Responses from the TSO group to the technical questions on Multi-Region Loose Volume Coupling (MRLVC)

Report by the EU - UK TSOs group

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Context:

On 10 February 2023 the UK TSO's and ENTSO-E were tasked with providing a joint answer to a set of technical questions to the European Commission and the Department for Energy, Security and Net Zero (UK) on the proposed trading solution Multi-Region Loose Volume Coupling (MRLVC), which has been agreed in the Trade and Corporation Agreement between the European Union and The United Kingdom of Great Britain and Northern Ireland, in order to reintegrate GB electricity market into the EU electricity market.

The answers to the set of technical questions are a joint work of the group of relevant TSOs (UK TSOs and the EU TSOs directly connected to the UK). The involved parties have engaged with an external consultant (CEPA), who has conducted quantitative analysis, interviews with relevant NEMOs, market participants, and facilitated workshops with EU experts to provide detailed insight on the technical questions. The joint group of TSO's has retained full editorial rights, and the answers shall thus be seen as the answers of the joint TSO group.

The work builds upon the Cost Benefit Analysis (CBA) carried out in the spring of 2021 and seeks to further investigate and provide insights into the possible MRLVC design options which were proposed and assessed in the CBA. The CBA identified two potential ways forward, a Preliminary Order Book (POB) design and a Common Order Book (COB) design solution, where the main difference is that the POB design uses preliminary order book information as available 15 minutes before gate closure time of the EU single day-ahead market (SDAC). The POB solution was proposed as an alternative to COB in order to avoid the impact of MRLVC on SDAC. The CBA further found that the efficiency of MRLVC would be highly dependent on an accurate so-called Bordering Bidding Zone (BBZ) forecast estimation, which represents the net BBZ position of each BBZ vis-à-vis the rest of the SDAC market and excluding flows between BBZs and the UK.

Findings:

The main findings of this report are:

1. The Preliminary Order Book design option identified in the CBA is associated with a significant number of risks for market manipulation since orderbooks undergo material revisions in the last 15 minutes before Gate Closure Time. Despite existing legal frameworks to prohibit market manipulation and insider trading, no adequate solutions were identified that can sufficiently prevent or identify market manipulation behaviours or that can ensure that such risks can be fully managed or mitigated. It would be very difficult to investigate such situations as orderbook changes could be related to normal portfolio optimisation strategies based on the latest available information or alternatively be a consequence of gaming strategies.

2. The Common Order Book design will take an end-to-end running time within the range of 13-42 minutes (estimated by CEPA) due to uncertainties around calculation times for relevant SDAC and MRLVC processes, and MRLVC results' validation. According to EU experts, a more realistic estimate could be in the range of 20-40minutes. This could lead to a likely delay of at least 20 minutes for SDAC results' publication, considered in normal conditions where fallback procedures do not apply.
   It is further found that it will not be possible to avoid an impact from MRLVC on SDAC, especially in the event of an incident or an exceptional event, as there is an operational interdependence between the two. The extra time required to run MRLVC reduces the operational contingency available to SDAC within the existing operational timings, increasing

the risk of a full decoupling or incurring an avoidable partial decoupling. There is some scope to reduce the impact of such incidents by decoupling MRLVC or using deemed flows, although that could increase the risk of inefficient flows on the MRLVC interconnectors (ICs) and would negatively impact market participants who would be unable to adjust their market positions. Even considering this and considering the number of incidents that has led to either a decoupling or a risk of decoupling over the past years, the best estimate according to EU experts is, that two full decouplings should be expected on a yearly basis.

3. The interval for the running time of MRLVC COB therefore comes with a trade-off between retaining enough time for MRLVC to provide an efficient solution maximising welfare gains, and minimising the risk of negative impact on SDAC.

4. As MRLVC would partially reintegrate GB into the EU electricity market, MRLVC will impact the existing operational procedures and regulatory framework of the GB market. This has not been assessed explicitly in this report. However, GB procedures will have to align with EU market operation procedures e.g., the publication of results from the GB market will have to be at the same time as the SDAC market results' publication, to avoid a situation where results are published in one area and are then unvalidated in the other. Moreover, any partial or full decoupling of SDAC without a rerun of MRLVC due to time constraints, would create a disadvantage for UK market parties who would be unable to hedge their position.

5. If MRLVC is assigned as much time as needed to provide the most efficient result, and taking into account solely the gains from an optimised trading solution, MRLVC can potentially provide improved economic welfare compared to existing explicit allocation mechanisms in the range of approximately €136m per year. The estimation is based on modelling of one reference year and without factoring in some unfunded financial payouts from Use It Or Sell It (UIOSI) towards Long Term Transmission Rights (LTTR) holders in the event of inaccurate MRLVC flow forecasts which would impose an additional loss for interconnectors. The estimated welfare gain of MRLVC over explicit auctions is also heavily dependent on the accuracy of the Bordering Bidding Zone (BBZ) methodology and the resulting forecast. The estimated welfare gain from MRLVC does not consider a number of additional factors. These include the increased risk of failures and decoupling events in SDAC and MRLVC, ramping restrictions, future reductions in trade due to Carbon Border Adjustment Mechanism (CBAM) and lost hedging opportunities for UK market participants in case of a decoupling of SDAC, which does not allow time for a rerun of MRLVC. All these elements will reduce the overall welfare gain from MRLVC.

6. Quantitative analysis confirms that the efficiency of the COB option would be significantly impacted by the accuracy of BBZ forecast. Estimations based on data from a commercial forecaster and from a TSO forecasting tool suggest that the BBZ forecast would be less accurate than anticipated in the CBA but results in better outcomes than explicit allocation. Accurate forecasting of BBZ Net positions is a significant challenge and further refinement, development and testing will be crucial for achieving a sufficient level of confidence.

7. Despite the estimated welfare gain related to trading efficiency compared to explicit auctions, MRLVC shifts risk from market participants to interconnectors, as flows against price differences with MRLVC will result in negative congestion income and foregone welfare opportunity. Under explicit auctions market parties have the possibility to not utilise the obtained transmission rights when the flow is against price differences. Interconnectors do not have the same option with MRLVC, as MRLVC determines a fixed flow and price taking

order. This is relevant for present interconnections, but also for future offshore hybrid projects, as it implies more risk to commercial offshore developers.

8. Quantitative analysis shows that net welfare losses under MRLVC consist entirely of lost/negative congestion income, which are carried by the interconnector TSOs. In addition, TSOs are exposed to shortfalls of congestion income compared to payouts for UIOSI LTTR for all scenarios where MRLVC schedules non-optimal flows. Assuming the entire NTC has been sold, the consultant's estimate for this shortfall is around €80m for the three analysed borders and the considered 12-month period.

9. It has been estimated by the consultant that the implementation time for the MRLVC is expected to be 4 years and 4 months, with both COB and POB designs taking approximately the same time. The overall high-level cost for the MRLVC implementation is estimated at around [redacted] (including 40% contingency), excluding procurement of BBZ net position forecaster and operation and local implementation costs. EU experts have reviewed the timeline and consider it to be realistic, but on the optimistic side.

10. The interdependence between MRLVC and SDAC processes will be very strong. Firstly, MRLVC process outputs will become firm only after SDAC process results are confirmed, so both MRLVC and SDAC will have firm results simultaneously. Secondly, in cases of incidents within the MRLVC or the SDAC processes, issues in one process will impact the other. An appropriate/minimum level of joint governance will be required to manage effectively such risks. Finally, a fallback in one of the processes, be it MRLVC or SDAC, will trigger a fallback in the other process. Time pressures increase the risk of incidents in SDAC, and this is expected to increase the risk of incidents in the MRLVC as well.

11. This report has not examined in detail the extent to which MRLVC is future proof in the light of future offshore developments and changes to both the EU and UK markets. MRLVC and explicit auctions may both face similar challenges with respect to delivering efficient trading arrangements in the context of offshore due to the impacts of their respective mechanisms of price formation, the separate allocation of offshore wind and cross-border capacities, the importance of forecasts' accuracy, amongst others. Evaluating MRLVC performance in relation to offshore will be difficult at this stage without quantitative studies and simulations/modelling. MRLVC performance in relation to 15-minute MTU implementation in SDAC, and future interconnectors becoming operational in late 2020s were also not assessed in detail. However, it is very important to take into consideration these future developments before any further development on MRLVC is initiated, to examine whether MRLVC can cope with future requirements, for instance related to offshore development.

12. A non-exhaustive list of high-level questions/topics to be assessed before initiating any development of MRLVC includes:

    a. How MRLVC will work together with Offshore Bidding Zones, when an OBZ cannot generate its own price and MRLVC does not fix prices but only volumes?
    b. What will be the operational timeline in SDAC when SDAC moves to 15 minutes market time resolution?
    c. What will be the impact of a possible change to zonal/nodal market in the GB market design in the future, for instance the need for a BBZ methodology at the UK side?
    d. What will be the effect on welfare if additional BBZs are included (e.g., Germany and Denmark)?
    e. What would be the implications on MRLVC if some of the current EU bidding zones (NL, FR, DE) would be reconfigured as part of the ongoing bidding zone review?

f. What would be the impact/implications of MRLVC implementation on the local GB market operational procedures, GB NEMOs, and the existing regulatory framework?
g. The impact of the EU Carbon Border Adjustment Mechanism (CBAM) has not been considered, and it is uncertain whether MRLVC will impose any changes in relation to CBAM.

13. Similarly, joint EU-UK guidance for the work will be needed, including acceptance of the interdependencies between SDAC, MRLVC and the GB-market; additional operational risks on SDAC; and that delivery after 2026 is compatible with the Energy Title of the TCA which will remain in force until 30 June 2026, unless extended.

2. Introduction

2.1. Mandate for this report

On 10th of February 2023, Transmission System Operators[1] (TSOs) in the EU via ENTSO-E[2] (EE) and TSOs in the UK received a letter from respectively the European Commission (EC) and the Department for Energy, Security and Net Zero (DESNZ) ("Requesting Parties"). In the letter, EE and UK TSOs are asked to provide a joint answer to a set of technical questions regarding Multi-Regional Loose Volume Coupling (MRLVC), which was agreed in the Trade and Cooperation Agreement (TCA) between the European Union and the United Kingdom of Great Britain and Northern Ireland. The questions build upon the Cost Benefit Analysis (CBA) conducted in the spring of 2021 ("the CBA"). EE and UK TSOs have been given five months to reply to the questions.

The letter states that the parties are invited to engage with third parties like power exchanges and Nominated Electricity Market Operators (NEMOs), and that all information gathered is solely for answering the questions. Unless any specific permission is given by the right holders of the information in these answers, the information shall be considered confidential.

EE and UK TSOs are also required to request for an informal opinion from their respective energy regulators (ACER, Ofgem and Uregni), and to submit these opinions together with the answer to the questions. Based on additional guidance from EC and DESNZ, EE and UK TSOs are asked to provide a joint answer to the questions.

2.2. Approach and methodology for fulfilling the mandate

The provided answers to the given questions are formulated as a joint response from all involved parties. On the EU side, the task to answer the questions has been delegated to the EU TSOs which are directly connected to the UK, namely Eirgrid/SONI, RTE, Elia, TenneT NL, Energinet and Statnett. On the UK side, the UK TSOs consisting of NG Interconnectors (IFA, IFA2, NSL, Viking Link), Nemo Link, BritNed, ElecLink, Moyle, EIDAC, and NG ESO worked together. The collective group of TSOs providing the joint response is for the purpose of this report, referred to as the TSO group[3].

To help develop the answers, the group of TSOs contracted an external consultancy; CEPA, who has subcontracted with Ignis Markets, SmartVision and TAMIS. These parties are, with small adjustments, the same parties who carried out the CBA in 2021. CEPA's support to the group of TSOs in the drafting process of the technical questions included desk research and data collection through interviews/data requests to specific key relevant stakeholders such as NEMOs, market participants, NRAs, and TSO experts. CEPA especially, interviewed and engaged with stakeholders currently involved in the Single Day Ahead Coupling (SDAC) and operating in the markets in and connected to/within GB and carried out quantitative analysis and modelling to complement the answers to specific questions and based on the inputs and data received throughout the interviews.

To provide answers to the question 1a and 1b, the TSO group asked the NEMOs to provide specific data and data analysis, as only the NEMOs are in possession of the data needed to answer these questions. Formally, the ask for contribution has been done through the SDAC Market Coupling

[1] Transmission System Operators are certified owners and operators of onshore and offshore transmission networks in electricity markets.
[2] ENTSO-E is the umbrella body for TSOs operating in the Internal Energy Market (the EU electricity Market).
[3] TSOs group in this report refers to the joint working group of EU - UK TSOs.

Steering Committee (SDAC MCSC) which is made up of EU TSOs and EU NEMOs, and governs the implementation processes for the EU single day-ahead market.

Further, the TSO group has asked SDAC MCSC to contribute with insight and knowledge required to answer the questions 1c-e, question 2 and question 3a. The contribution has been delegated to the SDAC Quality Assurance and Release Management group (QARM) (which includes EU experts)[4], where relevant persons have participated in a number of calls, workshops and discussions led by CEPA.

To gain a view from the market, the external consultants have conducted interviews with a number of organisations and federations who represent different market parties within UK and EU.

Additionally, the external consultants have engaged with TSO forecast tool experts and commercial forecasters to receive relevant forecast data for the analysis done in relation to question 3b on the bordering bidding zone flow forecast.

Despite engaging with external consultants, the TSO group has retained editorial rights on all parts of these answers. This has also been stated clearly in the contract between the TSO group and CEPA. The answers, thus, reflect the views of the group of TSOs.

The group of TSOs would like to thank all involved parties for their invaluable contribution, and the group of TSOs recognises that the contribution has required a substantial amount of work on top of daily business.

2.3. High-level summary and key conclusions from the CBA 2021 report

The CBA 2021 assessed costs and benefits and discussed the various advantages and challenges faced by the operation and implementation of two different MRLVC design options: Preliminary Order Books (POBs) and Common Order Books (COBs). The analysis further compared these two options with the existing, as well as planned at that time, arrangements on interconnectors between the UK and the EU (counterfactuals), i.e. ID implicit allocation (price coupling) as in place for the GB-SEM border, DA implicit (for NSL), DA explicit (as on all other borders).

The two MRLVC design options assessed in the CBA 2021 also reflect the following constraints set out in the TCA annex:

- Data restrictions – MRLVC only has access to order book data for the UK and for the bidding zones directly connected to the UK. It is required to use a forecast for expected commercial flows between bordering bidding zones ("BBZs" – i.e., connected to the UK and the rest of the IEM).
- MRLVC should be a specific process/algorithm and distinct from SDAC (which rules out operationally integrating the MRLVC and SDAC matching processes but does not prohibit the use of EUPHEMIA software in MRLVC).

The CBA 2021 concluded that "*MRLVC is potentially able, subject to the quality of the BBZ flow forecast, to offer improved economic welfare compared to the counterfactual.*" As a consequence, it is clear that a critical feature of the proposed MRLVC design is the use of a forecast for the net commercial flows to or from each of the bordering bidding zones (BBZs) to the rest of the IEM – i.e., a forecast of the net position of each bordering bidding zone, excluding flows between bordering bidding zones and UK, that will be later computed in SDAC. This BBZ forecast would be calculated by the bordering EU TSOs based on a BBZ methodology to be developed in the implementation phase.

[4] 'EU experts' in this report refers to the designated EU SDAC parties that we engage with – this includes the EU TSOs and EU NEMOs.

The CBA concluded that the MRLVC performance would be highly sensitive/reliant to the BBZ flow forecast methodology being able to produce a reasonably accurate forecast, and that the BBZ flow forecast largely determines the quality of, and market confidence in, the MRLVC arrangements.

The main findings from the CBA 2021 assessment were as follows:

1. MRLVC is potentially able, subject to the quality of the BBZ flow forecast, to offer improved economic welfare compared to the counterfactual.
2. TSO congestion revenue under MRLVC is very dependent on the BBZ flow forecast and market conditions, and the impact can vary by border.
3. The Preliminary Order Books MRLVC design option presents major risks in terms of welfare, interconnector revenues, and meeting market needs.
4. The Common Order Books MRLVC design option requires material changes to SDAC timings and processes, which have not yet been resolved.
5. A modified MLRVC may be necessary to support the development and operation of hybrid offshore projects in the North Sea.
6. A poor quality MRLVC adversely impacts the operation of and confidence in the energy markets, including the impact on DAM price formation and the potential loss of forward trading opportunities.
7. Efficient intraday allocation is very important but there are challenges to adopting the MRLVC model for intraday.
8. The interaction of four separate processes (MRLVC, BBZ flow forecasting, SDAC and GB DAM) increases operational and governance complexity.

The CBA 2021 concluded that:

1. MRLVC common order book design is potentially a beneficial solution. This reflects the potential welfare benefits over the counterfactual, and the advantages for the development of a North Sea Hub. The CEPA assessment identified these two major open questions regarding the successful implementation of a well-functioning MRLVC:
   (i) The accuracy that can be achieved by the BBZ flow forecast methodology.
   (ii) The scope for implementing a common order book MRLVC that is consistent with the operational constraints of SDAC.

2. POB MRLVC design is fundamentally flawed. It would face many of the similar implementation challenges to the COB MRLVC design. The main advantage would be that it would have far less impact on the operation of SDAC. The assessment highlighted that the performance risks (and the associated economic and market impacts) of such an option were too great to be acceptable.

The CBA 2021 further highlighted that there were several critical implementation challenges to address related to inter alia, establishing new frameworks, business processes, concepts, etc., and that the implementation costs and timeline for an MRLVC solution were dependent on further clarifications and choices.

These findings and conclusions are the basis of the technical questions which have been sent to the UK and the EU TSOs with the aim of getting further analysis and explanation on how the two potential MRLVC design options can be developed and implemented, taking into account the requirements, processes, obligations, potential risks, costs, etc.

2.4. Structure of the report

This report is structured as follows:

Chapter 1 provides an executive summary of the main findings and key insights on the technical questions.

Chapter 2 has set out the context and mandate for the TSO group on the technical questions, as well as the approach and the methodology undertaken by the TSOs group, with the support of the CEPA consultancy team, to fulfil the task. It also provides a high-level summary of the CBA 2021 findings and conclusions which underpins the technical questions and analysis carried out in this joint TSO report.

Chapter 3 provides a summary for decision-makers (Chapter 3.1.) and an overview of the assumptions undertaken as part of this study and the limitations of data, tools, and constraints that the TSO group has encountered in their work on the technical questions (Chapter 3.2). Chapter 3.3. provides an overview of the key findings on the technical questions, and Chapter 3.4 provides an overview of work in progress on next steps.

Chapter 4 provides the detailed assumptions, data, results/findings on each of the technical questions. To facilitate reading, the questions are organised in function of the main topics addressed:

- Chapter 4.1. provides analysis on the Preliminary Order Book option (including Q1a, 1b, 1d, 1e);
- Chapter 4.2. analyses the operational processes and timescales for the MCO function for both Common Oder Books (COB) and Preliminary Order Books (POB) (Q3a), for the Common Order Book specifically (Q2a, Q2b) and for the Preliminary Order Book specifically (Q1c);
- Chapter 4.3. analyses the BBZ methodology requirements/options for both POBs/COBs (Q3b);
- Chapter 4.4. elaborates on the implementation timelines and costs for the MRLVC solution (Q3c);

Finally, Chapter 5, Technical annex, contains feedback from interviews with NEMOs as carried out by the CEPA consultant team which underpins the findings.

3. Summary for decision-makers

3.1. Summary

TSOs have aimed to objectively and factually address the technical questions raised by the Requesting Parties.

Our aim is to ensure that Requesting Parties have all necessary information made available through the answers to the questions raised to further review the proposed use of MRLVC for day-ahead cross-border arrangements as set out in the TCA.

The key findings of this report are based on supplementary clarifications arising from the technical questions related to:

(i) Preliminary Order Books (POB);
(ii) Single Day Ahead Coupling (SDAC) timings;
(iii) The quality of a BBZ Flow Forecast; and
(iv) Delivery timeframe and associated costs.

Preliminary Order Books

In order for MRLVC to operate, order books[5] are required from both the UK and EU power exchanges. The CBA provided detailed summaries of how final UK order books and a "preliminary" SDAC order book created at the time of the UK submission could be used to run MRLVC in advance of SDAC gate closure. This approach could potentially allow MRLVC computation at an earlier stage within the SDAC process.

Answers to the technical questions raised in this report further emphasise that no adequate solutions were identified that can sufficiently prevent market manipulation if preliminary order books are utilised.

SDAC Timings and MRLVC

(a) To answer technical questions related to COB and SDAC timings in full, TSO's have examined all potential variables that influence and determine how MRLVC could operate alongside the existing SDAC process.

(b) This assessment involved a highly technical and detailed breakdown of SDAC operational process and timings with technical owners of these process, NEMOs and other expert parties contributing and providing unbiased assessment of the feasible introduction of changes to accommodate MRLVC.

(c) In a number of instances, these experts who successfully manage and operate SDAC on a day-to-day basis have raised significant concerns with the feasible use of some of the suggested changes to operational processes that have been examined to accommodate MRLVC.

(d) CEPA estimates that the end-to-end process for calculating MRLVC could take place in the range of 13-42 minutes following Gate Closure Time (GCT). According to the EU experts, a more realistic range to consider is a 20-40 minute impact on the European day-ahead market (SDAC). This

[5] Order Books are the generally used term for the lists of buys and sells from the market, as received and processed by Power exchanges / NEMOs.

means that the implementation of MRLVC will directly impact the SDAC process and increase the risks of decoupling of the European day-ahead market with all its consequences.

(e) There will be a trade-off between on the one hand minimizing the risk of negative impact on the European day-ahead market and, on the other hand, leaving enough time for MRLVC to maximise welfare gains.

(f) Changes such as the paralleling of existing sequential validation routines in SDAC or accepting to stop the EUPHEMIA algorithm after the first found solution for MRLVC are untested. Technical permutations are included in this report to ensure all feasible options are included to fully answer the technical questions raised, but important risks to the robust functioning of the European day-ahead market (SDAC) are also associated with them.

(g) For clarity, TSOs do not recommend following any of these ´technical permutations´ at this stage, specially without any further test or assessment, but all options are presented to provide an overview of the alternatives.

