CACM Annual Report 2022

ALL NEMO COMMITTEE

in coordination with entsoe

ALL

COMMITTEE

CACM
Annual Report 2022

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Letter to stakeholders

Dear Stakeholders, NRAs, ACER and Commission,

Energy crises, emergency measures, war and inflation were at the centre of every debate in 2022 and so was the role of the European internal electricity market.

The invasion of Ukraine prompted the current energy crisis and highlighted the need to quickly adapt the electricity market to better support the green transition and offer energy consumers access to affordable renewable and non-fossil electricity.

In light of all this, ACER was tasked with analysing the situation and in April 2022, published its Final Assessment of the EU Wholesale Electricity Market Design in which it concluded that "while the current circumstances impacting the EU's energy system are far from 'normal', ACER finds that the current electricity market design is not to blame for the current crisis. On the contrary, the market rules in place have to some extent helped mitigate the current crisis, thus avoiding electricity curtailment or even blackouts in certain quarters."

2022 brought more questions than answers and policy makers and politicians faced the challenge of looking for measures and finding a solution, with the clear understanding that one size does not fit all. Emergency measures were adopted at national levels within a pan-European framework, set out in the RePower EU Plan. Now sights are set on the Electricity Market Design reform (EMD) launched by the European Commission with the aim of building a future-proof regulatory framework.

This reform process has not only helped to re-assess the current electricity market model. It has also assisted acknowledgment of the achievements of 25 years of successful electricity market integration led by NEMOs and TSOs, providing security of supply, driving decarbonisation and achieving affordable and competitive prices.

The NEMO Committee welcomes the fact that the EMD maintains the fundamentals of well-functioning short- and long-term markets, further incentivising the deployment of flexibility, bringing markets closer to real time and improving consumers' rights and engagement. Furthermore, Recital 7 of the European Commission's proposal indicates that "short-term markets and the pricing mechanism based on marginal pricing should be preserved, as they function well and provide the right price signals. Short-term (day-ahead and intraday) markets are well-developed, and they are the result of years of implementation of EU energy legislation".

However, we are concerned that certain proposed amendments replacing the existing operational solution for the management of the Market Coupling by a Legal Single Entity might seriously alter parts of the existing short-term markets with significant negative consequences on the functioning of SDAC and SIDC and could be detrimental to market efficiency and its ability to incentivise decarbonisation at least cost. The NEMO Committee would like to encourage lawmakers (Member States and the European Parliament) to carefully assess these proposals and to ensure that the EMD is not perceived as a drawback to the functioning of short-term markets, the liquidity of long-term markets and the deployment of flexibility assets.

In the meantime, NEMOs have continued with their commitment to safeguard the operation of the day-ahead and intraday markets and to successfully run the internal electricity market together with TSOs, as established in the European Regulations.

In addition to this, NEMOs and TSOs have demonstrably gone beyond advocacy and have i) voluntarily implemented improvements in the joint governance body for SDAC and SIDC (Market Coupling Steering Committee – MCSC), with the Joint Qualified Majority vote to speed up decision making and avoid escalation to authorities; ii) created with stakeholders the Market Coupling Consultative Group (MCCG) with the objective of enhancing relations between NEMOs, TSOs and stakeholders and consulted market participants on issues related to the design, development, implementation and operation of SDAC and SIDC.

NEMOs have also addressed the price spikes that occurred in May and August 2022; by organising a public consultation and submitting to ACER in September 2022 a proposal for revision of the Harmonised Maximum and Minimum Clearing Price (HMMCP) methodologies. The general aim of the proposal was to reach a balanced approach between three main requirements: a) making the triggering of price limit increases less sensitive to occasional and non-structural events. b) minimising the risk that the price limit set forth in the methodology becomes a "price-cap" limiting price formation and c) ensuring maximum transparency and ease of implementation of the new rule, with the goal of promoting reliable operation of day-ahead and intraday market coupling activities by NEMOs, TSOs and market participants.

After public consultation with interested stakeholders, assessment and adaptation, ACER published the new methodology in January 2023 (ACER decision 01/2023 and 02/2023).

The past year was also of paramount importance because of the completion of the European SDAC and SIDC markets, Europe has become the only integrated continental power market worldwide. In June 2022, the Flow-Based Market Coupling was launched in the Core region, thus enhancing energy transition. Simultaneously, the Multi NEMO Arrangement on the Northern Italian borders went live marking another milestone in the completion of EU Market Coupling. Finally, in November 2022 the integration of Greece and Slovakia into the SIDC meant that a single integrated European intraday market is now entirely complete.

The NEMO Committee is proud of these achievements and improvements, despite the difficult times and is ready for the new challenges and opportunities beyond the European Union that will be brought up with the implementation of the European Electricity market rules in the Energy Community (EnC) countries. These will further enhance energy cooperation between the EU, the western Balkans and the three eastern partners – Ukraine, Moldova, and Georgia.

We need to support expansion of the EU market coupling model beyond the European Union and help our neighbours to achieve a robust and affordable electricity market across the continent. But we will not be able to do so if, in the midst of the implementation process by EnC countries, unnecessary changes with significant practical consequences are introduced first in the EU legislation and then, as a consequence, in the "acquis communautaire" that these countries are aiming to adopt into their national legislations by the end of 2023.

The NEMO Committee offers its expertise and collaboration to the European Commission, ACER, the regulatory authorities, EnC and stakeholders to assess and respond to the questions and challenges posed by the EMD and the future integration of new countries into SDAC and SIDC.

Please, allow me to conclude by congratulating both NEMOs and TSOs on their hard work and commitment to successfully continuing to develop and run this one-of-a-kind European internal electricity market. More than 25 years after the liberalisation of the electricity sector, it has proved that market coupling is the best way to optimise the use of cross-border capacities and that decentralisation, together with strong cooperation, are necessary pillars to build a resilient and reliable energy system.

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 17 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.

NEMO Committee Activities

Reporting

Publication of CACM Cost Report 2021, CACM Annual Report 2021

Communication

A free, live seminar about the CACM Annual Report 2021 was held in cooperation with ENTSO-E on 28 September 2022.

NEMO representation

Preparation and representation of NEMO positions in public and institutional fora (including among others the Florence Forum, MESC, the newly-established Market Coupling Consultative Group (MCCG), the Pentalateral Coordination Group together with European Commission, ACER, NRAs, TSOs and NEMOs and MCO review meetings with ACER).

Methodologies

In September 2022 NEMOs submitted to ACER proposals for revision of the harmonised maximum and minimum clearing price methodologies for SDAC and SIDC.

- **Continuous trading matching algorithm:** an update to the public description of the continuous trading matching algorithm was published on 17 November 2022 pursuant to the Algorithm methodology.
- **Common set of requirements for the price coupling algorithm** reporting the status of implementation and the expected implementation deadlines (publication based on ACER Decision on Algorithm methodology Annex II)
- **Common set of requirements for the continuous trading matching algorithm** and the intraday auction algorithm reporting the status of implementation (publication based on ACER Decision on Algorithm methodology Annex II)
- **Public report on the Requests for Change decisions in SDAC** published in accordance with art. 19.11 of Annex I to the ACER Decision on Algorithm methodology

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

Figure 01

Consultations

- Public consultation on SIDC products opened in January 2022 and closed in February 2022
- Public consultation on Harmonised maximum and minimum clearing prices for SDAC and for SIDC, opened in May 2022 and closed in July 2022

Replied to:

- ENTSO-E's Consultation of the Cross-zonal Capacity Allocation Harmonised Methodology and Explanatory Document pursuant to the Art. 38(3) of EB Regulation
- European Commission's Consultation on the revision of the Capacity Allocation and Congestion Management Regulation
- ENTSO-E's consultation on Network Code on Cybersecurity
- Annex 3 of ACER's recommendation n. 02/2021 (Initial impact assessment on the market coupling organisation as part of its Recommendation to the EC on the revision of the CACM regulation)

Proposals

A proposal for amendments to the Harmonised maximum and minimum clearing prices for SDAC and SIDC. As a result, ACER opened public consultation

Governance

Establishment of MCSC Governance and NEMO Governance Task Forces

Further Tasks

- Response to the European Commission's public consultation on the reform of the EU's electricity market design.
- **IDA:** NEMOs in collaboration with all TSOs are progressing 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.

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 on All NEMO Committee website here.

Creation of the Market Coupling Consultative Group (MCCG)

In the Market Coupling Steering Committee of February 2022, where the implementation of the new governance was announced, all NEMOs and TSOs decided of creation of a Consultative Group with stakeholders. The main objectives of the newly established Market Coupling Consultative Group (MCCG) are:

- To consult market participants on issues related to the design, development, implementation and operation of SDAC and SIDC;
- To facilitate the exchange of views and information among NEMOs, TSOs and market participants;
- To support the preparation of certain topics to be addressed in the MESC.

The MCCG is open to everyone, the active members are the MCCG co-convenors, market participants (EFET, Eurelectric, IFIEC, etc.), relevant conveners or experts from NEMOs and TSOs actively contributing, individual market participants, representatives of individual NEMOs and TSOs.

MCCG is first and foremost a forum aiming at reaching a better common understanding between market participants, and NEMOs and TSOs. It has no decision-making power related to operation or implementation, which is a role belonging to the MCSC. The outcome of MCCG discussions will be duly considered by the MCSC. The MCCG can facilitate reaching aligned positioning that could be presented jointly to e.g. MESC. The MCCG is convened by three moderators from NEMOs, TSOs, and stakeholders.

During the first MCCG held on 7 June 2022, different topics were presented and discussed among NEMO and TSO experts and the stakeholders, namely the Cross Product Matching, the Intraday auctions, 15 minute MTU in SDAC (timeline and implementation organisation, product granularity, etc.), and the Non Uniform Pricing concept. The questions and answers, as well as the support material remain available on the NEMO Committee and ENSTO-E website.

The MCCG convened online for the second time on 1 December 2022. In two separate sessions representatives of NEMOs, TSOs, and stakeholders discussed topics related to the MCO organisation, design, development, implementation, and operation of SDAC and SIDC such as non-uniform pricing (NUP), implementation of 15-min MTU, IDA implementation, curtailment management in EUPHEMIA algorithm among others. In addition, an update was provided on the on-going process of Harmonised Maximum and Minimum Prices Methodologies review.

The intention is to organise the similar meetings twice a year. The next meeting is planned in early summer 2023.

ENTSO-E

Enabling the European energy transition through:

- European long term grid planning
- European security analysis
- Technical/market rules
- European platforms
- Standardisation & research
- Regional cooperation

Figure 02

Executive summary

Single Day-Ahead Coupling

High level market data

The SDAC covered a large proportion of the EU, including 27 Countries. Its traded volumes slightly reduced to 1683 TWh (–2 %) with clearing prices heavily increasing with respect to the previous years, resulting higher than 240 €/MWh for most of the countries, with the exception of a few bidding zones in Nordic Countries, which show annual average prices ranging from 25 and 150 €/MWh.

Operations report

In 2022, the SDAC operations continued to show great reliability and experienced a decrease in the number of incidents with respect to the past year, 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 May 2022. The incident was also due to a local IT issue. Many RfCs of increasing complexity went live: among the others, we registered CORE FB, including Day-Ahead Market Coupling on Croatian – Hungarian border, and the MNA extension on Italian Northen border. 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 2020 (+5 %), an the usage of FB-PTDF constrains shows a huge increase (+42 %) due to the implementation of CORE FB in June 2022. The Time To First Solution (TTFS) remains, on average, well below the 17 minutes allowed for algorithm running, equal to 2.6 minutes. Optimality and Repeatability continued to perform well, maintaining the trend from 2018 to 2021. The individual impact of products study indicates that no product on its own seems to have a disproportionate key impact on performance.

Scalability report

The Scalability report shows only limited indication of performance issues prior to the introduction of the 15 minute MTU implementation, but after its introduction the situation can be expected to become more tense, even after accounting for a phase out of PUN merit orders and replacing MIC and Load Gradient orders by Scalable MIC and Load Gradient Orders. Euphemia manages to find solutions for most sessions (87/91), but not always within a reasonable time. R&D activities have continued and will continue throughout and beyond 2023. Combined with improvements in hardware and allocating more time to the algorithm we are increasingly confident we can manage 15 minute MTU by 1 Jan 2025.

R&D report

From 2020 to 2022, an important effort has been dedicated to prepare the implementation of 15 min MTU in SDAC. The go-live is foreseen in January 2025 via a „big bang" implementation, i.e. simultaneously in all SDAC bidding zones. Functionally, Euphemia is being ready for the 15 min MTU granularity. The multiannual work on the increase of algorithm´s scalability has been quite accomplished with the last improvements date to Q1/2023. Together with the hardware reinforcement (distributed architecture) and the foreseen extension of the computation time limit, the improvements in heuristics shall guarantee a sufficient performance and robustness to handle the 15 min MTU. Several other topics were also explored in Euphemia Lab, among them Non-Uniform Pricing, Offshore wind.

Single Intraday Coupling

High level market data

In 2022 we see a significant growth increase in the continuous market. The year of 2022 follows after previous three years with steady increase in annual market volumes since the market go live in 2018. The size of the coupled market in 2022 grew to 110.48 TWh traded – representing almost 89 million trades. Annual mean price per bidding-zone ranged from 41.00 €/MWh to 328.09 €/MWh. Price levels significantly higher compared to 2020 and 2021.

Operations report

Altogether 15 RfCs were implemented in 2022. Out of these, 9 were related to update of requirements set on various interconnectors as requested by TSOs. In July the Hungary-Slovenia borders was integrated, and in October 15 min MTUs were implemented between Romania and Bulgaria. No previous year have had fewer incidents, and only one incident of severity 1 leading to 46 min halt in trading.

Performance Monitoring report

With significant increase in activity, number of orders and trades; the performance of the system has remained stable throughout 2022. The 4th wave of the SIDC geographical extension has increased the SIDC topology by 2 market areas, borders and interconnectors withou any impact on the performance indicators. The 'total matched – hours to delivery' indicator shows that more than 75 % of the volumes daily traded are exchanged starting from the fourth hour prior to delivery.

Scalability report

Due to constant increase in the trading activity; time for execution of an order for 2022 grew compared to 2021, but is still faster roughly by 25 percent in comparison to the previous years. The year 2022 was focused on implementation and testing of new performance optimisation measures which allows SIDC to comply with constantly increasing performance requirements. The performance optimisation measures will be deployed in the operation at the beginning of 2023. The impact analysis intends, among others, to validate a possiblility of the extension of the number of processed transaction orders in order to ensure sufficient scalability for the outlook of the next 3 years.

R&D report

The R&D focus in 2022 was mainly on the principal functional extension of the SIDC functionalities, namely Intraday Auctions and Flow-Based Allocation. Also a key priority in 2022 has been the implementation and testing of the performance improvements for continuous trading.

Single Day-Ahead Coupling

SDAC main features

NEMO requirements

- Block products (simple, linked, exclusive, flexible MTU)
- PUN & merit orders
- MIC and load gradient orders
- Aggregated MTUs orders (curves)

TSO requirements

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

CACM requirements

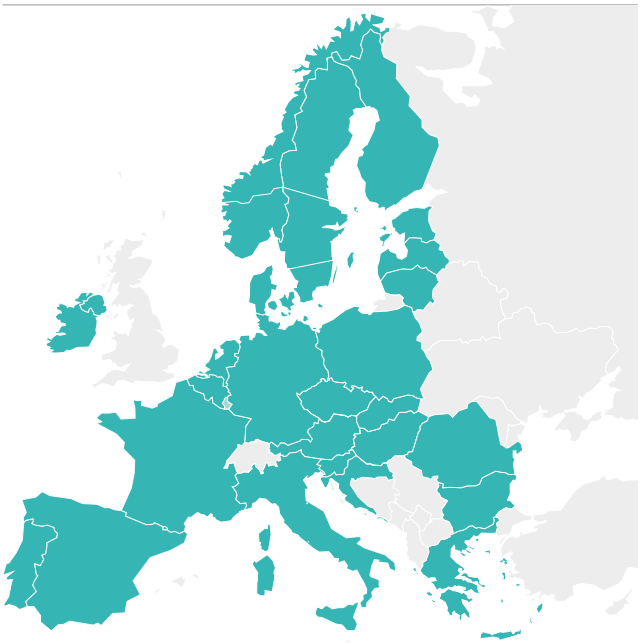
- Adequate optimality
- Adequate scalability
- Adequate repeatability
- MNA
- MTU: 60 min

Systems release(s)

- Improved releases of Euphemia 10.6 & PMB 11.2
  - › Anonymised Market Data Aggregation
  - › Improvements in external constraint and its shadow price calculation
  - › Improvements in LTA and PTDF domain usage.
  - › Improvement in local search heuristics.
  - › Cybersecurity: Correction of external library Log4j2 vulnerability fix.
- PMB 11.3 technological upgrade from 11 October 2022
- PMB 12.0 and Euphemia 11.1 implemented from 23 March 2023

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

SDAC members (non-operational)

Figure 03

High level market data

In 2022, the SDAC covered most of the EU, and, since from 18 June 2022, with the successful go-live of the CORE Flow Based, the 4MMC countries' day ahead market are fully integrated in the Pan-European day-ahead power market.

The "topology" of the coupling included 27 Countries, 62 bidding zones, 30 TSOs and 16 NEMOs, with inclusion of Croatian – Hungarian Market Coupling with respect to the previous year.

- The «economic dimension» of the coupling, decreased slightly (-2 %) from 1 718 TWh, in 2021 to 1 683 TWh in 2022. The welfare managed by the algorithm was, on average, around 9.9B€ per session.
- The clearing prices increased significantly compared to the previous years. With the exception of a few bidding zones in Nordic Countries — with an annual average price between 25 and 150 €/MWh — the average prices converge of all the other countries results greater than 240 €/MWh. Hourly prices ranged between -222.36 and 4 000 €/MWh.
- On delivery day 4 April prices of 2 712.99 and 2 987.78 EUR/MWh in France, in the hours 8 and 9, led to increase of the harmonised maximum clearing price from +3000 EUR/MWh to +4,000 EUR/MWh in line with the Harmonised Maximum and Minimum Clearing Prices (HMMCP) Methodology. The Max price was increased from delivery day 11 May 2022.

Price indexes are computed excluding hourly prices in 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.

Traded volumes (TWh)

Table 01

Annual	Daily average	Daily minimum	Daily maximum
1 683.30	4.62	3.70	5.50

Clearing prices – annual mean (€/MWh)

Table 02

Hourly minimum	Hourly maximum
– 222.36	4 000

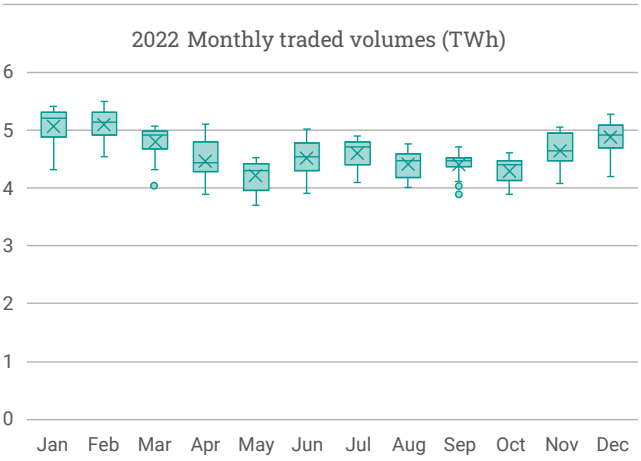


Figure 04

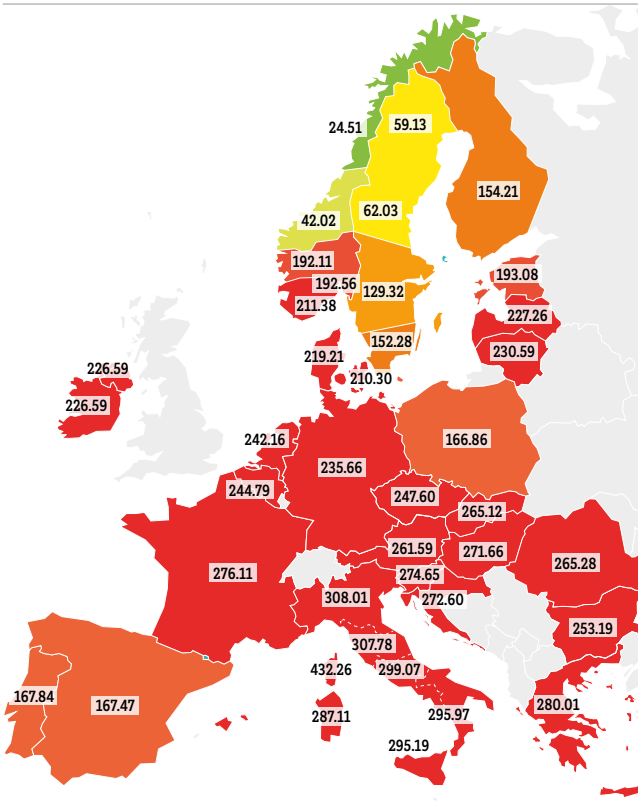


Figure 05

Operations report

In this section, 2019–2022 SDAC operational events are reported, including: the incidents, requests for changes and corrective measures.

"During 2022:
– product extensions and MNA extension went live
– a decoupling event occurred, due to local issues."

Incidents

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

The incidents in 2022, despite the exceptional context experienced in the energy system, experienced a decrease with respect to the past year, mainly concentrated on cases of low relevance.

- As regards severity, the most critical incident in SDAC was the one that lead to a partial decoupling, which occurred on 10/05/22. The incident was not caused by the SDAC algorithm or procedures, which performed as expected, but by an internal IT issue at OKTE (more details are provided in dedicated paragraph on Decoupling incident 10 May 2022).
- The majority of the incidents were visible to market participants but just in two cases out of 32, the message of risk of decoupling was sent (representing only a share of 6%).
- The totality of the incidents fell in the category "Non-MCO", mainly related to technical issues belonging to NEMO local trading. In particular, a local issue at the beginning of February 2022 lead to the restart of a PMB and to the late order book of the NEMO involved. Thanks to the presence of different, well working PMBs, this incident didn't cause any issue to the MCO level, and the market run properly.

Requests for change (RfC)

RfCs 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 2022, in particular: the product extensions on 01/03, 16/3 and 13/09/2022 and the MNA extension on Italian Northern border on 08/06/2021. The CORE FB, including Day-Ahead Market Coupling on Croatian – Hungarian border, went live on 08/06/2022; in the same day also a timing change, in order to give more time for declaration of decoupling, was allowed. Finally, two system releases went live: Euphemia 10.6_fix 3 on 29/03/2022 and Euphemia 10.6_fix4 on 26/10/2022

- In the context of the high prices registered in the market, NEMOs and TSOs actively followed the evolution of the energy systems and reacted in order to preserve the market, in particular:

  - following the high prices reached on delivery day 4th April 2022 in France, in line with the in force HMMCP Methodology, the harmonised maximum clearing price for Single Day-Ahead Coupling (SDAC) was increased up to 4 000 EUR/MWh on 10/05/2022. After a consultation which lasted from May to July, in September 2022, all NEMOs submitted an amended version of the HMMP methodology to ACER. The new version of the methodology entered into force on January 2023.
  - In October 2022, the Euphemia 10.6_fix4 release went live, which allowed welfare improving solutions reducing the eventuality of price spikes.

