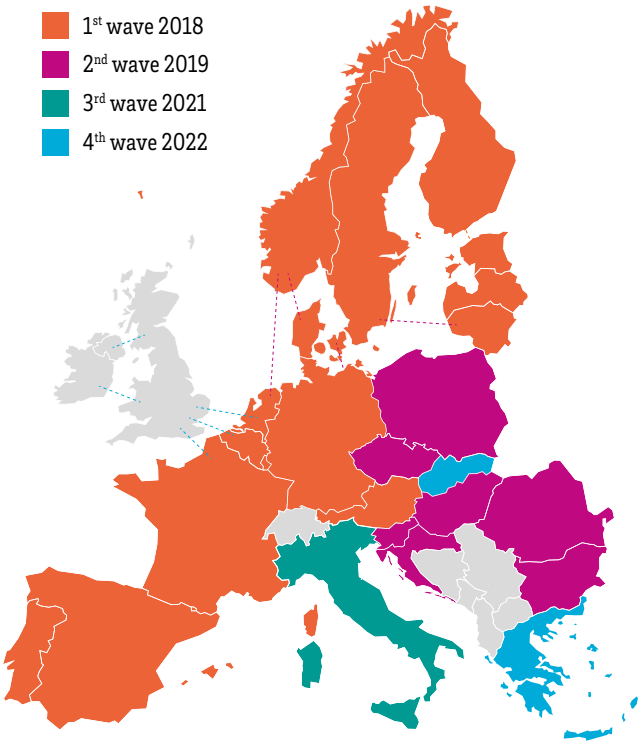
- Adequate scalability
- MNA
- MTU: 15 – 60 mins

Systems release(s)

- Deployment of XBID version 3.3, 18 January 2023
- R3.3.15 release (firmware upgrade on physical servers and hotfixes) deployed on 28 June 2023
- Major release of R4.0.26 deployed on 13 May 2024

Geographical scope

- 5th wave (concerning inclusion of ETPA in SIDC)



Note: Luxemburg is part of the Amprion Delivery Area. Market participants in Luxemburg have access to the SIDC through the Amprion Delivery Area.

Figure 34

High level market data

Through more than five years, since the go-live in 2018, the trading in the SIDC continuous market has shown steady growth. 2023 shows increasing growth and another record year.

- The coupled SIDC continuous-trading grew to 166.45 TWh traded - representing 150 million trades. In 2022 the relevant traded volume was 110.48 TWh.

The SIDC market includes 25 countries. The SIDC systems handle orders and transmission capacity from 34 bidding zones and 56 borders. Market participants trade on platforms of 14 NEMOs.

- The successful inclusion of ETPA as a NEMO in the Netherlands since 1 August is formally marked as the 5th wave in SIDC.

The operation of the systems remained stable and their performance unaffected by the significant increase in number of orders executed per day and number of trades matched. Incidents are even fewer than previous year and the unexpected down time close to none.

The annual average clearing price was about 95 €/MWh for hourly contracts and 97 €/MWh and 102 €/MWh for half- and quarter-hourly contracts, respectively. Block contracts tend to be traded with lower average price around 78 €/MWh. Average price on hourly, half- and quarter-hourly traded in the last hour before delivery does not significantly deviate from the average price overall. Blocks traded in the last hour were traded at an average price of 71 €/MWh.

- Annual mean price per bidding-zone ranged from 22.06 €/MWh to 185.72 €/MWh. Price levels were overall significantly lowered from the 2022 price levels.

Yearly prices are computed as volume-weighted average prices of all trades per contract per bidding zone.

Traded volumes (GWh)

Table 10

Annual	Daily average	Daily minimum	Daily maximum
166 450	456.03	302.34	812.66

"The operation of the systems remained stable and performance unaffected by the significant increase in number of orders executed."

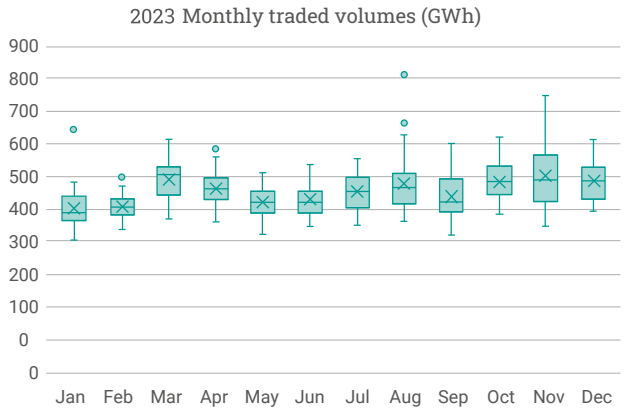


Figure 36

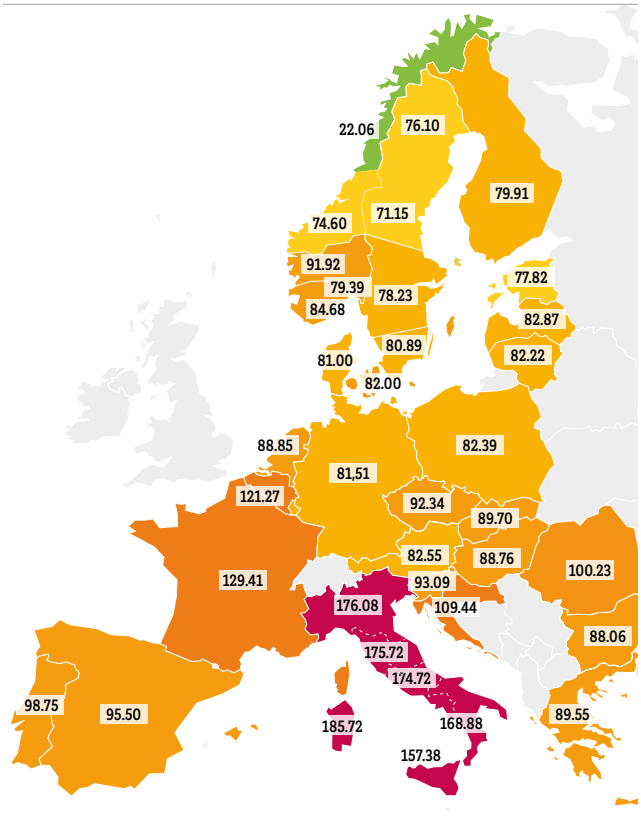


Figure 35

Operations report

This section reports on operational events occurred in SIDC during 2023, including: the incidents, requests for changes decided upon and corrective measures applied.

"2023 was another year of stable operations of SIDC continuous trading"

Incidents

They are classified according to severity and causes, with a classification in SIDC which is similar but not identical to the one applied in SDAC due to the specificities of the two technical solutions.

- Throughout 2023, SIDC experienced 8 incidents in total, of which 3 incidents of severity 4 were not visible to market participants. 4 incidents were caused by local issues not related to the MCO function.
- There was one incident of Severity 1 in 2023, i.e. an incident that led to a Market Halt. A Network outage caused a crash of the Primary Data Center of XBID and the failure of the redundancy mechanism. The incident resulted in 52 minutes of unexpected outage in the XBID operation.

Incidents 2023

Table 11

Date	Real duration	Comments and observations
27.02.2023	52 minutes	XBID core failover.

Requests for change (RfC)

RfCs are classified per type of requirement, with the same classification being applied in SDAC and SIDC despite the specificities of the two technical solutions.

- Altogether 7 RfCs were implemented in 2023.
- On 1 August there was the successful go-live for ETPA's trading platform to operate within the SIDC, also announced as "SIDC 5th wave". ETPA started hosting trading in the Dutch Market Area.
- One Network Topology change in December related to Italian Topology.
- 5 RfCs with various aims, like fulfilling prerequisites for the IDCZGOT, improving usability and update of interconnector.
- This report includes a complete list of the RfCs that were implemented.

Corrective measure (CM)

No Corrective Measures were applied in SIDC during 2023, as no relevant performance deteriorations were recorded during the year.