The Quality of the BBZ Flow forecast and comparison of Explicit vs MRLVC

(a) A key finding of the CBA is that MRLVC can potentially provide improved economic welfare compared to existing explicit allocation mechanisms but this is heavily dependent on the quality of the Bordering Bidding Zone (BBZ) methodology.

(b) The reason that the BBZ methodology is so important is that the TCA includes a restriction on the data that can be used in MRLVC – whereby the MRLVC calculation may only use the order book data for GB and BBZs directly connected to GB. This means that a forecast of the Net Position of each BBZ relative to the rest of SDAC is an essential element of an MRLVC design.

(c) TSOs have not yet developed a BBZ tool to complete this task however a) commercial tools do exist that can simulate this activity – albeit they are not necessarily designed specifically for this task and b) regional TSO tools exist to provide already today specific net position forecasts.

(d) TSOs have used such a flow forecasting tool to simulate and assess a) the quality of the BBZ flow forecast and b) the potential welfare benefits that MRLVC could generate using such a flow forecasting tool compared to explicit allocation.

(e) The comparative analysis shows that the simple MRLVC simulation assessment using the BBZ Net Position Forecasts from the commercial forecaster outperforms explicit auctions in terms of lost welfare compared to implicit price coupling. However, the results of the quantitative analysis shows that the accuracy of the BBZ methodology is a significant challenge and it is difficult to obtain very accurate forecasts for all scenarios. The result of the current assessment methodology which directly impacts the welfare benefit of MRLVC compared to explicit auctions is worse than what was expected and presented in the CBA but remains better than explicit, although it should be noted that a direct comparison is difficult because a) 2022 was seen as an unusually difficult year for forecasting, due to high and sharply changing gas prices compared to the CBA period (July 2019-May 2020), and b) the analysis has considered the three borders where there is a recent history of explicit auctions (namely GB-FR, GB-BE, GB-NL) unlike the CBA which considered all borders to GB. MRLVC's very simple simulation presented in the report, shows welfare gain on a subset of relevant borders of about €136 million in 1 year compared to explicit auctions.

(f) Despite the general welfare gain of MRLVC compared to explicit auctions, it must be noted that almost all negative impacts of Flows Against Price Differences and inaccurate flow forecasts are entirely shifted to the interconnector TSOs. They face the downsides as negative congestion incomes and as unfunded Use It Or Sell It (UIOSI) payouts. This will significantly impact the revenue stream of existing interconnectors as well as future (hybrid) interconnectors.

(g) This analysis considers that MRLVC has sufficient time to deliver the most efficient outcome, which means higher impact on SDAC processes.

(h) It is far from certain if BBZ in conjunction with MRLVC will provide better answers to the offshore challenges compared to explicit auctions.

(i) TSOs note that this is a time constrained comparative analysis that relies on an independent third-party modelling tool. It does not capture all of the complexities associated with determining the socio-economic welfare benefits associated with cross-border allocation mechanisms.

Delivery Timeframe and costs

(a) MRLVC is a complex multi-jurisdictional delivery program that will introduce significant change to existing, stable pan-European and UK electricity market places.

(b) Timeline estimations for the implementation of complex projects, like the implementation of MRLVC, is very difficult, especially for the design phase.

(c) The initial estimate of the overall time needed to implement the MRLVC project (for the COB and similarly for the POB designs) benchmarked against similar projects is 4 years and 4 months.

(d) Based on an estimated duration of 4 years and 4 months, the overall high-level costs for the MRLVC and SDAC streams is estimated at around [redacted], including a 40% contingency. This estimate does not include the cost of procuring the BBZ Net Position Forecaster as that is highly uncertain at this stage, as well as operation costs and local implementation costs.

The main body of this report provides detailed clarity on these key conclusions.

3.2. Assumptions and limitations

3.2.1. The wider EU and UK energy policy context

Both Europe and the UK have experienced significant changes to energy policy in the last couple of years since the signature of the TCA. This has meant reform processes in electricity markets in both jurisdictions, alongside a changed geopolitical context.

In view of this, the following section outlines the key assumptions and wider considerations the TSOs view as relevant to the development of the MRLVC, including the design and operation of SDAC and MRLVC, implementation processes and tools, the limitations of the analysis based on information/data availability, and the processes which are out of scope of this assessment:

Future policy and regulatory developments with potential impacts on MRLVC implementation

Work completed on this project indicates that the implementation time of the MRLVC solution would be considerably longer than initially anticipated as per the EU-UK TCA and the CBA.

In this context, EU and GB future policy and regulatory developments in electricity markets over the next 5 years emerge as important factors that should be assessed when considering the implementation of any MRLVC solution.

This report answers the questions posed by the Requesting Parties based on the status quo, without making presumptions about how the EU and the GB electricity markets are going to develop over the next 5 years. The potential impacts of the developments below were only partially considered (through qualitative analysis where possible) or were not considered/assessed at all in the current report, as the implementation time of approximately 4 years and 4 months (compared to the provisional TCA timeline of 15 months) was not known when the work on this report commenced.

The following developments can now be reasonably expected to be in place by the time the MRLVC solution will be implemented. They will have significant impact on the operation of MRLVC and are directly relevant to the questions asked of TSOs:

(i) implementation of the 15-minute MTU in the European market foreseen in the SDAC implementation timeline for 2025; and
(ii) future connection of NeuConnect (which would introduce German order book data into MRLVC) and the Celtic Interconnector scheduled for deployment in late 2020s. The impact of these new interconnectors has not been assessed/considered in this study.

Future offshore developments

The future offshore developments bring significant new challenges at various levels in the energy business, including for market coupling, amongst others. The future developments of offshore hybrid projects will require electricity market trading arrangements that support efficient pricing and capacity utilisation.

An initial (non-exhaustive list) of topics where issues could arise includes:

- Price formation of the (offshore) bidding zones;
- Capacity utilisation for wind and cross-border volumes (e.g., competition between wind and cross-border flows for interconnector capacity, etc); and

- Impact on business cases for investments in hybrid interconnectors and offshore windfarms.

Uncertainty around the future regulatory framework for offshore bidding zones and how it will be incorporated in SDAC/MRLVC present further challenges to evaluating how the MRLVC will perform in relation to offshore compared to for example, explicit auctions. While this report has not examined in detail the extent to which MRLVC is future proof in the light of future offshore developments, MRLVC and explicit auctions may both face similar challenges with respect to delivering efficient trading arrangements in the context of offshore due to the impacts of their respective mechanisms of price formation, the separate allocation of offshore wind and cross-border capacities, the importance of forecasts' accuracy, amongst others. Both methodologies might lead to challenges related to price and volume risks for commercial offshore wind and infrastructure developers, costs for remedial actions for TSOs and the risk of not utilising the offshore capacities to their full potential. These aspects are further elaborated in section 4.3.

Other policy and regulatory aspects

In addition, the following broader policy and regulatory developments could potentially have a significant impact on MRLVC and should be taken into consideration before deciding on the next steps for the project (their potential implications on MRLVC have not been assessed as part of this analysis) and they have not been considered in this report:

(i) Relevant offshore developments in the North Sea/NSEC such as hybrid interconnectors, meshed grids, offshore bidding zones have not been properly evaluated and will require further assessment;
(ii) EU electricity market design reform (2023) and amendments of Network Codes/Guidelines (2024-2025);
(iii) GB market design (Review of the Electricity Market Arrangements) and changes related to the Single GB price;
(iv) GB regulatory changes;
(v) EU Bidding Zones Review process (2024-2025);
(vi) TCA timelines for implementation and review (2026), etc.

3.2.2. Assumptions about the design and operation of SDAC and MRLVC

(a) For the purposes of this assessment, a common assumption has been made across both MRLVC designs that there is a single GB price.

(b) At the time of this report drafting, the full operational schedule and procedures for SDAC with 15-minute MTU have not yet been finalised, including the fallback procedures. SDAC is assumed to operate "as-is." Changes such as 15-minute MTU are not included except where explicitly referenced. However, it is likely that 15-minute MTU will be in place when MRLVC becomes operational given what was learned regarding implementation timeframes.

(c) Analysis in this report relating to questions on operational timings, uses the existing SDAC operational schedule, and is further supported by a qualitative assessment of how MRLVC could impact the types of changes to SDAC operational schedule which could be expected under the shift to a 15-minute MTU.

(d) It is assumed that the impact of 15-minute MTU on the time to first solution (TTFS) for EUPHEMIA in SDAC is expected to be significantly longer than the current TTFS with 60-minute MTU. This is

a critical indicator of the potential TTFS for MRLVC; although the details of the expected specific timings for SDAC are not available yet.

(e) For the purposes of this report, CEPA has estimated that the time taken to run MRLVC would be within a range of time. This was later determined during the project to be between 13-42 minutes. According to the EU experts, the realistic range to consider is a 20-40 minute impact on SDAC. The analysis by CEPA is based on an optimistic hypothesis of 20 minutes for the purposes of identifying trade-offs.

(f) Any move along the range would involve/require the acceptance of potential quality degradation in MRLVC results and an operational risk of overrun in the European single day-ahead market (SDAC).

(g) The report tests several hypotheses (lower range and higher range) to provide insight on the impact of the MRLVC end-to-end timings on SDAC in order to better understand the possible options. This is done in order to demonstrate trade-offs between the quality of the MRLVC process on one hand, and on the other hand reducing the impact on the SDAC processes and timings, and the interdependencies between the EU and the UK markets. These trade-offs need to reach a level that may be acceptable to stakeholders.

(h) The incremental impact of a lower-quality MRLVC calculation (which may provide certain operational time savings) can only be assessed through appropriate modelling and simulation which would need to be carried out separately from and additional to this work to provide more reliable estimates of timing within this range. Welfare gains of the MRLVC will be impacted directly by the quality of the MRLVC calculation.

3.2.3. Assumptions about implementation process and tools

(a) MRLVC and SDAC streams use existing tools where these are suitable for the needs of the project. Requiring development and/or selection of alternative tools would lead to an additional procurement process. This would lead to longer implementation timescales and more testing cycles. For example, the assumption is that the PCR Matcher and Broker (PMB) and EUPHEMIA tools are used by MRLVC. Although the EUPHEMIA tool used in MRLVC may be configured differently to that used in SDAC (e.g., shorter calculation time for MRLVC), no different branch in the optimisation exercise will be needed. UK and EU authorities would likely need to consider how to set up a joint governance mechanism in this case to manage the tools and their developments.

(b) The governance approach for the MCO function will be based on a contractual agreement between MRLVC NEMOs and TSOs, which will avoid a tender process for the MCO function and/or the need to create a separate entity to perform the MCO function.

(c) In order to have a streamlined effective and efficient testing approach, any changes to tools used in SDAC and MRLVC will be implemented in the same release. SDAC release and test plannings would therefore need to accommodate MRLVC release and planning.

(d) The mutual use of IT systems will require a joint governance process.

(e) A project agreement will need to be signed between the MRLVC TSOs and MRLVC NEMOs before any work will be undertaken by the NEMOs. It is taken as assumption that this task will as much as possible be completed during the period that the MRLVC TSOs are building and validating the BBZ net position forecaster.

(f) The performance of the BBZ net position forecaster is to be established as early as possible in the project, to inform any decision to proceed with spending time and resources on other parts of the MRLVC implementation phase.

(g) It is assumed that MRLVC can use the existing PCR IT tools, e.g., MPLS setup for SDAC, and does not need additional COLT MPLS lines. However, MRLVC TSOs need to connect to the MRLVC systems via a new MPLS connection – which could be a connection between BBZ net position forecaster and the MRLVC PMB directly or through MRLVC NEMO systems.

3.2.4 Limitations to the analysis:

(a) Market participants today send their orders ahead of a 12:00 CET gate closure deadline. They do not consider 11:45 CET as that timing has no relevance under SDAC arrangements. The requested 11:45 CET orderbooks were compiled by all NEMOs individually as no information exists regarding order data before gate closure at the MCO level. The data collected by the NEMOs show the differences between orderbooks available at 11:45 CET and at gate closure which include changes that are either added, modified, or withdrawn per NEMO, without the magnitude of such changes in terms of price and/or volume. The NEMOs provided data summarizing average orderbook changes after 11:45 CET in 2022 (including orders added after 11:45 CET and existing orders removed after 11:45 CET) across all BBZs.

(b) Implementation of new fallback arrangements for SDAC, MRLVC or BBZ net position forecaster are out of the scope of this assessment.

3.2.5 Elements out of scope of the analysis presented in this report include the following:

These processes will be relevant to the implementation of the MRLVC at the local level and can be expected to have additional impacts etc.

(i) GB Price Coupling, a detailed assessment has not been done and will have to be executed by the NEMOs in GB. However, an initial reaction of EPEX and Nord Pool has been provided in Technical Annex 5.1[6];
(ii) Local changes to systems of MRLVC TSOs, MRLVC NEMOs and Relevant Electricity Market Operators (REMOs) and possibly non-MRLVC NEMOs;
(iii) Local changes to systems and operational processes of market participants;
(iv) Modification to the current explicit mechanism to allocate cross-border capacities;
(v) Development of information flows to/from BBZ net position forecaster and to/from MRLVC (e.g. subset of orderbooks);
(vi) Changes to shipping systems;
(vii) Validation processes in local systems;
(viii) Currency conversion; and
(ix) Operational Risk.

These processes will be relevant to the implementation of the MRLVC at the local level and can be expected to have additional impacts etc.

[6] GB NEMOs EPEX and Nord Pool have provided an initial reaction regarding the MRLVC potential impacts on the GB market functioning, governance and cooperation processes. The comments are available in Technical Annex 5.4. They have not been taken into consideration in this report.

Glossary

ACER	Agency for the Cooperation of Energy Regulators
ATC	Available Transfer Capacity
BBZ	Bordering Bidding Zone
CBA	Cost-Benefit Analysis
CET	Central European Time
COB	Common Order Book
CZC	Cross-Zonal Capacities
DACF	Day Ahead Congestion Forecast
DST	Daylight saving time testing of the long- and short clock change
EU	European Union
EUPHEMIA	Matching algorithm used in SDAC
FAPD	Flows Against Price Difference
FIT	Functional integration test
GB	Great Britain
GCT	Gate Closure Time
LTTR	Long-Term Transmission Rights
MCO	Market Coupling Operator
MPLS	Multiprotocol label switching (IT protocol for data exchange)
MRLVC	Multi-Region Loose Volume Coupling
MTU	Market Time Unit
NEMO	Nominated Electricity Market Operator (EU)
OBKs	Orderbooks
OBZ	Offshore Bidding Zone
PAB	Paradoxically Accepted Block (Order)
PCR	Price Coupling of Regions
PTDF	Power Transfer Distribution Factor
PMB	PCR Matcher and Broker
POB	Preliminary Order Book
PTO	Price Taking Order
REMIT	Regulation on Wholesale Energy Market Integrity and Transparency
REMO	Relevant Electricity Market Operator (GB)
SDAC	Single Day-Ahead Coupling: The Pan-European cross-zonal market coupling at the day ahead timeframe
SIDC	Single Intraday Coupling: the pan-European cross-zonal market coupling at the intraday timeframe
SIT	Simulation integration test
TCA	Trade and Cooperation Agreement
TSO	Transmission System Operator
TTFS	Time to first solution (for EUPHEMIA)
XBID	The IT system inside the SIDC

3.3. Main findings to the different blocks of questions

3.3.1. Main findings on Preliminary Order Book design (including Q1a, 1b, 1d, 1e)

(a) The POB design option assumes that the Gate Closure Time (GCT) in the GB market is at 11:45 CET, i.e., 15 minutes earlier than the SDAC GCT, and the preliminary order books from the SDAC BBZs are taken into account for the MRLVC calculation. It is assumed that market participants in SDAC are still free (as they are today) to submit new orders or amend orders already submitted up until the SDAC gate closure at 12:00 CET.

(b) The historical data provided by NEMOs suggests that orderbooks (OBKs) undergo material revision between 11:45 CET and 12:00 CET. This implies that the POB option may result in material inefficiency in the results of the MRLVC process (i.e., flows against the price differential) compared to a fully efficient coupling process, and compared to the current status quo based on explicit auctions and forecasting tool of market participants. It is to be noted that these changes can be either related to normal trading activities as market participants try to use the latest information available ahead of GCT to optimise their portfolios or could also be a consequence of gaming strategies.

(c) Under the POB option, there appear to be multiple gaming strategies that market participants could use to actively distort market outcomes in their favour, by revising substantially their orders between 11:45 CET (GCT in the GB market) and the actual SDAC GCT at 12:00 CET.

(d) No adequate solutions were identified that can sufficiently prevent or identify this market distortion. There could be various approaches and strategies possible for market participants to influence MRLVC results in their favour and distort outcomes, which could result in significant loss of overall welfare (as well as compromise market transparency and integrity). While obligations exist in the current framework to prohibit market manipulation and insider trading on wholesale electricity markets, and for monitoring and cooperation between regulatory authorities (under the TCA Article 305 and existing REMIT framework), these provisions might not be sufficient to eliminate such risks. Further analysis carried out in the framework of this project on specific test cases highlights it will be very difficult to prevent or even identify market manipulations and subsequently to mitigate the risks.

(e) It cannot be assessed how the implementation of the POB solution will affect market behaviour, but changes in the bidding patterns of market participants can be expected, since the current bidding strategies do not presume to reflect the future behaviours in an environment with the POB solution.

3.3.2. Main findings on Common Order books and Operational timelines (Q3a, Q2a, Q2b, Q1c)

(a) The analysis estimates that the potential feasible end-to-end process for calculating MRLVC could take in the range of 13-42 minutes following GCT according to the consultant. According to the EU experts, a more realistic range to consider is a 20-40 minute impact on SDAC. The principal uncertainties are:
   (i) Calculation time and the trade-off between reducing the allowed time vs MRLVC performance and the risk of over-running and impacting SDAC contingency; and
   (ii) How the validation of the MRLVC results is done.

(b) The EU experts have opined that implementation of MRLVC under the Common Order Book (COB) design will lead to a likely delay of at least 20 minutes for SDAC results' publication. This delay is to be considered in normal conditions where fallback procedures do not apply.

(c) The COB design gives greater insight into the complex process steps needed for MRLVC. It utilises the identical order books (representing the aggregated and anonymous orders from the relevant GB power exchange and BBZ NEMO) as used in the GB DAM and SDAC respectively. Both GB and SDAC markets close simultaneously at 12:00 CET. This design implies a sequential process: the MRLVC algorithm cannot begin until after SDAC gate closure time, when the order books for the relevant BBZs and GB are available. SDAC and GB DAM cannot begin their matching calculations until after the MRLVC has calculated the interconnector flows. Minimising the MRLVC delay is accompanied by additional operation risk of overrun and/or risk of quality degradation. On the other hand, longer delays will impact the surrounding SDAC processes by reducing contingency etc.

(d) The impact of a shortened calculation time on MRLVC performance and SDAC contingency can, however, only be evaluated quantitatively through further investigation in the future which includes proper modelling and simulation.

(e) The impact of 15-minute MTU on SDAC processes and timelines could be considerable, but detailed evaluation is not possible yet – the new SDAC procedures with 15-minute MTU are still under development. The impact of MRLVC is likely to be additional to the changes required to SDAC for 15-minute MTU and it is not certain if both will be compatible when respecting operational time constraints of the existing market coupling processes.

(f) There is an operational interdependence between SDAC and MRLVC. It is unavoidable that MRLVC will impact SDAC processes in the event of an incident or exceptional event (such as a second auction or partial decoupling). The extra time required to run MRLVC reduces the operational contingency available to SDAC within the existing operational timings, increasing the risk of a full decoupling or incurring an avoidable partial decoupling. There is some scope to reduce the impact of such incidents by decoupling MRLVC or using deemed flows, although that could increase the risk of inefficient flows on the MRLVC ICs. The governance around these decisions is outside the scope of this document.

(g) While POB might help to mitigate some of the time pressure associated with COB, particularly under normal conditions, it however brings issues and risks on other levels. It does not eliminate all impacts – e.g., incidents in SDAC requiring a re-running of MRLVC which will result in a delay of the existing SDAC fallback process.

(h) Market parties are not in favour of earlier GCT nor delayed results' publication for SDAC, without mitigation of the impacts. They have strong concerns about changes to an already congested daily schedule, which will impede their ability to schedule efficiently. They believe that if SDAC publication times are delayed (whether for MRLVC, 15-minute MTU or incidents), then TSO nomination deadlines should be delayed by an equal amount. Earlier gate closure could be difficult for those trading in ancillary services markets that run in the morning. Their general concern can be summarised as follows: if markets are to work well and deliver efficiency, security, and sustainability, this requires not only good market design but also the ability of market participants to use the market efficiently.

(i) Existing SDAC processes are mature, efficient and time constrained. Changes to operational process times therefore require careful scrutiny to avoid unintended and potentially significant negative impacts to consumer welfare. Accommodating MRLVC within critical

future modifications such as 15-minute MTU that are now in development and fundamental to net zero operability poses a significant challenge that requires further detailed risk assessment.

3.3.3. Main findings regarding the BBZ methodology (Q3b)

(a) Tools already exist which can be used as a starting point for performing a BBZ net position forecast. Some commercial providers already provide day ahead price and flow forecasts.

(b) There are multiple possible principles for the BBZ methodology, some of which may require a balance to be achieved. For example, machine learning and/or manual intervention (to handle events the machine learning is unfamiliar with) should be balanced against a regulatory desire for a fully explainable, transparent, replicable/reproducible methodology.

(c) As indicated in the 2021 CBA conclusions, MRLVC is potentially able to offer improved economic welfare over existing cross-border allocation mechanisms (explicit auctions); however, a good quality BBZ forecast is critical.

(d) To answer the technical questions on BBZ methodology, additional engagement has been conducted with TSO forecasting experts and commercial forecast providers to understand existing and prospective capabilities for forecasting BBZ net positions. Existing mature forecasting tools were utilised to test the potential performance of the methodology.

(e) This has allowed some comparative analysis of the performance of existing explicit auctions and of existing BBZ net position forecasts, to determine the potential performance of MRLVC compared with existing explicit allocation mechanisms and implicit price coupling.

(f) Historical data was collected to determine Flows Against Price Difference (FAPDs) against interconnectors using explicit allocation while data and modelling of BBZs by a commercial forecaster was used to derive potential FAPDs for MRLVC.

(g) The comparative analysis shows that the simple MRLVC assessment using the BBZ net position forecasts from the commercial forecaster outperforms explicit auctions in terms of lost welfare compared to implicit price coupling on the FR-GB, BE-GB, and NL-GB borders.