Corrective measure (CM)

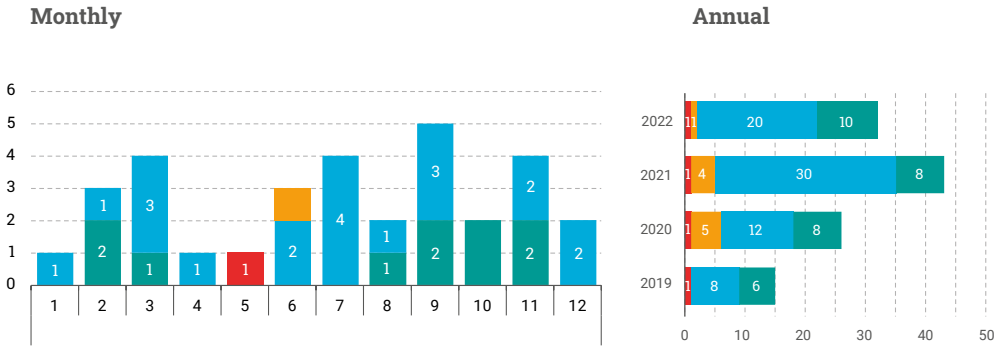
In 2022, no corrective measures were triggered.

Detailed operation report

More information can be found in the Excel-file reported in the nemo-committee website at the publications section.

Incidents

Severity



Severity 1
Incidents that lead to stopping ID trading

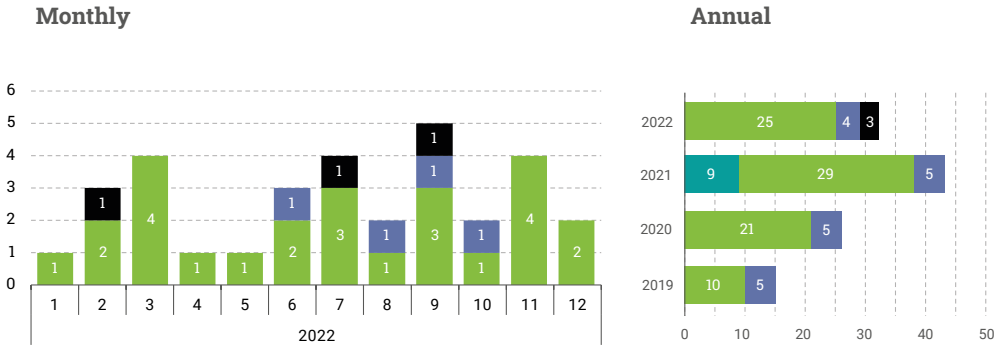
Severity 2
Incidents that lead to closing interconnector(s)/area(s)

Severity 3
Incidents that were visible to participants

Severity 4
Incidents that caused the breach of a critical deadline or any other major incident

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 10 May 2022

On Tuesday, May 10th, 2022, an incident took place in the Single Day-Ahead Market Coupling process that led to a partial decoupling of OKTE, affecting the day-ahead trades with delivery day Wednesday, May 11th in the Single Day-Ahead Coupling (SDAC). The partial decoupling of OKTE from SDAC was the consequence of OKTE's impossibility to provide their order book until the partial decoupling deadline (12:45). This resulted in decoupling the following six interconnectors: CZ-SK, SK-HU, DE_50Hz-PL, DE_50Hz-CZ, CZ-PL, SK-PL.

The day of the incident corresponds to the day that the maximum SDAC price was increased from 3 000 to 4 000 €/MWh, due to high prices reached in France on April 3rd. This change in maximum price was introduced in line with the Harmonised Min Max Price (HMMP) Methodology. The root cause was a wrong configuration in the OKTE Local Trading System for the new maximum price and that prevented OKTE from generating a correct order book. The problem was solved that very same day later in the afternoon.

The impacted borders were:

- Czech Republic – Slovakia
- Slovakia – Hungary
- Germany (50Hz) – Poland
- Germany (50Hz) – Czech Republic
- Czech Republic – Poland
- Slovakia – Poland

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 shortly before 14:00.

The local auction was successfully completed by OKTE around 13:20. 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

- Due to the complexity of the process and the large number of systems involved, also a small change (like a change in maximum price) in the common and local assets, even though thoroughly tested, could lead to local issues that finally prevented the global process to proceed and finish without problems.
- 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 08 June 2021.

Request for change (RfCs)[2]

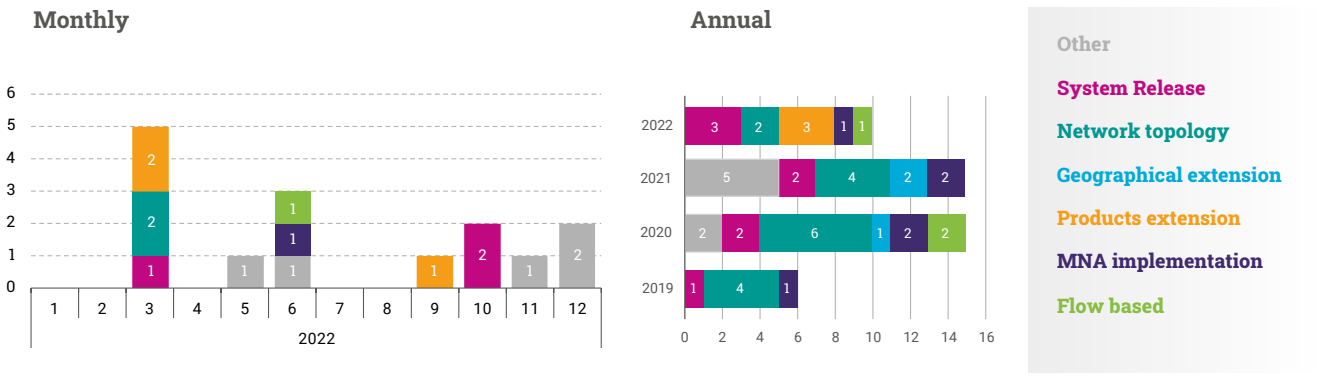


Figure 09

Table 03

Requirement	Name	Go-live Date*	Reason according AM article 14.1	Initiator/Owner
Product Extension	Overall limit on exclusive groups in OTE	01.03.2022	d	NEMOs
Product Extension	Increase of blocks by EMCO in Nordics and Baltics	16.03.2022	d	NEMOs
System release	Euphemia 10.6_fix3	29.03.2022	f	NEMOs/TSOs
Network topology	Reinstating Lithuania-Belarus Import bidding zone	29.03.2022	g	TSOs
Network topology	Lineset SE3A in Sweden	29.03.2022	g	TSOs
Other	New max clearing max price to 4 000 €/MWh	10.05.2022	a	NEMO
Flow based	CORE FB	08.06.2022	g	TSOs
MNA extension	MNA on Italian Northern border	08.06.2022	a, g	NEMOs/TSOs
Other	Timings changes	08.06.2022	NA	NEMOs/TSOs
Product Extension	Increase in C01 blocks in EPEX SPOT Nemo hubs	13.09.2022	d	NEMOs
System release	PMB technological updates	11.10.2022	NA	NEMOs/TSOs
System release	Euphemia 10.6_fix4	26.10.2022	f	NEMOs/TSOs

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

Performance monitoring report

During 2022 the performance of the SDAC continued to be positive, in which the performance has been better than previous years despite the usage of products has been greater in average.

- The usage of products, on average, show moderate increase with respect to 2021 (+5 %).
- The usage of FB-PTDF constrains shows a huge increase (+42 %) with respect 2021 due to the implementation of CORE FB in June 2022.
- The Time To First Solution (TTFS) – has significantly reduced from 2021 from 3.8 to 2.6 minutes in average (– 32 %).
- 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 2019 to 2022 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 2022. 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.

Following the approach from the previous years reports, usage of inputs to the algorithm and output of the algorithm are computed separately for MRC and 4MMC Regions, while the algorithm performance indicators are calculated only on the MRC perimeter, due to its greater scope and complexity, until 17th June 2021. After that date, the data for the entire SDAC coupled region are reported.

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 2.6 mins, well below the maximum the 17 mins allowed."

Usage indicators

- In 2022, we see a moderated increase in the average values for **product usage** (page 24 – page 27) indicators with respect to 2021. The increase in 2022 with respect to 2021 is on average +5 %, mainly concentrated in the increase on the "total number of PUN orders" (+37 %), "total number of block orders" (+9 %) and "total number of steps at bidding zone level" (+5 %).
- Among the **geographical extension** usages (page 28), the major variation can be traced back to the SDAC completion on 17th June 2021 with the merging of MRC and 4MMC which is reflected in the number of NEMO trading hubs.
- All indicators related to **network constraints** usage (page 28) show an increase. The FB-PTDF constraints show an increase of +42 % with respect to 2021, 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 an reduction w.r.t. the previous year (– 32 %), in which some "problematic" sessions were experienced in Q3 2021 that were addressed by Euphemia fixes later that year. The performance of the SDAC algorithm continued to show high reliability, with a yearly average of 2.6 mins for the TTFS. Such data shows that the algorithm was able to absorb the increase in the number of flow-based PTDF constraints that were consequence of CORE FB implementation.
- The welfare indicators show good quality of solutions, with 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 greater than in previous years and the economic surplus gain after increasing allowed calculation time by 10 minutes is slightly lower than previous years.
- The level of repeatability in 2022 increased measured by the frequency indicator per delivery day is always higher than 98.08 %, and the impact of differences over the relevant values, whenever present, proved to be negligible (average annual value around 0.17 %). The level or repeatability with the deterministic time is, as expected, equal to 100 %.

Output indicators

- Data shows that the daily welfare contribution of the SDAC reached on average 9.9 B€.
- Curve orders are responsible for the majority of the traded volumes, followed by merit orders, PUN orders, block orders and MIC and load gradient orders.
- The TTFS show a reduction of around -32 % with respect to 2021, mostly due to the scalability issues faced in Q3 2021 and fixes implemented by the end of 2021. As a result of the changes done in the algorithm, the time spent on the different phases of the algorithm calculation process has been reduced, returning to values better aligned from previous years.

Usage indicators

MRC/SDAC

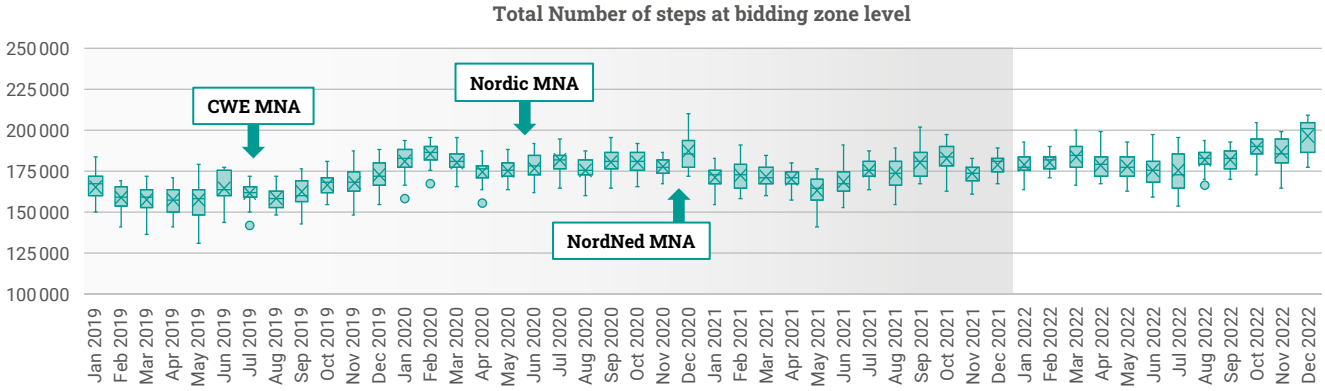
Table 04

Usage indicators Indicators to describe the Usage of SDAC products (Annex 3 of AM Article 10)	2019** MRC Avg	2020** MRC Avg	2021** MRC/SDAC Avg	2022** SDAC Avg	Min	Max
Total number of steps at bidding zone level*	162 492	179 746	173 392	182 216	153 901	208 520
Total number of block orders	4 360	4 498	3 745	4 076	3 096	5 448
Total number of block order exclusive groups	136	145	114	135	96	190
Total number of linked families	145	59	35	43	22	75
Total number of MIC and load gradient orders	106	95	80	81	68	100
Total number of demand merit orders	929	985	651	687	441	1040
Total number of supply merit orders	39 495	41 092	44 029	43 341	38 111	48 542
Total number of PUN orders	5 417	7 734	10 085	13 822	10 047	17 578

* 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.

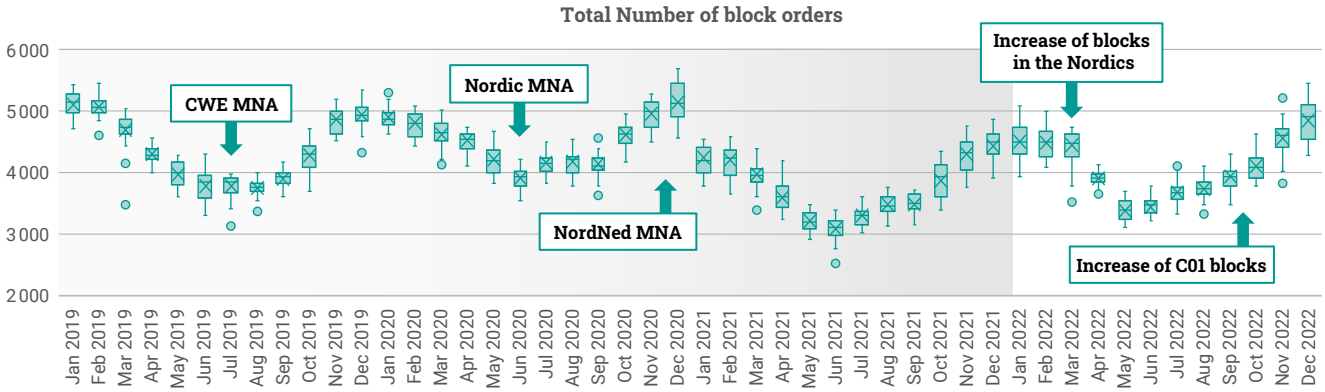
** The reported values are calculated excluding the days of Decoupling – one occurrence in each of the years 2019, 2020 and 2021.

MRC/SDAC[3]



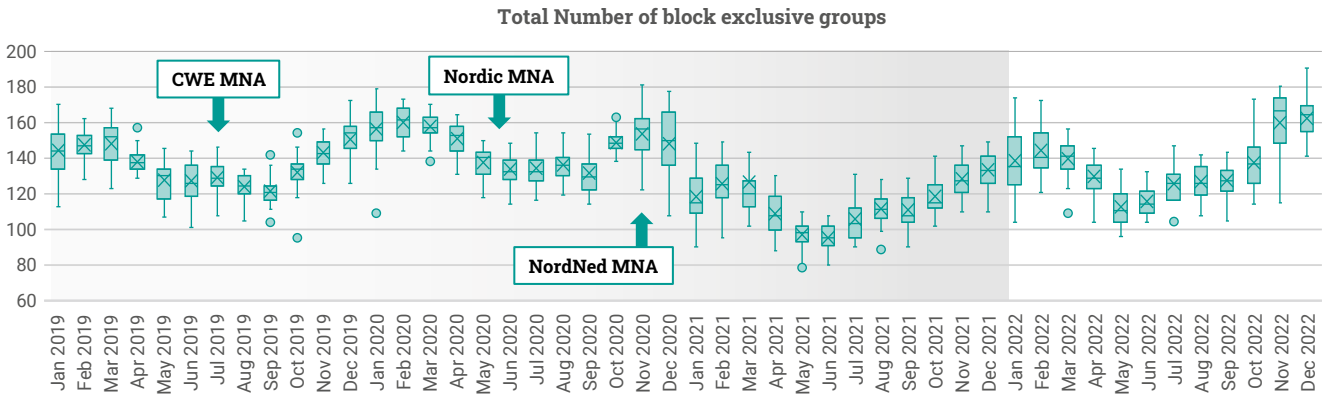
Weak seasonal variation, average increase w.r.t. 2021 around +5 %.

Figure 10



Marked seasonal variation, with a increase of the average annual level in 2022 w.r.t. 2021 (+9 %).

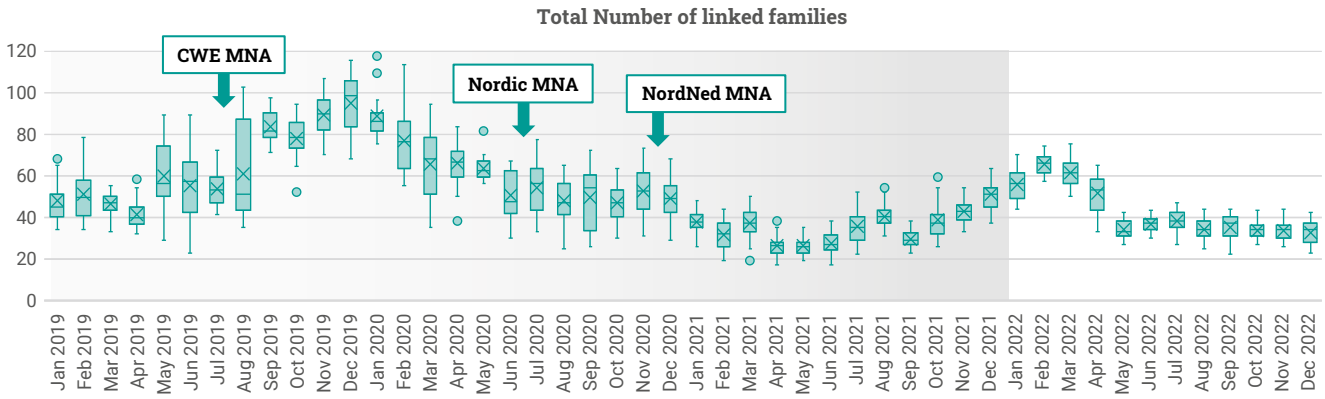
Figure 11



Average increase in 2022 w.r.t. 2021 around +18 %.

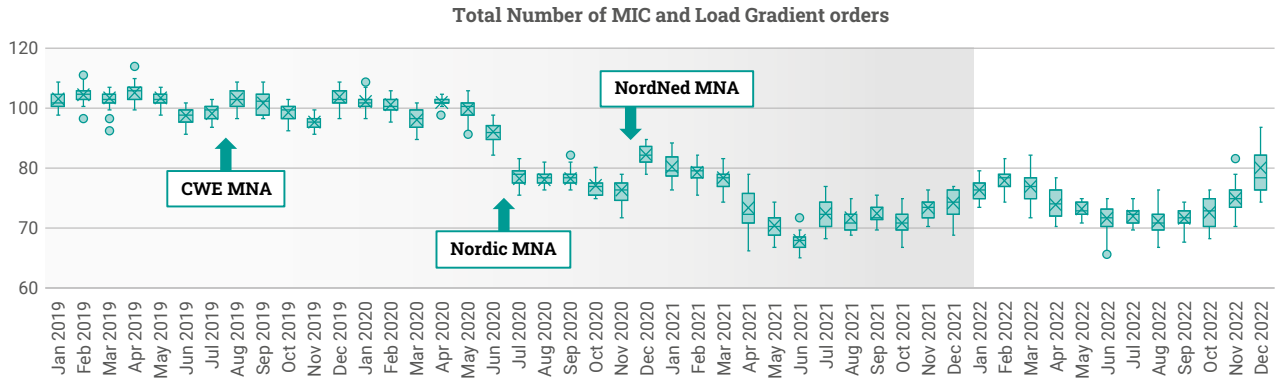
Figure 12

MRC/SDAC[3]



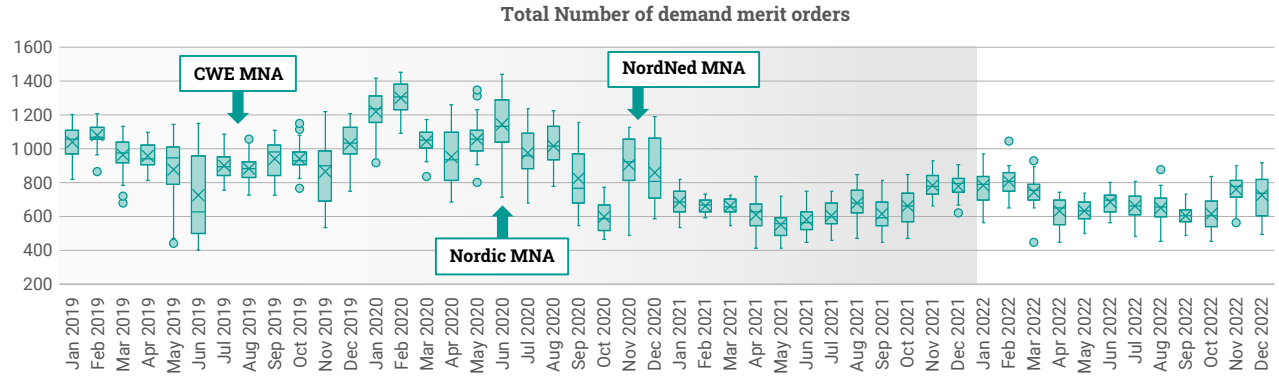
Increase in the first quarter of 2022 to later reduce and form a plateau.

Figure 15



Similar usage in 2022 compared to 2021.

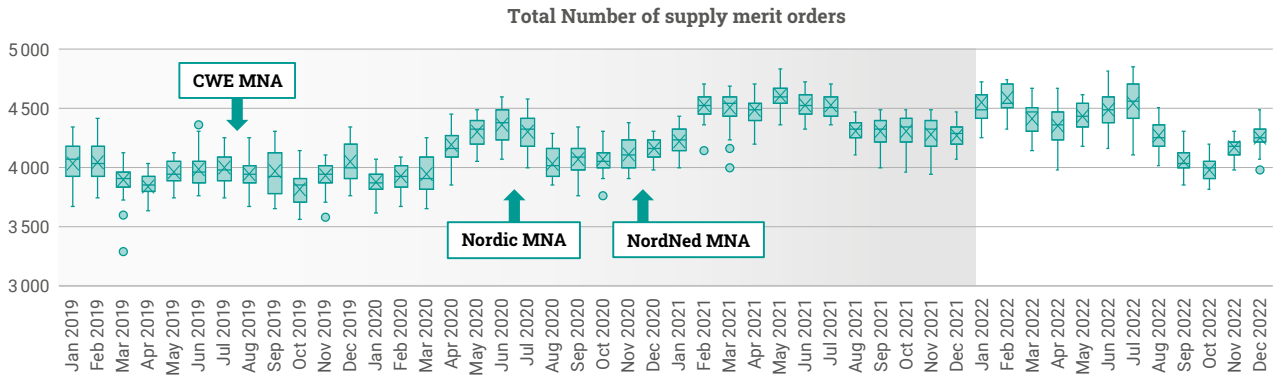
Figure 13



Moderate increase of the average usage w.r.t. 2021 (+5 %).