Incidents

Severity

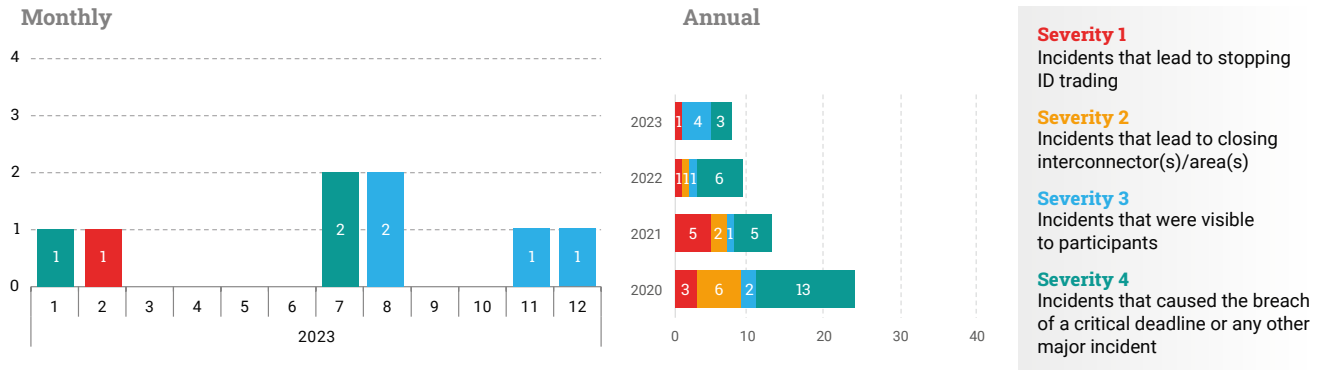


Figure 37

Causes[1]

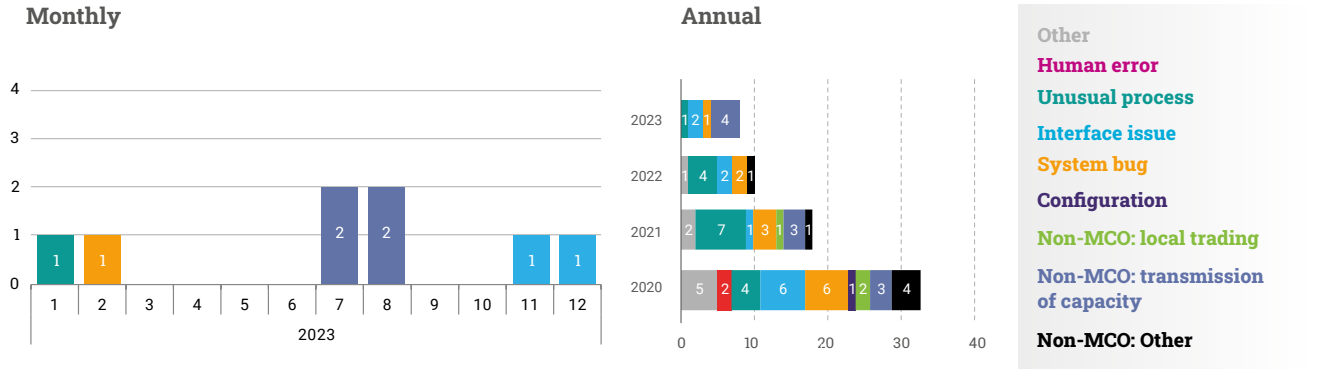


Figure 38

XBID network outage

On 27 February 2023, at 00:35 CET, a switch in the primary Data Center of XBID system crashed. Normally, the secondary Data Center should take over immediately. However, the redundancy mechanism in charge of switching from the Primary Data Center to the Secondary did not work as expected, and the XBID system was down, and market automatically halted.

Scope of the impact (Severity 1)

Severity 1 incidents have impact on all market areas and all borders, and therefore XBID solution is halted. Incidents with severity 2, 3 or 4 have less significant impact and in practice are considered as regular operational states. Lower severity incidents are thoroughly treated by XBID procedures.

Description of the incident on 27 February

In 2023, there was one Severity 1 incident leading to halt in trading and to intervention of the technical staff operating the XBID Solution:

- Incident Committee was opened at 00:47 and NEMOs and TSOs confirmed that the XBID systems were down.
- Supplier investigated the issue and tried to ensure that it was safe to restart the XBID system core instances.
- At 01:16, the supplier announced that the system was stable and it was safe to restart the market. NEMOs and TSOs performed the necessary checks and confirmed that connections between local systems and XBID system worked well.
- At 01:27, the market was successfully set back to trading. The issue thus resulted in 52 minutes of unexpected outage in the XBID operation.

Description of the incident(s)

Measures were not possible as connected servers are not able to alert on partially dropped traffic, and there is no way of reacting to this situation on the server side. Supplier rearranged the setup of the cluster network connectivity to ensure that the redundancy mechanism works properly, i. e. as soon as one core fails, the other one can take over.

Public incident report

Details of the 27 February incident can be found in the published incident report on NC website.

Request for change (RfCs)[2]

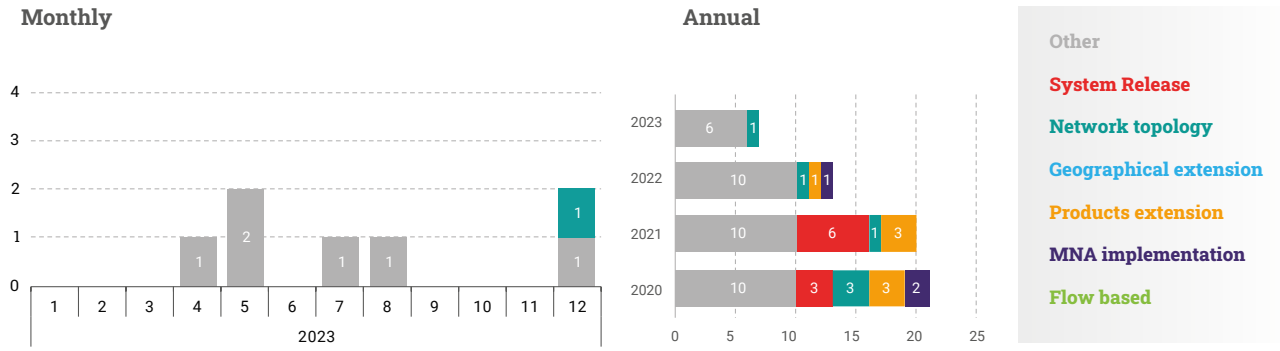


Figure 39

Table 12

Requirement	Name	Go-live Date	Reason	Reason, (AM article 14.1)	Initiator/ Owner (Annex I to AM article 15.2.c)	Details, Aim of the CR (Annex I to AM – 15.2.a)
Other	Adjustment of Operational Time Unit values in XBID CMM for borders BE-NL and DE-BE	08.04.2023	CACM	a,	TSOs	IDCZGOT prerequisity
Other	15 minutes products in Finnish, Swedish and Danish BZs	22.05.2023	CACM	a,	NEMOs/ TSOs	IDCZGOT prerequisity
Other	Update of XBID_Default_Schedule	22.05.2023	Other	e,	NEMOs	IDCZGOT prerequisity
Other	DK1A-NO2 max capacity change	08.07.2023	Other	h,	TSOs	Interconnector update
Network topology	Change of the Italian topology	13.12.2023	Other	g,	TSOs	Local change / NRA
Other	ITCOUPL-APG max capacity update	14.12.2023	Other	h,	TSOs	Improve usability
Other	Inclusion of ETPA in SIDC	01.08.2023	Other	g,	NEMOs	CCP extension

Performance monitoring report

For performance monitoring, the indicators listed in the annex 4 of the AM have been considered for all the days of 2023. The maximum, minimum and average values observed throughout the year are reported on the following pages. Where relevant, monthly values are also reported. Notes and explanations on the calculation of these indicators are included as asterisks below the diagrams on the pages where relevant.