(h) The outperformance is largest for FR-GB border while the smallest improvement is observed for BE-GB border. This is a more limited geographical scope than the original CBA due to the non-existence of historical explicit data for DK-GB and NO-GB borders.

(i) However, there are a number of key considerations that need to be taken into account when considering this comparison:
In relation to the assessment of accuracy of existing BBZ net position forecasts; analysis for this report indicates that accuracy is considerably worse than in the scenario in the 2021 MRLVC CBA[7] particularly for FR, BE, NL and DK1, although comparable for NO2. This implies that the CBA results for MRLVC would have been worse for those bidding zones. However, direct comparison is difficult because 2022 was seen as an unusually difficult year for forecasting, largely attributed to high and sharply changing gas prices, compared to the CBA period (July 2019 – May 2020).

[7] MRLVC CBA 2021 available here

(j) Welfare losses are most acute when flows are scheduled in the wrong direction (from a high price zone to a low-price zone). Such so-called flows-against-price-difference (FAPDs) result in negative congestion revenue and foregone welfare opportunity. Smaller markets with high price sensitivity to the net position are most vulnerable.

(k) An indicative comparison of MRLVC to explicit performance across the three borders GB-FR, GB-BE, GB-NL shows MRLVC mitigates welfare losses by €136m in 1 year compared to implicit price coupling. This has been carried out for a period which is recognised as particularly difficult for forecasting. This means the figure should not be interpreted as an absolute value gain applicable to any year.

(l) Under MRLVC, negative congestion rent (and losses) from FAPDs could be expected to make up most of the net welfare loss compared to price coupling. This effect is even further compounded by the UIOSI payouts interconnectors will have to compensate market parties who have bought long-term capacity on the interconnector. For any instance where MRLVC produces inaccurate flow forecasts, interconnectors could see a shortfall of Day Ahead auction revenue, which in total is calculated to be around €80m for the 12-month study period for the three borders GB-NL, GB-BE, GB-FR, and which would be in addition to the negative congestion rent effects of FAPD. Interconnector TSOs are thus faced with two negative effects, a negative congestion income associated with FAPD and the additional obligation for unfunded UIOSI payout where MRLVC flow-forecasts are non-optimal, while in the event of explicit auctions, income is always foreseen via the explicit auction.

(m) The BBZ net position forecast data provided by the commercial forecasting entity and used in the analysis is essentially a by-product of its current process. For the other BBZ net position forecast the data used are based on the TSO internal process for net position (NP) forecast based on TSO input data of the capacity calculation process. Outcomes of the assessment clearly indicate that accurate forecasting of NP is a significant challenge and that it is difficult to obtain very accurate forecast results for all scenarios. There would however need to be a process of refinement, development, and testing, both as part of the initial BBZ forecast prototyping and subsequently in parallel with the overall project implementation process.

3.3.4. Main findings regarding the implementation of MRLVC design options (Q3c)

(a) To implement all aspects of the MRLVC process, four project streams involving multiple parties need to be established (alongside changes to local processes) – BBZ Net Position Forecaster, GB Coupling, MRLVC, and SDAC.

(b) Other recent market coupling initiatives that were also complex and involving many parties have taken around 4-5 years, in each case much longer than initially estimated.

(c) The initial estimate of the overall time needed to implement the MRLVC COB project is 4 years and 4 months. It is not expected that a MRLVC POB option could be implemented more quickly because there will be no difference in the MRLVC implementation tasks that are on the critical path.

(d) The estimate of the direct implementation costs is driven by the timescales for the implementation of the MRLVC solutions. Based on an estimated duration of 4 years and 4 months, the overall high-level costs for the MRLVC and SDAC streams is estimated at around [redacted] including a 40% contingency. This estimate does not include the cost of procuring the BBZ Net Position Forecaster as that is highly uncertain at this stage.

(e) Governance and contractual tasks are assumed not to be on the critical path of the project. However, they could become a risk if started too late or if compromises cannot be reached.

3.3.5. Other emerging questions that would need to be explored

(a) The compatibility of different IC capacity allocation arrangements with the concept of Offshore Bidding Zones (OBZs) have not been assessed as part of this analysis. There are open questions as to the functioning of OBZs with either MRLVC or the counterfactual in the absence of MRLVC (intraday price coupling between GB and SEM, separate day-ahead coupling between GB and the NO2 price zone, and explicit capacity allocation on all other links). For example, there is uncertainty about the feasible accuracy that could be delivered by BBZ net position forecasts for an OBZ participating in the SDAC, and of the impact of the MRLVC process on price formation in OBZs. Exploration of the compatibility of OBZs with different capacity allocation methods is a no-regret task.

(b) This analysis does not include other aspects in the TCA such as technical procedures for capacity calculation as well as other timeframes.

3.4. Further work

Further work is needed before the decision on the implementation of the MRLVC.
Before starting the implementation of the MRLVC, joint guidance from EU/UK will be needed to acknowledge the main findings/conclusions of this report:

(i) Interdependencies between MRLVC/SDAC and its impacts on the governance;
(ii) Acceptance of additional operational risks on SDAC;
(iii) Whether delivery after 2026 is compatible with TCA as findings reveal the expected MRLVC implementation time of 4 years and 4 months is longer than anticipated;
(iv) Study impact and future proofness of MRLVC on hybrid/meshed offshore grids and need to look at alternative coupling approaches for these challenges;
(v) GB market procedures' alignment with EU market procedures, for example, the results' publication time for the GB market will be determined by SDAC/EU timings; and
(vi) Future changes in GB market design with respect to a single GB price, regulatory framework, etc.

Given the time it will take to develop and implement MRLVC, futureproofing is a key consideration. This means that MRLVC should be able to produce efficient results under future (5 year+) market conditions in both the EU and GB in the context of uncertainties related to wider policy and regulatory developments. Further analysis and investigation would be necessary to answer the question whether MRLVC can adapt to future changes e.g., bridge between 15-minute MTU in the EU and 30 minutes MTU in GB.

From a joint EU and UK TSO perspective, one of the single most important questions will be, if MRLVC is future proof and fit for purpose in terms of expected offshore developments. EU and GB both have significant ambitions to integrate large quantities of North Sea offshore wind into their power systems. This report does not consider how MRLVC will perform in relation to offshore, including a market design with offshore bidding zones (OBZ). Evaluating MRLVC performance in relation to offshore will be difficult at this stage without quantitative studies and simulations/modelling. However, it is possible to point towards a couple of elements where for instance an OBZ will behave differently compared to today's known bidding zones, as an OBZ largely will consist of only production and no load, and with only one (or at least very few) market participants (the wind farm operators). This will further challenge the BBZ methodology, and at the same time make the BBZ methodology even more important. Additional guidance would be helpful in this regard before the commencement of any MRLVC implementation program.

4. Detailed answers to the technical questions

4.1. Preliminary Order Book option (Q1a, 1b, 1d, 1e)

Q1. With respect to the Preliminary Order Book option identified by transmission system operator:

(a) What proportion of orders for Single Day-Ahead Coupling (SDAC) are typically submitted during the final 15 minutes before the Gate Closure Time (GCT), within what range does that proportion typically vary, and are there specific drivers for when market participants submit their orders and could these drivers change as a result of implementing the Preliminary Order Book Option?

There are three parts to the answer to this question:

(i) To what extent do SDAC orders currently vary during the final 15 minutes before SDAC gate closure?

(ii) Are there specific drivers for when market participants submit their orders?

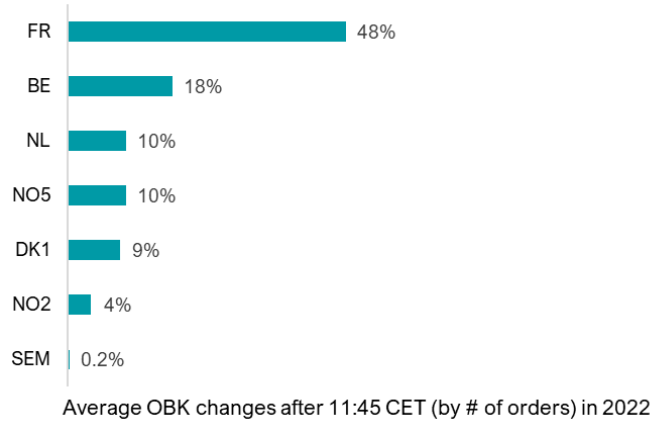
(iii) Could these drivers change as a result of implementing the preliminary order book (POB)?

(i)To what extent do SDAC orders vary during the final 15 minutes before SDAC gate closure?

EPEX SPOT, Nord Pool, and SEMOpx, the NEMOs in Bordering Bidding Zones (BBZs), provided data for 2022 on changes to their orderbooks (OBKs) after 11:45 CET. The average variation in OBKs between 11:45 CET and 12:00 CET in BBZ markets for 2022 are shown in Figure 1a and Figure 1b. These charts indicate that OBKs in some BBZs currently undergo material revision in the last 15 minutes prior to Gate Closure Time (GCT).

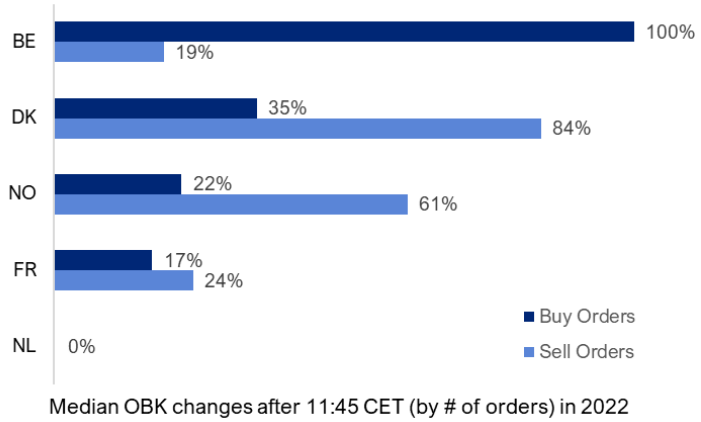
As this is not data that the NEMOs collect on an ongoing basis, it was challenging for the NEMOs to collect this data for a historical period. Furthermore, the data that they could provide depended on how their internal systems operate and are configured, which meant that they were not able to provide the data in a common format. The following figures therefore separately show variations in NEMO1 and NEMO2 (which are based on the mean variation in orders after 11:45 CET) and NEMO3 (which are based on the median variation in buy/sell orders after 11:45 CET).

Figure 1a: OBK variations (by # of orders) after 11:45 CET in 2022



Source: NEMO1 and NEMO2

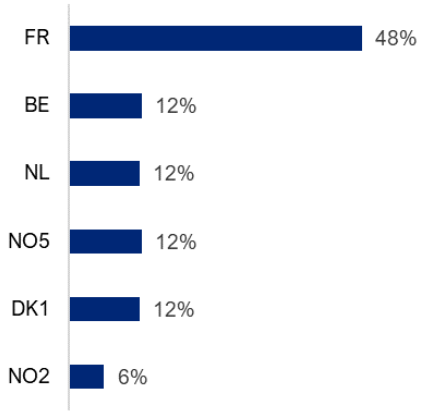
Figure 1b: OBK variations (by # of orders) after 11:45 CET in 2022



Median OBK changes after 11:45 CET (by # of orders) in 2022

Source: NEMO3

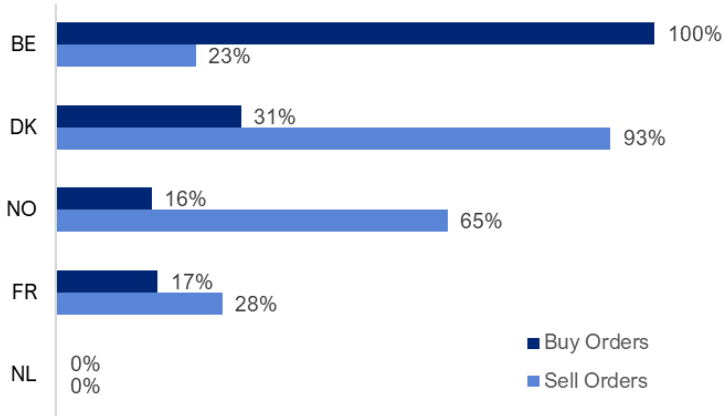
Figure 2a: OBK variations (by MWh) after 11:45 CET in 2022



Average OBK changes after 11:45 CET (by MWh) in 2022

Source: NEMO1

Figure 2b: OBK variations (by MWh) after 11:45 CET in 2022



Median OBK changes after 11:45 CET (by volume) in 2022

Source: NEMO3

The most material changes are observed in the one of the NEMOs' OBK in France, for which the data provided by that NEMO show that almost 50% of the orders are either created, modified or withdrawn after 11:45 CET (Figure 1a) and almost 50% of the submitted volume is modified in one way or another during the last 15 minutes before GCT (Figure 2a). Although to a somewhat small extent, OBKs in other BBZs also show significant modifications in the last moments before Gate Closure[8]. However, SEM appears an exception, with very infrequent material changes occurring in the last 15 minutes prior to GCT.

(ii) Are there specific drivers for when market participants submit their orders?

Discussions with NEMOs and with some market participants have suggested that participants follow one of two strategies for factoring in the latest available information while managing the operational risk of missing the 12:00 CET deadline for submitting orders into SDAC.

(i) An initial submission well in advance of 12:00 CET that is continuously updated as new information comes in.

(ii) A 'one-shot' submission close to GCT of a final market position, typically after 11:45 CET.

The general rationale for updating orders until the GCT relates to the need to use the most up-to-date information (e.g., latest weather forecasts, actual availability of production assets, latest information from OTC or gas markets) when setting orders.

In practice, market participants appear to use a range of strategies, for example, some participants self-impose a deadline a few minutes prior to 12:00 CET at which they submit their final position at once; while others start with a rough position well ahead of the deadline, and then continuously update their orders until the GCT.

Discussions with the NEMOs suggest that the transition to a 15-minute MTU in SDAC may increase the extent to which orders are submitted in the period after 11:45 CET. The NEMOs suggested that this may occur due to the increase in the complexity of optimization processes carried out by market participants as a result of this transition. Hence, the level of alteration of the order books presented in this report is likely to increase in the future after 2025 (implementation of 15-minute MTU in SDAC).

(iii) Could these drivers change as a result of implementing the preliminary order book (POB)?

Discussions with NEMOs and with market participants did not suggest that market participants will voluntarily implement significant changes in their bidding processes with the objective to minimise changes after 11:45 CET (i.e., to make the OBK at 11:45 CET a particularly useful snapshot).

On the contrary, a range of strategies have been identified which would allow a market participant to take advantage of the POB concept by influencing the final market results to its benefit, even if it is to the disbenefit of the market as a whole. These bidding strategies rest on the ability of participants to revise/modify/complement their orders after 11:45 CET.

For example, a producer in a BBZ market could voluntarily submit an order prior to the POB process (i.e., before 11:45 CET) that is for a larger supply volume (at a relatively low price) than it has available. Given this information, the MRLVC process under the POB option (holding all else equal) would

[8] Under the Multi-NEMO arrangements in SDAC, NEMO 1 and NEMO 2 both operate in some BBZs, which therefore appear on both charts – BE, NL, DK, NO. Understanding the MWh impact of the % changes would require the changes in the OBKs to be weighted by the market shares of the NEMOs in each BBZ. This data was not available for the analysis shown in this report.

overestimate the ability of the BBZ to export to GB, and therefore allocate more flows to GB compared to optimal results. The BBZ producer can then readjust its position between 11:45 CET and 12:00 CET, hence not impacting the actual producer's position in SDAC. As a result, the excessive export to GB as determined by MRLVC may increase the BBZ clearing prices, and hence the market revenue earned by the BBZ producer..

In conclusion, the timing of orders submitted under the POB option will continue to be influenced by the desire of market participants to use the most up-to-date information at GCT. However, the introduction of the POB option may incentivise market participants to alter their bidding patterns in order to increase market revenue at the expense of the quality of the results of the MRLVC process.

Q1. With respect to the Preliminary Order Book option identified by transmission system operator:

(b) To what extent would the proportion of orders submitted during the final 15 minutes before the SDAC GCT impact on the interconnector flows being consistent with the prices in the Parties' day-ahead markets?

Interconnector flows are fully consistent with the day-ahead market clearing prices when:

(a) an IC is fully utilised (or 'congested') by a flow of electricity from a low-price bidding zone to a high-price bidding zone; or
(b) when there is no congestion and no price difference between the connected bidding zones[9].

Flows against price differences are the most extreme and visible inconsistencies between flows and prices.

Under the POB or COB options for MRLVC, flows may not be consistent with day-ahead prices in the SDAC and in GB for the following reasons:

(a) The concept of 'volume coupling' by definition implies that prices are not computed simultaneously with flows.
(b) The concept of 'loose coupling' – which in the case of MRLVC implies that the non-BBZ OBK information is not to be used by MRLVC – can also create price discrepancies because the MRLVC flow calculation does not use the exact same information as the SDAC price calculation.
(c) The non-BBZ orderbooks are estimated thanks to a net position forecaster of the BBZ; such forecasters have an inherent inaccuracy leading to risks of inconsistency between prices and flow direction.

The POB concept induces an additional source of discrepancy because the BBZ orders used for MRLVC are not exactly the same as the BBZ orders used for SDAC.

Distinguishing quantitatively between these distinct sources of inconsistency between flows and prices is a non-trivial exercise. It requires extensive simulations with preliminary and final OBKs as well as with forecasts of non-BBZ net positions. Such simulations were not in the scope of the analysis for this report.

There are a number of reasons why quantitative assessment has not been in the scope of the analysis:

(a) First of all, as noted above, it has proven challenging for the NEMOs to collect the requested data at 11:45 CET, especially as that timing has no relevance under SDAC arrangements. Instead, the requested 11:45 CET indicators (data) needed to be compiled by all NEMOs individually. Even though the data compiled by the NEMOs showed the proportion of orders that are currently modified after 11:45 CET, the magnitude of such changes in terms of price and/or volume were not possible to quantify – for example, the number of orders that change does not differentiate between a modification of an order price by €0.02/MWh or one by €20/MWh.
(b) Secondly, the NEMOs mentioned that they considered that a quantitative assessment of the interconnector flows would be highly speculative. Apart from the preliminary OBKs, other inputs (e.g. BBZ flow estimates) would need to be required for the stimulation of MRLVC calculation at 11:45 CET.

[9] This simple definition ignores possible technical constraints, such as ramping and losses.

Q1. With respect to the Preliminary Order Book option identified by transmission system operator:

(d) Do the requirements of Article 305 (Prohibition of market abuse on wholesale electricity and gas market) of the Trade and Cooperation Agreement provide sufficient mitigation of the risks of market manipulation identified as arising under the Preliminary Order book option? Any residual risks of market manipulation should be fully explained and justified.

This answer focuses on the practical challenges related to preventing market abuses specifically implied by the POB concept, as it is not informed by legal expertise required to provide a legal opinion.

As discussed in the response to Q1(a), if the POB option is implemented, there is a range of ways in which market participants could influence the MRLVC results in their favour. For example, day-ahead price differences between GB and BBZs can be exacerbated by changes in BBZ orders between 11:45 CET (when submitted to the MRLVC) and 12:00 CET (when submitted to the SDAC). This provides an opportunity for a market strategy to increase the revenues accruing to Long-Term Transmission Rights (LTTR) holders that do not nominate a flow before the day-ahead market. [10] These gains are at the expense of reductions in overall welfare and TSO congestion revenues[11].

Such strategies suggest that the existence of the MRLVC POB concept could induce an additional driver for submitting/modifying/withdrawing orders before and after the MRLVC POB process with the intention of influencing the interconnectors' allocation.

Article 305 of the TCA may provide a foundation for mitigating market abuses once identified. However, there are material challenges for regulators and market monitors to identify which OBK changes after 11:45 CET are legitimate and which ones are not – under the scope of Article 305 of the TCA. This was illustrated in discussions with NEMOs, in which some of them questioned the ability of Article 305 in isolation to place any constraints on BBZ market participants updating their orders between 11:45 CET and 12:00 CET.

Some key challenges in identifying and monitoring market manipulation include:

a. <u>Definition of 'illegitimate' bidding strategies</u>

The notion of "market manipulation" is not clearly defined both legally and in practice, in order to ban them properly. This may imply identifying all possible market manipulation strategies, however it might be difficult to make an exhaustive and constraining list of strictly not-allowed strategies. Similarly, it is likely challenging to identify these strategies and prove that they were intentionally meant to manipulate the market (as opposed to be justifiable by some "standard" market reason).

b. <u>Availability of all related market data</u>

While several parties (including NEMOs and regulators) have a strong interest in avoiding market manipulation – and thereby in monitoring their markets to identify it, identifying the most advanced strategies requires having a complete view of at least all market data of all NEMOs/Power exchanges on all bidding zones (BBZ + GB). At this moment, no entity has access to such data. For example:

[10] This strategy can be seen as a 'one-way bet', whereby the LTTR revenues at worst (for the rights holder) stay the same.

[11] This finding is consistent with the recommendations made in the MRLVC CBA, particularly with reference to the POB option, to either fully abolish LTTRs for the interconnectors allocated through MRLVC, or to reduce their hedging capabilities in order to better cope with possible inconsistencies between flows and price differentials under MRLVC.

- Each NEMO has access to its own SDAC and GB data, but not to the data of the other exchanges; therefore, it would be difficult to identify manipulation strategies using bidding differently on both exchanges (e.g. buy on EPEX at 11:40 CET and sell on NP at 11:50 CET).

- ACER has full access to SDAC data, but not to GB data whereas some manipulation strategies could imply bidding in GB and SDAC areas.

Q1. With respect to the Preliminary Order Book option identified by transmission system operator:

(e) Are there further actions, requirements, or obligations, including of regulatory authorities or market participants, transmissions system operators, or market operators, that could be established to provide further mitigations to the risk of market manipulation identified with the Preliminary Order Book option? Any residual risks of market manipulation should be fully explained and justified.

As discussed in the answers to Q1(a) and Q1(d), the POB option provides opportunities for market participants to influence the market outcomes in their favour by changing their bid after 11:45 CET.