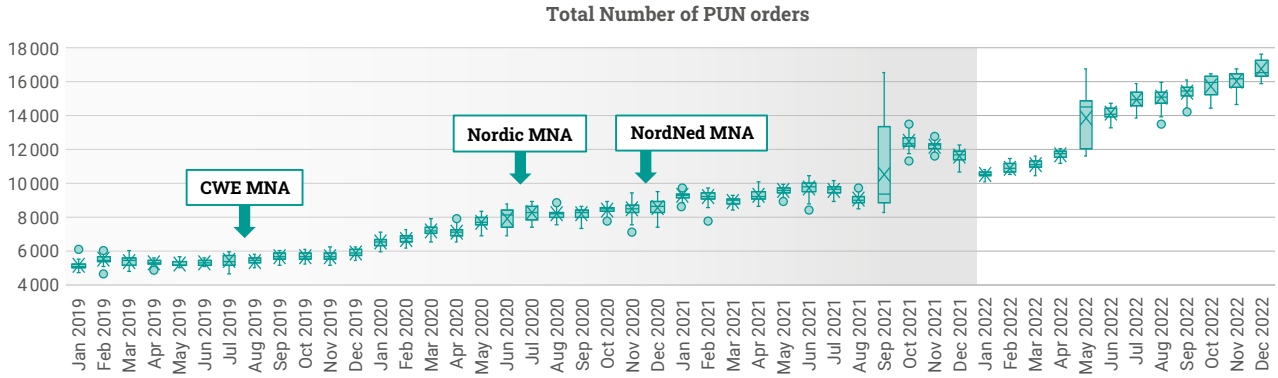
Figure 14

MRC/SDAC[3]



Small reduction of the average usage w.r.t. 2021 (-2 %).

Figure 16



Significant increase of the average usage w.r.t 2021 (+37 %)

Figure 17

MRC/SDAC

Table 05

Usage indicators	2019* MRC Avg	2020* MRC Avg	2021* MRC/ SDAC	2022* SDAC Avg	2022* SDAC Min	2022* SDAC Max
2) Indicators to describe geographical extension of the SDAC (Annex 3 of AM Article 11)						
Number of bidding zones	55.3	56.2	58.1	61.6	61	63
Total number of flow-based bidding zones	5	5.3	7	11	7	14
Number of scheduling areas	57	59.2	61.1	64.6	64	66
Number of NEMO Trading Hubs	64	80.8	95.9	99.4	97	103
3) Indicators to describe the network constraints (Annex 3 of AM Article 12)						
Total number of bidding zone lines	75	78	80.2	88.2	88	89
Total number of flow-based PTDF constraints	3 555	3 410	1 372.7	1 896.0	662	3 074
Total number of scheduling area lines	83	88	90.2	98.8	98	99
Total number of NEMO Trading Hub lines	108	161.7	207.8	224.8	222	229

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

MRC/SDAC[3]

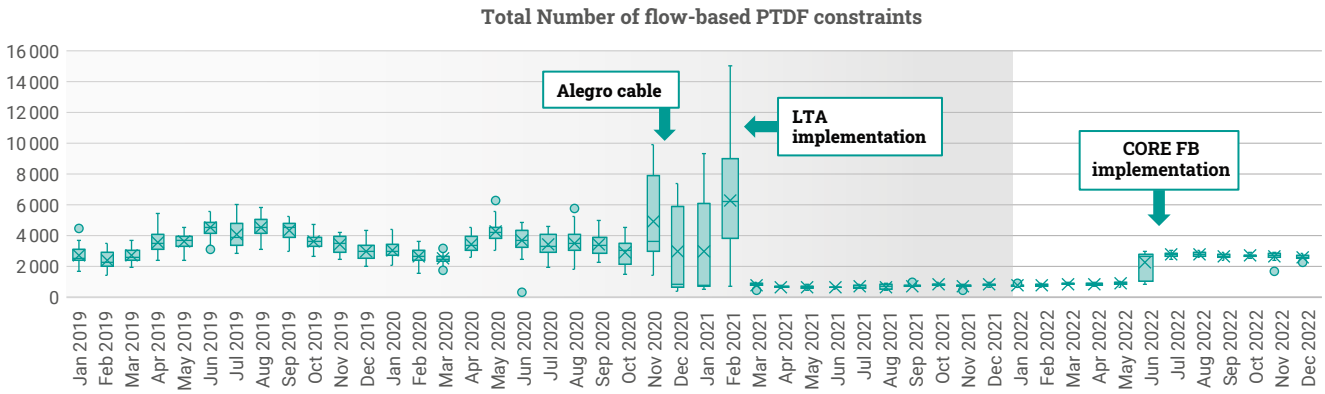


Figure 19

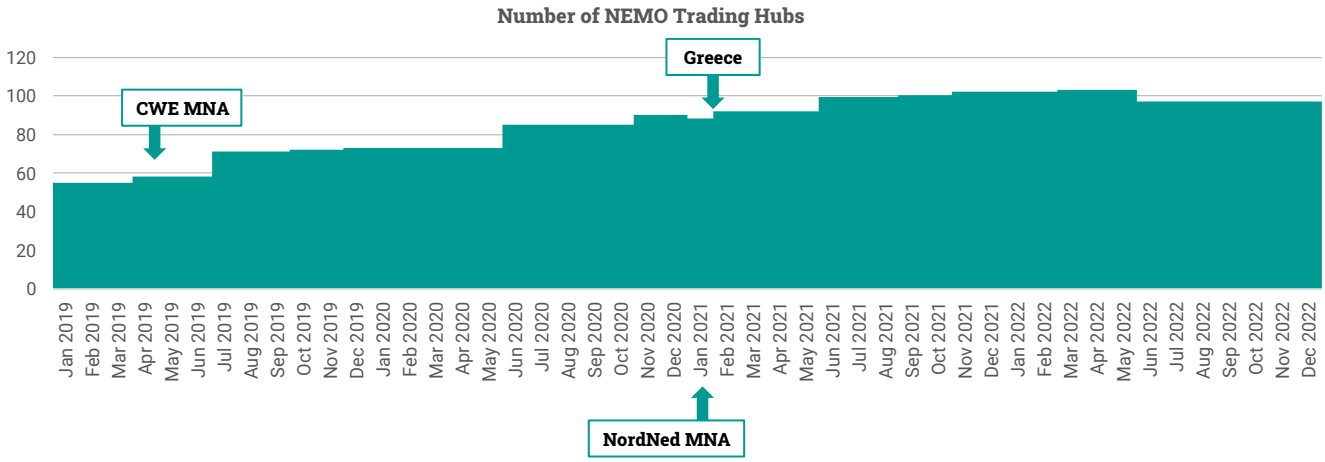


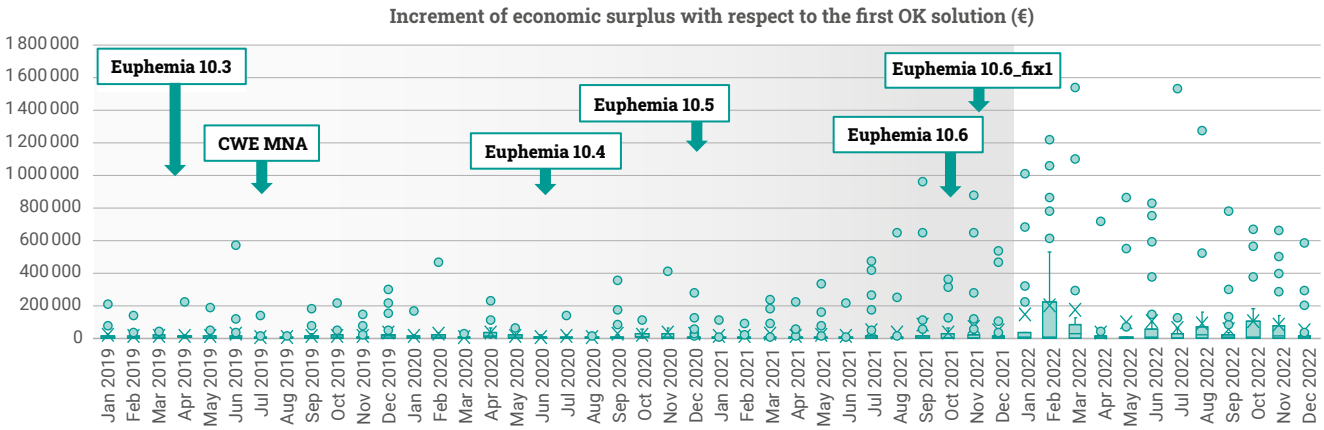
Figure 18

Performance indicators[4]

Table 06

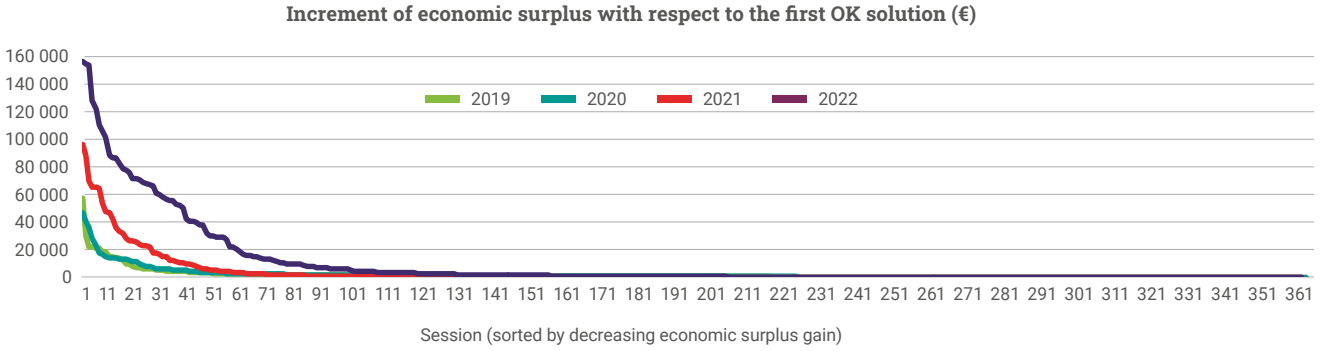
Performance	2019 MRC Avg	2020 MRC Avg	2021 MRC/SDAC	2021 SDAC Avg	2021 SDAC Min	2021 SDAC Max
1) Ability to maximise economic surplus (Annex 3 of AM Art. 7)						
(a) Increment of economic surplus with respect to the first OK solution (%)	0.000190 %	0.000205 %	0.000407 %	0.001021 %	0 %	0.017032 %
(b) Economic surplus gain after increasing allowed calculation time by 10 minutes (%)	−0.000020 %	0.000063 %	0.000092 %	0.000011 %	−0.01349 %	0.00898 %
2. Algorithm repeatability without deterministic time						
(a) Repeatability frequency indicator, measured as number of equal values over total values for the relevant results (%) [bigger is better]	99.65 %	99.83 %	99.86 %	99.88 %	98.08 %	100 %
(b) 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]	0.61 %	0.24 %	0.17 %	0.17 %	0 %	5.95 %
(b) Repeatability frequency indicator, measured as number of equal values over total values for the relevant results (%) [bigger is better]	Not available	100 %	100 %	100 %	100 %	100 %
(b) 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 %
3) Algorithm scalability (Annex 3 of AM Art. 9) TTFS (min)	3.43	3.21	3.78	2.56	1.24	8.60

Ability to maximise the economic surplus [3,5]



Increment of economic surplus with respect to the first OK solution: maximum increase around 1.56 M€ over 9 905 M€ average daily welfare. Negative axis is not shown due to the absence of negative values.

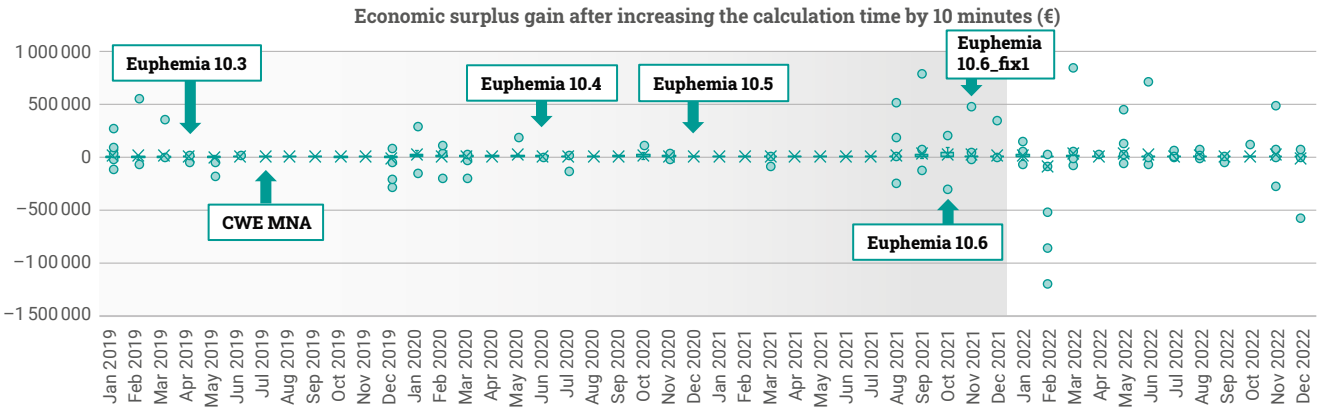
Figure 20



Duration curve shows the Increment of economic surplus with respect to the first OK ordered in descending order of magnitude, rather than chronologically. The "problematic" sessions of Q3 2021 made these values greater at the left of the curve.

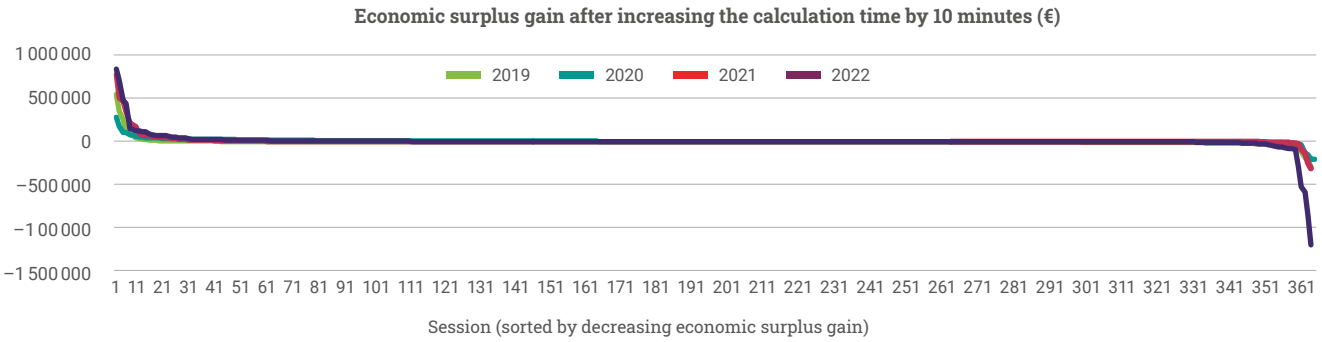
Figure 21

Ability to maximise the economic surplus [3,5]



Economic surplus gain after increasing the calculation time by 10 minutes: maximum/minimum gain ranges among + 840 k€ and – 1 199 k€ over 9 905 M€ average daily welfare.

Figure 22



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 23

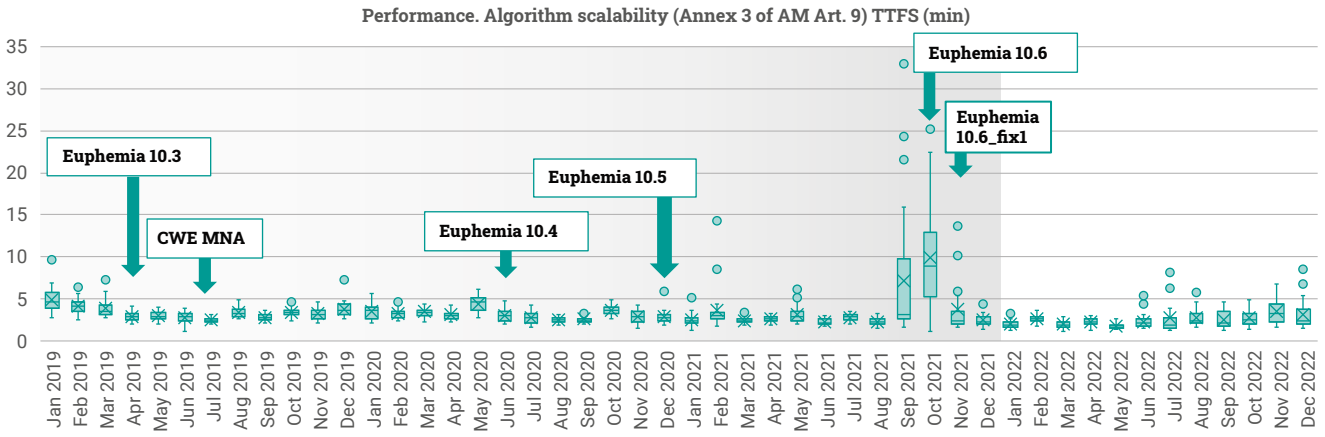


Figure 24

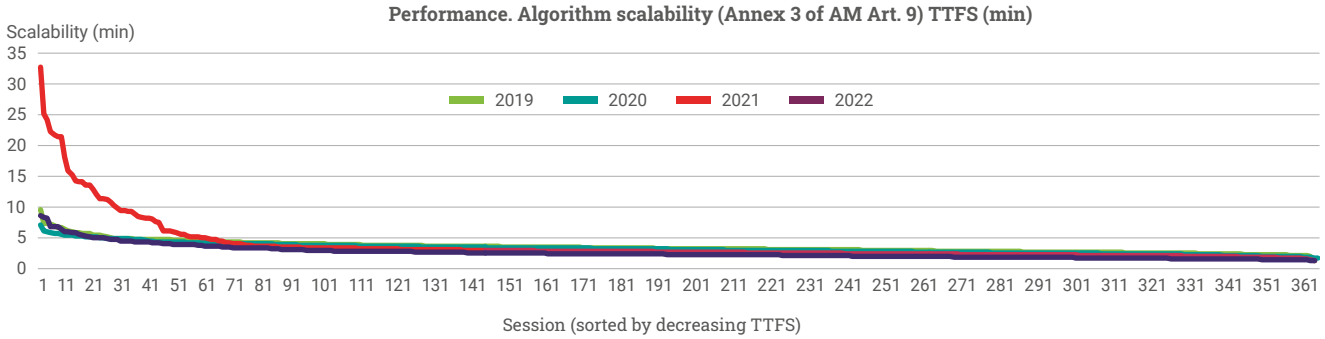


Figure 25

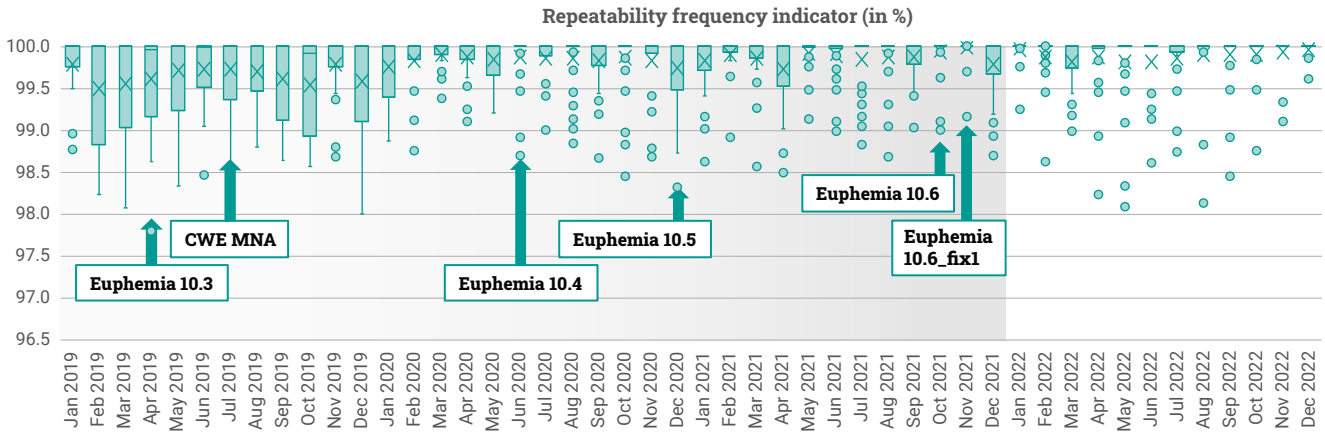
In September-early October 2021 we observed an increase in the TTFS due to the increase of PUN links.

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.

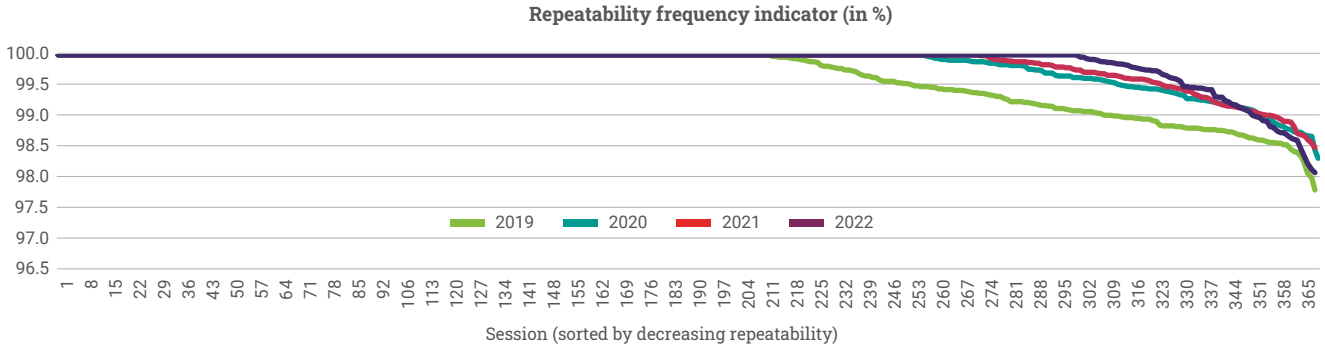
In 2022, the average TTFS has been reduced again, and the TTFS for the problematic sessions have been reduced significantly, returning to the values observed in 2019 and 2020.