"With significant increase in activity, number of orders and trades; the performance of the system remained stable throughout 2023"

Usage Indicators

The majority of the available data reflects the network topology with 34 bidding zones, 71 interconnectors, 14 NEMOs and the product types available; hourly, half-hourly, quarter-hourly and blocks.

The analysis of monthly values regarding executed orders and matched trades shows steady increase through 2023.

Performance Indicators*

The analysis of daily values, in terms of processing time for orders/trades and order book update shows improvement and stability through 2023. The deployment of the XBID version 3.3 in early 2023 extended the system boundaries, improved performance and infrastructure. Enhancements necessary for uplifting the Service Boundaries in order for the XBID solution to be able to handle daily 10 million order transactions.

Output Indicators

The "total matched – hours to delivery" indicator shows that still more than 50 % of the traded volume is matched in the last two hours before gate closure one hour before delivery.

* **Ability to maximise the welfare indicator:** As set out in the Title 3, Article 7 of the Annex 4 of the Methodology for monitoring the performance and usage of the continuous trading matching algorithm, the indicators on the continuous trading matching algorithm's ability to maximise economic surplus are not relevant for the continuous trading matching algorithm.

Repeatability indicator: : As set out in the Title 1, Article 2, Paragraph 1c of the Annex 4 of the Methodology for monitoring the performance and usage of the continuous trading matching algorithm, the continuous trading matching algorithm is by design optimal and repeatable. For this reason, the monitoring of the continuous trading matching algorithm's optimality and repeatability is not necessary.

Usage indicators[9]

Table 13

Usage indicators	2020		2021	2022	2023 Avg	2023 Min	2023 Max
1) Indicators to describe the Usage of products (Annex 4 of AM Article 8)							
Total number of products (per end of year)		4	4	4			4
Total number of daily submitted orders per product and per bidding zone	N/A	Hour ½-hour ¼-hour Block	26 674 4 939 155 110 86	41 214 9 826 272 364 4 940	80 214 56 048 384 603 602	1 28 1 1	2 287 270 261 369 4 290 594 163 587
Total daily submitted order volume per bidding zone (MWh – avg, min, max)			86 928	305 700	460 828	5	25 097 339
Total number of explicit capacity allocation request (avg, min, max - per day)		Avg 399	Avg 412	Avg 602	Avg 700	Min 484	Max 1290
2) Indicators to describe the geographical extension (Annex 4 of AM Article 9) [10]							
Total number of NEMO (per end of year)		10	11	13			14
Total number of delivery areas* (per end of year)		32	33	35			37
Total number of bidding zones* (per end of year)		29	30	32			34
Total number of interconnectors* (per end of year)**		59	62	67			71
Total number of borders* (per end of year)		48	51	54			56
3) Indicators to describe Network constraints (Annex 4 of AM Article 10)							
Total number of occurrences of ramping constraints on interconnector level***		Not available	437	715	882	16	2 402
Total number of occurrence of Biding Zone net position ramping constraints****		–	–	–	–	–	–
Total number of occurrence of Biding Zone net position volume constraints****		–	–	–	–	–	–

* Delivery areas, bidding zones, interconnectors and borders required for system setup are excluded (with Morocco and Russia, Italian virtual areas):
** Interconnectors that represent the connections with the VDAs to their PDA were removed. (TN_IC = 62)
*** This count started in May 2021. There are 11 interconnectors with Ramping limit; EE-FI, DE-DK2, DE-NO2, DK1-SE3, DK1-DK2, DK1-NL, DK1-NO2, LT-SE4, LT-PL, NO2-NL, PL-SE4
**** The net position ramping constraint and the net position volume constraint are not in use in SIDC today, i.e. no values to be reported for these two indicators.

Performance

Table 14

Usage indicators		2020 Avg	2021 Avg	2022 Avg	2023 Avg	2023 Min	2023 Max
Algorithm scalability (Annex 4 of AM Art. 7)							
a) Time for the execution of an order (milliseconds)*	Lower percentile 93 %	16	18	28	21	13	39
	Upper percentile 96,5 %	21	26	41	30	18	54
b) Rate of executed orders (number per day)		1 645 724	2 532 418	4 214 466	7 892 767	4 840 092	11 723 289
c) Time for the execution of a trade*		Equal to (a)	Equal to (a)	Equal to (a)	Equal to (a)	Equal to (a)	Equal to (a)
d) Rate of executed trade (number per hour)		109 965	166 866	243 753	411 947	268 256	622 123
e) Time for generation of post coupling files (milliseconds)		15 001	11 983	12 137	16 719	9 415	49 657
f) Time for processing an order book update (milliseconds)**	Lower percentile 93 %	28	31	34	20	16	37
	Upper percentile 96,5 %	36	44	56	30	22	66

* This indicator measures the time between the moment that an order receives a timestamp from the system and the moment that it is reported by the system as executed. As of today, there is no separate value for the execution of a trade and for execution of an order. The parameter includes together order and trade execution (trades executions are a subset of order executions in the existing reporting.)

** For each orderbook update, this indicator measures the longest time lapse between the moment that an order enters the system and the moment that the system sends the order book update comprising that order.

Time for the execution of an order/trade (millisec)[3]

Time for execution of an order/trade in 2023 is stable and it is even possible to observe improvement after the deployment of XBID version 3.3 in early 2023.

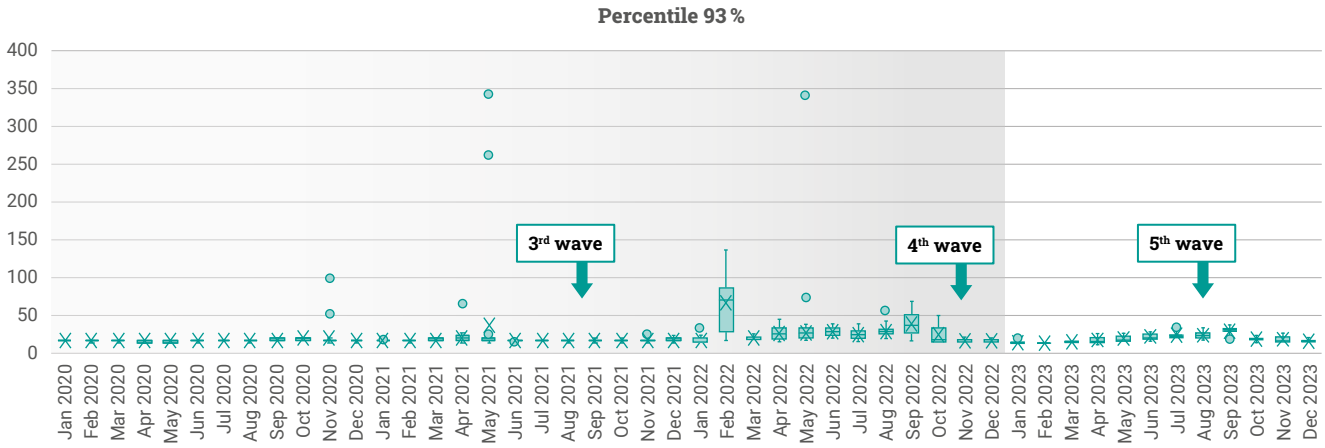


Figure 40

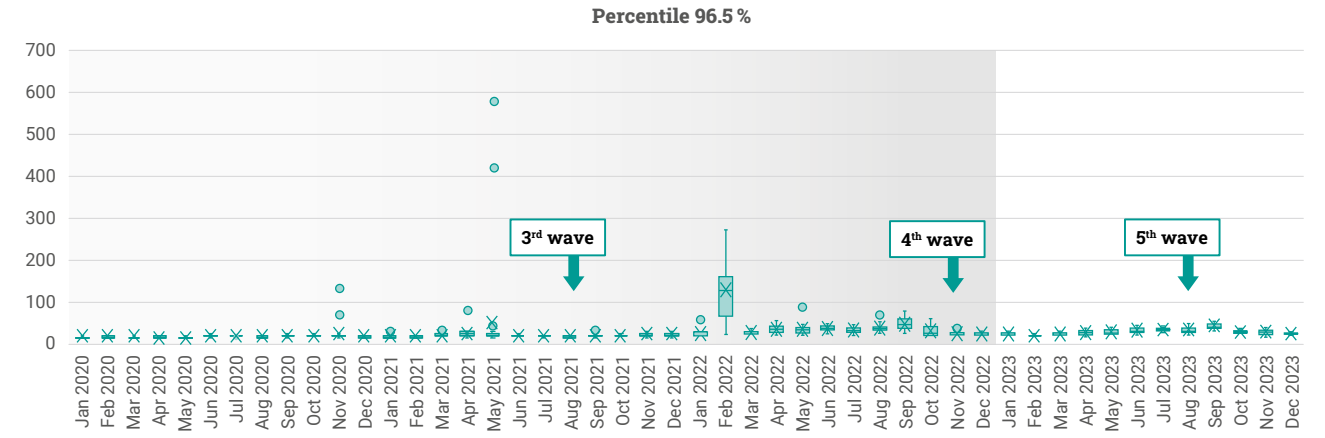


Figure 41

Time for processing an order book update (millisec)[3]