There are challenges in mitigating the risks of such bidding strategies being employed. The first challenge lies in the precise definition of 'market manipulation' even though this is a defined term under REMIT.[12] For regulations aimed at preventing such abuses to be effective, it is imperative to establish a clear and unambiguous definition of "market manipulation" that encompasses both legal and practical aspects. On the one hand, relying solely on general principles, such as preventing "behaviours which go against the spirit of the market" has proven to be hard to enforce in practice. On the other hand, a more ex-ante approach would require the explicit and exhaustive listing of all possible manipulative strategies without unduly restricting legitimate changes to the orderbooks between 11:45 CET and 12:00 CET, as happens today, which presents further challenges.

Secondly, there will be a challenge in identifying ex-post any change in bids specifically designed to change market outcomes through the use of a POB (i.e. without any change in the data informing the bids before and after 11:45 CET). As shown in the answer to Q1(a), it has been empirically observed that OBKs already undergo significant changes in the final 15 minutes before GCT. In addition, methods to potentially influence or distort the results of the MRLVC under the POB concept are numerous. Striking the right balance in defining rules for distinguishing between 'legitimate adjustments' induced by late changes in market conditions and intentional distortions qualifying as market abuse is challenging. While existing regulations may theoretically restrict behaviours designed to distort MRLVC (e.g., REMIT prevents the placement of orders without the prior intention of executing them), the enforcement of such rules would be highly challenging. Similarly, developing new rules that are too loose may be easily circumvented, while overly strict regulations may also lead to inefficient outcomes. For instance, imposing restrictions on BBZ order changes after 11:45 CET could potentially discriminate between the BBZ markets and non-BBZ markets, or limit the execution of legitimate changes due to perceived legal risks.

Thirdly, despite the genuine interest of numerous stakeholders, including NEMOs, Ofgem, EU NRAs, and ACER, in preventing market abuses, effective market monitoring necessitates sophisticated tools capable of identifying such behaviours. Complex market abuse strategies may involve positions in both the GB and EU markets, and/or across multiple NEMOs/Power Exchanges. No entity currently has access to all the necessary data sets (orders of all NEMO/Power Exchanges, over all EU and GB areas, from other markets such as LTTRs) to efficiently monitor and prevent MRLVC market abuses.
Further extensive cooperation between regulatory authorities, market participants, transmission system operators, and market operators across the EU and GB would be necessary to address these challenges.

[12] Following the UK's departure from the EU, REMIT is retained under national legislation by effect of the European Union (Withdrawal) Act 2018 and amended by the Electricity and Gas (Market Integrity and Transparency) (Amendment) (EU Exit) Regulations 2019 (SI 2019/534).

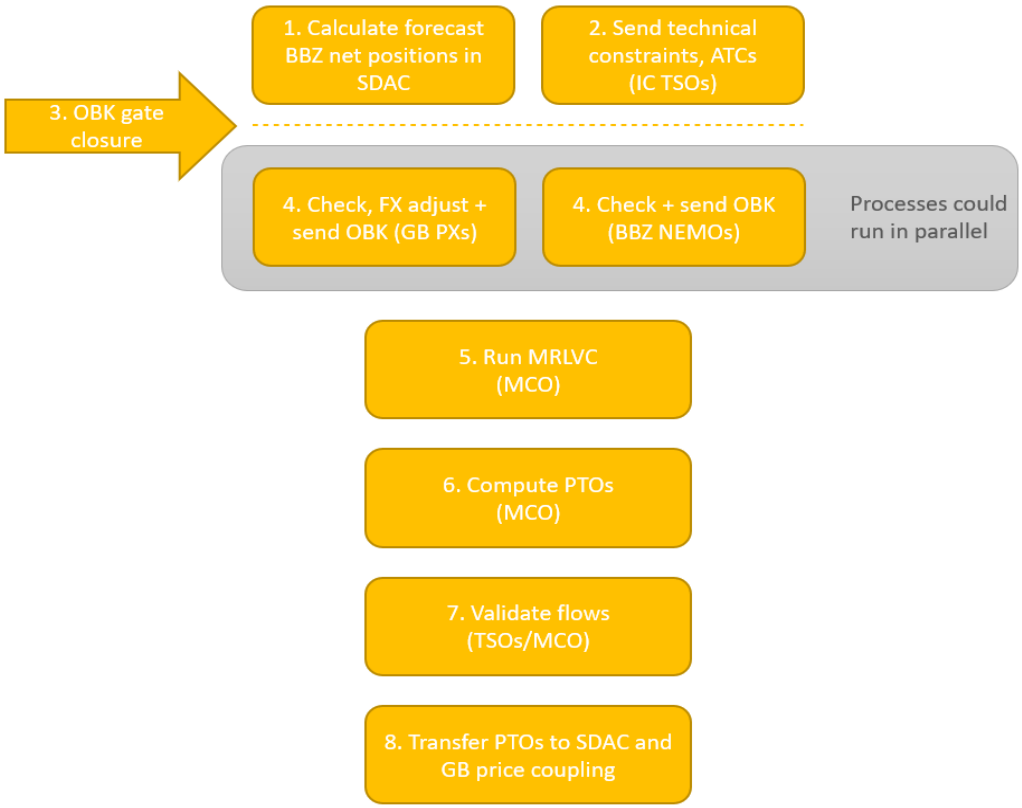
4.2. Operational processes and timescales for the MCO function for both COB and POB (Q3a), for the Common Order Book specifically (Q2a, Q2b) and for the Preliminary Order Book specifically (Q1c)

Q3. With respect to both the Preliminary and Common Order Book options:

(a) What are the different processes required for performing the MRLVC MCO calculation, and what is the range of time that would be required for each of those processes? Any range in potential timeframe should be fully explained and substantiated.

Figure 3 below represents the individual processes that are required prior-to and after the running of the MRLVC MCO calculation process. All processes documented are integral and will need to be run regardless of whether a COB or POB approach is taken. For the purposes of this question, processes that are run after the gate closure are referred to as being on the 'critical path.' A number of processes have been identified as being distinct with no interdependence. These processes could potentially be run in parallel to reduce the overall operational running time. However, depending on whether a COB or POB approach was taken, and decisions on whether to run eligible processes in parallel, the configuration of the end-to-end process could vary slightly from that documented below (i.e., gate closure time).

Figure 3: Process steps for MRLVC calculation



Source: Consultant's discussions with EU experts

1. Calculate forecast BBZ net positions in SDAC

The process of calculating the forecasted BBZ net positions in SDAC could be run any time prior to gate closure (GCT). However, running the process as close as possible to GCT would take advantage of the most up-to-date information available. For example, data on the latest Cross-Zonal Capacities (CZC) and allocation constraints in SDAC are normally available at 10:30 CET.

The initiation time of the BBZ net position forecast calculation should leave sufficient time – including a safety cushion – to do any required operational checks. This process should not form a part of the 'critical path.' To minimise operational risks, a forecast could be prepared earlier in the day (for example, using Preliminary Flow-based parameters which are available at 08:00 CET), and used as a fallback if necessary. However, this would affect the accuracy of the forecasted positions.

2. Send IC technical constraints

The TSOs need to provide the technical constraints data to the MRLVC (e.g., Available Transfer Capacities (ATC); ramping restrictions on some borders). Like step 1, this can be done any time prior to MRLVC GCT, but ample time should be allowed to conduct any required operational checks.

3. Order Book (OBK) gate closure (for MRLVC)

Under a COB design, OBK gate closure will be at the same as the SDAC GCT. In the case of POB design, the OBK gate closure will occur 15 minutes before to enable MRLVC to complete before SDAC, without any changes to the SDAC timings. This is the key difference between the two MRLVC options. However, under either MRLVC option, the MRLVC GCT will be at the same time for both GB and BBZ markets.

4. Check, adjust FX (if necessary) and submit OBKs

BBZ NEMOs and GB REMOs[13] compile and check their OBKs, and submit them to the MRLVC MCO PMB platform[14] as used in SDAC. In the case of the GB REMOs, their OBKs must be converted from GBP to EUR before they are sent to the MRLVC MCO using a common FX rate (provided the process is very similar). Currently, the average time to submit OBKs in SDAC is 3 minutes, with the minimum time being 2 minutes and the maximum time being 10 minutes.

SDAC procedures currently allow 10 minutes (which includes some contingency for late OBK submissions) after GCT for the submission and checking processes, with the computation starting at 12:10 CET. The SDAC calculation can't start until all OBKs have been received.

In comparison, it has been estimated that the MRLVC computation will require 4-7 minutes for checking order books. This time allows for later-than-average OBK submission. However, as fewer OBKs will be submitted in the MRLVC process (in comparison to SDAC), less time should be required. Furthermore, the SDAC process includes a global sharing and verification step that would not be required in MRLVC, as this step will continue to take place under the SDAC process.

5. Run MRLVC computation

It is difficult to estimate the time required to perform the MRLVC computation without performing simulations.[15] In the absence of simulations, CEPA's estimation approach is to look at the processing times of comparable implicit auctions – as shown in Table 1 below – and the factors that most strongly

[13] Assumption for this document is that REMOs are operationally equivalent to NEMOs.
[14] The PMB platform is the system in SDAC that manages the interface between NEMOs and EUPHEMIA.
[15] The consultant and/or NEMOs were unable to run simulations in the time available due to the complexity and turn-around time required.

affect calculation time, to infer an approximate calculation time of between 5-20 minutes. EU experts on the other hand have advised that from their perspective 10-30 minutes is a reasonable estimate of the time required for an acceptable computation.

Table 1: Comparative calculation times for implicit auctions

Example	Typical calculation time	Factors of greatest impact on calculation time				
		15-min MTU	PUN/ MIC*	Flow-based	Block orders	# zones
Current SDAC	20 min		X	X	X	30
Current SDAC time to first solution (TTFS)	2-5 min		X	X	X	30
15-min MTU SDAC (estimate)	50 min	X cross-matching MTUs	X	X	X	30
MRC 2017	10 min		X		X	25
Intraday Auctions (estimate)	7 min	X (but no cross-matching MTUs)			X (but fewer than SDAC)	
MRLVC	?	X cross-matching MTUs			X	7

Source: Consultant discussion with EU experts[16,17]

The EU experts' view reflects the risks associated with the impact on SDAC. The processing time being nearer to the lower bound under the current version of SDAC and the higher end following the introduction of 15-minute MTU. This differing position is premised on the MRLVC MCO calculation operating under the same calculation quality conditions that SDAC operates in. However, as MRLVC is not a price coupling calculation, CEPA suggest that it is possible to minimise the calculation time by relaxing the quality optimisation measures of the MRLVC solution as described below.

Time to first solution

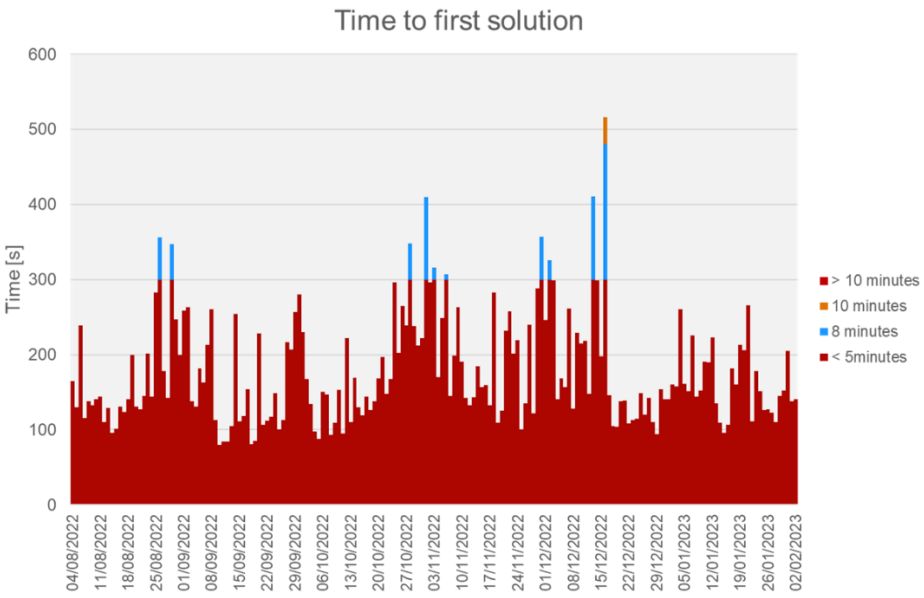
a. Stopping at the first solution found

EUPHEMIA's approach to finding the optimal solution is to rapidly find a good first solution from which it continues trying to improve and increase the overall welfare. SDAC currently allows 17 minutes to find a solution with scope to extend the calculation time if needed, although this has not been needed recently[18].

[16] MRC 2017 refers to the market coupling taking place in northwest Europe in 2017.
[17] PUN/MIC Prezzo Unico Nazionale is the National Single Electricity Price in Italy. MIC refers to bids 'Minimum Income Conditions.
[18] There were instances in 2021 due to a technical issue that has now been resolved.

As illustrated in Figure 4, between August 2022 and February 2023, on the majority of days, the time to first solution (TTFS) for EUPHEMIA in SDAC was less than 3 minutes, with the TTFS exceeding 8 minutes on about 5% of days. Once the first solution has been determined, the remainder of the 17 minutes allowed for the process is spent finding an alternative (more optimal) solution, although in some instances the first solution is the only solution found in the available time.

Figure 4: Time to first solution (TTFS) in SDAC (August 2022 – February 2023)



Source: NEMO Status Report to MCSC, March 2023

Rather than spending time seeking an improved solution as the EUPHEMIA algorithm does, MRLVC could instead stop once the first solution is found. Whilst this could reduce the calculation time required, EU experts have advised that in SDAC the first solution in only a handful of situations has been the final solution. This relates to the fact that the EUPHEMIA algorithm was not designed for this approach. Instead, it utilises an iterative approach after the first solution to improve and increase the overall welfare. This also implies computation wise, that a new and more global optimum is easier found, when the starting point is another more local optimum. As MRLVC is assumed to be built upon the existing EUPHEMIA algorithm, EU experts therefore believe, that stopping the process after the first solution is found, will rarely lead to the optimal solution, resulting in welfare losses for consumers.

[redacted]

SDAC today has the option to extend the time allotted for the EUPHEMIA calculation if no solution has been found. The consultant's analysis indicates that this has not been required in the large majority of days – so normal publication times can be earlier, with the occasional late day being an exception.

A similar concept could be applied to MRLVC: operate to a computation time that is adequate to reach first solution on most days but have a contingency to extend the calculation time if MRLVC is over-running. A balance would need to be struck between minimising the standard processing time and the frequency that this deadline, and hence the normal SDAC publication time, is missed.

This would mean on some days an extra delay to SDAC, implying a reduction in the contingency time available to SDAC in case it has any incidents. There should also be a hard deadline for the MRLVC calculation process to avoid excessive impact on SDAC.

b. Relaxing some solution requirements

EUPHEMIA is subject to a number of detailed requirements that the final solution must satisfy. Some of them are technically more challenging to achieve than others. For example, EUPHEMIA's results should contain no paradoxically accepted block (PAB) orders (i.e., block orders accepted even though the calculated price is below that set by the seller).

Many similar algorithms in other countries allow PABs, combined with compensatory payments and such an approach has been considered as an option for SDAC in the past. However, as only the flows, and not the prices, calculated by MRLVC are effectively used, allowing PABs is likely to be of less consequence for MRLVC.

As illustrated in Table 1 above, the MRLVC computation is also likely to be able to save time by ignoring or excluding requirements related to the PUN and MICs, which are required in SDAC.

If the MRLVC has to produce a result by a hard cut-off deadline (e.g., if the other measures to reduce the calculation time have been insufficient), it would be possible to further relax the requirements on a particular day - for example, allowing block orders to be curtailed.

EU experts have indicated severe concerns about any deliberate reduction in quality of the MRLVC outcome, compared to SDAC. The significance of errors caused by a lower quality MRLVC calculation need to be considered in this context: the incremental impact can only be assessed through appropriate modelling and simulation.

As stated above, there are a number of uncertainties on the time needed for the calculation. A number of scenarios have been examined. According to CEPA, in a scenario where all potential optimisations of time are used, an MRLVC result could be achieved in a 5-10 minutes range[19]. According to EU experts, the final MRLVC solution will need at least 20 minutes. The additional time would also impact the performance and SDAC contingency and finding the right balance can only be evaluated quantitatively through further modelling and simulation.

6. Compute PTOs

The output from MRLVC calculation will need to be converted into price taking orders (PTOs) that can be submitted to SDAC and the GB price coupling. In the case of GB, the PTOs need to be converted back into GBP. The estimated time for this step is 1-2 minutes.

7. Validate flows

Interconnector TSOs have indicated that they wish to validate that the MRLVC results are consistent with the technical constraints – i.e., ATC, loss factors and (in some cases) ramping constraints. Similar validation processes operate in SDAC. If the IC TSOs wish to perform the check themselves, this could potentially add 1-10 minutes to the MCO process.

In theory, an alternative option could be to perform the validation in parallel with the sending of (unvalidated) PTOs to SDAC. In this case the incremental time impact could be negligible. This would

[19] This is solely the time required to run the MRLVC computation. Additional time is need for surrounding processes.

avoid any delay on normal days, and if an error is detected it would probably have similar implications for SDAC – e.g., triggering an incident and a probable decoupling of MRLVC. In terms of the empirical benefits of a sequential validation process, there has never been an instance when EUPHEMIA has produced invalid results.

However, EU experts are of the firm view that SDAC should not start a process with inputs that are still subject to validation. There are concerns that such an approach breaches good operational practice and could set a precedent that weakens the whole process. Prior validation ensures that potential problems are contained and managed to one process only, and do not contaminate others. For this reason, EU TSOs consider that the only suitable option is for the process to run sequentially.

8. Transfer PTOs to SDAC and GB price coupling

Once MRLVC has calculated the flows, which are validated, and they have been put into the required PTO format, they need to be sent to the appointed NEMO in each BBZ, who then submits them to the SDAC PMB. There may be some additional checks done by SDAC before EUPHEMIA can begin its calculation, but this should be minimal.

Measures can be taken to streamline this process, such as:

- avoid the need for the NEMOs to check or modify the PTO file (e.g., TSOs take full responsibility for the contents; file format ready to be sent to SDAC PMB);
- create unique PMB for the PTOs in each BBZ (avoiding the need to modify the main OBK from the BBZ NEMO); and/or
- use of common communications platform.

The time required for these steps is estimated to be about 2-3 minutes.

A potentially quicker process could be whereby the MRLVC MCO directly submits the PTOs to the SDAC PMB on behalf of the BBZ NEMOs. EU experts, however, find that this will not be acceptable, as every single NEMO is responsible for its own OBK and liable for any costs or damages (both financial and reputational) associated with failure of submitting an OBK. Therefore, it cannot be expected, that the NEMOs will allow anyone else to submit PTOs into their OBK on their behalf. Secondly, it is thought that potential time savings would be limited, if the proposed process via NEMOs is suitably designed, as step 8 is estimated to last 2-3 minutes.

An equivalent parallel process will be needed for the GB price coupling.

Summary

These steps are summarised in Table 2 below.

Table 2: Estimated timings for each step in the MRLVC calculation process

Process	Who	Start	Duration
1. Forecast BBZ net import/export position in SDAC and send to MCO	Forecaster	11:00 D-1	2-5 min
2.Send GB-BBZ interconnector capacities and technical constraints (losses, ramp rates, etc) to MCO	IC TSOs	11:00 D-1	2-5 min
3.Order book gate closure	BBZ NEMOs, GB PXs	COB: 12:00 POB: 11:45	
4.Check, convert to EUR at a provided FX rate and send GB PXs' order books to MCO	GB PXs	After Step 3	4-7 min
Check and send BBZ NEMOs' order books to MCO	BBZ NEMOs	After Step 3	4-7 min
5.Run EUPHEMIA and compute interconnector flows	MCO	After Step 4	5-20 min CEPA 10-20 min + EU experts
6.Compute PTOs, convert to GBP	MCO	After Step 5	1-2 min
7.Validate MRLVC flows as compliant with capacities, technical constraints	IC TSOs	After Step 6	1-10 min
8.Transfer PTOs to SDAC via BBZ NEMOs Transfer PTOs to GB price coupling via GB PXs	BBZ NEMOs GB PXs	After Step 7	2-3 min
Total MRLVC computation time (step 4-8)	**All**	**Step 4 to 8**	**13-42 min**

Source: CEPA estimations

In summary, for the purposes of this report, CEPA has assumed that the time required to run the end-to-end MRLVC process (after order book gate closure i.e. processes 4 to 8 above) will be in the range of 13-42 minutes. However, following advice from EU experts, the lower end of the range is considered to be extremely challenging from an operational perspective, with a more realistic range being 20-40 minutes. The principal variables that need to be taken into consideration are:

a. Calculation time and the trade-off between reducing the allowed time vs MRLVC performance and the risk of over-running and impacting SDAC contingency. This has a potential impact on timings of up to 15 minutes;
b. Achieving the lower end of the time range would likely require the acceptance of some quality degradation in the calculation and increased risk of operational overrun; and
b. How validation of MRLVC results is done; with a potential impact on timings of up to 10 minutes.

This working hypothesis is used in the assessment of the impact of MRLVC on SDAC (Q2).