Algorithm repeatability without deterministic time [3,4]



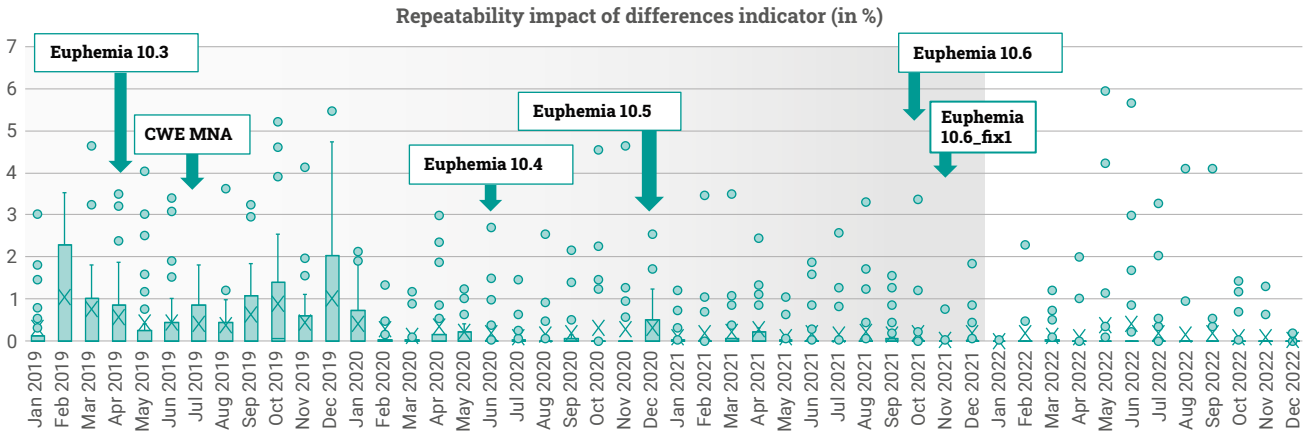
Repeatability frequency indicator: ellipses underlines the high level of repeatability, which, in 2022, is always higher than 98.08 %.

Figure 26



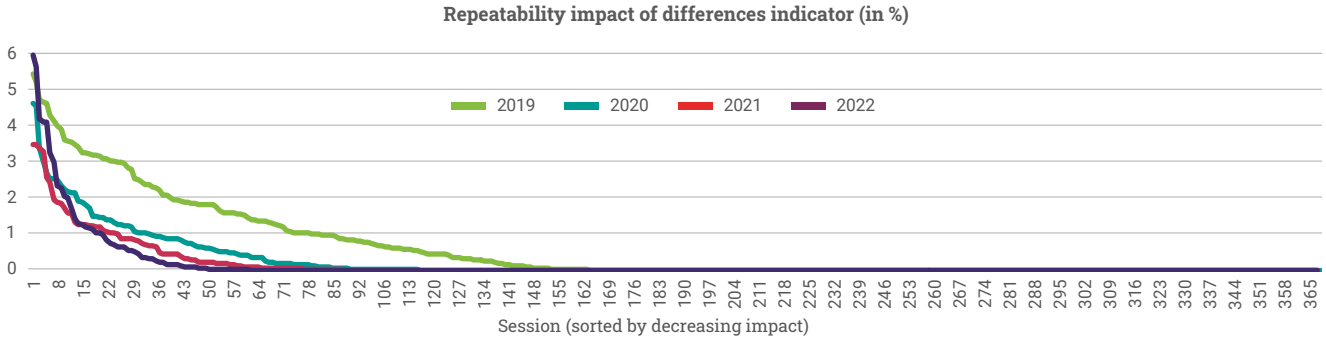
Duration curve shows the Repeatability frequency indicator ordered in descending order of magnitude, rather than chronologically. The number of sessions reaching 100 % value for repeatability frequency indicator has increased consistently since 2018.

Figure 27



Repeatability impact of differences indicator: the impact of differences over the relevant values, whenever present, proved to be negligible.

Figure 28



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

Figure 29

Output indicators

MRC/SDAC

Table 07

Output indicators	2019* MRC Avg	2020* MRC Avg	Year 2021* MRC/ SDAC Avg	2022* SDAC Avg	2022* SDAC Min	2022* SDAC 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€)	8 710.010	8 923.448	8 528.200	9 904.509	6 987.207	12 845.28
Economic surplus of the final solution (M€)	8 710.026	8 923.467	8 528.234	9 904.607	9 881.208	12 845.29
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	736	692	742	808	557	1 444
Total number of matched MIC and load gradient orders	33	25	31	42	15	69
Total number of matched non-PUN merit orders	31 589	31 270	33 421	32 883	27 830	39 509
Total number of matched PUN orders	3 567	5 190	7 184	11 354	5 671	15 060
Total matched volume from curves (MWh)	5 723 417	6 020 578	5 917 323	5 707 128	4 694 261	7 054 328
Total matched volume from blocks (MWh)	353 754	383 456	343 177	398 544	191 594	704 807
Total matched volume from MIC and load gradient orders (MWh)	184 490	128 051	114 367	210 601	4 247	470 039
Total matched volume from (non-PUN) merit orders (MWh)	763 822	732 547	733 778	730 972	457 279	949 533
Total matched volume from PUN orders (MWh)	791 937	741 481	783 501	776 821	533 860	995 897
Paradoxically rejected orders						
Number of PRBs in the final solution	17	16	11	13.0	1	74
Number of PRMICs in the final solution	1	1	1	2.1	0	12
Maximum Delta P in the final solution	4	3.3	10.2	41.7	0.0	640
Maximum Delta MIC in the final solution	2	1	2.2	6.1	0	179.5
PRB utility loss in the final solution (k€)	20.264	18.363	50 687	129.859	0.000	1 554.462
PRMIC utility loss in the final solution (k€)	11.507	5.701	11 542	50.669	0	2 719.69
Volume of PRBs in the final solution (MWh)	22 663	21 941	13 021	12 704	5.4	69 885
Volume of PRMICs in the final solution (MWh)	7 549	4 628	5 143	10 955	0	56 394
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	792	868	856	1 059	779	1 299

Table 07

Output indicators	2019* MRC Avg	2020* MRC Avg	Year 2021* MRC/ SDAC Avg	2022* SDAC Avg	2022* SDAC Min	2022* SDAC Max
3) IT calculation process (Annex 3 of AM Article 15)						
Time spent in every phase of the algorithm calculation process						
TTFS (s)	205.9	192.8	227.2	153.6	74.2	516.2
Input data reading time (s)**	9.5	10.6	72.1	10.4	4	32
Input data delivery day creation (s)**	10.7	12.5	1 978.9	23.1	6	77
Time to solve the root node for the master computer (s)**	9.6	19.5	11.9	15.0	9.9	29.5
Time to solve the root node for the job that found first solution (s)**	14.9	17.2	3	3.49	0	18
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	3.4	38	2.4	1	9
Total number of nodes in the master branch and bound tree***	875	911	12.8	405	30	3 392

* 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

Analysis on the usage of each product and its impact on algorithm performance[6]

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 on January 2020.

Methodology

The analysis is performed for the 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 2021.

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 form the exclusive group, maintaining its MAR and price.

- **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 profiled 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 MIC/MP and load gradient orders. The variable term from the MIC/MP and load gradiant order and their impact on the acceptance of the order is incorporated to the fixed term of the Scalable MIC 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 participants 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 when we replace a product 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 despite the average behaviour may be negative, there may exist a few sessions that are not single outliers and its 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, we have selected the Q4 of 2022, which contain many of the most challenging sessions of the year. Despite the size of the sample used for input data has been extended from 1 month for 2019 study to 3 months for 2020, 2021 and 2022 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 (+ 41.8 % 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 in a previous slide.

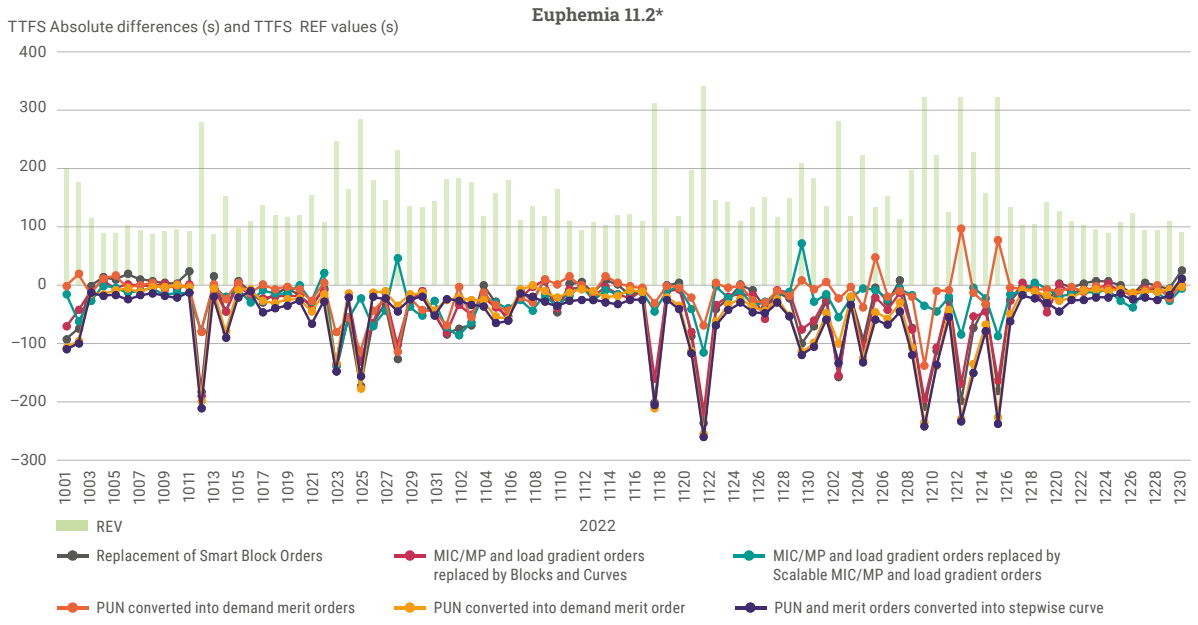
In conclusion, the main findings of the study seems being:

- The outcome is heavily depending 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 having a standalone key impact on performance.

As a final remark, all these observations suggest to reconsider 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) E11.0	ΔTTFS (s) E11.2	ΔTTFS (%) E11.2	# 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			149.1	–	–	190 764	4 496	2 682	83	0	58 115	16 135
Scenarios in which products are replaced	Stepwise Curves	190 764	5 750	Not estimated				–	–	–		–	–
	Piecewise Curves			108.6	–40.5	–27.2 %	181 559	4 496	2 682	83	0	58 115	16 135
	Merit orders	41 980	690	Not estimated			–	–	–	–	–	–	–
	Block Orders	4 496	439	Not estimated			–	–	–	–	–	–	–
	Smart Block Orders (exclusive groups + linked blocks)	2 682	Not available	108.7	–40.4	–27.1 %	190 764	1 978	0	83	0	58 115	16 135
	MIC/MP and load gradient orders (BO+Curves)	83	188	123.5	–25.6	–17.2 %	193 550	4 571	2 682	0	0	58 115	16 135
	MIC/MP and load gradient orders (Scalable MIC/MP and load gradient)	0	0	133.5	–15.6	–10.5 %	190 764	4 496	2 682	0	83	58 115	16 135
	PUN Orders	16 135	730	99.3	–49.8	–33.4 %	190 764	4 496	2 682	83	0	57 875	0
	PUN and Merit Orders	58 115	1 420	89.8	–59.4	–39.8 %	207 572	4 496	2 682	83	0	0	0

Figure 30



* 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 31

Scalability report

With the successful implementation of CORE Flow Based in 2022, the main 2024 Roadmap change will be the Flow Based implementation in the Nordic region. After that the ongoing challenge, and focus of most R&D activities will be the 15 minute MTU introduction by 1 Jan 2025.

"Combined with improvements in hardware and allocating more time to the algorithm we are increasingly confident we can manage 15 min MTU by 2025"

Corrective measures to phase out PUN merit orders and replace MIC/MP and Load Gradient orders by Scalable MIC/MP and Load Gradient Orders are assumptions reflected in the 2026 15' MTU data set. Euphemia finds solutions for most sessions (87/91), but not always within a reasonable time. R&D activities have continued and will continue throughout and beyond 2023. Combined with improvements in hardware and allocating more time to the algorithm we are increasingly confident we can manage 15 minute MTU by 1 Jan 2025.

In this section, the scalability of the SDAC is assessed, simulating the performance of the scalability indicator in relation to the expected evolution of foreseen requests for change (included in the roadmap), as well as to the exogenous usage of requirements. This exercise is carried out for the 2024 – 26 period, as understood at the end of 2022, and using the latest available version of the SDAC Algorithm (Euphemia 11.2).[7]

Roadmap

The Roadmap anticipates the impact of RfCs expected to go-live in the next three years. Based on this three scenarios have been tested.

- **Scenario 1:** including the anticipated usage of existing products and requirements in 2024. This includes the FB extension to Nordic Regions.
- **Scenario 2:** including the anticipated usage of existing products and requirements in 2026.
- **Scenario 3 (c.d. Full CACM Requirements):** including Scenario 2 assumptions, plus go-live of 15 minutes MTU throughout EU (c.d. Big Bang approach, simulated on a 91 days batch exploded by 4).

Anticipated usage

The expected usage of products and requirements reflects the actual usage recorded between 2021 and 2022 and projected to 2024 – 26 usage by applying the historical growth of each product/requirement usage projected into the future (for full details see slide on anticipated usage).

In general, the large increase of the usage values in 2026 reflects not only the multi-year growth rate but also the fourfold increase in the size of the problem due to the shift to 15 minutes. Since Euphemia supports cross product matching, we reflect an assumption that 80 % of curve orders will become 15 minute orders, i.e. quadrupling their number. The remaining 20 % will stay as 60 minute orders. Merit orders don't support cross product matching, so these are necessarily quadrupled. Finally scalable MIC/MP and Load Gradient orders follow the time resolution of their bidding zone (15 minute in Spain and Portugal, but 30 minute in Republic of Ireland and Northern Ireland).

Network data is also quadrupled when switching to 15 minutes.

Finally only for multi-hourly products (block orders) a conservative assumption was made and only the multi-year growth rate was applied, with a consequent potential underestimation of the impact on performance.

Scalability indicator

This year's scalability indicator shows some of the immediate performance challenges from last year were resolved. The 15 minutes MTU implementation continues to be challenging.

Scenario 1 requires on average 4 minutes and 25 seconds to find a solution, and 2 % of sessions required > 17 minutes, but never more than 27 minutes. I.e. the scalability thresholds for scenario 1 (97 % < 17 minutes, and 100 % < 30.6 minutes) are respected;

Scenario 2 requires on average 4 minutes and 45 seconds to find a solution, and 1 % of sessions required > 17 minutes, but never more than 25 minutes. I. e. the scalability thresholds for scenario 2 (97 % < 17 minutes, and 100 % < 30.6 minutes) are respected;

Scenario 3 requires on average ~24 minutes to find a solution, on those sessions where solutions could be found. For 4 % of the simulated sessions the algorithm was not able to find a solution that met our precision requirements.

The scalablity thresholds for scenario 3 (97 % < 40 minutes, and 100 % < 72 minutes) are not respected:

- Only 92 % of sessions could be solved in 40 minutes;
- Only 95 % of sessions could be solved in 72 minutes;
- 4 % of sessions did not result in a feasible solution;

Roadmap of RfCs

The following tables list the different requests for change as captured by the roadmap.

Requirement	Name	Go-live Date	Reason	Initiator/Owner
15 min MTU	15′ MTU implementation	January-25	CACM	NEMOs/TSOs
Capacity Calculation	Nordic DA FB	2024 Q1	CACM/Nordic CCR	TSOs
Capacity Calculation	Advanced hybrid coupling (Core)	2025 Q4	CORE CCR	TSOs
System Release	Co-optimisation	Not defined	CACM	
Algorithm release	Non-uniform pricing	Not defined		
Network topology	Merger of Core & ITN for CCM (DA)	Not defined	CORE&ITN CCRs	
Network topology	Integration of CH borders in Core CCM (DA)	Not defined	CORE CCR	TSOs
System Release	MRLVC with UK	Not defined	Brexit Arrangement	TSOs
MNA - Multi-NEMO	Baltic MNA	Q4 2024	CACM	NEMOs/TSOs
MNA - Multi-NEMO	NASDAQ in Nordic	Not defined	CACM	NEMOs
Network topology	New cable between Poland and Lithuania (Harmony Link)	2028 Q1	TSO	TSOs
Network topology	New HansaPowerBridge	2026 Q1	TSO	TSOs
Capacity Calculation	Flow-based in region IT-North	Not defined	CACM	TSOs
Network topology	ES–FR capacity increase	2026	TSO	TSOs
MNA - Multi-NEMO	MNA on FR-ES border (on French side)	2023 Q4	CACM	TSOs
Network topology	Celtic Interconnector	2026 Q4	TSO	TSOs
Extension	SDAC Extension – Montenegro – Italy	Not defined		NEMOs/TSOs
Extension	SDAC Extension – Albania – Greece	Not defined		NEMOs/TSOs
Extension	SDAC Extension – Albania – North Macedonia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Albania – Kosovo	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Albania – Montenegro	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – North Macedonia – Greece	Not defined	NEMOs/TSOs	

Table 08

Details	Scenario 1 2024 (Y+1)	Scenario 2 2026 (Y+3)	Scenario 3 2026 (Y+3 with 15 minutes MTU)
According to ACER's decision of 24.04.2018, by 01.01.2021, MTU shall be implemented on each border as equal to the shortest common ISP of the corresponding BZ	○	○	⊗
Implementation of (plain) FB coupling for the Nordic region	⊗	⊗	⊗
NO4-FI inclusion under study	○	○	○
It would cover external FB area borsers (HVDC and AC borders through Virtual hubs)	○	○	○
Optimisation of Energy and balacing capacities together in SDAC	○	○	○
	○	○	○
	○	○	○
	○	○	○
Introduction of multi-NEMO framework in the Baltic region. EPEX becomes operational NEMO in Baltic region	⊗	⊗	⊗
Operational go-live of NASDAQ in the Nordic region. Legal arrangements are however of high complexity even if technical side is medimum complexity	○	○	○
New (undersea) HVDC line between PL and LT areas	○	○	○
New (undersea) HVDC line between DE(50Hertz) and SE4(SVK) (Svk: propose Go live date "Not defined" since it is not procured yet.)	○	○	○
Flow-based approach to be applied on IT-North according to art 20.3 of CACM	○	○	○
Increase in ATC capacity between Spain and France (both senses), from 2 800 MW to 5 000 MW (+2 200MW increase)	○	⊗	⊗
Only EPex is active on French side on this FR-ES border, then NordPool will also be active, and MNA fully applied in French BZ Challenging legal aspects compared to technical ones	⊗	⊗	⊗
New interconnection between France-Ireland	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○

Requirement	Name	Go-live Date	Reason	Initiator/Owner
Extension	SDAC Extension – North Macedonia – Bulgaria	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – North Macedonia – Kosovo	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – North Macedonia – Serbia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Kosovo – Montenegro	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Kosovo – Serbia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Bosnia and Herzegowina – Croatia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Bosnia and Herzegowina – Serbia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Bosnia and Herzegowina – Montenegro	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Serbia – Croatia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Serbia – Hungary	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Serbia – Romania	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Serbia – Bulgaria	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Ukraine – Moldova	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Ukraine – Poland	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Ukraine – Slovakia	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Ukraine – Hungary	Not defined	NEMOs/TSOs	
Extension	SDAC Extension – Romania – Moldova	Not defined	NEMOs/TSOs	
System Release	CORE FB enduring solution (Change of Euphemia SEC in case of Core fallback)	2023 Q2		
Network topology	Hansa CCR CCM Phase 2	Not defined		

Table 08

Details	Scenario 1 2024 (Y+1)	Scenario 2 2026 (Y+3)	Scenario 3 2026 (Y+3 with 15 minutes MTU)
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
Legal aspects are the most complex part compared to purely technical developments. Complexity is set to Medium for Technical developments, but Legal aspects are set to high complexity	○	○	○
	○	○	○
	○	○	○

Requirement	Name	Go-live Date	Reason	Initiator/Owner
Network topology	Hansa CCR CCM Phase 3	Not defined		
Network topology	Hansa CCR CCM Phase 4	Not defined		
System Release	IDA Handling of AAC and Ramping constraints	2023 Q2		
System Release	IDA topology, virtual areas, products, 15 min MTU support and performance requirements	2023 Q2		
System Release	PMB12.0 + Euphemia 11.1	2023 Q1		
System Release	PMB12.1 + Euphemia 11.2	2023 Q4		
System Release	PMB12.2 + Euphemia 11.3	2024		
MNA - Multi-NEMO	Austria-Slovenia MNA	2023 Q3		
Extension	New German-GB HVDC link (NeuConnect)	2028		
System Release	Update on LTA results granularity for Core	2023 Q2		TSOs
System Release	IDA Reference to Auction ID	2023 Q2		NEMOs/TSOs
System Release	IDA partial decoupling automation	2023 Q4		NEMOs/TSOs
System Release	Negative ATC support for IDAs	Not defined		TSOs
Network topology	Change of CCP EIC Code for EPEX Norwegian NEMO hubs	Not defined		NEMOs
15 min MTU	CPLEX → Xpress transition	2025	Performance	NEMOs/TSOs
15 min MTU	Numerical challenges	2025	Performance	NEMOs/TSOs
15 min MTU	Volume problems	2025	Performance	NEMOs/TSOs
Algorithm release	PTDF matrix precision improvement	2025	Performance	NEMOs/TSOs
2030 Scenario	Off-shore wind study, part I	Not defined		NEMOs/TSOs
Algorithm release	SEC based PTDF improvements	2025	Performance	NEMOs/TSOs
2030 Scenario	2nd 2030 study item finalization: Alteranative Storage Orders	Not defined		
15 min MTU	IDA simulations and results comparison	2024	Performance	
15 min MTU	OA decision	2025	Performance	
2030 Scenario	Optimization of PSTs & HVDCs in the market	Not defined		
2030 Scenario	LTA removal	Not defined		
15 min MTU	Revisit how advanced solver features are leveraged in Euphemia	2025		
15 min MTU	Finalization of the fallback mechanism	2025		
2030 Scenario	Flexibility in zonal topology	Not defined		

Table 08

Details	Scenario 1 2024 (Y+1)	Scenario 2 2026 (Y+3)	Scenario 3 2026 (Y+3 with 15 minutes MTU)
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
Process-wise, activation of usage only after IDA golive in Q2 2024	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○