The times for processing an orderbook update are stable and show even a lower trend compared to 2022.

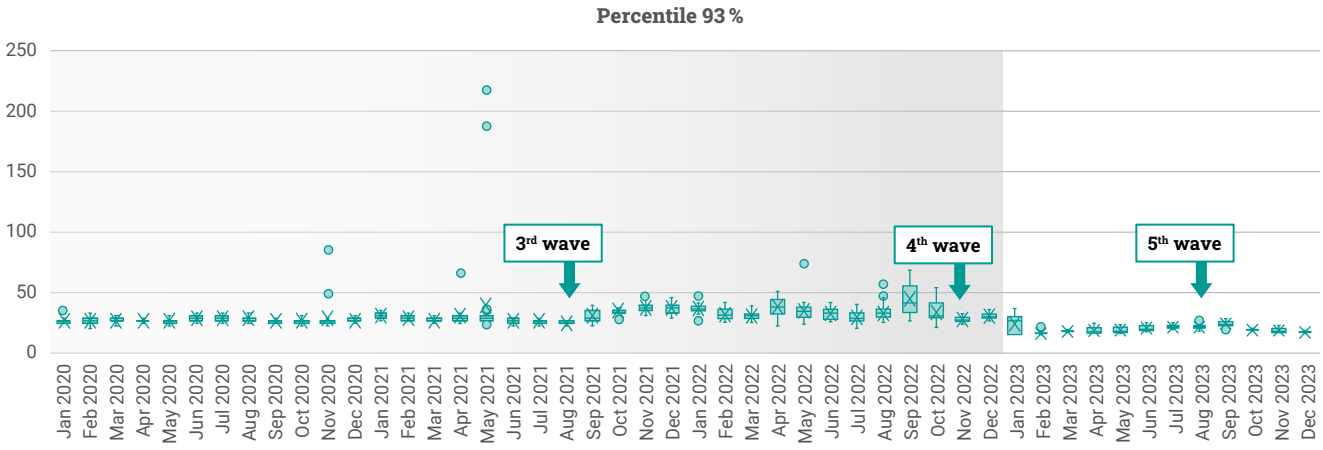


Figure 42

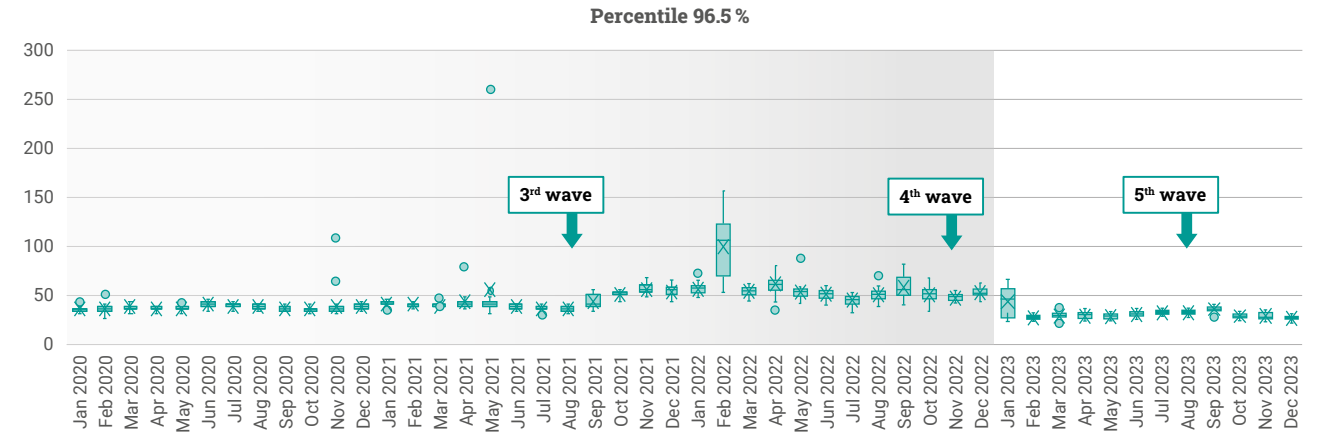


Figure 43

Rate of executed orders (number per day)[3]

Steady increase in the number of executed orders and trades through 2023.

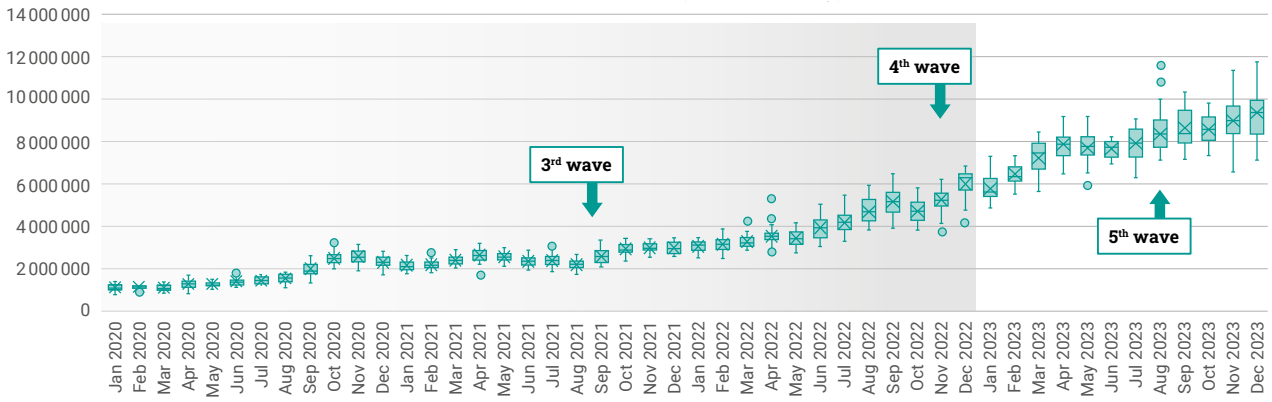


Figure 44

Rate of executed trades (number per day)[3]

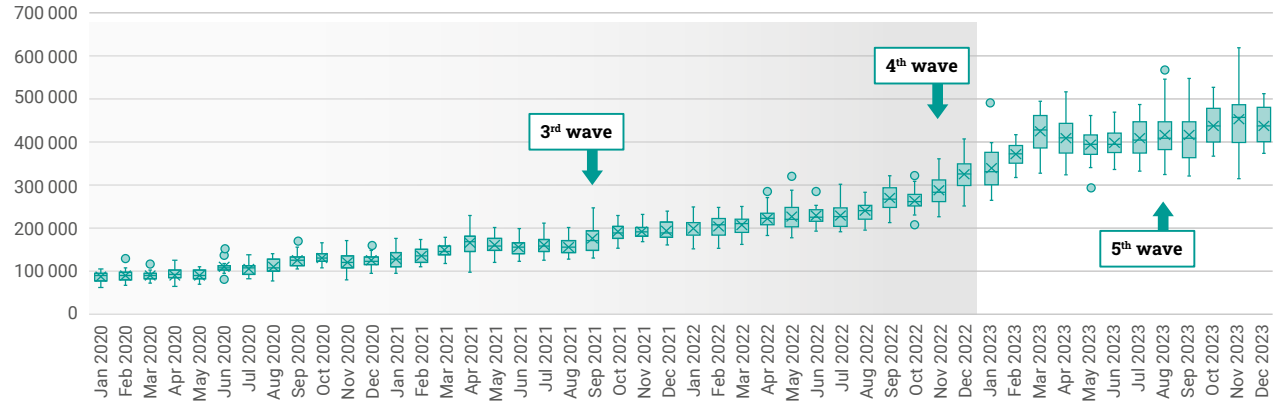


Figure 45

Time for generation of post coupling files (millisec)[3]

Time for generation of post coupling files is stable despite increase in number of orders and trades.