Q2. With respect to the Common Order Book options identified by transmission system operators:

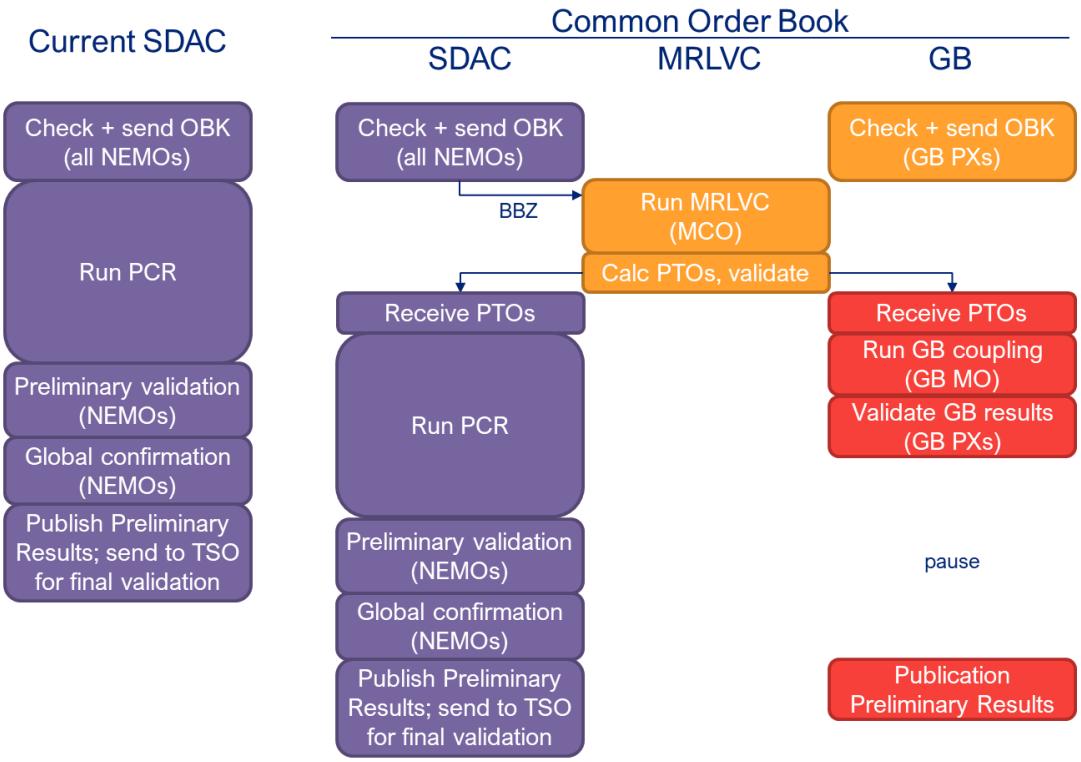
(a) What are the full range of options that could allow for the MRLVC MCO calculation processes to be run between SDAC GCT at 12:00 CET and publication of SDAC results at 13:00 CET, including any options that allow for the MRLVC MCO calculation processes to be run in parallel with aspects of SDAC? What are the advantages/disadvantages between these options, including:

(1) the potential impacts on the operation of SDAC and fallback processes, (i.e., risks of decoupling of SDAC);
(2) the impact on transmission system operators, market operators, and market participants
Any operational impacts and risks should be fully explained and substantiated.

Normal day scenario

An outline of the SDAC plus MRLVC process after GCT compared to the current SDAC standalone process on a normal day (no incidents) is shown below.

Figure 5: Outline of SDAC processes without and with MRLVC (Common Order Book option)



Source: CEPA assessment

Normally, SDAC aims to publish preliminary results at 12:45 CET and provide global final confirmation at about 12:57 CET.[20] If the incremental impact of MRLVC is assumed to be a 10-minute delay (for illustrative purposes) in the start of the SDAC calculation (which is towards the low end of the estimates discussed in Q3(a)), preliminary results could still be published on a normal day before 13:00 CET (under current SDAC timescales).

[20] These timings were recently changed from 12.42 and 12.55 respectively.

EU experts advise that a more realistic incremental impact of MRLVC is expected to be at minimum 20 minutes and up to 40 minutes. Under that assumption, preliminary results would not be able to be published by 13:00 CET.

With the introduction of 15-minute MTU, it is very unlikely that SDAC will be able to publish preliminary results before 13:00 CET, so it will not be possible with MRLVC either. The impact of 15-minute MTU could be to delay SDAC timelines by 20-50 minutes. This is significantly more than the impact of MRLVC (based on the 10-minute working hypothesis), but the effects would be cumulative.

In the following paragraphs, addressing the potential impacts on operations and timing, there will be alternatively two sets of assumptions. The very optimistic delay of 10 minutes of MRLVC on SDAC, as it is today (meaning without 15-minute MTU products for instance), and a more realistic assumption, based on EU experts' analysis, leading to a minimum delay due to MRLVC of 20 minutes.

Impact on market participants

Market participants have expressed concern about any postponement to SDAC publication times. They have operational processes to complete in order to optimise their national schedules and make nominations to the TSOs. Any delay, even just 10 minutes, reduces the contingency they have to deal with technical issues, and increases the risk of sub optimal scheduling.

Market parties have also indicated that if market changes, such as MRLVC or 15-minute MTU, mean SDAC publication times are delayed, then TSO nomination deadlines should be delayed by an equal amount. Their view is that if markets are to work well and deliver efficiency, security, and sustainability, this requires not only good market design but also the ability of market participants to use the market efficiently.

Impact on market operators and TSOs - incident scenarios

The term "incident scenario" includes anything which is abnormal and triggers an incident committee. An incident committee brings together market operators and TSOs to deal with abnormal issues at a short notice within operational timeframes. For example, in SDAC this includes scenarios that may lead to second auctions, partial or full decoupling, reopening order books and/or delay to the publication of results, or that the issue is resolved. Some other changes to a "normal day," such as having to delay the start of the calculation due to a technical delay, are usually managed within the normal procedures, where there is some contingency allowed for.

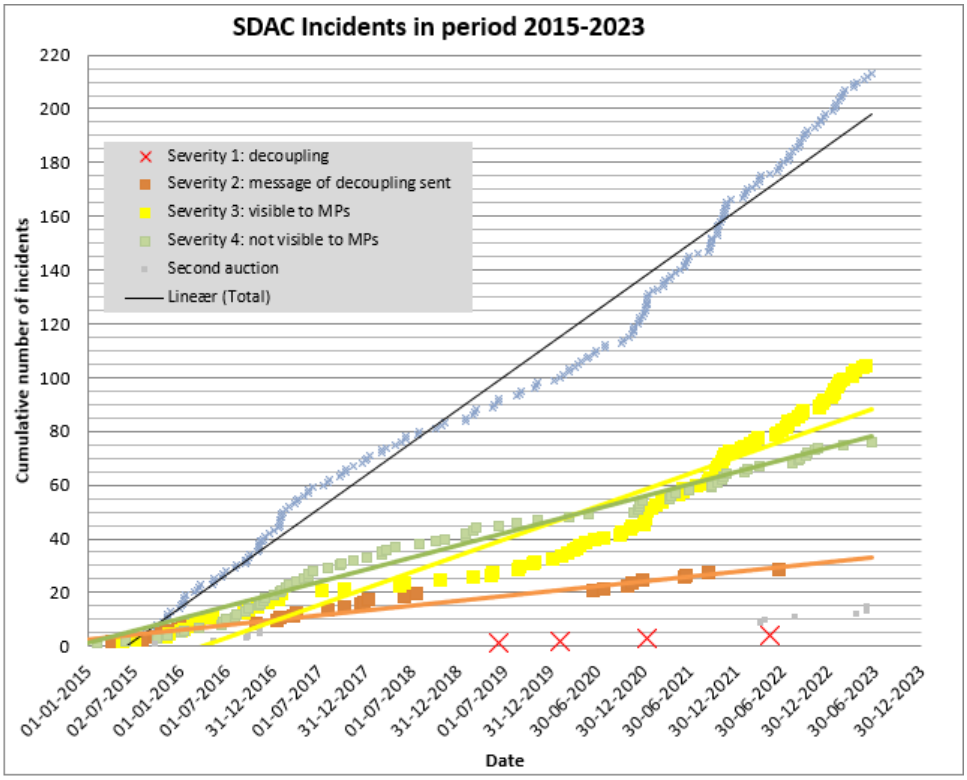
Figure 6 below illustrates the cumulative total of SDAC incidents for the period 2015-2023. There have been more than 200 incidents in SDAC: four incidents have led to a partial decoupling, while the other incidents have been solved before the deadline for partial decoupling. A total of a little less than 150 times, it has been communicated to the market, that an incident has happened. The rest of the incidents have been resolved before the deadline for communicating to the market.

The figure shows that incidents are a regular occurrence. However, so far, Severity 1 decoupling has occurred four times in the past four years. Overall, it is clear the importance of having sufficient time to resolve even minor issues, as incidents do occur. The number of incidents of Severity 2 illustrates that this contingency time is key to avoid partial decoupling and full decoupling. Anything that reduces the time available to address these incidents will lead to a higher risk of some kind of decoupling taking place. Ten Severity 2 incidents did occur in the last four years, without leading to a partial or full decoupling, as there has been time to solve the issue. With time pressure from MRLVC and 15-minute MTU in the future, it is estimated by EU experts that 50% of those Severity 2 incidents would have ended in a decoupling event (so estimate is five decouplings in four years). Since the time to trigger a

partial decoupling is very short, it is likely that these could have ended in a full decoupling because less time would be available for resolution. It can therefore be estimated that Severity 1 and Severity 2 incidents in the future could lead to an average of two yearly full decoupling incidents, if MRLVC is live together with 15-minute MTU in SDAC.

Consequently, UK parties could be harmed by any incident located in the EU market, leading to full decoupling of both MRLVC and SDAC, without time for UK market parties to hedge their market positions (i.e., reopening of order books in the UK). Such dedicated time to hedge UK market parties, if performing a new MRLVC run, would increase additionally the time pressure on partial or full decoupling events, and the delay introduced by MRLVC would be doubled, so delay would be at minimum 40 minutes (twice 20 minutes).

Figure 6: SDAC incidents in the period 2015-2023



Source: EU SDAC Experts

MRLVC will inevitably have an impact on SDAC incident scenarios and complicates the handling of these incidents. How best to manage incidents, and the impact the approach has on decoupling risk, orderly markets and delays is not straightforward. The challenge would be even more difficult once 15-minute MTU is implemented. This is illustrated by the following incident scenarios.

a. Second auction triggered by extreme prices

A second auction can be triggered if SDAC finds prices outside preset levels. Not all countries apply this rule, but three BBZ's do: France, Belgium, and the Netherlands. Second auctions are becoming a not uncommon event in SDAC: there have been six such incidents, all in the past two years. There have already been five such events in 2023 due to extremely low prices.

Figure 7: Impact of second auctions on SDAC timescales

Source: CEPA assessment

Potentially, a second auction in SDAC today means a final results confirmation at about 13:47 CET, a delay of about 50 minutes.

14:20 CET is the current deadline to have validated SDAC results before a full decoupling is called. This deadline is designed to allow market parties time to complete their nominations by the 15:30 CET deadline applied by several TSOs. In effect, SDAC today has about 33 minutes of contingency in the event a second auction is called. This is needed in case of any technical issues – for example, final confirmation on the recent second auction on 18 April 2023 (low prices in the Netherlands) were not published until 14:13 CET, an extra delay of 26 minutes, using all but 7 minutes of the contingency. There is a real risk under current arrangements (and without the introduction of MRLVC) of a full decoupling being called, and SDAC parties are currently considering whether to retain the second auction facility.

If MRLVC is included in the second auction, the incremental time associated with running MRLVC would be incurred twice – e.g., leading to an additional delay of 20 minutes if the normal incremental time is 10 minutes (optimistic estimation), and leading to an additional delay of about 40 minutes (EU experts' estimation). Assuming the current deadline of 14:20 CET for validated SDAC results, this reduces the contingency time in SDAC to 13 minutes and substantially increases the risk of a full SDAC decoupling with the optimistic estimation, and contingency time is reduced to 0 minutes with the EU experts' realistic estimation.

If instead MRLVC is not rerun, either the results from the first MRLVC run can be used or MRLVC is decoupled and shadow auctions are used to allocate capacity.[21] Either way, the SDAC timeline is only impacted by the (normal) incremental time associated with a single MRLVC run. The contingency is reduced to 23 minutes from today's 33 minutes (optimistic estimation) and is reduced to 13 minutes

[21] The shadow auctions can be run while the order books are reopened.

(EU experts' realistic estimation), which still represents a material increase in the risk of a full decoupling. Not rerunning MRLVC adds the additional challenge that the market players in the EU would be able to adapt their market position in the new SDAC run whereas UK players would be adapting their position in a decoupled market. This implies, that it will not be possible to obtain equal and non-discriminatory treatment as market participants in the GB market will be in a disadvantaged situation, compared to market parties in the EU market.

There are also performance issues with not rerunning MRLVC:

- Shadow auctions are a difficult mechanism for the market to use and for prices to adjust efficiently. For example, any impact that would not allow allocation of the transmission rights on BritNed (on a day like 18 April 2023, where there was a second auction in the Netherlands due to the minimum price being reached) would probably exacerbate the extreme prices problem in the Netherlands, assuming that in this situation, BritNed were scheduled to export from NL to the UK.

- If the results of the first run are used, there could be degradation in the MRLVC performance if the BBZ OBKs change materially in the second auction in SDAC. This is possible if market conditions have changed. For instance, sell bids could be withdrawn due to the negative prices.

With the inclusion of 15-minute MTU, even without MRLVC, there is severe pressure on the SDAC timeline and almost no contingency to handle any technical delays. Without changes – e.g., to the nomination deadline – second auctions may create an unacceptable risk of having to fully decouple. The additional effect of MRLVC, even if it were decoupled, would further exacerbate this.

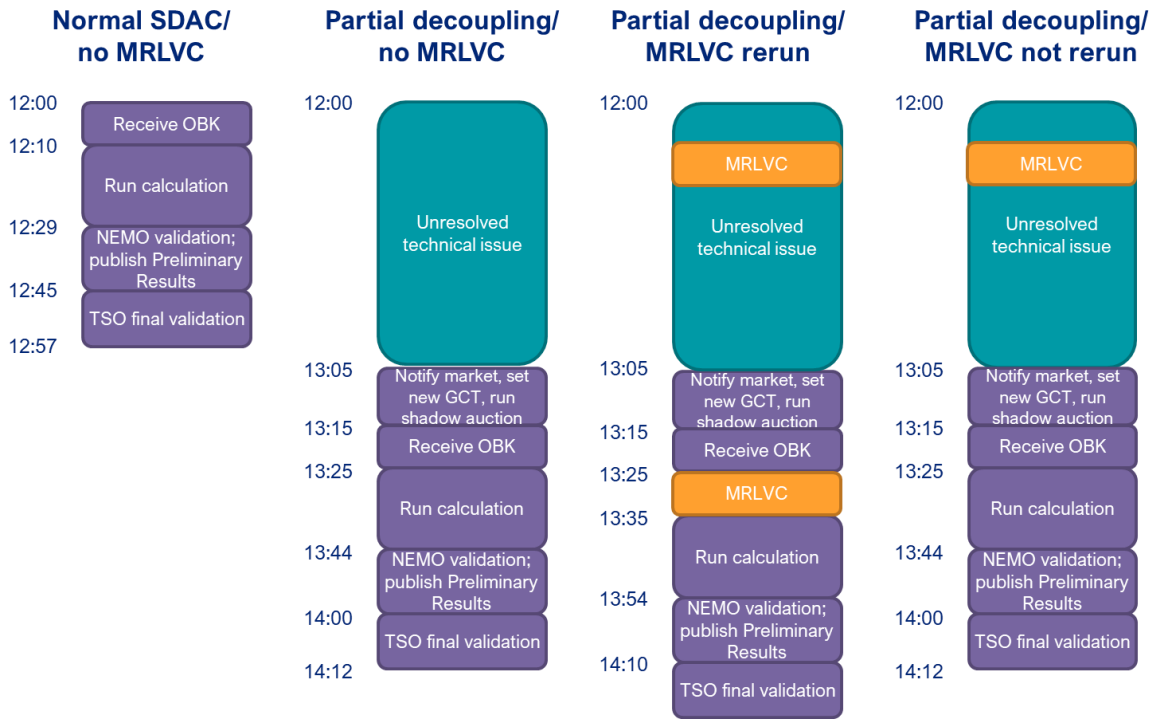
b. Partial decoupling triggered by technical problem in a NEMO

A partial decoupling can be triggered in SDAC if, for example, a country or set of countries are unable to submit compliant OBKs for technical reasons. Partial decouplings are rare but do happen: there have been 4 such incidents in the past 10 years, the last one in 2022.

There is some flexibility within the current SDAC procedures to attempt to resolve the problem. The deadline for a partial decoupling decision is currently set at 13:05 CET. With the normal SDAC duration of 57 minutes to publication of final results, this allows only eight minutes contingency for completing the partial decoupling before the 14:20 CET full decoupling deadline.

If MRLVC is included, the incremental time associated with running MRLVC may be incurred twice – i.e., the SDAC timeline is impacted by the (normal) incremental time associated with a first MRLVC run at 12:00 CET, and with a second run at 13:25 CET. With the assumption of MRLVC run in 10 minutes this already breaches the current full decoupling deadline which is 14:20 CET. Alternatively, the deadline for calling a partial decoupling could be brought forward but this increases the risk of having a partial decoupling that could have been avoided. Contingency time to avoid partial decoupling in SDAC before 13:05 CET is already decreased with MRLVC first run at 12:00 CET, and even with optimistic MRLVC delay partial decoupling would most likely end with a full decoupling.

Figure 8: Impact of partial decoupling on SDAC timescales



Source: CEPA assessment

If instead MRLVC is not rerun, MRLVC would be decoupled and shadow auctions used to allocate capacity. These can be run while the shadow auctions in SDAC are run. Alternatively, if the partial decoupling does not involve any BBZs and all BBZs have submitted OBKs, MRLVC could be run as normal at 12:00 CET, while the technical issue for SDAC is being investigated and addressed. In this case, the results from this run could be used, avoiding the need for a rerun. Either way, the SDAC timeline is not impacted by MRLVC, and the contingency for SDAC remains at best eight minutes.

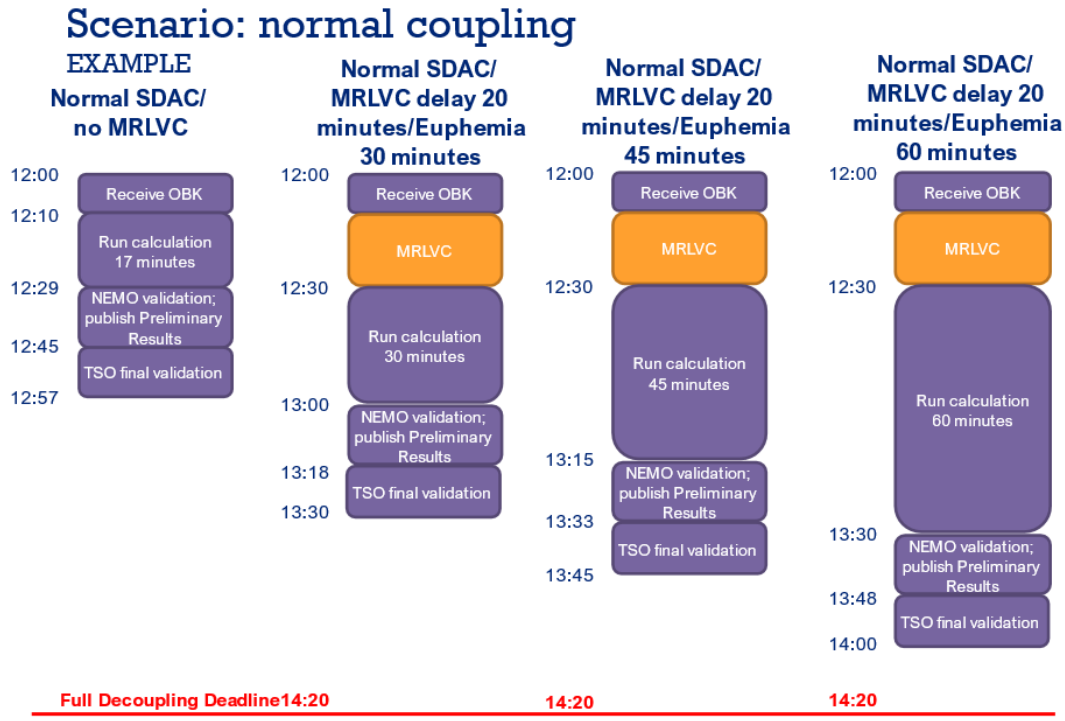
There are, however, potential performance issues with not rerunning MRLVC. If the results of the first run are used, there could be degradation of MRLVC performance if the BBZ OBKs are changed materially in the second gate closure. This is possible if market conditions have changed and if BBZs reopen their OBKs.

With the inclusion of 15-minute MTU, even without MRLVC, there is increased pressure on the SDAC timeline. This may imply a combination of further reducing contingency (increasing the risk of full decoupling) and an earlier deadline for partial decoupling (increasing the risk of having a partial decoupling that could have been avoided), unless other deadlines can be changed. This is explained in more detail below.

Delay introduced by MRLVC (within a realistic range of 20-40 minutes) would significantly reduce any mitigation time for SDAC to avoid partial decoupling (it not being unusual for a NEMO to incur technical delays) or full decoupling. Any minor unexpected event in SDAC would increase the probability of a full decoupling outcome. However, a full decoupling has never occurred since Market Coupling started.

Figure 9 below presents a number of different scenarios for the EUPHEMIA computation time – 30 minutes, 45 minutes, or 60 minutes – which are potential options that are currently under consideration for 15-minute MTU implementation. The status quo is also presented on the left-hand side. Later Figures show how MRLVC reduces the contingency time required for partial decoupling. Under certain circumstances there is no time for partial decoupling, meaning that any incident which in the past would have led to a partial decoupling will now lead to full decoupling under the current deadlines.