Requirement	Name	Go-live Date	Reason	Initiator/Owner
2030 Scenario	Long Term market Trends: Storage orders	Not defined		
2030 Scenario	Long Term market Trends: Moving to finer time granularity, e.g. 5' MTU granularity	Not defined		
2030 Scenario	Off-shore wind study, part II (with flow-based)	Not defined		
Extension	Extension to new countries (future EU members)	Not defined	NEMOs/TSOs	
System Release	Systems integration (holistic view of the systems linked to market coupling)	Not defined	NEMOs/TSOs	
System Release	Cybersecurity and technological failures	Not defined	NEMOs/TSOs	
System Release	Continuous improvement of Euphemia: Scalability, Repeatability, traceability	Not defined	NEMOs/TSOs	
System Release	Yearly Data reporting based on the CACM requirements	Not defined	NEMOs/TSOs	
15 min MTU	Design and recommendation of product offering for 15 min MTU go-live	2023	NEMOs	
System Release	PMB13.0 + Euphemia 11.4	2024 Q2	NEMOs/TSOs	
System Release	PMB13.1 + Euphemia 11.5	2024 Q4	NEMOs/TSOs	

Table 08

Details	Scenario 1 2024 (Y+1)	Scenario 2 2026 (Y+3)	Scenario 3 2026 (Y+3 with 15 minutes MTU)
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○
	○	○	○

Scope of scalability scenario 2024 (Scenario 1: Y+1)

Table 10

Requirement	Name	Details
Capacity Calculation	Nordic DA FB	Implementation of (plain) FB coupling for the Nordic region NO4-FI inclusion under study
MNA – Multi-NEMO	Baltic MNA	Introduction of multi-NEMO framework in the Baltic region. EPEX becomes operational NEMO in Baltic region
MNA – Multi-NEMO	MNA on FR-ES border (on French side)	Only EPex is active on French side on this FR-ES border, then NordPool will also be active, and MNA fully applied in French BZ Challenging legal aspects compared to technical ones

Scope of scalability scenario 2026 (Scenario 2: Y+3 excl. 15 minutes MTU)

Table 11

Requirement	Name	Details
Capacity Calculation	Nordic DA FB	Implementation of (plain) FB coupling for the Nordic region NO4-FI inclusion under study
MNA – Multi-NEMO	Baltic MNA	Introduction of multi-NEMO framework in the Baltic region. EPEX becomes operational NEMO in Baltic region
Network topology	ES–FR capacity increase	Increase in ATC capacity between Spain and France (both senses), from 2 800 MW to 5 000 MW (+2 200 MW increase)
MNA – Multi-NEMO	MNA on FR-ES border (on French side)	Only EPex is active on French side on this FR-ES border, then NordPool will also be active, and MNA fully applied in French BZ Challenging legal aspects compared to technical ones

Scope of scalability scenario 2025 (incl. 15 minutes MTU)

Table 12

Requirement	Name	Details
15 min MTU	15 MTU implementation	According to ACER's decision of 24.04.2018, by 01.01.2021, MTU shall be implemented on each border as equal to the shortest common ISP of the corresponding BZ
Capacity Calculation	Nordic DA FB	Implementation of (plain) FB coupling for the Nordic region NO4-FI inclusion under study
MNA – Multi-NEMO	Baltic MNA	Introduction of multi-NEMO framework in the Baltic region, EPEX becomes operational NEMO in Baltic region
Network topology	ES–FR capacity increase	Increase in ATC capacity between Spain and France (both senses), from 2 800 MW to 5 000 MW (+2 200 MW increase)
MNA – Multi-NEMO	MNA on FR – ES border (on French side)	Only EPex is active on French side on this FR-ES border, then NordPool will also be active, and MNA fully applied in French BZ Challenging legal aspects compared to technical ones

Anticipated usage

Table 13

Usage indicators		Years			
		historical	Scenario 1	Scenario 2	Scenario 3
		2022	2024 (Y+1)	2026 (Y+3)	2026 + 15 minutes MTU (Y+3)
1) Indicators to describe the Usage of SDAC products (Annex 3 of AM Article 10)	Total number of steps at bidding zone level	182 207	192 443	204 137	693 888
	Tot. number of block orders	4 074	4 883	5 642	5 657
	Total number of block order exclusive groups	135	176	214	215
	Total number of linked families	43	59	72	72
	Total number of complex orders	81	0	0	0
	Total number of scalable complex orders	0	85	87	87
	Total number of demand merit orders	686	719	752	143 817
	Total number of supply merit orders	43 347	45 067	46 787	187 434
	Total number of PUN orders	13 818	24 680	35 542	0
2) Indicators to describe geographical extension of the SDAC (Annex 3 of AM Article 11)	Number of bidding zones	62	77	77	77
	Total number of flow-based bidding zones	11	45	45	45
	Number of scheduling areas	65	80	80	80
	Number of NEMO Trading Hubs	99	133	133	133
	Number of NEMOs	15	15	15	15
3) Indicators to describe the network constraints (Annex 3 of AM Article 12)	Total number of bidding zone lines	88	105	105	105
	Total number of flow-based PTDF constraints	1 893	6 225	6 225	24 845
	Total number of scheduling area lines	99	116	116	116
	Total number of NEMO Trading Hub lines	225	286	286	286

Performance indicators[7]

Condition of the simulations

2024

- Euphemia successfully found solutions for all sessions, although 7/365 (2 %) sessions required more than 17 minutes, with a maximum time of 26 minutes;
- I.e. the scalability criteria are respected;

2026

- Similar as for the 2024 scenario Euphemia found solutions for all sessions. Only 3/365 (1 %) sessions required more than 17 minutes, with a maximum time of 24 minutes;
- I.e. the scalability criteria are respected

2026 + 15 minutes MTU

- In this scenario PUN orders were replaced by demand merit orders, and classical MIC/MP and Load Gradient orders were converted to scalable MIC/MP and Load Gradient orders.
- 15′ MTU sessions are considerably more challenging than the 60′ sessions. Compared to last year's report results show progress: only 4 sessions failed to find a solution (solutions that failed to respect precision requirements set be NEMOs + TSOs were found, but we don't report these invalid solutions here).
- To secure the 15′ MTU introduction in SDAC following changes are still foreseen before 1 Jan 2025:
  - › Updating Euphemia hardware to a distributed architecture;
  - › Industrialise more R&D improvements (see next section) into production releases of Euphemia (these are the results from E11.2 whereas for the introduction of 15 minute MTU either E11.3 or E11.4 will be in production).
  - › Corrective measures where some features Euphemia supports today will be (temporarily) deactivated to support the transition to 15 minute MTU
  - › Increase the time allocated to Euphemia beyond 17′

Scalability assessment – duration curves

The most notable increase in topology data relates to FB constraints:

- The different scalability scenarios consider Nordic FB, whereas the 2022 data only includes CWE FB (before 9 June) or Core FB (after 9 June).
- The 15 minutes MTU scenarios introduce 4 × as many network constraints.

Usages for the demand merit orders are clipped from the chart as the scale was limited to 500 %:

- The 15 minutes MTU scenario replaces PUN merit orders with demand merit orders. Since there are more PUN merit orders than demand merit orders, after scaling to the 2022 demand merit orders, we have a large increase, necessitating the clipping.

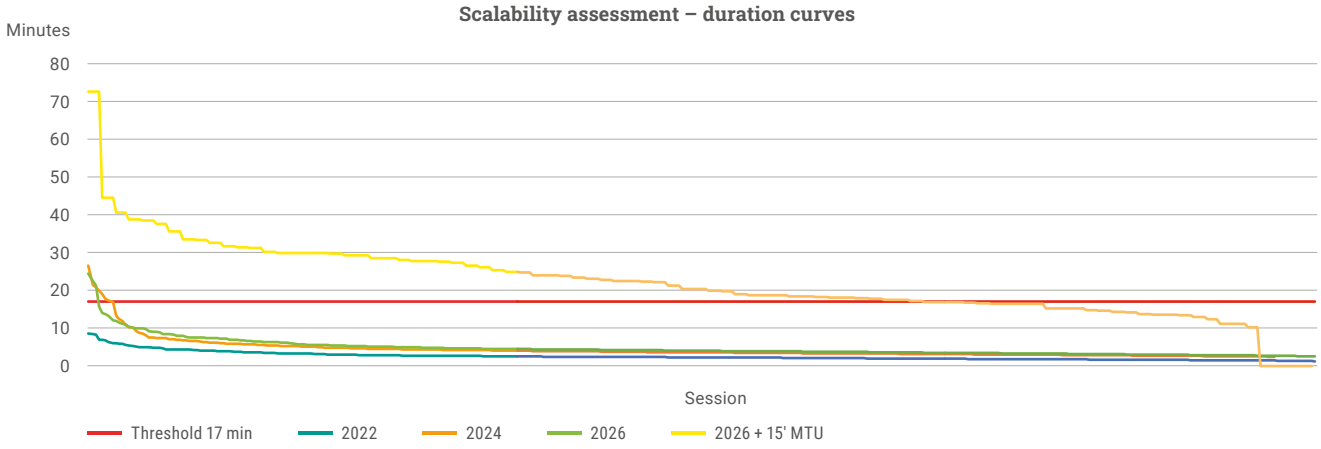


Figure 32

Algorithm scalability

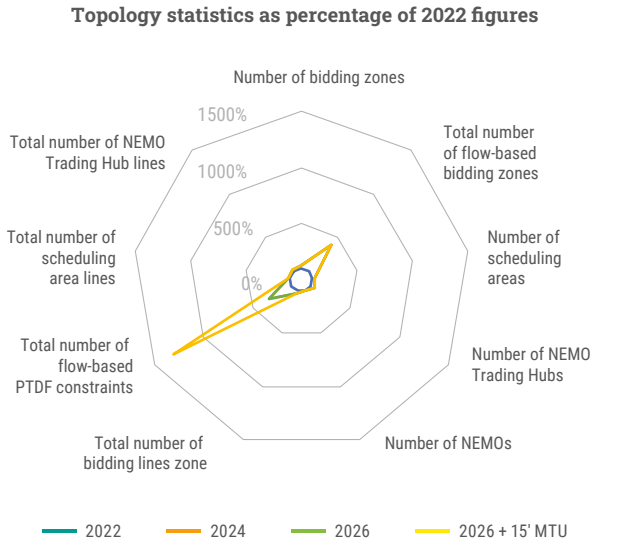


Figure 33

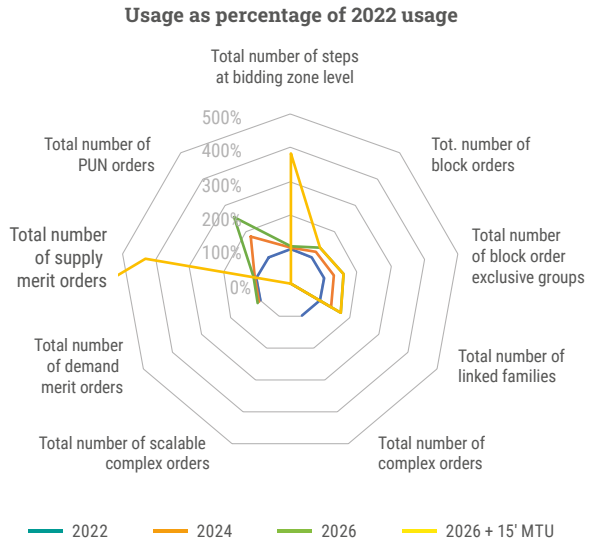


Figure 34

The most notable increase in topology data relates to FB constraints:

- The different scalability scenarios consider Nordic FB, whereas the 2022 data only includes CWE FB (before 9 June) or Core FB (after 9 June).
- The 15 minutes MTU scenarios introduce 4 × as many network constraints.

Usages for the demand merit orders are clipped from the chart as the scale was limited to 500 %:

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R&D report

Since the beginning of Euphemia Lab in 2019, the SDAC R&D program has allowed to develop several items that have been since implemented into Euphemia releases, such as scalable MIC/MP and load gradient orders (in production in Ireland since several months) and LTA inclusion.

From 2020 to 2022, an important effort has been dedicated to prepare the implementation of 15 min MTU in SDAC. The go-live is foreseen in January 2025 via a „big bang" implementation, i.e. simultaneously in all SDAC bidding zones (except Ireland due to a specific exemption). Functionally, Euphemia is being ready for the 15 min MTU granularity: after a several months of work on functional specifications, and research and development performed in the Euphemia Lab, the necessary adaptations were implemented into Euphemia 11.1 release. The latter was introduced in production in March 2023, even if in the current 60 min MTU context these adaptations are not yet exploited.

On the top, implementing 15 min MTU represents an exponential increase in the computational complexity, very challenging for the performance of the algorithm. The multiannual work on the increase of algorithm´s scalability has been quite accomplished; the last improvements date to Q1/2023. Together with the hardware reinforcement (distributed architecture) and the foreseen extension of the computation time limit, the improvements in heuristics shall guarantee a sufficient performance and robustness to handle the 15 min MTU, as long as there are no or only minor delays from the Big Bang implementation.

"In 2022, efforts to guarantee a safe 15 min MTU implementation remained one of key attention points."

Nonetheless if for the main scenarios the performance gap is considered as closed, a risk management is required to make sure the algorithm can cope in time with the most challenging GL scenarios. On the top of the 15 min MTU topic, different other topics were explored within Euphemia Lab. The research on the Non-Uniform Pricing (NUP) continued in Iteration 7 and 8. A study on the offshore wind was performed within the „2030 Future of the algorithm" framework.

2022 Outcomes

For 15 minutes MTU implementation, substantial performance improvements have been reached for the main Go-live scenarios. First, the volume problems were refactored, relying among others on leveraging the outer approximation on different levels. Second, the input-data reading time was improved. Third, further work on configurations allowed gains in performance. These improvements shall be included into different Euphemia releases, so that they are fully tested and ready for use for the 15 min MTU Go-live. With these improvements, it is considered that the performance gap for the 15 min MTU implementation is closed. Nonetheless a risk management is still required to make sure the algorithm can cope in time with the most challenging GL scenarios.

For the non-uniform pricing (NUP), the already existing prototype was adapted in order to include the last improvements implemented in Euphemia (e.g. outer approximation) and support 15 min MTU. With such an up-to-date prototype simulations were performed, allowing valid comparisons with the outcomes of the Euphemia „uniform pricing" releases, in an „apple-to-apple" logic. A dedicated framework was also created, so that the NUP prototype can be run iteratively for a chosen session, with possibility to modify the orders based on the results and a specific strategy. This might provide further elements for studying the possible impacts on market participants behaviour. Altogether, a series of NUP studies has been thus closed, providing

an overall picture on key aspects of the NUP, and impacts and conditions of its potential implementation in SDAC. In the immediate future, no further research is foreseen on this topic. Nonetheless as interesting gains in performance were demonstrated, especially for more challenging sessions, this topic might be later again included in the R&D pipeline.

Within the „2030 Future of the Algorithm", a small study was performed on the offshore wind farms. SDAC MSD provided input and defined the scope. This first study aims to assess the technical feasibility of the offshore wind concept. The study scope was limited to cover some offshore wind farm in the North and Baltic Sea. Performing full market assessments was not foreseen to be in scope – therefore, the results are valid for this limited use case (including several simplifications), and cannot be used as a base for any generic conclusions concerning the offshore wind.

In June 2022, a second edition of the workshop on future of the Algorithm was organised with ACER and NRAs. The status of the Euphemia Lab R&D program was presented, and a special section was dedicated to the 15 min MTU implementation, with contributions from both SDAC parties and regulators. It was highlighted that with a continuous and open dialogue about future insights and plans and challenges, we can adapt the SDAC market coupling systems to cope with many future requirements.

For both iteration 7 and 8, the biggest share of the budget was dedicated to the 15 minutes MTU implementation – as for iterations 5 and 6. The diagnosis cost varies between 6,7 % and 8,3 %: it reflects the continuous need to measure improvements and simulate different scenarios for the 15 minutes MTU implementation. The cost of both iterations is 774 000 €, to which is added the amount of 114 000 € for the testing in cloud. The cost for cooptimisation study was 87 000 €; IDA simulation costs (SIDC) was 11 000 €.

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

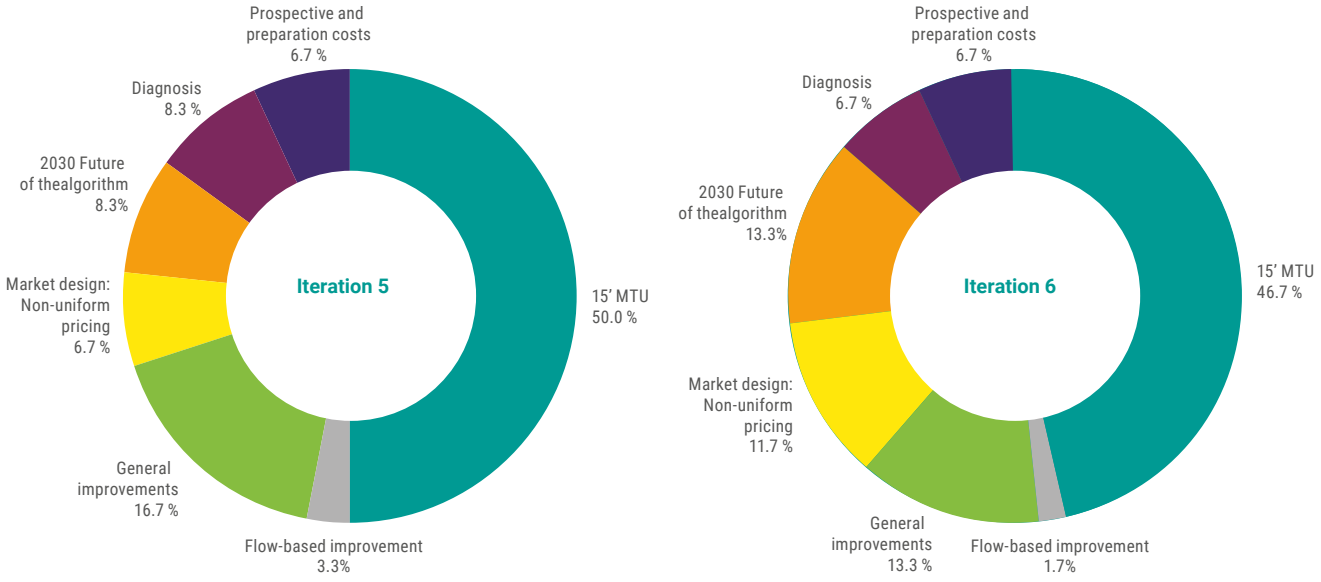


Figure 35

Future R&D

New requirements, market growth and increasing complexity are indeed expected in SDAC, also within the transition to a high-renewables energy system. This shall translate into necessary adaptations of the algorithm, in addition to a continuous improvements needed to maintain the algorithm´s scalability and to guarantee safe operations.

Further R&D research shall thus be conducted to define and develop the appropriate designs.

Though while a lot of attention is naturally being paid to the 15 min MTU implementation, there needs to be also a view and an anticipation of longer term challenges. Therefore, based on a common workshop with regulators, the "2030 Future of the algorithm" work stream is being developed.

In parallel to this, Euphemia has already incorporated requirements for the SIDC Intraday Auction (IDA), expected to go-live in 2024. Further cooperation shall be ensured between SDAC and SIDC, to reflect the future IDA needs of requirement implementation.

For the 15 minutes MTU implementation:

- Further software improvements have been analysed in 2023;
- The expected go-live set-up, together with the product portfolio, shall be finalised in 2023, relying also on research and simulation results;
- Risk Management is required to make sure the algorithm can cope in time with the most challenging GL scenarios. For this purpose might be further explored the corrective measures (art. 12 of Algorithm Methodology), and different fallbacks in heuristics.

For the mid-term horizon, the following topics are among those that might require (further) research and development efforts:

- Continuation of the stream "2030 Future of the algorithm" based on the workshop in 2021 with ACER and NRAs
- Further progress within the co-optimisation is also dependent on having additional and more thorough inputs from research (to be conducted).

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 behaviour...

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 it actual usage in production. This time is due to the finalisation of developments and a comprehensive testing.

R&D programme for the price coupling algorithm – ITERATION 7

R&D topic	Description	Iteration #*	Share of Iteration workload and budget	Share of both iterations workload and budget	
15 minutes MTU	15 minutes MTU support for the go-Live: improvements of numerical stability (e. g. scaling repairing mechanisms, etc.), algorithm adaptations and simulations based on selected corrective measures	7	26.7 %	13.3 %	
	Dedicated software improvements in order to increase performance asnd robustness: adaptations, testing, simulations, debugging, tuning	7	23.3 %	11.7 %	
Flow-based improvements	Various FB improvements: support for the Core FB go-live in June 2022, other improvements	7	3.3 %	1.7 %	
Heuristic algorithms	Follow-up tracks from iteration 6: follow-ups on volume problems redesign (linearisation), application of outer approximation in parts other than root nodes	7	16.7 %	8.3 %	
Market design: Non-uniform pricing	Non-uniform pricing study IV: prototyping and simulations according to the program proposed at the end of the study 3	7	6.7 %	3.3 %	
2030 Future of the algorithm	Future of the algorithm 2030: stream initiated following the conclusions of the 2021 workshop with ACER and NRAs	7	8.3 %	4.2 %	
Diagnosis	Diagnosis	7	8.3 %	4.2 %	
Prospective and preparation costs	Wrap up prototype iteration 7	7	6.7 %	3.3 %	

*The Iteration 4 (September 2020 – February 2021) is presented in the 2020 CACM Annual report; Iteration 5 and 6 took place from March 2021 until March 2022.

Table 14

	CACM compliance	Outcome and impact on CACM compliance	Implementation in production (forecast)
	15 minutes MTU implementation	Major improvements coming from the Euphemia Lab are noticeable, with max / average TTFS reduction.	E11.3 and potentially the following release
	Scalability improvement	Simulations performed. Adaptation of parametrization initiated, identifications of weaknesses and potential mitigations. Exploration of further benefits of applying outer approximation.	To be further investigated
	Scalability improvement	Analysis on presolve improvements and potential rounding and its impacts.	N/A
	Scalability improvement	OA for all-kills price problems: ready for industrialization. Further potential improvements identified (OA in the master computer).	E11.3
	Scalability improvement	Adapting the non-uniform pricing prototype to support 15MTU & Analyzing the impact of the addition of a price adjustment limit on the performances of the prototype.	To be further investigated
	N/A	Preparation of the study on the offshore wind.	To be further investigated
	N/A	Simulations run and analysis performed. Recent production and forward looking batches helped to identify specific challenges to be adressed.	N/A
	N/A	N/A	N/A

R&D programme for the price coupling algorithm – ITERATION 8

R&D topic	Description	Iteration #*	Share of Iteration workload and budget	Share of both iterations workload and budget	
15 minutes MTU	15 minutes MTU support for the go-Live: further improvements depending on the upcoming tests with new batches (big focus on volume problems); implementation and harmonization of fall back procedures in case of risks of decoupling (leveraging it.7 results)	8	35.0 %	17.5 %	
	Dedicated software improvements in order to increase performance and robustness: adaptations, testing, simulations, debugging, tuning	8	11.7 %	5.8 %	
Flow-based improvements	FB Improvements	8	1.7 %	0.8 %	
General improvements	Outer approximation: further tuning and improvements	8	13.3 %	6.7 %	
Market design: Non-uniform pricing	Non-uniform pricing study IV Part 2: on Gaming ; integration of outer approximation and update of the prototype, simulations	8	11.7 %	5.8 %	
2030 Future of the algorithm	Future of the algorithm 2030: stream initiated following the conclusions of the 2021 workshop with ACER and NRAs	8	13.3 %	6.7 %	
Diagnosis	Diagnosis	8	6.7 %	3.3 %	
Prospective and preparation costs	Wrap up prototype iteration 8	8	6.7 %	3.3 %	

*The Iteration 4 (September 2020 – February 2021) is presented in the 2020 CACM Annual report; Iteration 5 and 6 took place from March 2021 until March 2022.