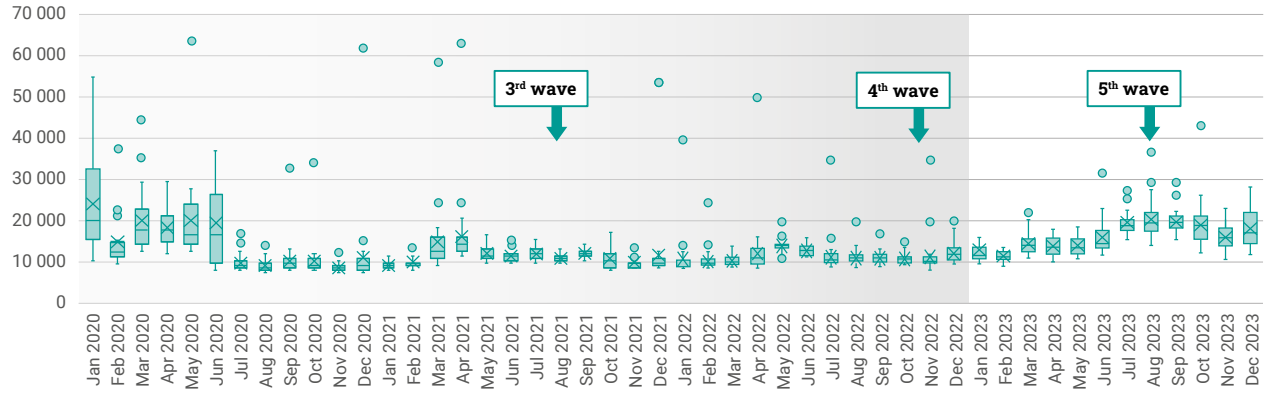


Figure 46

Output indicators

Table 15

Output		2020 Avg	2021 Avg		2022 Avg	2023 Avg	2023 Min	2023 Max
Indicators on the maximisation of economic surplus (Annex 4 of AM Article 11)								
Number of matched orders of each contract	Total matched volume (MWh) – daily value (MWh)*	224 956	256 134		302 681	456 028	302 343	812 658
	Total matched volumes – hours to delivery (MWh)	See separate graph						
	Total number of trades per contracts**	Not available	1 468		1 834	2 808	1	29 758
	Total number of trades per contract – hours to delivery***		1 952 423		3 640 941	6 173 413	2 561	79 751 844
Number of explicit capacity allocation	Total number of daily explicit capacity allocations	5 209	5 335		6 762	6 145	5 086	9 840
Prices	Volume-Weighted Average Intraday Prices (€/MWh)	Hour	29.23	97.43	218.19	94.58	-345.99	978.43
		Half-hour	34.63	109.06	274.24	96.69	-1 000.81	1 268.51
		¼-hour	32.44	107.47	253.77	102.16	-705.36	2 863.66
		Block	25.23	71.61	138.13	78.10	-999	622.21
	Volume-Weighted Average Intraday Prices – last trading hour (€/MWh)	Hour	32.00	97.27	213.70	94.08	-1 140.75	2 426.80
		Half-hour	33.74	133.90	263.28	98.56	-407.56	2 527.38
		¼-hour	31.58	107.75	251.92	100.72	-1 000.13	4 383.33
		Block	23.67	72.54	141.36	71.19	-40.00	220.00
	Bid-Ask Spread (€/MWh)	Hour	24.30	80.63	124.16	49.18	0.01	10 151.51
		Half-hour	123.11	115.85	174.58	65.71	0.82	10 001.12
		¼-hour	38.98	118.59	272.19	115.69	0.01	8 132.49
		Block	204.61	436.02	243.10	607.96	-1.11	19.998

* Total matched volume is in the table shown as a daily value – average traded volume in MWh per day and the min and max volume in MWh traded in one day.
** Data available since 1 May 2021. Shows how many times each contract has been traded on average, min and max.
*** Data available since 1 May 2021. Shows total number of trades 0-33 hours before delivery. Avg is average number of contract traded per hour to delivery. Max is number of trades in the hour one hour before delivery. Min value in the hour 33 before delivery.

Total volume matched hours before delivery

Total matched volumes – hours to delivery – this indicator counts the traded volumes, grouped per contract with same "delivery time start-end", per combination of Bidding Zones and grouped according to the hours left to delivery and aggregated per month.