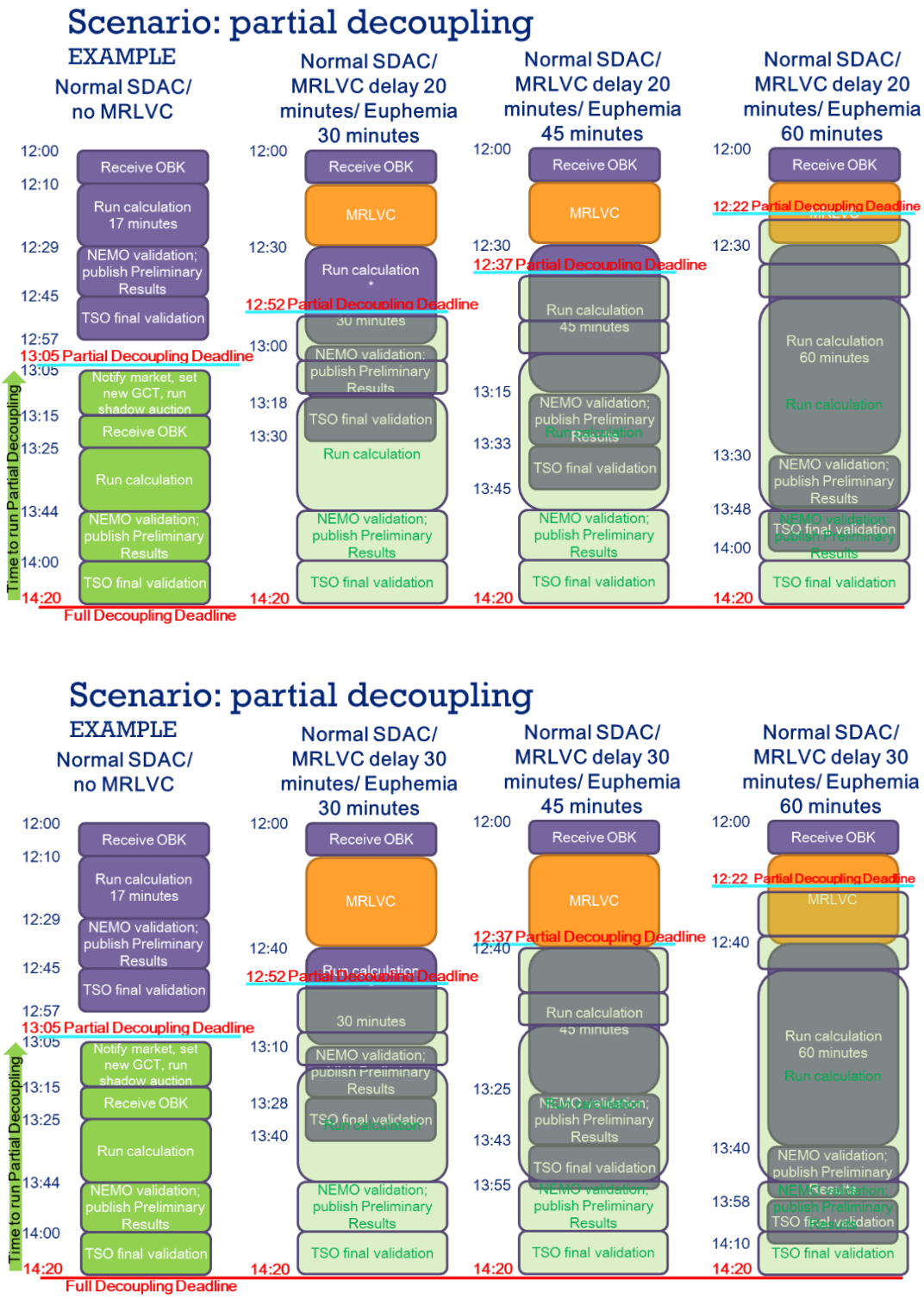
Figure 9: 15-minute MTU timings impact on partial coupling



Source EU SDAC Experts

Under the existing SDAC process, it is very challenging to trigger partial decoupling in the event that an issue arises. However, upon MRLVC being introduced, should an issue arise, MRLVC will consume time – in an already constrained SDAC process – likely resulting in either SDAC running normally or a full decoupling scenario. Any issue in one SDAC process could decouple the full SDAC area plus the UK interconnectors. Such a scenario must be avoided, and a partial decoupling process is a 'must have' for SDAC parties. See the Figures below. There is no known analysis of the financial impact of such a full decoupling event, as it has never happened. However, welfare losses could potentially be significant and could impact both the EU and the UK as MRLVC would then also have to decouple. The cost of a recent partial decoupling event for example has amounted to €20m.

Figure 10: Scenarios: partial decoupling with different MRLVC calculation times



Source EU Experts

c. Technical problem in the MRLVC MCO

The MRLVC MCO could have technical problems or the GB OBKs could be delayed, delaying the calculation of results (a delay due to the unavailability of any BBZ OBKs would also affect SDAC and is covered by incident scenario (b) above).

There would probably be some flexibility in the normal procedures to allow for a moderate delay. Beyond this cut-off time, SDAC would need to decide whether to decouple MRLVC or allow more time. Allowing more time reduces the contingency available to SDAC, increasing the risk of full decoupling. However, calling a partial decoupling also takes up time and increases the risk of full decoupling.

An option to ignore the MRLVC's results and use some default flow values in SDAC for the interconnectors (flows at zero values/flows equal to long-term nominations/flows based on historical values etc. converted as bids in SDAC) could also be used. This would minimise the impacts of MRLVC disfunction on SDAC operations at the cost of a loss of general welfare and at the risk of disrupting market parties' bid positions. Market parties, who would have bid both in the BBZ and in GB taking into account possible flows between GB and EU, would likely not be able to fully adapt their bid position in case of a MRLVC failure. This could impact the market parties' bidding behaviour as market parties are used to being able to adapt their bids in case of any coupling failure.

That last option to ignore MRLVC results would be the only one that could be compatible with the additional time constraints on SDAC process added by 15-minute MTU.

In practice, it is likely that there would need to be good communications between the SDAC and MRLVC MCO to understand the problems and the level of assurance that they can be fixed.

Summary

In summary, there is an operational interdependence between SDAC and MRLVC in the event of an incident or significant delay. In some cases, it may be possible to mitigate the impact MRLVC has on the timeline to some extent, but it is at the risk of inefficient flows on the interconnectors, as well as a welfare loss for consumers.

This analysis has been conducted on the assumption of MRLVC having an incremental impact of 10 minutes. This is only an assumption, as EU experts advise that they believe MRLVC will take longer (optimistically at least 20 minutes) which will have a particularly big impact on incident risks.

The incident procedures for 15-minute MTU are currently still under development, but it is clear that 15-minute MTU will have a significant impact on the time required to run the end-to-end process and likely remove the possibility for any fallback in case of a MRLVC failure. Even without the integration of MRLVC, it is likely that many of the incident procedures will need to be revised to accommodate the implementation of 15-minute MTU. The integration of MRLVC will result in the processes becoming more complex and challenging. Until the new SDAC procedures for 15-minute MTU have been developed, it will not be possible to assess the actual impact(s) on the functioning of SDAC should the MRLVC MCO be integrated with a 15-minute MTU. Following discussions between the consultants (CEPA) with market participants, TSOs and NEMOs, the general consensus is that full decoupling is the key risk they wish to avoid. Occasional delays to publication or a low risk of partial decoupling are less critical, but still present a material risk. Any delay in SDAC publication due to an incident should automatically result in a postponement of the nomination deadlines.

A further concern expressed in discussions with stakeholders was the potential impact on the new intraday auction scheduled for 15:00 CET.

Q2. With respect to the Common Order Book options identified by transmission system operators:

(b) For other additional common order book options identified by TSOs in the cost benefit analysis (a change in timing of SDAC GCT and/or the publication of SDAC results), what are the advantages/ disadvantages between these options, including:

(1) the impact on the processes before (e.g., capacity calculation) and after SDAC (e.g. intraday/ balancing markets);

(2) the impact on transmission system operators, market operators and the impact on market participants of any increased time between SDAC GCT and SDAC results. Any operational impacts and risks should be fully explained and substantiated.

The principal option is to bring forward the SDAC GCT. The alternative option of delaying the publication of SDAC results is an inevitable consequence of the COB option and is addressed in Q2(a).

The main benefit of bringing forward the SDAC GCT is that it restores some or all of the contingency time available to SDAC to resolve technical issues (in particular, if an incident occurs) and avoid full decoupling. Given that no stakeholder expressed strong objections to the normal SDAC publication being delayed by, say, ten minutes because of MRLVC, there does not appear to be a strong case to bring forward GCT for this reason.

SDAC currently has a full decoupling decision deadline at 14:20 CET, driven by a TSO deadline to receive nominations from market participants by 15:30 CET in some countries. This 15:30 CET deadline is in turn constrained by later processes, such as delivering DACF grid models. If anything, there is increasing pressure on these subsequent processes.

Moving SDAC GCT forward by 10-15 minutes would largely mitigate the impact of MRLVC on both normal and incident processes – on the assumption of a minimum 20-minute end-to-end process for MRLVC. If the MRLVC timelines are towards the upper end of the range estimated in Q3(a) (13-42 minutes), then the SDAC GCT would need to be moved forward even earlier under this option.

An earlier GCT is likely to have an impact on the receipt of network data in SDAC. Normally, this is completed before 10:00 CET, but it is common for there to be delays – for example, data was not received until 11:48 CET last November and has been later than 11:30 CET five times in 2022. If SDAC GCT is brought forward, the risk that the network data is not available may increase – the earlier the SDAC GCT, the greater the risk. Either a procedure is established where preliminary data is made available earlier in the day and is used as a fallback, or the start of SDAC will have to be delayed on that day. There are also additional processes that operate in the morning, such as balancing services auctions. However, nothing has been identified in the analysis for this report that would be significantly impacted by a SDAC GCT of, say, 11:30 CET.

Market participants raised concerns about an earlier gate closure time:

- It reduces the time between the manual Frequency Restoration Reserve[22] (mFRR) tender results (BE, DE, and FR), which is fixed at 10:30 CET, and the spot bidding deadline (12:00 CET). That makes it much harder to prepare the bids for the flexible assets that participate in the mFRR auctions.
- More generally, it reduces the time available to prepare optimal SDAC bids and to assess volume exposures (power, gas, CO_2, etc). Power price forecasts and the forward markets (power and gas) are most liquid between 11:00 CET and 12:00 CET.

[22] A service to manage an imbalance between generation and consumption.

- The forecasts themselves (power) depend heavily on PTDF data (flow based). Reducing the time available to prepare SDAC bids might lead to less optimal bids, hence welfare losses.

15-minute MTU is likely to have a greater impact on the SDAC timeline (normal and incident situations) than MRLVC alone. Adopting an earlier GCT could be a way for SDAC to maintain its current incident procedures and avoid a reduction in the contingency available (which is directly related to full decoupling risk). Again, the effect of MRLVC on SDAC timelines is cumulative on top of changes needed for 15-minute MTU.

Q1. With respect to the Preliminary Order Book option identified by transmission system operators:

(c) Would this option fully mitigate or still face any of the timing issues identified with the Common Order Book Options? Any operational impacts and risks should be fully explained and substantiated.

Based on the estimated MCO process timings set out in Q3(a), and assuming the acceptability to stakeholders of some quality degradation in the MRLVC calculation and some operational risk of overrun, MRLVC would take 20 minutes from gate closure to having the results in SDAC ready to start the calculation. Given that the current start of the SDAC calculation is at 12:10 CET, a GCT for the POB of 11:45 CET would be feasible in terms of not changing SDAC timescales under normal conditions. It would provide a modest amount of contingency (5 minutes).

Under normal conditions, the POB would fully mitigate the impact on the current SDAC timings of MRLVC under the COB option. It would also mitigate the impact of MRLVC on the SDAC timings following the introduction of 15-minute MTU – although the size of that impact cannot be quantified at this stage, as previously noted.

The POB option would only partially mitigate the impact of MRLVC under COB in the case of incidents or delays.

- If the incident only arose in SDAC (e.g., partial decoupling of a non-BBZ market, second auction), it would be detected after MRLVC had run. An earlier POB would not mitigate the impact of MRLVC on the SDAC incident procedure (e.g., if MRLVC is rerun) but an incident like a second auction may be detected earlier with POB because SDAC starts earlier than under COB.

- If the incident arose in MRLVC, it would be identified earlier than under COB, which should enable more time to seek to resolve it.

POB does not provide a material mitigation of the timing issues associated with SDAC incidents under 15-minute MTU. To alleviate these risks implies an earlier GCT for SDAC as a whole.

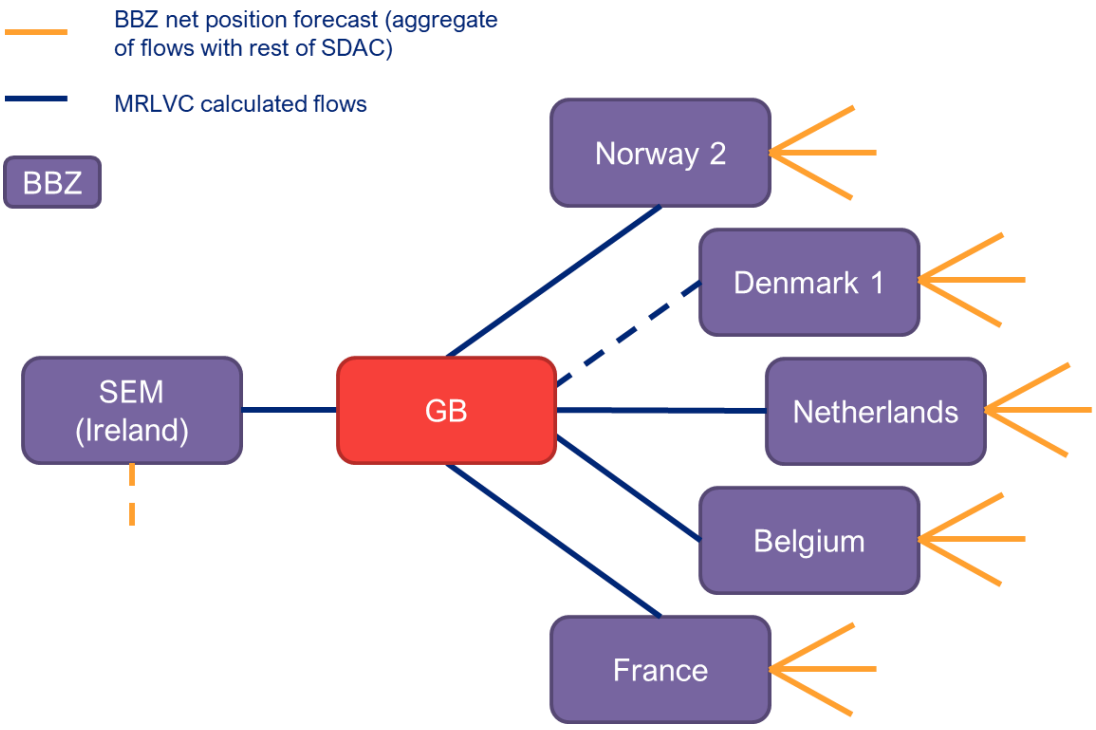
4.3. BBZ net position forecast (Q3b)

Q3. With respect to both the Preliminary and Common Order Book options:

(b) Please provide an outline proposal for the Bordering Bidding Zone (BBZ) Methodology for establishing an accurate and robust forecast. In setting this out, please include;
(1) the key issues, principles, and parameters (including input data, outputs, and the use of outputs in MRLVC) that need to be addressed and established by the BBZ methodology;

The TCA includes a restriction on the data that can be used in MRLVC – whereby the MRLVC calculation may only use the order book data for GB and BBZs directly connected to GB. This means that a forecast of the net position of each BBZ relative to the rest of SDAC is an essential element of a MRLVC design that operates as a radial configuration, as depicted in Figure 11.

Figure 11: Stylised configuration of BBZ net position forecast



Source: CEPA

Principles

The principles which should guide the design, implementation, and operation of a BBZ net position forecast relate primarily to delivering a good feasible forecast that is trusted by market participants, supporting trade in the day-ahead markets covered by the MRLVC arrangements, and other stakeholders. These principles are:

- **Respecting the physical limitations of the power system,** and calculated capacity under coordinated methodologies as developed and approved by NRAs, in terms of available transfer capacity between the BBZ and neighbouring SDAC zones.

- **Supporting the MRLVC and SDAC processes to maximise socio-economic welfare**, which is the sum of consumer surplus, producer surplus and congestion rents. This is consistent with achieving a high level of accuracy in the BBZ net position forecasts. Inaccurate forecasts will drive a poor-quality MRLVC outcome with welfare losses compared to what might be achieved through price coupling. The performance of the MRLVC process is particularly sensitive to the accuracy of the BBZ net position forecasts, when there are small differences between GB prices and BBZ prices. When the price differences are large, the MRLVC-determined flow direction is more likely to be correct, even if there is some inaccuracy in the BBZ net position forecast.

- **Clearly explaining how the forecast operates, including how the design of the forecast and choice of inputs affect the results**. This could extend to a suitably qualified party being able to audit the algorithms and other calculations involved in producing the forecast. This principle has become increasingly prominent with the increased use of machine learning techniques, and the associated concerns around 'black box' processes that lack the transparency which users of the outputs and other stakeholders (e.g., regulators) may expect and require.

- **Demonstrating the repeatability of the forecasts**, in terms of the likelihood that the forecast will produce the same or similar outputs across multiple runs with the same inputs.

- **Providing transparency in performance of the forecast**. On a daily basis, this would include publishing the outputs in a timely fashion on a public platform, with commentary on any outliers in forecasting performance. Over a longer time period, say one year, this could include a regular review process with a report on trends in performance, and proposed measures to improve performance.

TSOs would expect the BBZ net position forecasting tool to be a bespoke development specific for its purpose. It could either be in-house-developed and operated, or via a service provider, or in some combination. In the case of externally developed/operated model TSOs would expect to retain the IP and the general ownership of the process.

Methods

There are several methods currently being used by different parties to forecast prices, flows and net positions in European wholesale electricity markets. These can be grouped as follows:

- Statistical relationships – using statistical techniques (e.g., regression analysis) to identify relationships in historical data and applying these to project future market dynamics.

- Machine learning – using artificial intelligence techniques to identify patterns in data and make predictions.

- Replicating central market processes (e.g., welfare-optimising allocation consistent with the grid model), perhaps combined with machine learning techniques and other modelling to build supply and demand curves.

As these methods are not mutually exclusive, the BBZ net position forecast could use a combination of all three.

Inputs

Based on analysis of existing forecast methodologies and engagement with forecasting experts from TSOs and commercial providers, the following inputs would be considered for use in a BBZ net position forecast.

- Cross-border transfer capacities.
- Load forecasts, possibly by customer category, for BBZ and surrounding regions.
- Temperature forecasts for BBZ and surrounding regions, possibly including an adjustment for 'perceived temperature' after cooling effects of wind.
- Renewable energy forecasts for BBZ and surrounding regions.
- Generation availability in BBZ and surrounding regions.
- Fuel and carbon costs of prevailing generation technologies in BBZ and surrounding regions.
- BBZ net positions in recent periods.

While these input categories may appear relatively simple, thousands of individual data points may need to be collected – because of the number of zones involved (and possible locational granularity of data within those zones) and the various types of generation technologies that would be individually considered. For example, the net position forecast tool for CORE TSOs features over 4,000 input variables.

Outputs and Production

The required outputs would be the forecast net position of each BBZ relative to SDAC for each MTU of the next day. These values would be used as inputs to the MRLVC calculation to determine the flows on each GB-BBZ interconnector. The model for transmission capacity is still to be decided in dedicated regulation. However, the statements and analysis in this report (and the earlier CBA) were drafted with an NTC-type "hub and spoke"/radial model in mind.

The operational processes and associated timings for producing and using the BBZ net position forecast in MRLVC are covered in the response to Q3(a). To summarise, the forecast should be done close to GCT as reasonably practicable to take advantage of the most up-to-date information. However, it should not be on the critical path of MRLVC or SDAC and so should be prepared with sufficient time, including contingency, for operational checks. To mitigate operational risk further, a preliminary forecast could be produced earlier in the morning to provide a fallback position in the case the pre-GCT forecast fails to produce acceptable results.

Issues

The following are issues relating to a BBZ net position forecast which would need to be addressed either before or during the implementation of MRLVC:

- Feasible levels of forecast accuracy – the 2021 MRLVC CBA found that MRLVC is only beneficial relative to explicit auctions if the BBZ forecasts are sufficiently accurate. As discussed further in the answer to Q3b(3), the analysis undertaken for this response investigates the impact of BBZ net position forecast inaccuracy on market flows and welfare relative to the optimal market clearing point. The same analysis is presented for explicit coupling for comparison.

- Aligning the incentives of the MRLVC TSOs to procure a BBZ net position forecast that achieves an appropriate trade-off between forecast accuracy (with associated welfare benefits) and the costs (financial and other) of achieving that accuracy. The MRLVC TSOs will be directly exposed to the costs of poor forecasts, unlike in explicit auctions where capacity holders (i.e.

commercial market participants) may lose money in the event of nominating sub-optimal flows. In the explicit case, such capacity holders might nominate in the correct direction but either too much or too little or alternatively nominate counter-intuitive flows against the price difference (FAPDs). The impact of such situations is a loss of value to holders of capacity rights and the risk of loss-making trades. To avoid such situations, traders may rely on their own forecasts, as well as judgement and appetite for risk. In this way, for explicit auctions traders are responsible for forecasting (or procuring an external forecast) and bear the risk of being wrong. In contrast, MRLVC does not present the same alignment between risk allocation (i.e., exposure to loss-making trades) and ability to manage risk. Forecasting would be undertaken by a central entity and under a regulated methodology which does not seek profit-maximization or assessing risks of inaccuracy vs. profits.

- Aligning the incentives of the forecast provider to achieve accurate forecasts, which will depend on the procurement approach taken by the MRLVC TSOs.

- Uncertainty about the feasible accuracy that could be delivered by BBZ net position forecasts for Offshore Bidding Zones (OBZ) participating in the SDAC, given the sensitivity of an offshore bidding zone to the MRLVC result and the issues to be investigated according to section 3.4.

Q3. With respect to both the Preliminary and Common Order Book options:

(b) Please provide an outline proposal for the Bordering Bidding Zone (BBZ) Methodology for establishing an accurate and robust forecast. In setting this out, please include;
(2) a timescale within which this methodology could be established and made operational.

Implementation timelines are covered in the response to Q3(c). The central role of the BBZ net position forecast in the performance of the MLRVC process means that it makes sense to keep testing and refining the forecast approach until quite late in the implementation process – i.e., there is little benefit from having a BBZ net position forecasting process established early in the process which is then left 'on the shelf' until the other necessary arrangements are implemented and tested.

The first phase of the implementation of the BBZ net position forecasting methodology is the design and validation of the BBZ net position forecasting prototype, which is a priori scheduled to last for 9 months. This is on the critical path in the initial phase of implementation – as confidence that a sufficient level of forecast accuracy can be achieved in the BBZ net position forecast will inform a go/no-go decision which is scheduled to be taken after this first 9-month period of the implementation programme. This first phase consists of the following tasks (with indicative timings):

- Define a first high-level set of requirements for the BBZ net position forecaster (4 weeks);
- Prepare, issue tender for and select a prototype based on first set of high-level requirements (12 weeks);
- Set up the prototype (4 weeks);
- Finetune/analysis of prototype to produce working model (12 weeks);
- Review/validate prototype results, including simulations of MRLVC outcomes using forecasts (4 weeks).