Table 15

	CACM compliance	Outcome and impact on CACM compliance	Implementation in production (forecast)
	Scalability improvement	Sufficient performances are reached for main scenarios (numerical stability improvements in the post-processing problems lifting volume indeterminacies). Risk Management is required to make sure the algorithm can cope in time with the most challenging GL scenarios.	Expected in E11.4
	Scalability improvement	A plug-in "prototype" created, simulations performed with promising results.	To be further investigated
	Scalability improvement	Exploration of presolve strategies	Analysis provided ?
	Scalability improvement	Finetuning of the mechanism (master computer), adaptations wrt the solver	Expected in E11.4
	Scalability improvement	Creation of a dedicated Simulation Framework: allows to run the NUP prototype iteratively for a chosen session, possibility to modify the orders based on the results and a specific strategy. Updates of the prototype, including the outer-approximation, simulations performed.	N/A
	Scalability improvement	Offshore bidding zone study performed.	Delivered
	N/A	Simulations run and analysis performed. Recent production and forward looking batches helped to identify specific challenges to be adressed.	N/A
	N/A	N/A	N/A

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 constrain for set of cross-zonal interconnectors)
- Ramping constraints
- Explicit capacity requests

CACM requirements

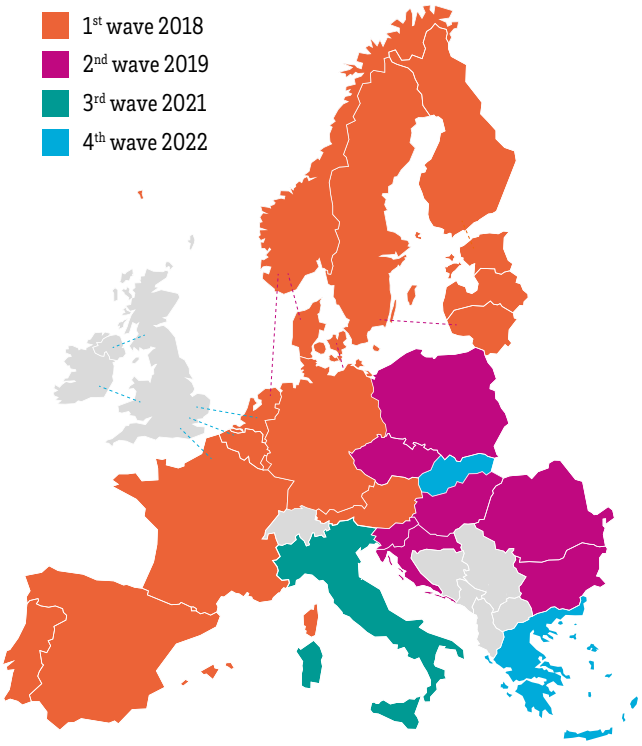
- Adequate scalability
- MNA
- MTU: 15-60 mins

Systems release(s)

- R3.1.8 was updated to R3.1.9 (hotfix) on 13 January
- Major release of R3.2 deployed on 31 January
- R3.2.8 (hotfix) deployed on 24 February
- R3.2.10 (due to DST issue) on 24 March
- System release, R3.2.11 for reporting engine update, on 13 October

Geographical scope

The geographical scope of SIDC was extended in November 2022. The 4th wave adding Greece and Slovakia



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

Figure 36

High level market data

In 2022 we see a significant growth increase in the continuous market. The year of 2022 follows after previous three years with steady increase in annual market volumes since the market go live in 2018. The size of the coupled market in 2022 grew to 110.48 TWh traded – representing almost 89 million trades. In 2021 the traded volume was 93.4 TWh.

"The traded volume in SIDC in 2022 grew to 110.48 TWh, representing almost 89 million matched trades."

The 'topology' of the intra-day coupling market includes 25 countries after the inclusion of Slovakia and Greece in the 4th wave that was realised in November. The SIDC systems handles orders and transmission capacity from 32 bidding zones and 54 borders, 30 TSOs and 16 NEMOs.

There is also a steady increase in number of orders that are executed per day and the number of trades matched. Especially in the last half of 2022 the number of orders and trades increased significantly. The operation of the systems have remained stable with very few incidents and almost no unexpected down time.

The annual average clearing price was around 218 €/MWh for hourly contracts and 274 €/MWh and 253 €/MWh for half- and quarter-hourly contracts respectively. Block contracts tends to be traded with lower average price around 138 €/MWh. Average price traded in the last hour before delivery does not significantly deviate from the average price overall.

- Annual mean price per bidding-zone ranged from 41.00 €/MWh to 328.09 €/MWh. Price levels, are significantly higher compared to 2020 and 2021.

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

Traded volumes (GWh)

Table 16

Annual	Daily average	Daily minimum	Daily maximum
110479	302.68	208.59	476.35

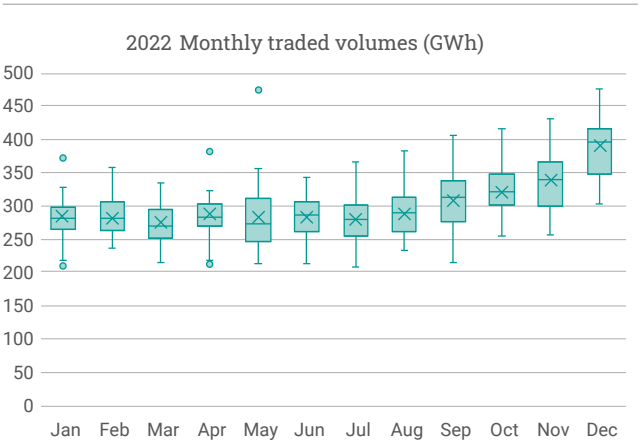


Figure 38

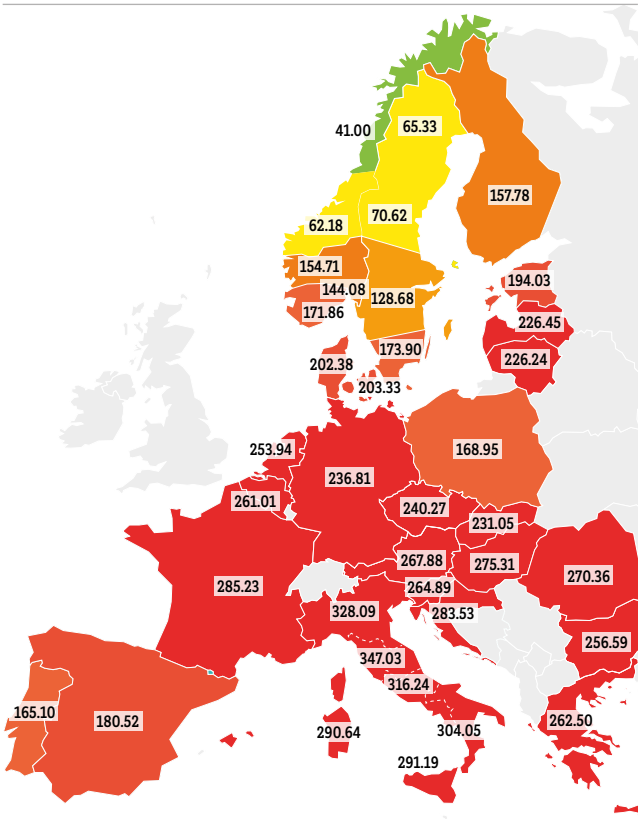


Figure 37

Operations report

This section reports on operational events occurred in SIDC during 2021, including: the incidents, requests for changes decided upon and corrective measures applied.

"The stable operation of SIDC continued in 2022."

Incidents

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

- 2022 brought even lower number of incidents than 2021. SIDC experienced 9 incidents in total – 4 incidents less than in 2021. One of these were not related to MCO function (incident caused by local issue).
- The one critical incident in 2022, i.e. that led to a Market Halt, was caused by missing validation of quantity when modifying an iceberg order. A system bug was identified. The issue resulted in 46 minutes of unexpected outage in the XBID operation.

Incidents 2021

Table 17

Date	Real duration	Comments and observations
25.07.22	46 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.

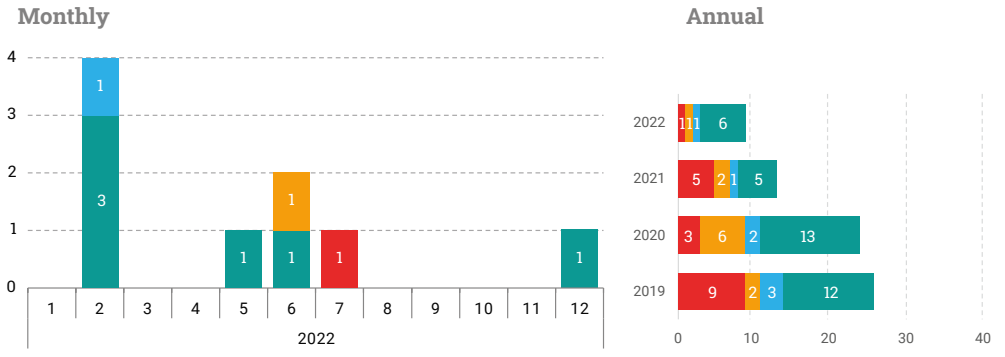
- Altogether 15 RfCs were implemented in 2022.
- 9 RfCs were related to update of requirements set on various Interconnectors as requested by TSOs.
- In July one new border was integrated; the Hungary-Slovenia border. In October 15 min resolution and products were implemented between Romania and Bulgaria.
- Two RfC were implemented to improve usability of the systems.

Corrective measure (CM)

No CM has been applied in SIDC during 2022, as no relevant performance deteriorations have been recorded during the year.

Incidents

Severity



Severity 1
Incidents that lead to stopping ID trading

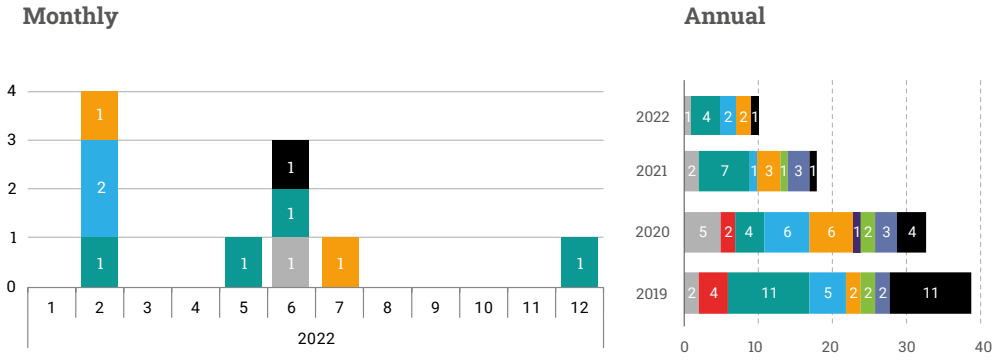
Severity 2
Incidents that lead to closing interconnector(s)/area(s)

Severity 3
Incidents that were visible to participants

Severity 4
Incidents that caused the breach of a critical deadline or any other major incident

Figure 39

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 40

XBID core failover activation

The central SIDC System is operated on the technical platform referred to as XBID Solution. The XBID Solution is constructed in the high availability mode which allows for operation of two instances in the independent data centers. In case of the technical issue in the one data center the XBID Solution fails over to the second datacenter.

Scope of the impact (Severity 1)

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

Description of the incident on 25 July

In 2022, there was one Severity 1 incident leading to halt in trading and to intervention of the technical staff operating XBID Solution:

- XBID core failover was received and Shared Order Book (SOB) WebGUI, was impossible to access. The XBID system was automatically halted.
- The incident happened because of the missing validation of quantity when modifying an iceberg order.
- If the Iceberg is matched in a way that it tries to route the invalid quantity, it crashes the core.
- The issue resulted in 46 minutes of unexpected outage in the XBID operation.
- Bug fix has been developed and deployed, assuring that there is a validation check whenever an Iceberg order is modified so that if new quantity doesn't adhere to the low size, the change will be invalid and not effective, preventing matching of invalid quantity.

Description of the incident(s)

Following the incident, transmission capacities for Germany were not available for 16 hours and 34 minutes. TSOs using auto-publish functionality were reminded that manual upload of capacities is necessary after XBID crash. (first auto-publish will not happen after gate-opening).

Public incident report

Details of the 25 July incident can be found in the published incident report on NC website.

Request for change (RfCs)[2]

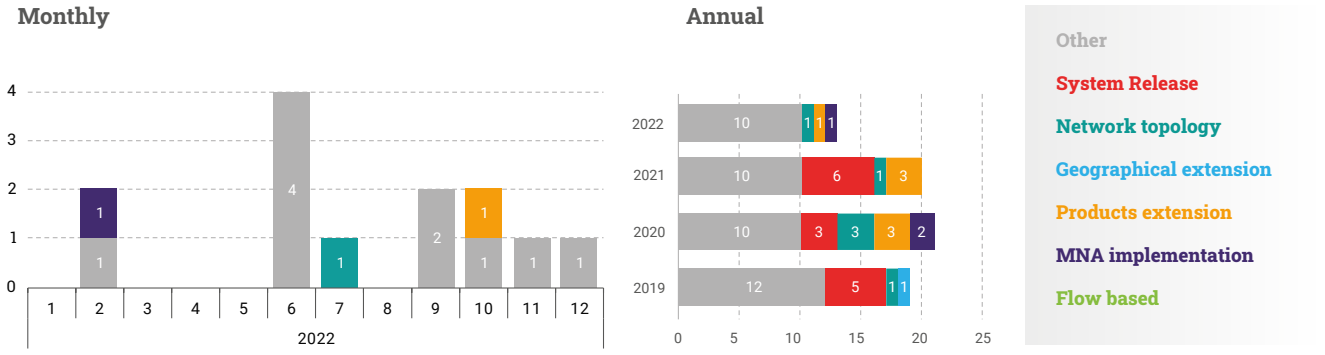


Figure 41

Table 18

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)
MNA implementation	CCP & Shipper role activation for EPEX/ECC in Poland	2022/02/02	CACM	g,	NEMOs	CCP extension
Other	ITCOUPL-ITNORD Max capacity update	2022/02/15	Other	a,	TSOs	Interconnector update
Other	Adjustment of values in CMM with CORE FB MC	2022/04/04	Other	a,	TSOs	Interconnector update
Other	Adjustment of Min Capacity Values in XBID CMM	2022/04/15	Other	a,	TSOs	Interconnector update
Other	Configuration PROD CMM max-min NTC change for HU-RO	2022/06/05	Other	a,	TSOs	Interconnector update
Other	NO3-NO5 max capacity change	2022/06/06	Other	a,	TSOs	Interconnector update
Other	Configuration PROD CMM max-min NTC change for HU-AT	2022/06/13	Other	a,	TSOs	Interconnector update
Other	CEPS-APG, MAVIR-APG and ELES-APG Capacity limit adjustment	2022/06/30	Other	a,	TSOs	Interconnector update
Network topology	New Border, InterConnector-HU-SI	2022/07/04	CACM	g,	NEMOs/ TSOs	New interconnector
Other	Adjustment of Operational Time Unit values in XBID CMM for borders BE-NL (and DE-BE/ Alegro included either)	2022/09/15	CACM	a,	NEMOs/ TSOs	IDCZGOT prerequisity
Other	ECP Upgrade to version 4	2022/09/22	Other	a,	TSOs	Improve usability
Products extension	15 minutes resolution and products RO-BG	2022/10/01	CACM	a,	NEMOs/ TSOs	IDCZGOT prerequisity
Other	Increase of Ramping limit on the Bidding Zone Border DK1-DK1A	2022/10/08	Other	h,	TSOs	Interconnector update
Other	Change of Publish Time of Default Capacity	2022/11/07	Other	a,	TSOs	Interconnector update
Other	TSO configuration for SvK with ECP Endpoint ID	2022/12/21	Other	a,	TSOs	Improve usability

Performance monitoring report

For performance monitoring, the indicators listed in the annex 4 of the AM have been considered for all the days of 2022. The maximum, minimum and average values observed throughout the year are reported in the following slides. Where relevant, monthly values are also reported. Notes and explanations on the calculation of these indicators are included as asterisks below the diagrams in the slides where relevant.

"With significant increase in activity, number of orders and trades; the performance of the system has remained stable throughout 2022"

Usage Indicators

The majority of the available data reflects the network topology with 51 market areas, 11 NEMOs and the product types available; hourly, half-hourly, quarter-hourly and blocks. The data for the last period of 2022 contains additional 2 market areas/NEMOs as the geographical extension with Greece and Slovakia took place as the end of November 2022.

The analysis of monthly values regarding executed orders and trades shows an upward trend.

Performance Indicators*

The analysis of daily values, in terms of processing time, shows a stability in the values for the lower percentiles in the indicators and an increment of the variations in the values for high percentiles.

The performance shows stable processing times which is due to algorithm performance optimisation of the SIDC, implemented on the hardware and software levels, and deployed shortly before the start of the 2nd wave in end 2019 thought there is an increase in the processing times in 2022 in comparison to 2021 which is mainly due to a significant increase in trading activities as demonstrated by "Rate of executed orders/trades".

The 4th wave of the SIDC geographical extension has increased the SIDC topology by a 2 market areas, borders and interconnectors without any impact on the performance indicators.

Output Indicators

The "total matched – hours to delivery" indicator shows that more than 75 % of the volumes daily traded are exchanged starting from the fourth hour prior to 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 19

Usage indicators	2019	2020	2021	2022 Avg	2022 Min	2022 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 order per product and per bidding zone	Not available	Hour ½-hour ¼-hour Block	26 674 4 939 155 110 86	41 214 9 826 272 364 4 940	1 1 32 1	1 621 537 97 576 2 913 014 1 408 048
Total daily submitted order volume per bidding zone (MWh – Avg, Min, Max)			86 928	305 700	0	79 111 730
Total number of explicit capacity allocation request (Avg, Min, Max – per day)	Avg 2 000	Avg 399	Avg 412	Avg 602	Min 376	Max 1 208
2) Indicators to describe the geographical extension (Annex 4 of AM Article 9) [10]						
Total number of NEMO (per end of year)	10	10	11			13
Total number of delivery areas* (per end of year)	34	32	33			35
Total number of bidding zones* (per end of year)	31	29	30			32
Total number of interconnectors (per end of year)**	62	59	62			67
Total number of borders (per end of year)	48	48	51			54
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	30	2 371
Total number of occurrence of Biding Zone net position ramping constraints****	–	–	–	–	–	–
Total number of occurrence of Biding Zone net position volume constraints****	–	–	–	–	–	–

* Delivery areas required for system setup shall be excluded (with Morocco and Russia, Italian virtuals): same applied for MA, IC,BR (TN _DA =51)
** 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 20

Usage indicators		2019 Avg	2020 Avg	2021 Avg	2022 Avg	2022 Min	2022 Max
Algorithm scalability (Annex 4 of AM Art. 7)							
a) Time for the execution of an order (milliseconds)*	Lower percentile 93 %	36	16	18	28	14	136
	Upper percentile 96,5 %	48	21	26	41	19	274
b) Rate of executed orders (number per day)		708 934	1 645 724	2 532 418	4 214 466	2 481 017	6 829 925
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)		63 898	109 965	166 866	243 753	155 024	405 604
e) Time for generation of post coupling files (milliseconds)		10 917	15 001	11983	12 137	8 548	50 369
f) Time for processing an order book update (milliseconds)**	Lower percentile 93 %	63	28	31	34	21	74
	Upper percentile 96,5 %	113	36	44	56	32	156

* 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 are stable and only marginally increased in 2022. The longer processing times in February were due to a performance issue caused by the blocking operation on the logging mechanism which is used for rolling log files on an hourly basis. This behaviour was introduced with Release 3.2. The performance degradation was fixed by the correction deployed on 24 February.