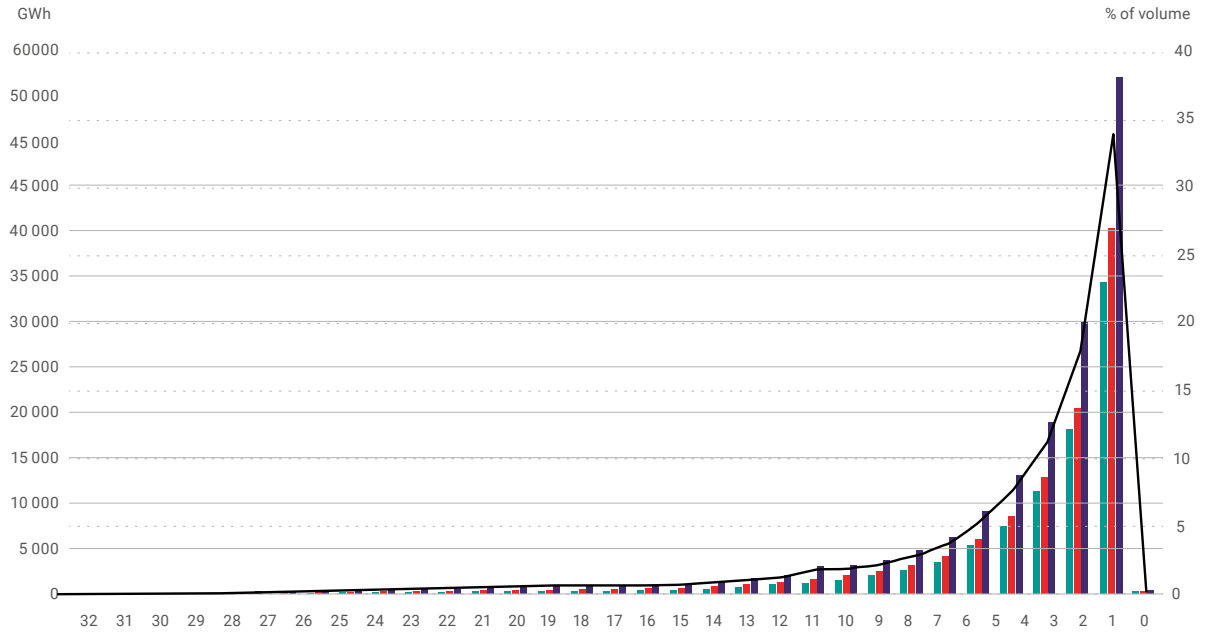


Figure 47

ATC utilisation rate per border – both directions

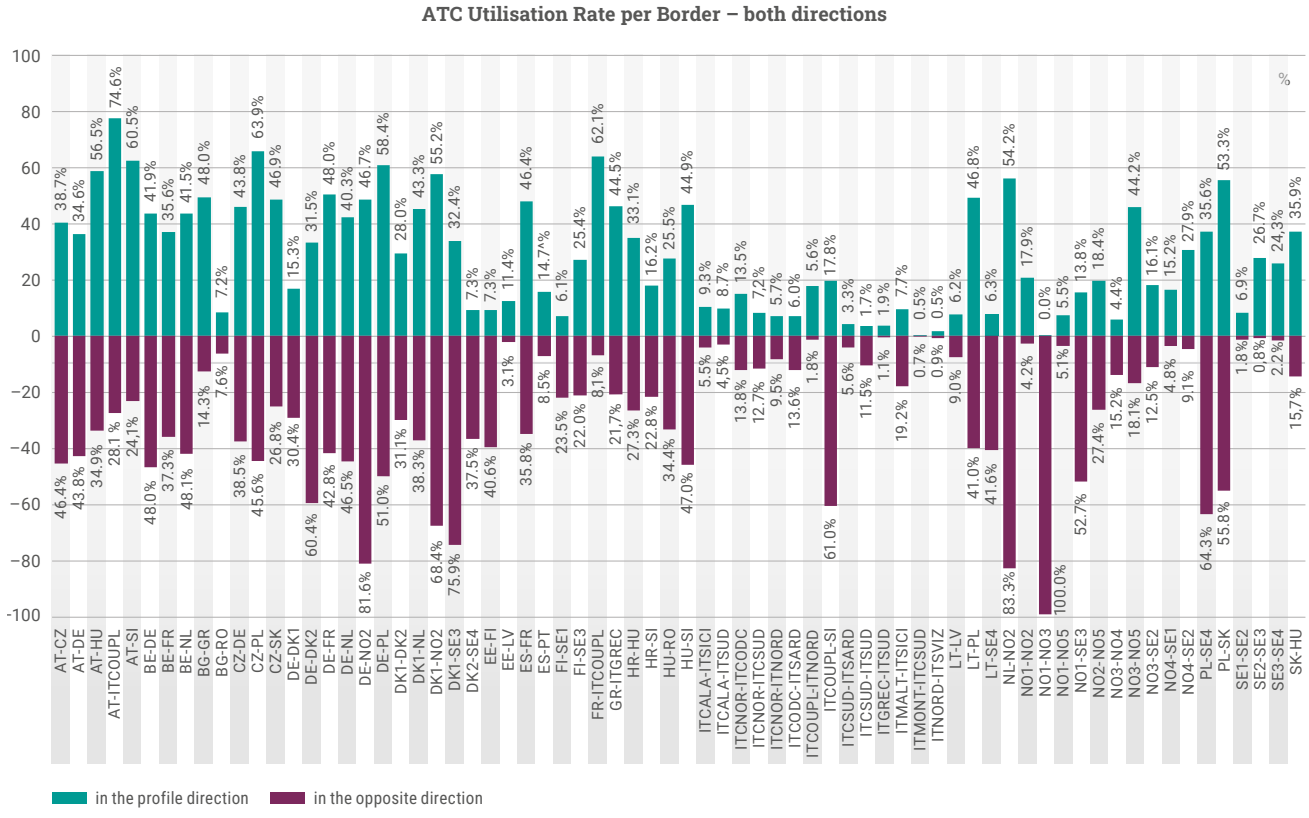


Figure 48

Net position in GWh per bidding zone

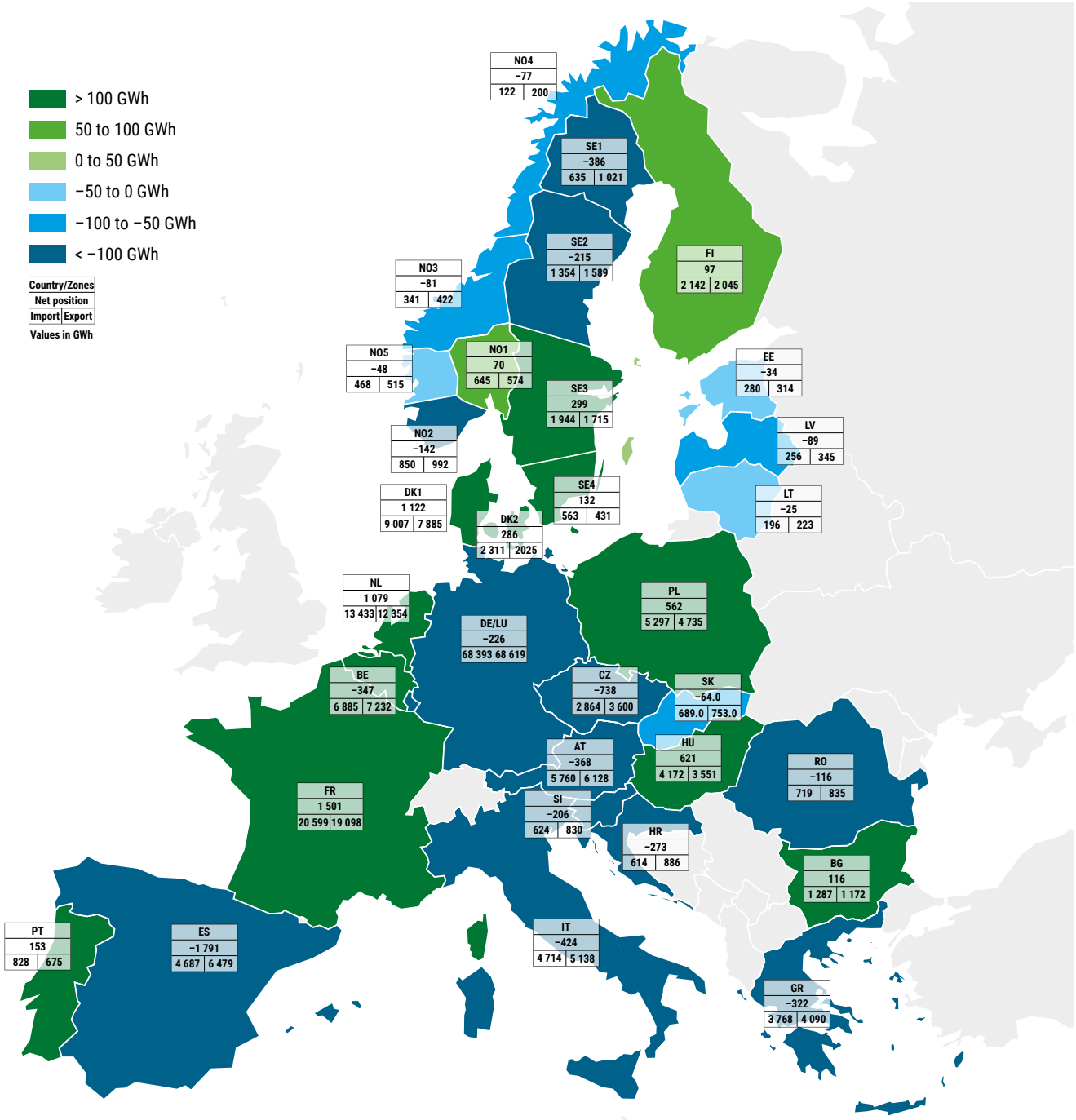


Figure 49

R&D report

2023 Outcomes

The R&D focus in 2023 was mainly on the principal functional extension of the SIDC functionalities, namely Intraday Auctions and Flow-Based Allocation.

Intraday Auctions (IDAs)

A selected implementation option of IDAs was further developed including substantial testing covering functional and non-functional testing such as performance, procedural, failover etc. The repetition of the conceptual tests of the key components and processes such as matching algorithm (Euphemia) or capacity allocation module of the continuous trading were executed. Initial solution for the partial (de)coupling process was completed and solution for go-live was agreed while the target solution was also agreed (subject of future implementation).