The results will then be presented to relevant authorities for 'informal' review (4 weeks). This timeline assumes that parties involved will have quick access to the relevant data and are relatively familiar with the type of data being processed. If this is not the case, the timeline could be extended. In addition, there remains a risk of delay in iterating different versions of the prototype to come to a viable model. In addition, potential additional costs/time needed related to transparency/publication of the forecasted flows is not included in this analysis.

Assuming the decision is taken to continue with implementation, the second phase for the BBZ net position forecast is to finalise the set-up of the selected tool, with three specific tasks:

- Define detailed set of requirements for BBZ net position forecaster (16 weeks);
- Prepare, issue tender for and select the tool based on final detailed set of requirements (12 weeks);
- Set up the selected tool (4 weeks).

At this point (18 months into the implementation project), the BBZ net position forecasting methodology can be described as operational. During the rest of the implementation phase, the tool will be tested and refined as part of the testing of the overall MRLVC arrangements – e.g., the internal review of MRLVC results before the external parallel run process.

Q3. With respect to both the Preliminary and Common Order Book options:

(b) Please provide an outline proposal for the Bordering Bidding Zone (BBZ) Methodology for establishing an accurate and robust forecast. In setting this out, please include;
(3) a preliminary qualitative assessment of how the proposed BBZ methodology in conjunction with MRLVC is expected to perform, compared to the results of the allocation of capacity through explicit auctions to deliver more efficient trading arrangements, and, in particular, under what conditions the proposed methodology in conjunction with MRLVC outperforms explicit auctions.

This response is informed by analysis of the performance of explicit auctions and of existing BBZ net position forecasts, as well as engagement with TSO forecasting experts and commercial forecast providers to understand existing and prospective capabilities for forecasting BBZ net positions.

Analysis of explicit auctions
This analysis of the performance of explicit auctions covers the following metrics (between January 2021 and April 2023):

- percentage of hourly intervals in which there were Flows Against Price Differences (FAPDs) for each of the existing interconnectors between GB and Continental Europe; and
- aggregate welfare loss from inefficient flows on existing interconnectors between GB and Continental Europe.

Table 3 shows the percentage of hourly intervals in which there were FAPDs for each of the existing interconnectors between GB and Continental Europe.[23] This analysis is shown by calendar year as well as for the period of May 2022 until April 2023 for comparison with the analysis of BBZ net position forecasts.

Table 3: Percentage of hourly intervals in which there were Flows Against Price Differences (FAPDs) for each of the existing interconnectors between GB and Continental Europe

IC	2021	2022	2023 YTD[24]	May 2022 – April 2023 (provisional)[25]
Nemo Link	11%	20%	20%	18%
IFA2	11%	17%	19%	15%
IFA	11%	16%	19%	13%
BritNed	12%	21%	16%	18%
ElecLink	N/A	14%	20%	14%

Source: Analysis of data from ENTSO-E Transparency Platform; Low Carbon Contracts Company; Bloomberg

[23] The same analysis is not possible for NSL (GB-Norway) and for Moyle/EWIC (GB-SEM) because there is no explicit allocation of IC capacity on these borders.
[24] "2023 YTD" covers the period from 1 January 2023 until 28 April 2023.
[25] Provisional values.

Some FAPDs could be associated with baseload day trades which are logical in aggregate even if they appear 'out of the money' for individual intervals. Trades could also have been undertaken at prices which differ from those used for this analysis (i.e., 'over the counter' trades). Nonetheless, even if part of an overall profitable trade, FAPDs represent a lost welfare opportunity.[26]

The second metric is the aggregate welfare loss from inefficient flows on existing interconnectors between GB and Continental Europe[27], as shown in Table 4. These values include both intervals with FAPDs as well as intervals in which flows are in the correct direction (i.e., from the higher priced region to a lower priced region) but flow is less than 100% such that the interconnector is underutilised. Similarly, this metric is reported for each calendar year and the period of May 2022 until April 2023.

Table 4: Aggregate welfare loss for explicit auctions from inefficient flows on existing interconnectors between GB and Continental Europe.

	2021	2022	2023 YTD	May 2022 – April 2023
GB-BE	€9.8m	€36.0m	€3.2m	€28.9m
GB-FR	€23.4m	€98.0m	€19.7m	€95.6
GB-NL	€10.9m	€50.5m	€4.3m	€40.0m
Total welfare losses	€44.1m	€184.5m	€27.2m	€164.5m

Source: Analysis of data from ENTSO-E Transparency Platform; Low Carbon Contracts Company; Bloomberg

Analysis of existing BBZ net position forecasts

A commercial forecaster has been identified who already provides regular forecasts of prices and flows across most of SDAC[28]. Their methodology combines AI machine learning to develop national supply curves together with explicit modelling of transmission network capacity. Their focus is on price forecast accuracy, with flow forecasts largely a by-product of their methodology.

Forecasts are updated on a continuous basis. The analysis presented here uses a key reference forecast – used by traders in SDAC – that is provided at 11:00 CET D-1.

The mean absolute error of this commercial forecast over the past 12 months (May 2022 – April 2023) has been estimated as being significant. The errors for hours with small GB-BBZ price differences (i.e. less than €10/MWh) are similar to errors for all hours. The hours with smaller price differences are the periods when accuracy is most important as an error is more likely to cause a FAPD in the MRLVC process.

The [redacted] forecast tool performs a D-2 net position forecast for zones within CORE as an input to flow-based calculations of the CORE TSOs. The accuracy of this [redacted] is not directly comparable to the commercial forecaster as it does not cover all FR borders (ES, IT not covered) and NL borders (DK1, DE, NO1 not

[26] This is based on the assumption that day-ahead prices represent efficient prices that should determine efficient flows.
[27] This analysis assumes that the DA prices in each market represent efficient prices for the purposes of calculating efficient flows.
[28] Ireland is not currently included in these forecasts.

covered). Adding these non-CORE borders to the FR and NL to the Core TSO tool forecast is likely to increase the size of the error.

Comparing the commercial forecasts with the BBZ net position forecast errors modelled in the CBA indicates that accuracy is worse than in the scenario in the 2021 MRLVC CBA[29] particularly for FR, BE, NL and DK1, although comparable for NO2. This implies that the CBA results for MRLVC would have been worse for those bidding zones. However, direct comparison is difficult because 2022 was seen as an unusually difficult year for forecasting, largely attributed to high and sharply changing gas prices, compared to the CBA period (July 2019 – May 2020).

Forecast errors in the BBZ net position lead MRLVC to anticipate BBZ prices higher or lower than ideal. The GB-BBZ price spread calculated in the MRLVC process can reverse, causing MRLVC to schedule FAPD (i.e., compared with the outturn day-ahead prices in SDAC and GB) (slide 18). The effect of a forecast error depends on the price sensitivity in that BBZ. Price sensitivity is the slope of the net export curve: how much a BBZ market clearing price will increase as it exports more or reduces as it imports (slide 19). Smaller markets, such as Denmark 1 (DK1) and Belgium tend to have higher price sensitivity; Norway 2 (NO2)'s price sensitivity is unusually low, given that it is not a large market, due to the large volume of hydro resources.

The possible hours when MRLVC would schedule a FAPD has been estimated using the commercial forecast data for the past 12 months. As shown in Table 5, the % of hours is significant for all markets other than NO2; for Belgium and DK1 it appears most severe.

Table 5: Percentage of hourly intervals in which MRLVC using the commercial forecasts would schedule a Flows Against Price Difference (FAPD)

IC	May 2022 – April 2023
Nemo Link	15%
IFA1/2, ElecLink	7%
BritNed	6%
Viking	23%
NSL	2%

Source: Simulated MRLVC using commercial forecasts

If the GB-BBZ price spread predicted by the MRLVC process is large (e.g., over 5 EUR/MWh), then it is likely that MRLVC will schedule 100% utilisation of ATC. If this large spread as predicted by the MRLVC is in the wrong direction (noting that occurrence of FAPD will only become apparent after SDAC and UK market clearing as only then the final prices are known), this scenario would produce a 100% Flow Against Price Difference on the interconnector. FAPDs such as these are likely to be the periods with the highest welfare loss.

In the simulation, DK1 appears especially vulnerable to FAPDs, reaching over 30% of hours in April 2023. Until the Viking Link interconnector is operational there is no comparison possible with the performance of explicit auctions. Interestingly, however, the accuracy of the commercial forecaster's price forecast for DK1 is comparable to that of other markets. This may mean that as nominations are

[29] MRLVC CBA 2021 available here

informed by price forecasts, explicit auctions on this interconnector will perform similarly to other interconnectors.

One advantage price forecasting has for a market like DK1 (heavily interconnected to other, larger markets) is that the market price is likely to be range bound by the neighbouring countries. The MRLVC methodology, at least as envisaged so far in the radial configuration, does not model the impact of these other prices. This would not be straightforward given that these flows are, or soon will be, allocated through flow-based methods in the CORE and Nordic regions.

Table 6 compares the frequency of observed FAPDs with explicit auctions and the simulated FAPDs that would have arisen with the BBZ net position forecasts from the commercial forecaster, which would be an important input into the MRLVC process.

Table 6: Comparison between occurrence of FAPDs with MRLVC using the commercial forecasts versus explicit auctions, May 2022 – April 2023

IC	MRLVC	Explicit Auctions
Nemo Link	15%	18%
IFA1/2, ElecLink	7%	14%
BritNed	6%	18%
Viking	23%	n/a
NSL	2%	n/a

Source: Simulated MRLVC using commercial forecasts

This shows that the simple MRLVC simulation using the BBZ net position forecasts from the commercial forecaster outperforms explicit auctions on this measure in FR, BE and NL. The outperformance is largest for NL while the smallest improvement is observed for BE. It however has to be noted that this comparison does not consider the size of the flow deviations and at which price spread level they occur; both are expected to be different under explicit compared to MRLVC.

The estimated welfare loss arising from suboptimal BBZ net position forecasts can be estimated based on a simulated MRLVC using historic DA prices, estimated isolated prices[30] and average price sensitivities by market. The aggregate welfare loss compared to optimal coupling on GB-FR, GB-BE and GB-NL is €28.5m for the period between May 2022 and April 2023. Under MRLVC, negative congestion rent (and losses) from FAPDs could be expected to make up most of the net welfare loss compared to optimum implicit coupling, compounded also by the potential for unfunded payouts via UIOSI for non-accurate flow-forecasts.
Table 7 compares the estimated welfare loss of explicit auctions with the estimated welfare loss that would have arisen with MRLVC using the BBZ net position forecasts from the commercial forecaster .

Table 7: Comparison between estimated welfare loss with MRLVC using the commercial forecasts versus explicit auctions, May 2022 – April 2023 (in € millions)

[30] These isolated market prices are estimated by reversing the effect of the observed interconnector flows, and assuming efficient market prices.

IC	MRLVC	Explicit Auctions	Difference (Explicit-MRLVC)
Nemo Link	€14.4m	€28.9m	€14.5m
IFA1/2, ElecLink	€10.5m	€95.6m	€ 85.1m
BritNed	€3.6 m	€40.0m	€36.4m

Source: Simulated MRLVC using commercial forecasts

This shows that the welfare loss in the MRLVC simulation is lower than for explicit auctions by a total of €136m comprising €85.1m on the GB-FR interconnections, €14.5m in on the GB-BE interconnector, and €36.4m on the GB-NL interconnector.

By comparison, the estimated welfare loss of MRLVC compared to optimal coupling is greater than was estimated in the CBA scenarios as following: HD: -€42m; HS: -€34m[31]. To clarify: the CBA numbers represent the entire geographic perimeter analysed therein (i.e. UK + all bordering bidding zones) whereas this analysis only shows the 3 analysed borders (GB-FR, GB-BE and GB-NL). In other words, the total difference in welfare loss between the current study and the CBA should be higher still. The limited number of borders presented here is due to the absence of historical explicit data for other BBZs (i.e., GB-DK1 and GB-NO2) which does not allow for the same comparison, nor is the GB-SEM border taken into account. The CBA estimate included all interconnectors/bordering countries (i.e., also Denmark, Norway, and Ireland/Northern Ireland). However, 2022 has been reported as being an unusually difficult year for forecasting, which has been largely attributed to high and sharply changing gas prices, compared to the CBA period (July 2019 – May 2020). This impacts both MRLVC's and explicit auctions' respective welfare losses (e.g., losses for explicit in 2021 and 2023 (the half year to date) were significantly lower).

The following tables below show the breakdown of welfare loss per production, consumption, and congestion rent, for each border. It shows that overall welfare losses consist entirely of lost/negative congestion revenue, impacting the interconnector TSOs. Producer/consumer surplus is even slightly higher than under optimal coupling, at the expense of the lost congestion income. Furthermore, two values of GB price sensitivity are used: price sensitivity of 2 EUR/MWh/GW, and the figures in brackets show impact of GB price sensitivity of 4 EUR/MWh/GW. It shows that increased price sensitivity aggravates the welfare loss and, in general shifts welfare losses to more price-sensitive zones. It is important to understand the dependence of the numbers resulting from this exercise on the hypothesis taken for price sensitivity.

Table 8: Breakdown of MRLVC welfare loss on France-GB border. May 2022 – April 2023

[31] "HD" is short for "High Demand" and "HS" is short for "High Supply", representing the scenarios with the highest forecasting errors analysed in the CBA.

mil EUR	Optimal Coupling	MRLVC	Change
Congestion Revenue less Losses	1042.1 (943.7)	1029.3 (930.4)	-12.8 (-13.3)
Net producer/consumer welfare gain: GB	61.1 (109.6)	62.1 (111.4)	+1.0 (+1.9)
Net producer/consumer welfare gain: France	76.4 (68.5)	77.7 (69.6)	+1.3 (+1.2)
Overall	**1179.6** (1121.8)	**1169.1** (1111.4)	**-10.5** (-10.3)

Table 9: Breakdown of MRLVC welfare loss on Belgium-GB border. May 2022 – April 2023

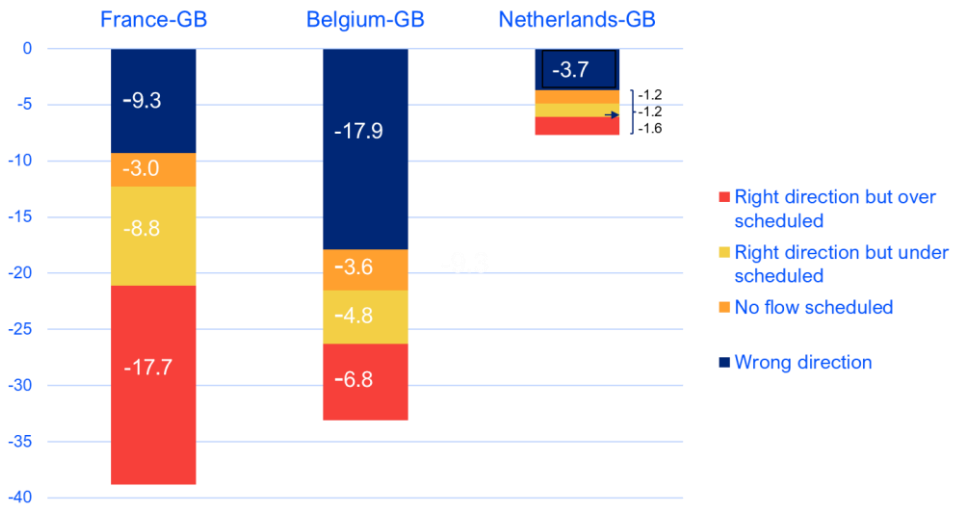
mil EUR	Optimal Coupling	MRLVC	Change
Congestion Revenue less Losses	266.2 (255.5)	250.3 (239.3)	-15.9 (-16.2)
Net producer/consumer welfare gain: GB	6.1 (11.9)	6.3 (12.3)	+0.2 (+0.4)
Net producer/consumer welfare gain: Belgium	40.5 (39.3)	41.8 (40.7)	+1.3 (+1.4)
Overall	**312.8** (306.8)	**298.4** (292.4)	**-14.4** (-14.4)

Table 10: Breakdown of MRLVC welfare loss on Netherlands-GB border. May 2022 – April 2023

mil EUR	Optimal Coupling	MRLVC	Change
Congestion Revenue less Losses	322.0 (307.3)	318.1 (303.2)	-3.9 (-4.1)
Net producer/consumer welfare gain: GB	8.0 (15.4)	8.1 (15.6)	+0.1 (+0.2)
Net producer/consumer welfare gain: NL	17.1 (16.5)	17.3 (16.8)	+0.2 (+0.2)
Overall	**347.0** (339.2)	**343.4** (335.6)	**-3.6** (-3.6)

In addition to the congestion revenue reductions identified in the above tables, there would be "Use It Or Sell It" (UIOSI) payouts by TSOs that is unfunded by auction revenues in the events of inaccurate flow forecasts, as shown for the same three borders in Figure 12. Four cases are distinguished where there is a "shortfall" of congestion income to pay out the UIOSI, depending on how the interconnector flow scheduled by MRLVC compares to the exercised UIOSI payments. The total shortfall over the three analysed borders and considered period is around €80 m.

Figure 12: UIOSI compensation shortfall (Annualised based on 1 May 2022 to 28 April 2023)



Source: CEPA estimates

Explicit auctions and MRLVC in relation to future offshore challenges

MRLVC could face similar challenges as explicit auctions with respect to delivering efficient trading arrangements in the context of offshore.
Given that Europe is in the initial stages of developing complex offshore infrastructure, there is no practical experience yet with respect to how such solutions work. Therefore, a very initial qualitative assessment has been made to compare characteristics of explicit auctions and MRLVC for offshore. It has to be noted that this is not exhaustive.

The main challenge related to explicit auctions is that the cross-border capacity is auctioned separately from the electrical energy. This has effects on the volumes available for cross-border exchange and wind generation on the interconnector and on the prices that would be set in (offshore) bidding zones connected to hybrid interconnectors.

a) Due to this nature of explicit auctions, there is a need to ex-ante split the interconnector capacity to be performed by the (onshore) TSOs. A wind forecast will be required to estimate the interconnector capacity reserved for wind production. The remaining capacity is then made available for the explicit auctions. However, such wind forecasts will not exactly match the exact wind production. This means that the initial remaining part of the interconnector capacity for the explicit auctions would be either an underestimation or an overestimation. This would lead to either additional system costs for the TSO or to an opportunity loss due to the reduced capacity initially made available to the market compared to the alternative.
b) Since explicit coupling is only applicable for the fixing of the volume for the cross-border capacity, there is no efficient price setting for the energy in the (offshore) bidding zones connected to the hybrid interconnector. The price of EU (OBZ) and GB (OBZ) are not interlinked.
c) Due to the separate auctioning of cross-border capacity there will be positive congestion income for (hybrid) interconnectors, however subject to the shortcomings of explicit auctions in general.

The main challenge related to MRLVC is that it is a volume-only coupling methodology and therefore does not provide a joint allocation of the connected offshore wind and cross-border capacities of an offshore hybrid interconnector.

a) The absence of a joint allocation of the connected offshore wind and cross-border capacities of an offshore hybrid interconnector leads to similar needs of ex-ante forecasting wind to determine the residual amount of capacity available for the allocation of cross-border capacity, but in this case via the MRLVC. This is a similar challenge to the explicit auctions' mechanism. In the MRLVC design, an accurate BBZ methodology and forecast will be even more important to reflect the relevant bordering bidding zones.
b) Since MRLVC is a volume only coupling solution, the OBZs on a hybrid interconnector still cannot have an efficient price setting across the hybrid interconnector. An EU OBZ cannot have its price set by GB, and vice versa, a GB OBZ cannot have its price set by the EU while it would be most efficient to have consistent price setting over the hybrid interconnector, taking into account (non) congestions.
c) MRLVC's performance could be challenged further, because unlike with explicit auctions where capacity is allocated first and then market participants decide whether or not to use it, the MRLVC generates fixed price taking orders, which cannot be changed, even if it would have been more efficient to adjust those orders than curtailing offshore wind.
d) Given the welfare shift MRLVC could lead to significant negative congestion rents on interconnectors (including hybrids) due to potential FAPDs impacts. This is relevant for the business case of present interconnections, but also for future offshore hybrid projects.

These initial considerations show that MRLVC could face some similar difficulties as the explicit auctions' trading arrangements to provide the right answers to tackling future offshore challenges.

Both explicit and MRLVC might lead to challenges related to price and volume risks for commercial offshore wind and infrastructure developers, costs for remedial actions for TSOs and the risk of not utilising the offshore capacities to their full potential.

4.4. Implementation timelines and costs (Q3c)

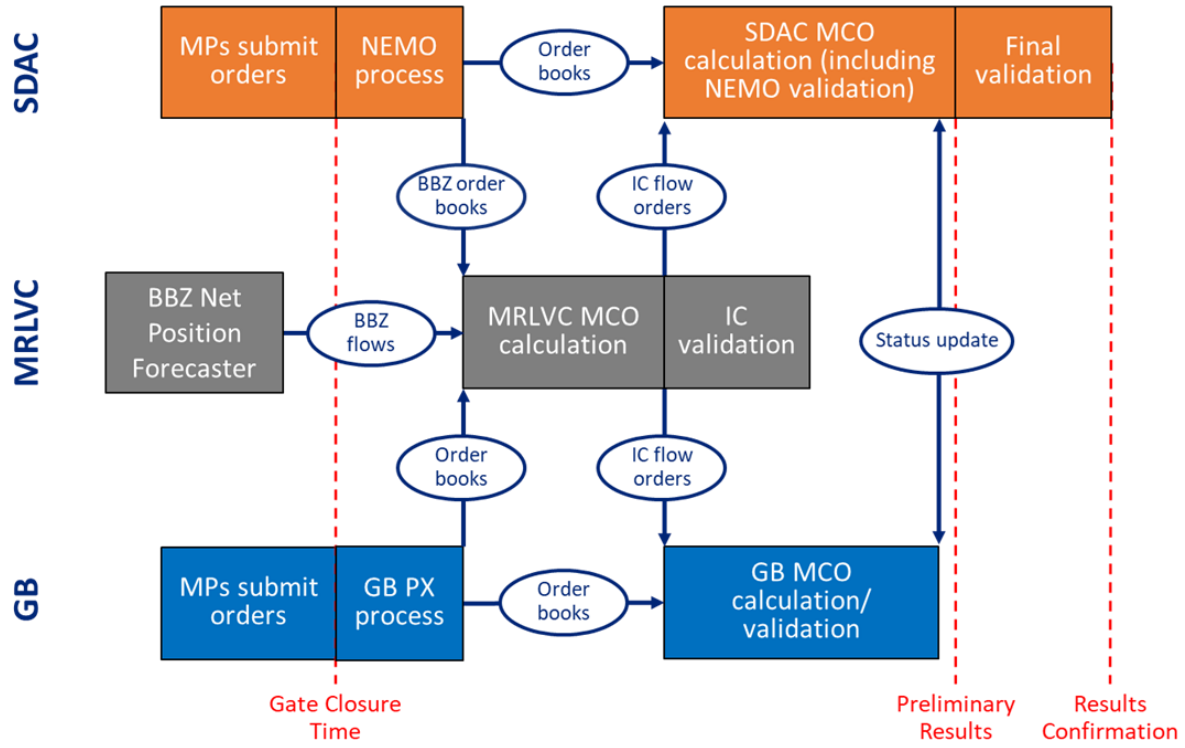
Q3c. Implementation:

1) What are the detailed steps required to implement all aspects of both Preliminary and Common Order Book options, including processes to test and verify the performance of MRLVC before full operation, roles and responsibilities of transmission system operators, market operators, and market participants, how could these aspects be implemented in the shortest possible time, and how could the structure and content of the technical procedures best support efficient implementation?