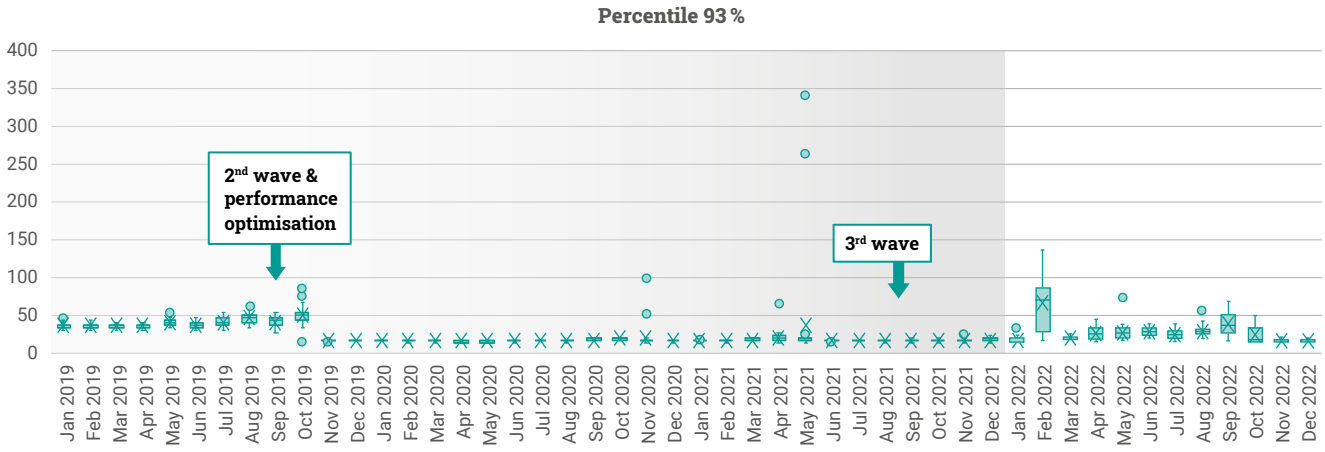


Figure 42

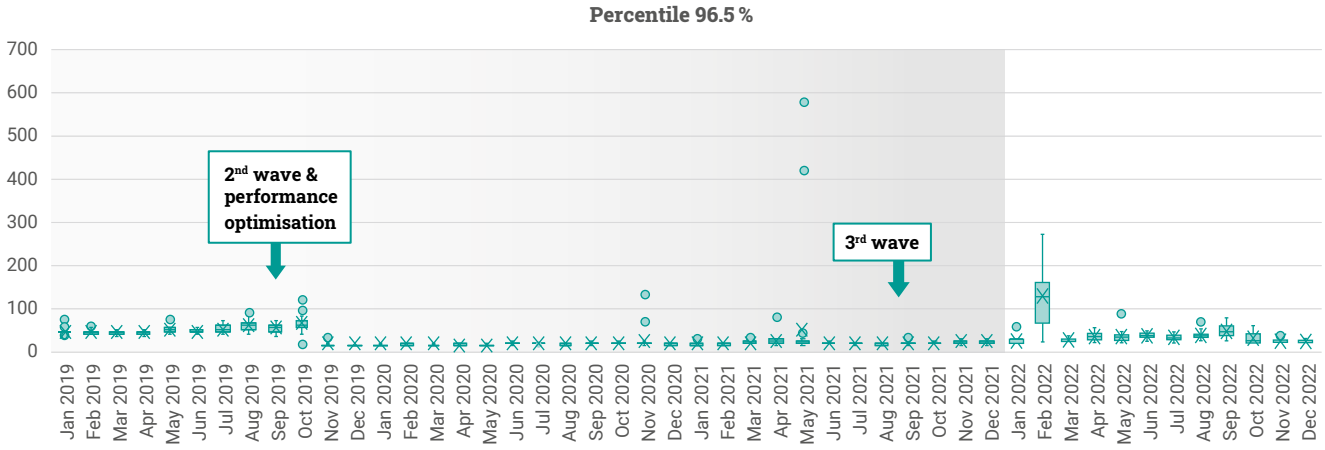


Figure 43

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

The times for processing an orderbook update are stable. The longer processing times in February were due to a performance issue caused by the blocking operation on the logging mechanism which is used for rolling log files on an hourly basis. This behaviour was introduced with Release 3.2. The performance degradation was fixed by the correction deployed on 24 February.

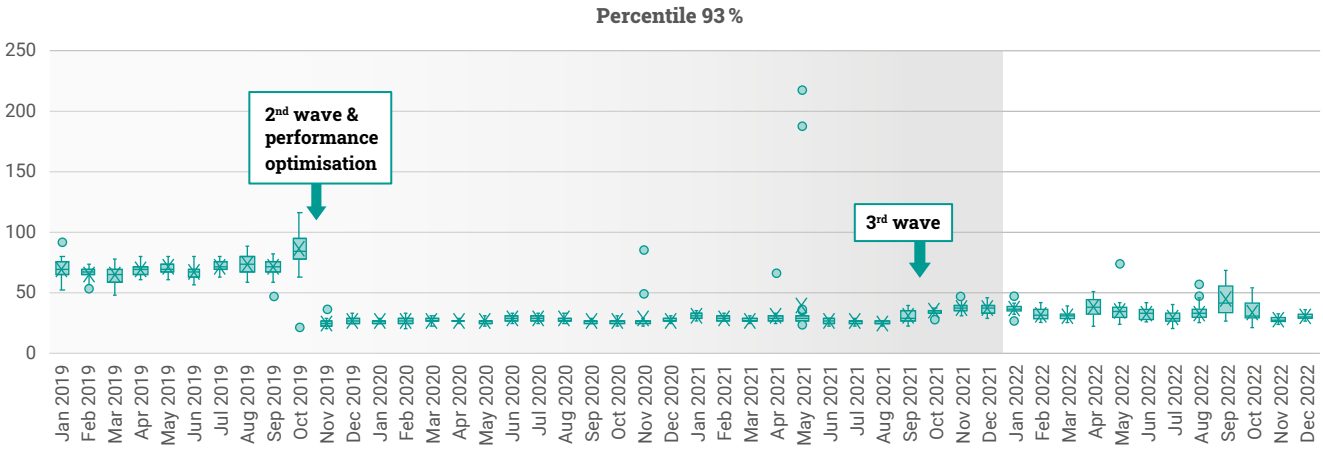


Figure 44

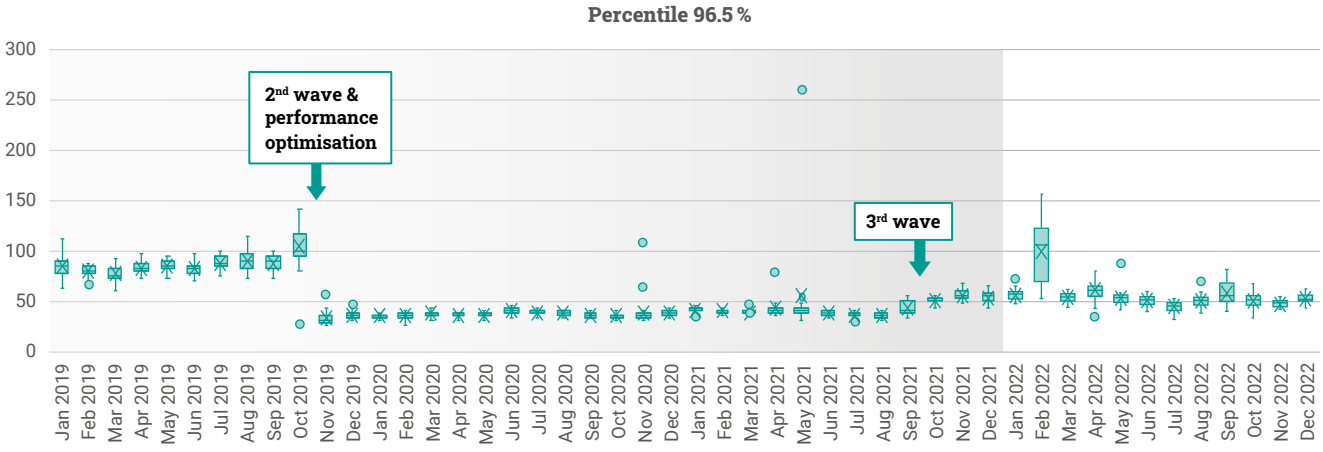


Figure 45

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

Significant increase in the number of executed orders and trades especially through second half of 2022.

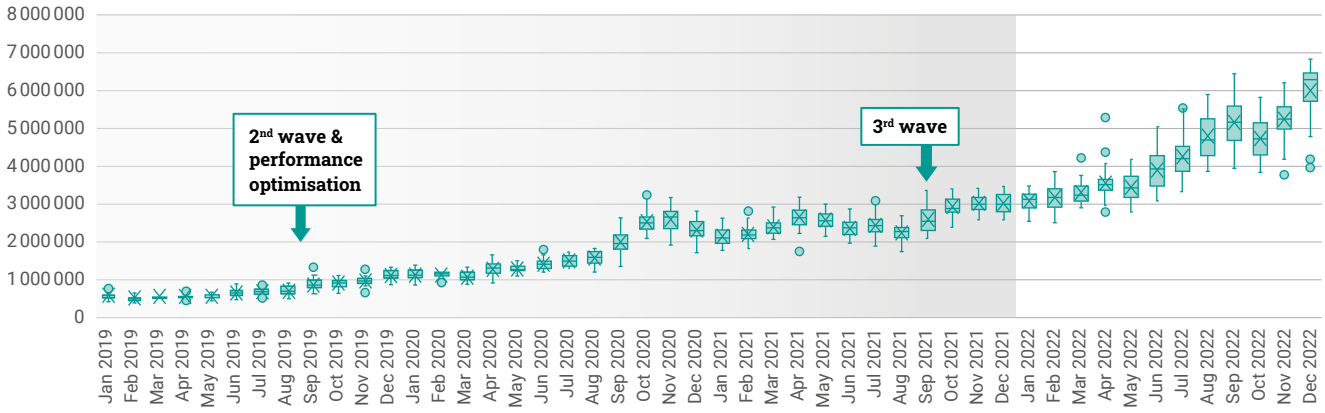


Figure 46

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

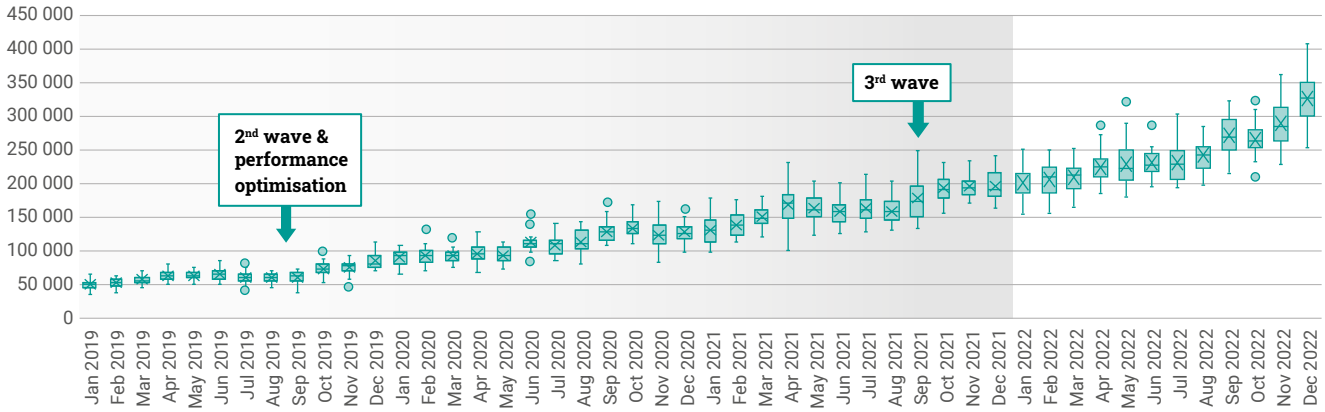


Figure 47

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

Time for generation of post coupling files is stable with no noticeable effect from 3rd wave.

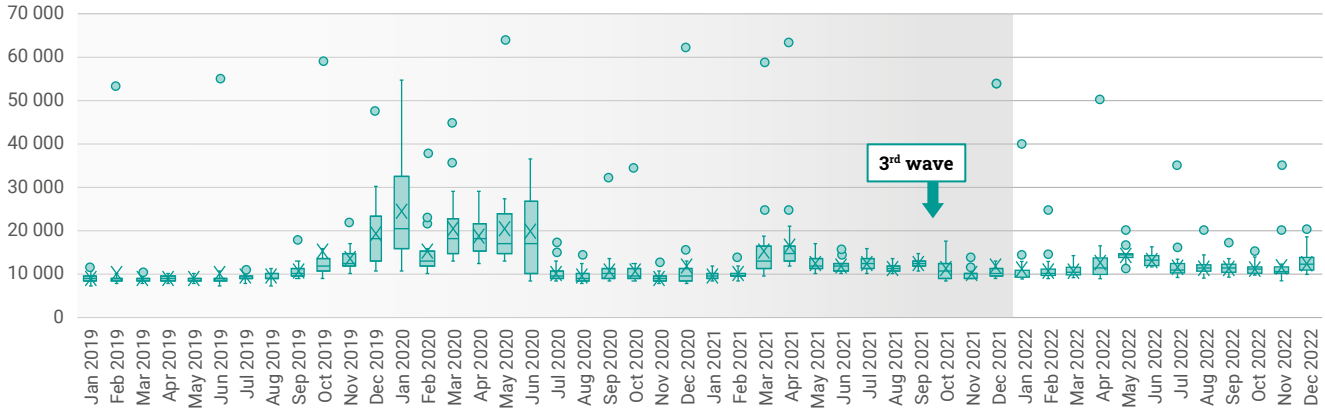


Figure 48

Output indicators

Table 21

Output		2019 Avg	2020		2021 Avg	2022 Avg	2022 Min	2022 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)*	161 425		224 956	256 134	302 681	208 592	476 348
	Total matched volumes – hours to delivery (MWh)	See separate graph						
	Total number of trades per contracts**	Not available			1 468	1 834	1	17 726
	Total number of trades per contract – hours to delivery***				1 952 423	3 640 941	6 287	48 693 028
Number of explicit capacity allocation	Total number of daily explicit capacity allocations	2 124		5 209	5 335	6 762	4 876	8 081
Prices	Volume-Weighted Average Intraday Prices (€/MWh)	39.93	Hour	29.23	97.43	218.19	-1 247.00	1 846.22
			Half-hour	34.63	109.06	274.24	-174.80	2 463.00
			¼-hour	32.44	107.47	253.77	-9 200.00	1 170.61
			Block	25.23	71.61	138.13	-20.00	800.00
	Volume-Weighted Average Intraday Prices – last trading hour (€/MWh)	40.02	Hour	32.00	97.27	213.70	-423.13	3 066.95
			Half-hour	33.74	133.90	263.28	-71.93	2 313.18
			¼-hour	31.58	107.75	251.92	-599.95	1 462.27
			Block	23.67	72.54	141.36	0.00	800.00
	Bid-Ask Spread (€/MWh)	21.58 ****	Hour	24.30	80.63	124.16	0.01	9 783.94
			Half-hour	123.11	115.85	174.58	0.50	10 057.01
			¼-hour	38.98	118.59	272.19	0.01	15 999.98
			Block	204.61	436.02	243.10	-61.28	6 436.65

* 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 0-32 hours before delivery. Avg is average number og contract traded per hour to delivery. Max is number of trades in the last hour before delivery. Min value in the 32 hour before delivery.
**** Data for Bid ask Spread is available only from November 2019.

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.

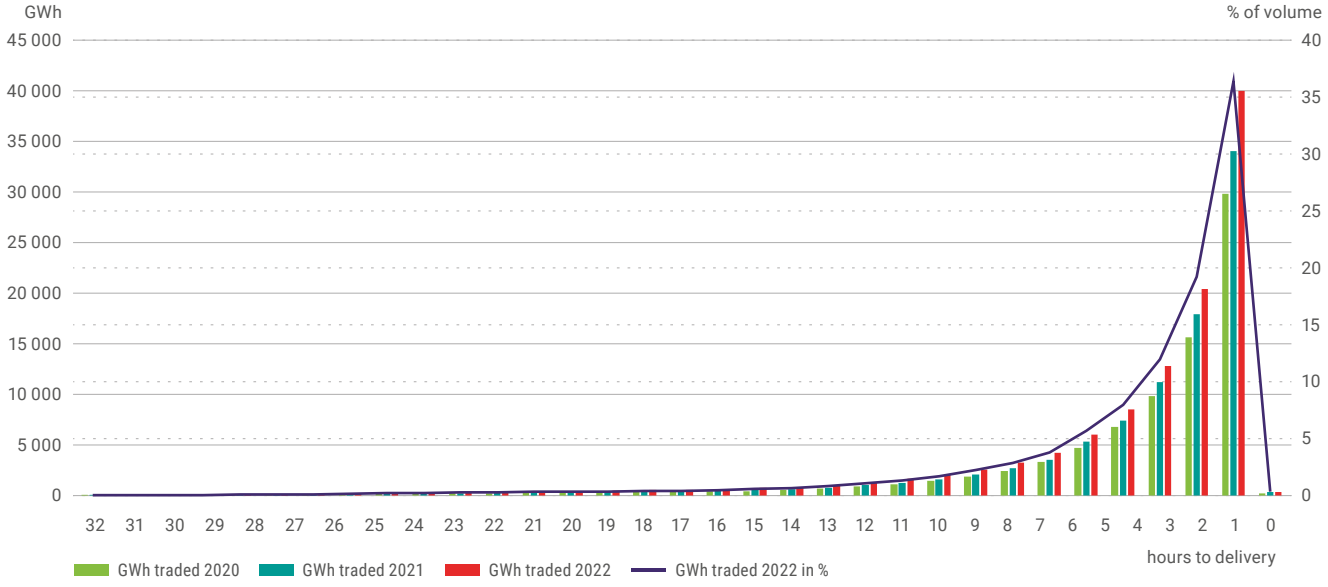


Figure 49

ATC utilization rate per border – both directions

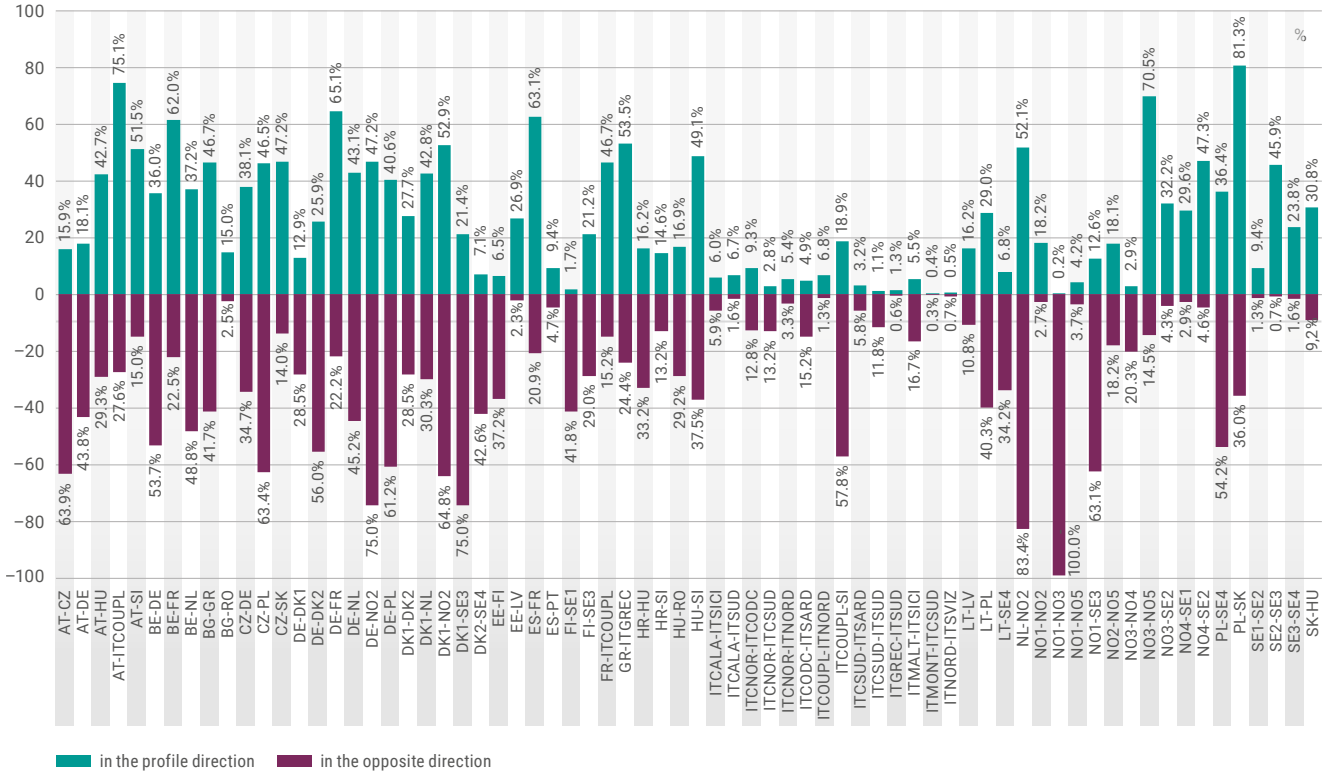


Figure 50

Net position in GWh per bidding zone

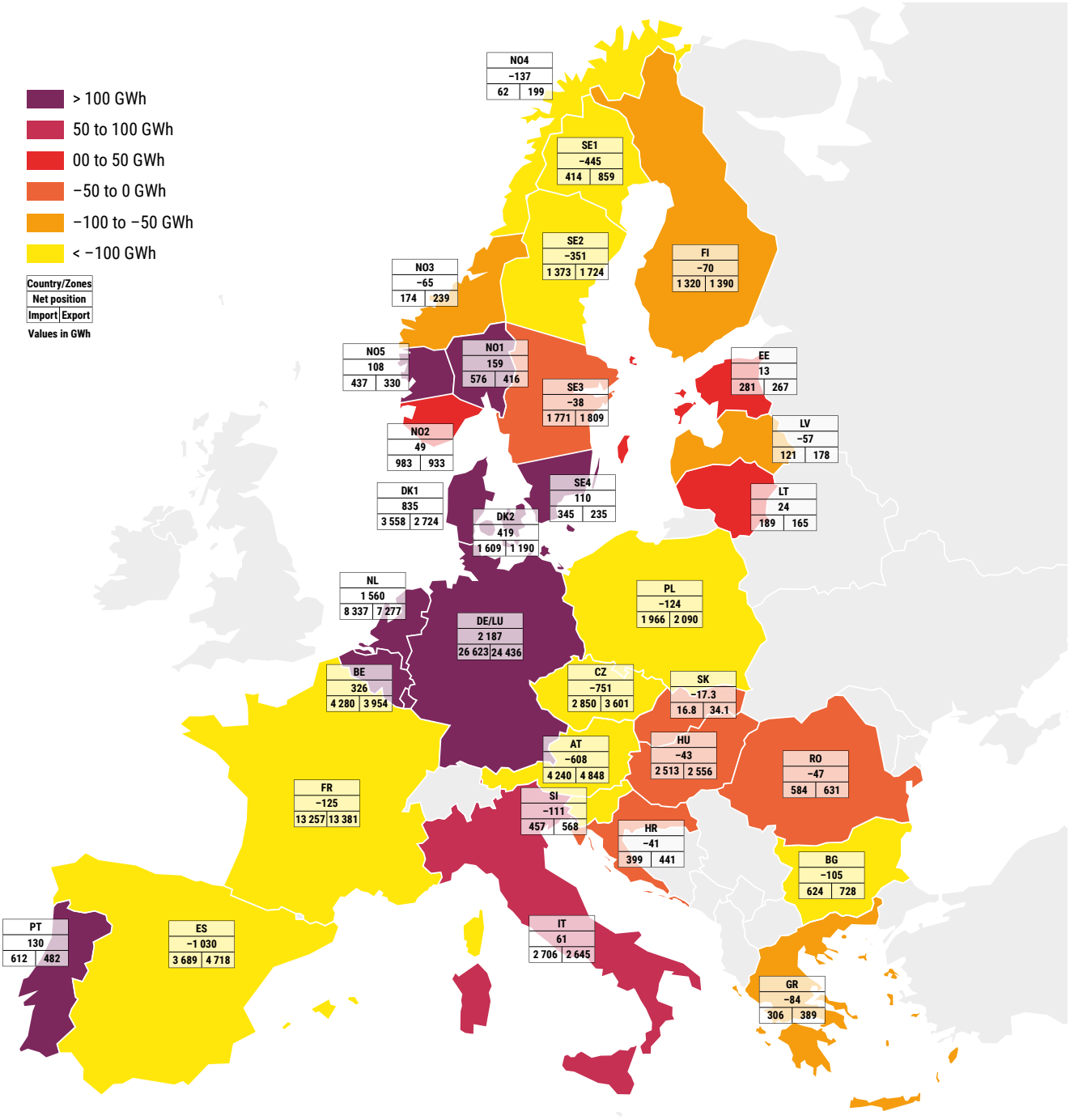


Figure 51

Scalability report[8]

SIDC monitors operational data related to the agreed SLA (service level agreement) regarding time and indicators on a monthly basis. These are used for the prediction of the future load of the system for the period of one year, as well as for future usage of products. The predictions are compared with the results of different stress tests which were executed to explore the behaviour of the system along different stress test scenarios. The stress tests always represent various situations covering, among others, a busy hour of the day.