Performance improvements

The implementation and testing of the first package of performance improvements for continuous trading (RTS4 Slice A) was delivered in 2023. The implementation and testing of the second package of performance improvements for continuous trading (RTS4 Slice A) was done jointly with IDAs. Further performance improvements for providing optimised integration of continuous and auction trading (including impact on the NEMOs trading systems) in SIDC were analyzed in 2023 (RTS4 Slice B). These performance improvements will further increase contractually agreed system boundaries.

Flow-Based Allocation (FB)

Implementation of the initial so called Minimum Viable Product was completed and results were analyzed in detail. The analysis of the results led to the conclusion that the foreseen solution is leading to a very adverse impact on the performance of continuous trading. Therefore, SIDC agreed to execute analysis of further options in order to indicate potential options which would mitigate the adverse impact.

REMIT reporting

In 2023 optimisation and improvements in the central functionalities of REMIT reporting for continuous market were implemented.

Cross Product Matching

For the time being the next steps are on hold, following results of CPM Minimum Viable Product and NRAs recommendation.

Losses

As the main priority was focused on IDAs, Performance and FB, the losses were not further developed.

Major items in SIDC R&D programme

Budget/cost share per topic

The biggest investment of R&D is in IDAs and execution of the Minimum Viable Product of Flow-Based Allocation. There was also a substantial investment in the increase of the performance to extend the system boundaries so that constant increase in trading (both order transactions and trades) can be accommodated. The R&D mainly consist of 3 elements:

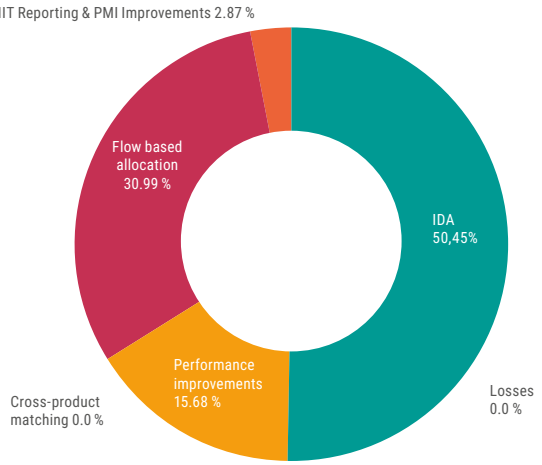


Figure 50

- Central cost of chairs and team leaders.
- Cost for drafting and testing activities – this is usually done evenly by the team members and therefore it is not reflected as central cost.
- Cost provided by 3rd parties (usually solution providers). This may cover implementation cost for final deliverables, analyses and cost for the prototypes usually focused on the limited functionalities with high impact on the performance.

Table 16

R&D topic	Description	Share of Cost	CACM compliance	Outcome and impact on CACM compliance	Future steps/Implementation in production (forecast)
IDA	Intraday Auctions – based on Commission regulation 2015/1222 of 24 July 2015 – Capacity allocation and congestion management – implementation of a methodology to price cross-zonal intraday capacity (Article 55)	50.45 %	Regulatory requirements implementation	Major development, performance and testing activities were executed in 2023 for all IDA assets used by (XBID, CIP, Euphemia, PMB).	Foreseen steps: – Finalisation of FIT/SIT testing-Trial Period with Market Participants-Go Live process-Implementation in production: Q2 2024
Losses	In line with Algorithm Methodology requirements the continuous trading matching algorithm shall allow to incorporate losses on interconnector(s) between bidding zones during capacity allocation, if requested by the owner(s) of the relevant interconnector after approval by the relevant NRAs.	0.00 %	Regulatory requirements implementation	High Level design adjustment proposed clarified (balancing account introduction)	Foreseen steps: – Considering performance impact of losses and SIDC priorities the losses in continuous allocation were put on hold-Losses possible consideration under IDAs is part of IDAs development
Cross-product matching (CPM)	Cross-product matching is required to be enabled between 15-minute and 60-minute products, between 30-minute and 60-minute products, and between 15-minute and 30-minute products and also for any combinations of the products	0.00 %	Regulatory requirements implementation.	1st part of the design completed, implementation is completed (minimum viable product), 2nd part of the design is completed. Preliminary indication of the degradation higher than factor 35, Overall implementation cost on both central and local SIDC level very high	Foreseen steps: – CPM implementation remains on hold
Performance improvements	The development of the market, a geographical extension and implementation of the new functionalities contributes to the grow of the system performance needs. The performance is constantly monitored and improved if needed.	15.68 %	Increase performance	The design, implementation and testing of the 2nd part of optimisation for (Asynchronous persister, ComTrader for Asynchronous persister, Routing key change, API clean-up). Clarification on the extension of service boundaries (20 million order transactions) .	Foreseen steps: – Validation of 2nd part (jointly with IDA validation) is completed – deployment into operation in line with roadmap-Clarification on the measures foreseen in the analysis of RTS 4 Slice B
FlowBased allocation (FB)	In line with Algorithm Methodology requirements the continuous trading matching algorithm shall allow for FlowBased allocation in order to introduce a method in which energy exchanges between bidding zones are limited by power transfer distribution factors and available margins on critical network elements.	30.99 %	Regulatory requirements implementation	Implementation of the prototype and evaluation of performance impact on continuous trading including discussion on the mitigation measures (the impact on continuous trading is adverse, sufficient mitigation measures not available for the time being)	Foreseen steps: – Discussion on further performance mitigation measures including impact analysis – Assessment on implementation feasibility-Re-assessment of implementation in production
REMIT Reporting & PMI Improvements	In line with the methodology, NEMOs provide market information to ACER so that ACER can monitor market behavior.	2.87 %	Regulatory requirements implementation	Major development including improvements requested by ACER implemented, tested and deployed in operation	Foreseen steps: – Minor improvements in line with the operational experience

Annexes

Annex 1: Parameters

SDAC parameters

Table 18

Indicator	Parameter	Description	Value	Purpose	Annex 3 of AM
	K	Number of months which define the recent historical set	3	Definition of recent historical set	Art. 2(a)
Scalability	X %	Minimum percentage of cases which have to comply with the scalability indicator threshold	1. 97 % of cases should be below Running time; 2. 100 % of cases should be below 180 % of running time.	• Monitoring purpose • RfC assessment for the past scenario • RfC assessment for the future scenario • Scalability assessment for the near future scenario • Scalability assessment for distant future scenario • Research and development	Art. 3(4) Art. 4(2)(a) Art. 4(2)(b) Art. 5(2)(a) Art. 5(2)(b) Art. 6(2)(a)
	y	Threshold for scalability indicator on the indicator values distribution	1. TBD accordingly for the SDAC Scalability Report	• Monitoring purpose • RfC assessment for the past scenario • RfC assessment for the future scenario • Scalability assessment for the near future scenario • Scalability assessment for distant future scenario • Research and development	Art. 3(4) Art. 4(2)(a) Art. 4(2)(b) Art. 5(2)(a) Art. 5(2)(b) Art. 6(2)(a)
	Z	Threshold for scalability indicator on the average value	∞	• Monitoring purpose • RfC assessment for the past scenario • Scalability assessment for the near future scenario • Scalability assessment for distant future scenario • Research and development	Art. 3(4) Art. 4(2)(a) Art. 5(2)(a) Art. 5(2)(b) Art. 6(2)(a)
Ability to maximise economic surplus	T	Time extension for first OK-solution calculation	10 min		Art. 7(2)
Repeatability	pi	Weight for the different component of the repeatability indicator	1	• Clearing prices • Products output	Art. 8

SIDC parameters

Table 19

Parameter	Value	Scope	Proposed Annex 4 of AM
K	12	Number of months which define the recent historical set	Art. 2(a)
t	n. a.[8]	Scalability threshold as defined in the service agreement with the service provider	
X %	n. a.[8]	Minimum percentage of cases which have to comply with the scalability indicator threshold	

Annex 2: Notes

[1] Incidents causes

"Unusual process" category involves any unattended procedures that may cause delays; "Interface issues" is related with mistakes in the format of offers/results; "System bug" involves problems with common systems; "Configuration" is related with topological configuration; "Human error" is related with incidents caused by an external party (e.g. market participant); "Other" involves any other cause. Incidents not related to MCO assets are classified in three different categories: "Non-MCO: local trading", "Non-MCO: transmission of capacity" and "Non-MCO: Other".