To implement all aspects of the MRLVC process shown in Figure 13 below, four project streams involving multiple parties need to be established:

1. **BBZ Net Position Forecaster** project in which the MRLVC TSOs would be participating;
2. **GB Coupling** in which the REMOs active in UK would be participating. This stream is out of scope of the analysis for this report;
3. **MRLVC** in which the MRLVC TSOs and MRLVC NEMOs would be participating;
4. **SDAC** in which all SDAC parties would be participating.

Figure 13: Overview of the MRLVC process



As well as these four streams, the MRLVC TSOs and MRLVC NEMOs also need to start up **local projects** in order to make changes to local systems (e.g., trading or shipping systems) and create the procedures needed – e.g., to allow for input to MRLVC and the BBZ net position forecaster and validation of results from MRLVC and the BBZ net position forecaster. If flows coming from or going to PMB, as used currently in the SDAC processes, must be adjusted for MRLVC then this will lead to local changes also for the non-MRLVC NEMOs. All these local projects are out of scope of this assessment. In addition, the implementation of fallback arrangements for MRLVC and the BBZ net position forecaster are out of scope of this analysis. Those tasks are foreseen to increase the overall timeline and cost presented in this report.

A short overview of the steps to implement all aspects of Streams 1, 3 and 4 is set out below. This excludes GB coupling (stream 2), which is out of scope of this analysis and hence not detailed or estimated..

1. BBZ Net Position Forecaster project stream

The BBZ Net Position forecaster project stream will start with a tender process to select an existing tool that is able to perform the forecasting of the BBZ net positions as part of a prototype. The prototype will then be finetuned and validated against the requirements to conclude if there is sufficient confidence in the methodology and tool to proceed with the remaining implementation tasks. It will be necessary, as part of the fine tuning and assessment, to run MRLVC simulations with historic data to test the quality of the BBZ net position forecaster. Although no formal NRA approval is foreseen at this stage, NRAs will participate in the review of the outcomes of the prototype. The quality of the BBZ net position forecast is crucial for the quality of the performance of the MRLVC process. Therefore, the validation of the results of the prototype is a very important milestone in the project. Proving the efficacy of this process would be essential for the efficient running of MRLVC and there should be strong consideration around a go/no-go decision for continuing the overall project

and starting work in the other streams if the results of the BBZ net position forecaster lack quality and stability.

The proposed duration of 9 months for the planning phase represents the minimum time that is expected to be needed to prove the quality of the BBZ net position forecasting approach and tool. The initial timeline of 9 months was determined as follows:

- 1 month to define the high-level set of requirements for the prototype of the BBZ net position forecaster;
- 3 months to prepare, tender and select the prototype;
- 4 months to setup, finetune and analyse the prototype including running MRLVC simulations (preparations to be done before these 4 months start),
- 2 months to review and validate the results and present/discuss results with authorities.

If further testing of the BBZ net position forecast is required, e.g., to test the impact on quality/welfare from curtailing the MRLVC calculation time, then this planning phase must be prolonged. It would be an important decision early in the implementation process as to whether any further testing is done in parallel with the other streams or as part of the assessment process before the other streams are started. In the latter case, the overall timeline needs to be extended accordingly beyond what is shown in this report. It is intended that the 9-month validation should give adequate confidence that an acceptable minimum quality of solution is feasible, and within an acceptable operational timeframe. This should be based on a basic methodology – probably including the use of the first solution – which could be refined and improved upon later.

If the BBZ net position forecasting approach is proven, the project will continue with a second tender to select the final tool for the BBZ net position forecaster based on the more detailed requirements and knowledge built up during the prototype phase. After a first period of finetuning of the selected tool, which may or may not be the same as the tool used for the prototype, it will run on a parallel (test) basis for a year to check on a daily basis the results and continue finetuning where necessary. Results during this phase will only be shared amongst the parties involved in the implementation. When the results are of sufficiently good quality and stability, the daily checks will continue as part of an external run, i.e., shared with stakeholders, until the final go-live of the BBZ net position forecaster together with MRLVC.

3. MRLVC project stream

The MRLVC project stream will only start once Stream 1 has proven that sufficiently high quality BBZ net position forecasts can be produced. It is expected that a project contract between MRLVC TSOs and MRLVC NEMOs must be signed before any work on the NEMO side will be undertaken.

After the project setup phase, the parties will firstly describe in detail what the requirements of the MRLVC solution are (i.e., 'what' MRLVC must accomplish). This will be followed by a design phase during which detailed descriptions are developed for how these requirements will be implemented. Then the typical project tasks (development, test preparation, testing, procedural work, etc.) can start. Once MRLVC is successfully tested 'stand-alone' it will become part of the integrated test phases with SDAC.

Table 11: Common orderbook vs Preliminary orderbook implementation

MRLVC Common Orderbook	MRLVC Preliminary Orderbook
BBZ orderbooks are sent from BBZ NEMO LTS's to MRLVC PMB at orderbook gate closure.	BBZ orderbooks are sent from BBZ NEMO LTS's to MRLVC PMB 15 minutes before orderbook gate closure.
MRLVC process runs after orderbook gate closure and delivers input to SDAC after gate closure, reducing time of the overall SDAC process, which will likely require changes to all procedures and add to time pressure.	MRLVC process is run and input is delivered to SDAC before SDAC process starts at orderbook gate closure.
Reducing the SDAC process due to MRLVC has immediate impact on the SDAC fallback processes/procedures from a timing and content perspective, i.e. 2nd auction might not be possible anymore.	No impact on SDAC fallback measures and procedures as long as MRLVC delivers results in time and MRLVC does not need to be rerun.
Changing the SDAC timings has an impact on all SDAC parties and market participants	Impact on MRLVC parties, but far less on all SDAC parties and market participants
Results of COB more accurate than POB, so validation process probably shorter.	More uncertainty about quality of MRLVC results under POB, so the validation process might probably be longer (longer parallel run in comparison with COB)

For the implementation of MRLVC it is assumed that adapted versions of PMB and EUPHEMIA are used. These are the tools used in SDAC and appear to be suitable in MRLVC with the evaluation that changes to the source code, configuration and other parameters is required.

Examples of necessary adaptations for MRLVC include:

- input of the results of the BBZ net position forecaster;
- the conversion of the MRLVC results into PTOs (price taking orders) which will be sent to SDAC via the NEMO systems; and
- output of MRLVC results for validation purposes.

In parallel, the MRLVC implementation parties need to perform tasks regarding governance and contracts. With regards to governance, it is assumed that the MCO function will be performed by MRLVC NEMOs having the knowledge of running the SDAC MCO function. This is assumed to be done on the basis of a contract with the MRLVC TSOs – as this setup can probably be realised more quickly than other options, such as a tender for such MCO function, or creation of a new entity that will operate such MCO function.

4. SDAC project stream

The SDAC project stream runs in parallel with the MRLVC project stream. As with the MRLVC project, it only starts after the BBZ net position forecast has been proven to be of sufficient quality. After setting up the project, the requirements for SDAC including MRLVC must be defined. As discussed in the MRLVC CBA and in answers to the technical questions on operational timescales (Q2a, Q2b, Q3a), the implementation of the COB could materially affect the SDAC normal and fallback procedures due to the need to accommodate the extra process of running MRLVC. Based on experience to date and experience in other market coupling projects, it is expected that an extended period of time will be needed for discussion and to allow for the necessary agreements and compromises to be reached on any changes to SDAC processes and timescales, including fallback procedures. The impact on market participants on any changes will likely require a market consultation to take place before any changes are finalised and implemented. Changes to the SDAC procedures will not only impact the MRLVC project parties but the entire SDAC TSOs and NEMOs.

It is assumed that any SDAC changes to PMB can be developed in the same release as the changes in PMB for MRLVC, leading to a streamlined testing process.

Testing of the combined SDAC and MRLVC stream (including the input of the BBZ net position forecaster) will follow the phases of the current testing process used in SDAC combined with best practices used in the SIDC and used for the IDA implementation. This means that after a short stand-alone test (the so-called CTT and to be replaced by PCR-TWG), integration testing can start, followed by FIT testing (functional tests of the systems). This will be followed by SIT testing (end-to-end testing, procedural testing, DST testing etc.) During the SIT testing, the parallel run will start, allowing to verify the quality of the results for a period of six months. This is necessary to assure that when going live, the solution will produce results of sufficient stability and quality. These testing phases may require participation from all SDAC TSOs and NEMOs. Such testing phases in similar projects have required up to several months of testing and must be incorporated in the existing SDAC project roadmap.

Description of the tests:

- FIT testing (functional integration test) – to ensure all functionalities of the system work (in isolated mode) and that data between systems can be exchanged (correctness of format and content).
- SIT testing (simulation integration test) focusses on the correctness of the overall business processes and the overall consistency of data
- End-2-end test: includes all pre-coupling, coupling and post-coupling processes/systems/entities (End-2-end tests can also be performed during FIT).
- Procedural tests – testing of the normal and backup procedures hence simulating 'normal day' scenarios and scenarios with incidents (systems down, interfaces down, use of backup channels, etc.) These tests are in general performed by operational staff.
- DST tests focus on the testing of the long- and short clock change which requests specific behaviour of systems.

Q3c. Implementation:

(2) Please provide a realistic timeline for implementation for each option (such a timeline should take into account current and established future developments and include all the necessary steps such as stakeholder consultations, implementation of new IT systems for MRLVC MCO, testing phases, governance processes, etc.).

The answer to Q3a(1) listed the four project streams to be carried out by multiple parties working together, as well as any local development to be performed by MRLVC TSOs and MRLVC NEMOs and possibly the non-MRLVC NEMOs.

Timeline estimations for the implementation of complex projects, like the implementation of MRLVC, is very difficult, especially for the design phase. This is because such estimates must take into account the complexity of the environment with many parties involved with their own strategies and priorities. If opinions differ on the design and/or implementation, then long discussions and negotiations must be held in order to reach the necessary compromises.

This can be seen in comparisons with recent market coupling initiatives that were also complex and involving many parties.[32] For example:

- the NWE+ implementation took more than 4 years;
- the XBID implementation took 5 years, excluding the tender and selection of the XBID system; and
- the ongoing IDA implementation is now expected to take more than 4.5 years.

As summarised in Table 12, the initial estimate of the overall time needed to implement the MRLVC COB project is 4 years and 4 months. It is to be noted that seeing the SDAC algorithm roadmap, the SDAC design activities linked to algorithm analysis cannot start before 2025.

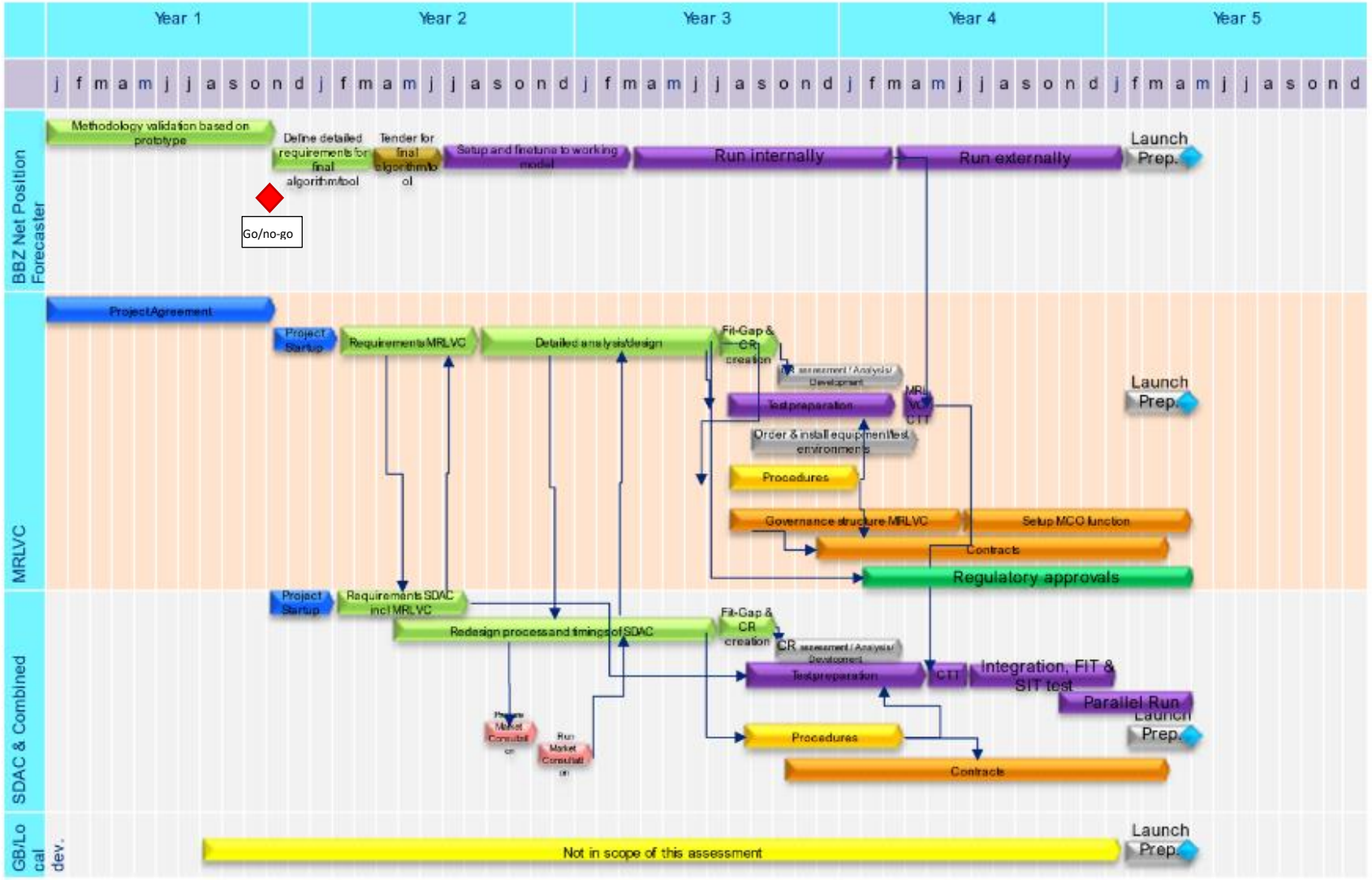
In the implementation of a MRLVC POB project, some tasks in the SDAC project will be shorter, as the impact on the SDAC operational timings and hence the procedures is expected to be less under the POB option. However, the overall timescales for implementation will be the same as for the COB because the same tasks identified for the MRLVC COB project must be performed, all of which are on the critical path of the implementation. In fact, because of the expected lower quality of the MRLVC outputs, being based on a preliminary orderbook and not a final orderbook, the implementation timeline would be longer than the COB option if there is a need for a longer parallel run to prove that the solution is of sufficient quality and stability. This is despite the expected shorter timescales on SIT testing, reduced impact to SDAC procedures and ultimately shorter SDAC discussion on change of operational timings, removing it from the critical path.

Table 12: High-level critical path of the MRLVC COB project

Tasks	Duration
Project agreement negotiation and validation of the BBZ Net position forecaster	9 months
Start up of the different streams	3 months
Establish MRLVC methodology/requirements in parallel with impact on methodology/requirements SDAC (what must the solution accomplish)	6 months
Detailed design MRLVC including shipping in parallel with redesign of the processes from orderbook gate closure till publication (how will the solution accomplish the what)	9 months
Fit – Gap analysis and CR creation for PMB / Euphemia / other	3 months
CR assessment / Analysis / Development of PMB (Euphemia) by service provider (s)	5 months
CTT testing MRLVC/ SDAC / Performance testing	1,5 months
Combined integration, FIT and SIT testing BBZ NP Forecaster, MRLVC, SDAC	7 months
Parallel Run (3 months overlap with SIT testing, total 6 months)	3 months
Overall duration (including 6 weeks of no/limited activity per year) : 4 years and 4 months	

[32] These implementations were all initially estimated to have a shorter duration, but the timescale for each project has had to be extended at least once.

Figure 14: High-level Gantt chart for implementation of the MRLVC COB project



Q3c. Implementation:

3) What are the anticipated direct costs of implementing and operating MRLVC for the different roles and functions necessary for MRLVC?

Direct costs of implementing MRLVC

The total costs for implementing MRLVC will include the overall costs of the four streams listed in Q3a(1) and the costs for the local implementation projects. This section estimates the costs for two of the three workstreams that are in scope of the analysis in this report – MRLVC, SDAC – based on the elements shown in Table 13. This does not include the cost of procuring the BBZ net position forecaster as that is highly uncertain at this stage.

Table 13: Cost categories included in estimate of direct costs

Cost category	Cost elements	High Level Estimate (€k)
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]

The estimate of the direct implementation costs is driven by the timescales for the implementation of the MRLVC solutions. Based on an estimated duration of 4 years and 4 months, the overall high-level costs for the MRLVC and SDAC streams are estimated at around [redacted] including a 40% contingency.

The GB coupling and the local implementation projects are not in scope of the analysis of this report. The procurement cost for the BBZ net position forecaster is not included either. Therefore, the estimates provided in this section represent only a part of the overall costs.

Direct costs of operating MRLVC

Estimates of the direct cost of operating MRLVC could not be obtained as part of this analysis. It is assumed that the MRLVC NEMOs would perform the MCO function on a contractual basis with the MRLVC TSOs. However, these MRLVC NEMOs are competing NEMOs and are therefore not allowed to share any of such information in this type of exercise.

5. Technical annex:

5.1. Initial feedback from GB NEMOs

This reflects the views of EPEX and Nord Pool as provided in discussions with the CEPA consultant team:

"The impact of the MRLVC implementation in the GB market is out of scope for the questionnaire and must be assessed separately to accurately evaluate this implementation impact with respect to the GB market. As the assessments carried out so far already show that the MRLVC will result in critical inefficiencies in the SDAC, we expect that the MRLVC will result in inefficient price formation on both the SDAC and the GB markets.

Moreover, the proposal to include only SDAC Bordering Bidding Zones (BBZs) in the MRLVC design is deeply flawed, because the requirement to include estimates of the SDAC flows between the BBZs and the other SDAC BZs as input to the MRLVC calculation is extremely likely to result in major forecasting errors, which, in turn, would result in MRLVC resulting in adverse flows and negative congestion income for the SDAC-GB interconnectors. Because of the amount of electricity transported through the concerned interconnectors, even small forecast errors may have a very significant impact on some BZs. The scheduled MRLVC flows on the SDAC-GB Interconnectors will be included as price-independent buy and sell (meaning buy on export side and sell on import side) orders in respectively the SDAC and GB price calculations, which will then result in sub-standard, non-efficient outcomes.

Furthermore, we have these more detailed, while preliminary inputs:

Spot Market Operators in GB were not asked to perform an impact assessment; the exercise conducted by TSOs with cooperation of the NEMOs in the SDAC BBZs to GB only considered the impacts on SDAC assets and processes. It does not mean that GB related impacts are negligible, and SDAC NEMOs in BBZs to GB would like to highlight some of the activities that NEMOs or market participants must conduct in case MRLVC sub-optimal model would be implemented.

Market design:

- The same forecasting tool will be used on SDAC and GB side. As a consequence, the same consequences of a wrong flow direction on SDAC-GB interconnectors given from MRLVC results will be experienced on the GB side.
- The detrimental effects that have been highlighted for SDAC (risk of market manipulation, wrong forecast, not finalised OBK input, etc.) in the MRLVC report will be valid for GB. A specific focus must be done on the risk of market manipulation under especially but not only in the Preliminary Order Book option, and apart from that risk it is key to remind of the given fact that market parties are both allowed and per se required to amend their OBKs until 12:00 CET in SDAC to reflect what is their fundamental ability and readiness to produce, consume and trade power contracts at SDAC GCT.
- The current separate GB auctions will be modified again (e.g., changes similar to what was applied before the application of Brexit):
    - Timings and organization of market participants trading desk as well as for GB Market Operators
    - Systems (local and central IT)
    - Procedures

- Contractual frameworks between all involved TSOs and Market Operators ("NEMOs") and separately towards market participants
- Cross-borders pre- and post-coupling processes; Market participants trading assets and processes

Governance and cooperation:

- No governance existing today for the MRLVC process. This new coupling process creates a need for a new GB-SDAC cooperation framework, as well as new model of operations between SDAC and UK TSOs and Market Operators ("NEMOs"). This was not discussed so far because the report centralised its focus on SDAC; but involves the SDAC NEMOs in the BBZs to GB of the initiatives.
- Moreover, the intra-GB operational model will be strongly impacted by MRLVC process.

From a GB perspective, the SDAC NEMOs in the BBZs to GB can only convey the same messages as with a SDAC angle and for now limited to assessment of the Day Ahead timeframe: status quo or going back to a direct implicit coupling model are the only viable, fair, and solid solutions.

Also, we question the methodology and the outcome of the assessment included in the study in Table 6, page 60 of the TSO report, which shows that the MRLVC would create smaller Flow Against Price Difference (FAPD) than explicit auctions. NEMOs had no access to the methodology underpinning this study and therefore are in no position to assess the robustness of its conclusions. We argue that a new assessment must be carried out based on the current proposals and a transparent methodology."