The increased trading activity has an impact on the key SLA parameters as well as the system boundaries agreed for the XBID Solution. The main system boundaries monitored by SIDC are number of order transactions, number of trades, peak situations.

Therefore, SIDC has adopted in 2021 new scenarios foreseeing a further market development leading to the increase of the system boundaries. The adopted scenarios are labeled as Realistic Test Scenario no 4 (RTS4). The RTS4 reflects the experience gathered during operation of XBID Solution, putting emphasis on the situations which are more likely in the real operation and represent a basis of the scalability report as well as a new system boundaries resulting in the new contractual agreement.

The year 2022 was focused on implementation and testing of new performance optimisation measures with allows SIDC to comply with constantly increasing performance requirements. The performance optimisation measures will be deployed in the operation at the beginning of 2023.

The stress tests, or parts of them, were performed using the latest available version of the SIDC algorithm (R3.3) and did not cover the performance impact of some future RfCs as it is impossible to measure or model the impact of such RfCs in advance.

It has been also proven, in the dedicated performance test of the SIDC algorithm (R3.3), that that SIDC algorithm complies with the expectations defined for the performance improvements introduced in this version.

The impact analysis intends, among others, to validate a possibility of the extension of the number of processed transaction orders (transaction order is an event that manipulates with orders – creation, modification, removal) in order to ensure sufficient scalability for the outlook of the next 3 years.

"Time for execution of an order since 2020 was below the times observed in 2019"

It shall be noted that the technical threshold of the system is above the agreed SLA, however, these boundaries are not explicitly defined. The design of the SIDC Solution handles high peak situations by queuing up the incoming orders which may lead to the extension of the Time for execution of an order.

Time for the execution of an order is measured for every order and evaluated on the regular basis. As stated in the performance report the Time for execution of an order for 2022 grew up in comparison with the year 2021, still it was faster roughly by 25 percent in comparison to the previous years (consequence of the performance optimisations deployed at the end of 2019). Note that this is due to a constant increase in the trading activity –Rate of executed orders group up in 2022 in comparison to 2021 by 66 %.

Response time indicators contractually agreed via SLA for Order execution and trade capture response are 895 milliseconds for Lower percentile (93 %) respectively 1790 milliseconds for Higher percentile (96.5 %). Hence the current average utilisation of the SIDC solution in terms of the response times is well below 5 % of the contractually agreed parameters.

The scalability report of the roadmap provides an indication of the intended go-live period for listed RfCs. The go-live period may be subject to revisions reflecting the SIDC prioritisation process which considers the regulatory, technical and commercial aspects of RfCs and introduces an aspect of planning flexibility.

Development of key system boundaries

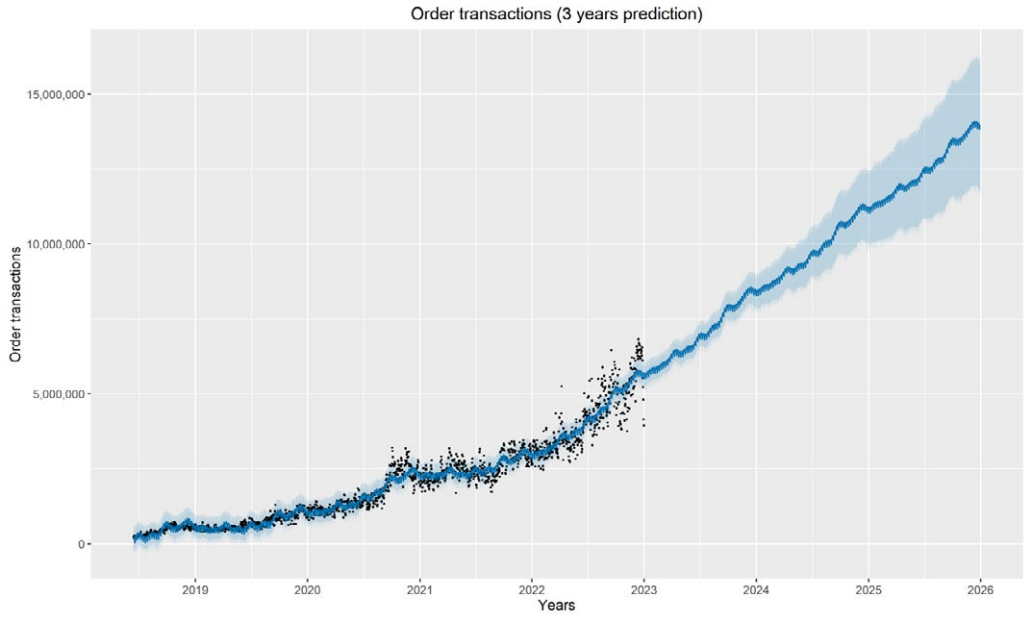


Figure 52

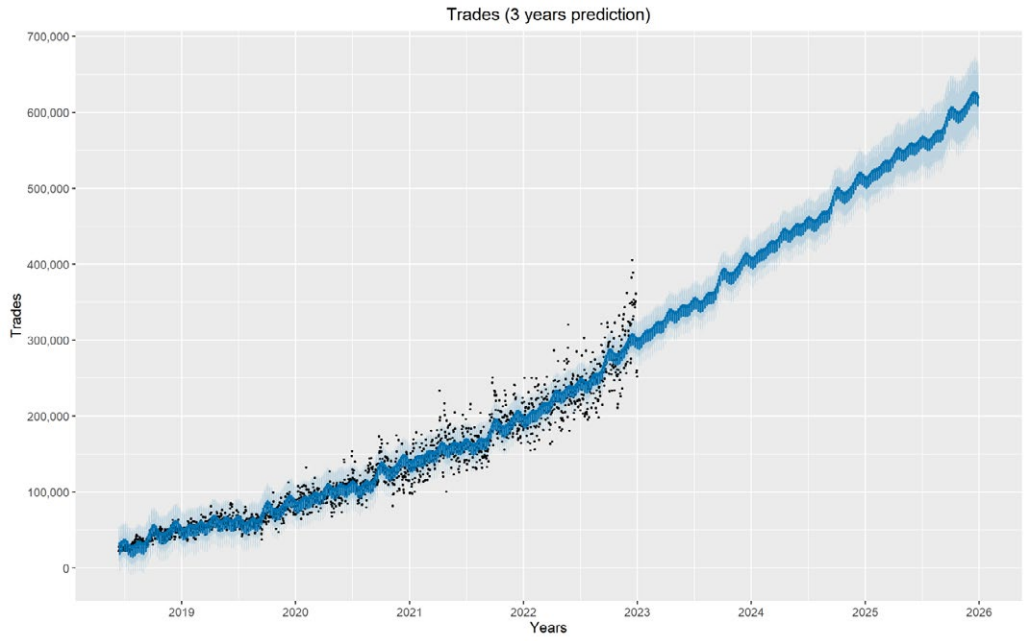


Figure 53

Growth prediction based on technical time series analysis:

- The blue line shows the middle scenario which reflects the constant growth in the trading, considering known seasonality components. The spread indicates a potential development of the growth in the trading in case the trading deviates from the expected trend. Logically, the probability of deviation growth with the time.
- Peak load situations are evaluated monthly as a part of SLA Performance reports analysis.

Summary: The charts indicate that with the application of above-mentioned assumptions in combination with the prediction based on technical time series, the SBs will breach currently contractually agreed SBs (10 million for order transaction; 600 thousand trades) for order transactions in H2 2024 and for trades in H2 2025. In 2022 we could observe more dynamic increase in the number of order transactions and trades leading to the slight exponential increase.

Synthetic chart showing growth prediction, tested system performance and agreed SLAs via triangular chart:

The simulation is based on the average 2022 data (applicable for order transactions, orders and trades), applying a growth factor based on trends.

- The 2022 data are the basis of a triangle.
- The predictions for 2023, 2024, 2025 are expressed as green and blue triangles. The applied ratio between order transactions and orders is identical with the ratio from 2022.
- The agreed systems boundaries, which are applicable since R3.3 deployment (18th of January 2023), are expressed as the red triangle. The performance optimisation for the new system boundaries was a key development in 2022.
- The last, yellow triangle, describes the theoretical situation in which the contractually agreed ratio between trades and order transactions would follow real 2022 data (the number of order transactions form the basis, and the number of trades is derived by the ratio).

Summary: The triangle indicates that with the application of above-mentioned assumptions in combination with the prediction based on technical time series, the System Boundaries will not breach contractually agreed System Boundaries (10 million for order transaction; 600 thousand trades) in 2023 and 2024, however, the above-mentioned assumptions indicates a risk of exceeding of the of the contractually agreed System Boundaries for order transactions in 2025 as the elaboration is based on the average data. This also may imply, as indicated in the previous slide, that on the daily basis the system boundaries may be breached already in 2024. The mitigation measures to deal with the risk, including the magnitude of the risk, are under evaluation.

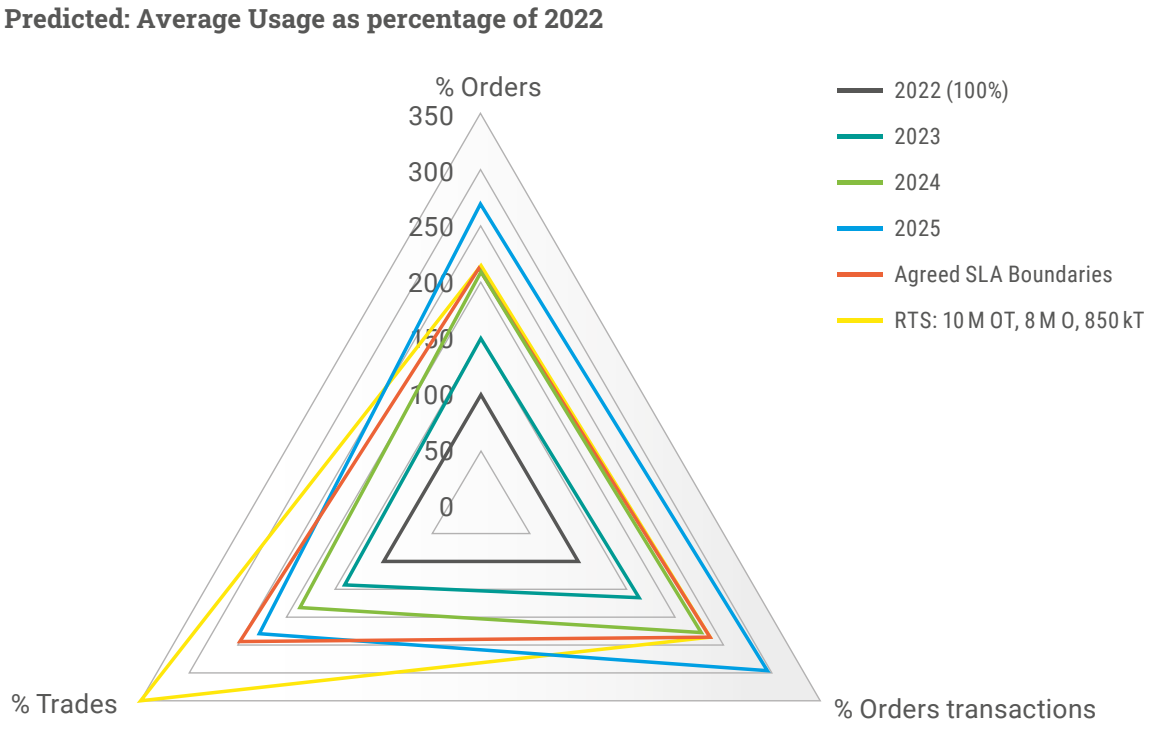


Figure 54

Roadmap of RfCs

Table 22

Requirement	Name	Go-live Date	Reason	Ref. AM article 14.1	Initiator/ Owner	Details	Outcome	Included in scalability study – yes/no
Products extension	15 minutes resolution and products for internal Nordic ICs and BZs (cross zonal)	Q3–Q4 2024	Electricity Balancing Guideline article 53	a	Affected TSOs and NEMOs	Configuration update	Included to assessment	No
	15 minutes resolution and products in Finnish, Swedish and Danish BZs (intra zonal)	Q2 2023	Electricity Balancing Guideline article 53	a	Affected TSOs and NEMOs	Configuration update	Included to assessment	No
	15 minutes resolutions on ICs and BZs and products in whole SIDC (Last remaining countries)	2025	Electricity Balancing Guideline article 53	a	Affected TSOs and NEMOs	Configuration update	Included to assessment	No
	15 minutes resolution and products in whole SIDC (Last remaining countries)	Q2–Q4 2024	Electricity Balancing Guideline article 53	a	Affected TSOs and NEMOs	Configuration update	Included to assessment	Yes
Flow based	Flow based support in SIDC Continuous trading and XBID platform	2026	CACM	a	NEMOs/ TSOs	R & D	Performance impacts mitigations under assessment	Yes
	Flow based allocation in SIDC IDA and IDC	2026	CACM	a	NEMOs/ TSOs	R & D	Performance impacts mitigations under assessment	Yes
Configuration changes	Implementation of DK1A-NO2A and new virtual area SE3A	Q3 2023	Geographic extension	g	Affected TSOs and NEMOs	Configuration update		No
	Configuration Core Capacity Calculation Tool as capacity provider for Core TSOs	Q2 2023	Configuration change for IDCC1		Core TSOs	Configuration update		No
	Alegro DE-BE 15 minutes operational time unit (96 gates)	Q1 2023	IDCZGOT prerequisite	a	Affected TSOs	Configuration update		No
	BE-NL 15 minutes operational time unit (96 gates)	Q1 2023	IDCZGOT prerequisite	a	Affected TSOs	Configuration update		No
MNA implementation	Inclusion of ETPA in SIDC	2023	New NEMO	g	EPTA	Configuarion update + local System development	Included to assessment	No
	Baltic MNA	Q4 2024	CACM	g	Baltic NEMOs	Configuration update	Indluced to assessment	No
Intraday Auctions (IDAs)	Pan-EU Intraday Auctions (IDA)	Q2 2024	CACM	a	NEMOs/ TSOs	System evelopment	Included to assessment	No
Network Topology	New border Baltic Cable in SIDC (TTG-SE4)	2024	Geographical extension	g	Affected TSOs and NEMOs	Configuration update	Included to assessment	No

Table 22

Requirement	Name	Go-live Date	Reason	Ref. AM article 14.1	Initiator/ Owner	Details	Outcome	Included in scalability study – yes/no
System release (approved)	RTS4 Slice B – Performance optimisation/implementation (2nd set of optimisation measures)	2024	Improve security/ performance	d, e, f,	NEMOs/ TSOs	R & D	Assessment completed – Approved	No
	Change of Auction.type attribute in OCC files	Q2 2024	Improve usability/ robustness		TSOs	System development	Assessment completed – Approved	No
	IDA automatic cancellation button	Q2 2024	Improve usability/ robustness		NEMOs/ TSOs	System development	Assessment completed – Approved	No
	Extend Contract Halt function with a selection of direction(s)	Q3 2024	Improve usability/ robustness	e	TSOs	System development	Assessment completed – Approved	No
	TSO Password reset functionality	Q3 2024	Improve usability/ robustness	e	TSOs	System development	Assessment completed - Approved	No
	CMM inbound file covering only part of the day	Q3 2024	Improve usability/ robustness	e	TSOs	System development	Assessment completed – Approved	No
	Mass Trade Cancellation	Q3 2024	Improve usability/ robustness	e	NEMOs	System development	Assessment completed – Approved	No
System release (under assessment)	SM Sent Files FTC revamp II	2025	Improve usability/ robustness	e	NEMOs	System development	Included to assessment	No
	SM – Allocation situational overview	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No
	Capacity Overview Layout Change	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No
	Capacity Overview Screen focus improvement	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No
	Shipping module handover enduring solution improvement	2025	Improve usability/ robustness	e	NEMOs/ TSOs	System development	Included to assessment	No
	CMM Process Execution after System failure	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No
	Scheduled Service Halt	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No
	Multi Contract Modification	2025	Improve usability/ robustness	e	NEMOs	System development	Included to assessment	No
	Partial decoupling Option 2 (IDA)	2025	Improve usability/ robustness	e	NEMOs/ TSOs	System development	Included to assessment	No
	Support for mix of capacity (contract) resolution on VDA connected interconnectors	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No
	NSF file update to explicitly identify to which allocation process the content corresponds	2025	Improve usability/ robustness	e	TSOs	System development	Included to assessment	No

R&D report

2022 Outcomes

The R&D focus in 2022 was mainly on the principal functional extension of the SIDC functionalities, namely Intraday Auctions and FlowBased Allocation.

Intraday Auctions (IDAs)

A selected implementation option of IDAs was further analyzed and developed. The conceptual and performance tests of the key components such as matching algorithm (Euphemia) or capacity allocation module of the continuous trading were executed. During the performance tests simulation of various scenarios was executed. Analysis of the partial (de)coupling process was completed and solution for go-live was agreed.

Cross-product matching (CPM)

Implementation of the 1st part (so called Minimum Viable Product) was finalised included assessment of the performance impact of CPM on SIDC Solution. The analysis of the 2nd part of CPM was finalised. The assessment has proven to have an immense performance impact on SIDC Solution, and an analysis of the proposed performance mitigation measures proved to be very cost demanding on both local and central SIDC levels. Reflecting the CPM implementation cost, the complexity and performance impact of the solution in central and local level, the alternative given with 15' parallel stream and the position of the market participants, the NEMOs and TSOs in accordance with NRAs agreed to put further development of CPM on hold.

Performance improvements

The implementation and testing of the performance improvements for continuous trading was one of the key priorities in 2022 with the delivery in early 2023. Further performance improvements for providing optimised integration of continuous and auction trading (including impact on the NEMOs trading systems) in SIDC were analyzed and agreed for implementation.

Losses

Minor clarification on the open topics such as rounding were addressed. The analysis showed that the losses will have substantial impact on the performance of SIDC which in combination with other functionalities as e.g. IDAs will lead to the substantial investment without a guarantee of the requested performance. Therefore the losses were put on hold.

FlowBased Allocation (FB)

Initial analysis of the FB allocation resulting in the high-level concept was executed. In cooperation with IT provider several approaches for two key aspects of FB were assessed from performance and changes complexity point of view – routing and shipping. This enabled to select the solutions to be further analyzed within Minimum Viable Product.

Major items in SIDC R&D programme

Budget/cost share per topic

The biggest investment of R&D is in IDAs and finalisation of the Minimum Viable Product of CPM. 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:

- 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 the 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.

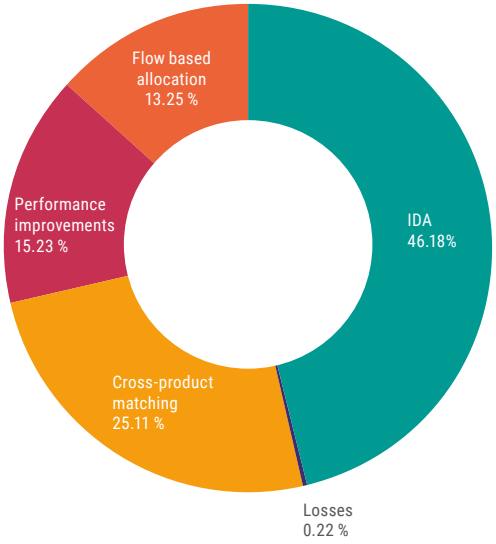


Figure 55

Table 23

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)	46.18 %	Regulatory requirements implementation	Major development and performance testing activities we executed in 2022 for all IDA assets used by (XBID, CIP, Euphemia, PMB).	Foreseen steps: – Validation of SIDC assets – Common Interface Point (CIP), XBID – Validation of SDAC assets – PMB, Euphemia – Functional Integration Test and Simulation Integration Test – Planning of Go Live Activities – 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.	0.22 %	Regulatory requirements implementation	High Level design adjustment proposed clarified (balancing account introduction)	Foreseen steps: – Considering performance impact of losses and SIDC priorities the losses were put on hold
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	25.11 %	Regulatory requirements implementation.	1st part of the design completed, implementation is completed (minimum viable product), 2nd part of the design is completed	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.	15.23 %	Increase performance	The design, implementation and testing of the 1st part is completed – Increase of system boundaries (order transaction 10mil per day, trades 600 thousand), ready for production use. The design of the 2nd part is completed, implementation is ongoing.	Foreseen steps: – Implementation in the production of the 1st part in 01/2023 – Validation of 2nd part (jointly with IDA validation) – Implementation in production: 2nd part Q2 2024 (IDA related optimisation)
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.	13.25 %	Regulatory requirements implementation	High level analysis is completed. Analytical and design activities are ongoing involving DBAG.	Foreseen steps: – Complete discussion with DBAG on High Level Design – Detailed design preparation & Proof of concept including performance analysis (achieved via minimum viable product development) – Implementation in production: earliest 2026 considering impact of other releases foreseen to be delivered prior FB

Annexes

Annex 1: Parameters

SDAC parameters

Table 25

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) 17 min (40 min assumed for scalability scenario 3, but final value to be confirmed) 2) 30.6 min (72 min assumed for scalability scenario 3)	• 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 26

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 non 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, are impacting also product extension to different BZs. Note that the Non-notifiable changes are not included in the list provided. These changes are not directly affecting the MCO function assets, and not causing 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 blot). 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 find (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 12 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 (-0.00404 %), 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 and 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 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 2019 repeatability study, it was run using E11.0 and time limit as 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 different from previous years, in which only reference scenario was run using default configuration and the other scenarios were run using the same special configuration. For 2022 Q4 data it has been observed that the special configuration used in previous years only provided a significant improvement in just one of the scenarios. The other ones delivered same 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, namely 2024, and distant future scenario representing Y+3, namely 2026), which includes anticipated growth of historical usages and anticipated Requests for Changes. Two versions of the Y+3 scenario are considered: the proper version considers the 15′ MTU implementation, whereas a version without 15′ MTU implementation has been added to better allow to assess the impacts from the 15′ MTU implementation. 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 of 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 a proposal for the SIDC Solution improvements which are jointly discussed.

Disclaimer

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

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