[2] Requests for change

"Geographical extension" category involves any RfC, including in the SDAC new MSs; "Network topology" category involves any RfC modifying the topology of the existing MSs (for example by splitting existing BZs, removing BZs, adding or eliminating cables); "Flow based" category involves any RfC introducing or modifying the flow based methodology in one or more BZs; "MNA implementation" category involves any RfC introducing MNA in one or more BZs; "product extension" category involves any RfC extending the usage of existing products in further BZs; "System release" category involves any RfC introducing the usage of a new version of one or more MCO system; "other" category involves any RfC not included in the previous categories, among which especially related to procedural changes. When a single RfC impacts more than one category among those reported in the graphs, they are conventionally counted for the number of categories impacted. Typical is the example of the "Geographical extension" RfCs, which, by definition, impact also product extension to different BZs. Note that the Non-notifiable changes are not included in the list provided. These changes do not directly affect the MCO function assets, and not cause a detriment to the performance of the relevant algorithm and not relevant to market participants.

[3] Box plot

The monthly trend of the indicators is reported through "box and whisker" chart (or box plot). The chart shows the distribution of data into quartiles, highlighting the median, mean and outliers. The boxes have lines extending vertically called "whiskers" which indicate variability outside the upper and lower quartiles, and any point outside those lines or whiskers is considered an outlier. The reported charts show the mean markers (X symbol) and the quartile calculation uses the exclusive median method (i.e. The median is excluded from the calculation if the number of values in the data is odd).

[4] Performance indicators

1) Ability to maximise the welfare indicator:

The first indicator illustrates the economic improvements realised in production, from the first valid solution found (corresponding to the TTFS solution) and the finally chosen solution. The second indicator shows foregone economic surplus improvements, identifying the incremental welfare which would have derived from prolonging calculation time by 10 minutes after the maximum allowed time (currently 17 minutes). These latter results were obtained re-running the sessions on a simulation environment.

For individual sessions the economic surplus gain after increasing allowed calculation time by 10 minutes can be negative, i.e. a decrease. This is evidenced by the reported minimum values (-0.003643 %), as well as the plot with differences, which has a tail with some negative values. Such effects may stem from differences between the production and simulation machine, lack of reproducibility or different paths followed when exploring the branch & bound tree.

2) Repeatability indicator:

A session is repeatable if Euphemia returns, for each iteration, the same value for all the relevant variables in both runs when comparing solutions with the same solution id. Potential differences are calculated using the same inputs, configuration of hardware and software and at the end comparing the last common solutions in both runs. Comparison is made on

the latest common solution over two consecutive runs of production input data in a production like machine. The machine used for the study fulfils the minimum requirements set for machines used in production. Comparisons are done considering 6 decimal places precision (1e-6 tolerance).

One indicator measures what is the proportion of the values equal with respect to the total number of indicators, the other indicator measures the average impact on the relevant results when differences exist. Since Euphemia 10.4, there exist the possibility of activating a parameter named "deterministic time" that allows to use an internal clock that can be used to assure that the decisions are taken in the same time sequence in two consecutive runs on the same input data on the same machine. For 2023 repeatability study, it was run using E11.2 and time limit as a stopping criterion. The same input data has been run with and without the "deterministic time" parameter activated, but only the case without the parameter activated has been plotted because when using "deterministic time" activated the results were able to obtain the same relevant results in all cases.

[5] Ability to maximise the welfare indicator

The indicator on foregone welfare due to limiting calculation shows for some sessions the economic surplus decreases with the time extensions. This effect reflects, among others, the non full repeatability of the SDAC Algorithm when the parameter "deterministic time" is not activated, the usage of newer machines in production that outperform the testing production-like machine used in the ex-post calculations and the differences that might exist in the algorithm versions used for the extended time calculation (the newest version of the algorithm used in the historical data is used for the extended time calculation).

[6] Individual impact of products

Usage of default and special configurations. All the scenarios, except for the one in which piecewise curves are converted in stepwise curves, are calculated using default configuration (the one used in production). For the scenario in which piecewise curves are converted in stepwise curves, different internal parameters have been used, as suggested by the algorithm provider (these are different than the default configuration). This approach is the same as was followed for previous year 2022. For 2023 Q4 data it has been observed again that the special configuration used in previous years only provided a significant improvement in just one of the scenarios. The other ones delivered similar or better performance when default configuration was in use.

[7] Scalability report

1) **Indicator.** This indicator for SDAC applies the standard scalability indicator (TTFS) and relative thresholds currently applied to approve RfCs to future scenarios (the near future scenario representing Y+1, and distant future scenario representing Y+3), which includes anticipated growth of historical usages and anticipated Requests for Changes. All simulations are calculated using the latest available version of the SDAC algorithm (Euphemia 11.2), which means that by construction this indicator under-estimates the future level of scalability, as it cannot consider the expected impact of the future releases of the SDAC algorithm which will be used in production in Y+1 and Y+3. Furthermore, it may be impossible to model the impact of some RfCs, whenever they request new releases of the algorithm or network data not already modelled at the time of the simulation. Note that functional RfCs cannot be included in scalability studies as they require new functionalities to be implemented in the algorithm. Anticipated usage of operational RfCs that are included in the scalability scenarios are either directly included or emulated when the RfCs are requesting new algorithm requirements not available yet.

2) **PUN orders** were discarded from the Y+3 scenario with 15' MTU implementation and replaced by demand merit orders. This skewed the usage statistics, as it hugely increases the number of demand orders in this scenario.

[8] SIDC

Technical operation of SIDC is fully regulated by the Master Service Agreement (MSA) between NEMOs and the XBID system vendor. MSA's contractual arrangements stipulate that the vendor is the sole party having access to the XBID technical components as e. g. XBID databases. Hence, the data which are included in this report are mainly based on the technical regular reports provided by vendor to SIDC parties. This also implies that all requests on the extension of the reporting obligation (including the existing reporting obligations which are not implemented yet), and which require extension of XBID source data provided by the vendor, are subject to the change management process and release management process stipulated with the vendor.

It shall be also noted that the MSA sets out principles of confidentiality which, among others, apply to the provisions of the Service Level Agreement regulating e. g. availability and performance of the XBID system. Based on the confidentially principles, the details may be, and are, shared with SIDC stakeholders (NRAs, ACER, EC) but cannot be revealed to the general public and therefore they are not integrated within this report. Note that NRAs have full access to the MSA.

[9] SIDC Performance indicators & Performance monitoring

The evaluation of the performance indicators is carried out in SIDC on a monthly basis in line with the processes stipulated in the MSA. As a basis for the evaluation of the performance the Service Level Agreement (SLA) applies. The SLA represents contractually agreed parameters and in combination with agreed system boundaries it defines the performance of SIDC guaranteed by the vendor. The technical thresholds of SIDC are not defined (known) though it is assumed that they are well above the SLAs (which is also proven by the scalability report). Every month the vendor provides an evaluation of the performance indicators, based on the production data, in the form of a performance report. SIDC parties review the performance report and provide the vendor with anticipated changes of the processed data, as e. g. changes/growth in the number of implicit and explicit orders. The vendor analyses the provided data and in case the analysis indicates a risk or need of the optimisation measures the vendor provides proposals for the SIDC Solution improvements which are jointly discussed.

[10] Order Transition

Means Order entry (including activation of new iceberg slice), Order modification (including Order activation and deactivation) and Order deletion (excluding Order deletions due to contract expiration); partial matches as well as full Order executions are not to be considered as Order Transaction.

Disclaimer

The data source of this report has been provided by SDAC and SIDC respectively.

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Design:
DreiDreizehn GmbH, Berlin
www.313.de

Publishing date:
1 July 2024

For questions, comments or clarifications:
secretariat@nemo-committee.eu

ALL NEMO COMMITTEE

in coordination with entsoe