RCP PAPER NO.	:	**EMC/RCP/135/2023/CP92**
SUBJECT	:	**PUBLICATION OF FILTERED RESERVE AND REGULATION OFFER CURVES**
FOR	:	**DISCUSSION**
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Executive Summary

This concept paper assesses the proposal for EMC to publish filtered reserve and regulation offer curves based on unit status (e.g., via removing offers for units on outage, running below Minimum Stable Load, desynchronised from the grid).

For now, there does not appear to be a compelling case to produce/publish filtered reserve and regulation offer curves.

If published offer curves are to be used for monitoring changes in genco offer behaviour over time, EMC proposes that no filtering of offer curves is needed – the current unfiltered offer curves are sufficient for such monitoring purposes. Furthermore, switching from unfiltered offer curves to filtered offer curves may even introduce inconsistencies when attempting to compare offer behaviour before and after filters are applied.

If published offer curves are to be used to infer dispatch outcomes (i.e., dispatch quantities by offer block, market clearing price), filtering to reflect some MCE constraints is possible. However, the improvement in inferred dispatch outcomes would likely be limited because:

- The number of constraints that can be used as filters are limited, limiting effectiveness
- The majority of discrepancies are likely attributable to co-optimisation effects, which are impossible to filter for without conducting an MCE run

Given these limitations, there is a lack of clear benefits. EMC therefore proposes not to publish filtered reserve and regulation offer curves.

At the 135th RCP meeting held on 20 July 2023, the RCP unanimously supported EMC's recommendation.

1. Introduction

This concept paper assesses the proposal for EMC to publish filtered reserve and regulation offer curves based on unit status (e.g., via removing offers for units on outage, running below Minimum Stable Load (MSL), desynchronised from the grid).

2. Background

In 2019, the RCP supported EMC's recommendation to publish offer curves for reserves and regulation, in addition to energy offer curves already published at the time[1]. It was noted that the benefits of publishing offer curves for reserves and regulation likely outweighed the drawbacks.

Benefits of doing so pertained to improved transparency due to increased information disclosure, including:

- Reducing information asymmetry among Market Participants (MPs) and increasing market participation
- Improving market monitoring by regulators, academics and other analysts
- Improving demand response by increasing demand responsiveness to price signals

A potential drawback for publishing offer curves was an increased risk of facilitating coordinated behaviour among gencos. This risk at the time was deemed to be relatively low, given that:

- Based on the Herfindahl-Hirschman Index (1,681 as of November 2017), there was only moderate industry concentration
- Based on the pivotal supplier test for regulation, none of the periods in 4Q17 had a pivotal supplier for regulation

As such, (unfiltered) offer curves for reserve and regulation have been published by EMC since July 2019.

3. Identified Issues

During the 2020 Rules Change Panel Work Plan prioritisation exercise, a rule change proposal was received for EMC to publish filtered reserve and regulation supply curves, with similar data format dimensions as the current published energy supply curve.

It was proposed for such filters to remove offers submitted by MPs who are unable to fulfil their submitted offers based on real time status of their units (e.g., on outage, running below MSL, desynchronised from the grid).

If offers for ancillary services do not accurately reflect unit status, EMC recognises that the usefulness of reserve and regulation offer curves may then be limited. This will also depend on what kind of information is sought from the offer curves.

3.1 Use Case 1: Monitoring changes in offer behaviour over time

If published offer curves are to be used for monitoring changes in Generation Registered Facility (GRF) offer behaviour over time, existing unfiltered offer curves should be sufficient – they provide a clean comparison of all GRF offers for every period across time, regardless of whether they accurately reflect unit status.

[1] EMC/RCP/105/2018/355: Publication of Offer Data

3.2 Use Case 2: Inferring dispatch outcomes

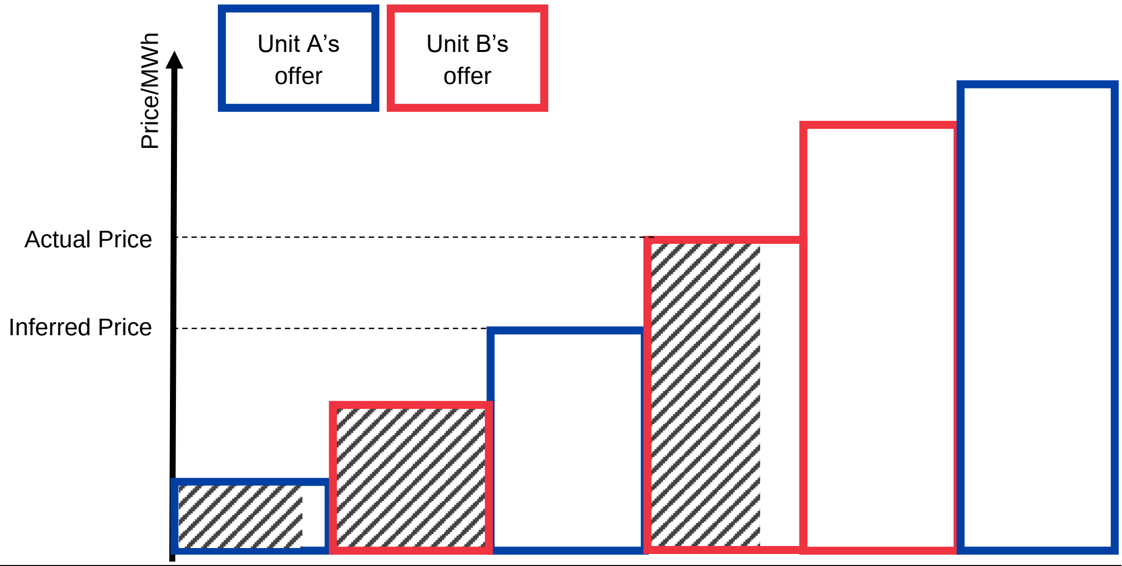
If published offer curves are to be used to infer dispatch outcomes (i.e., dispatch quantities by offer block, market clearing price), unfiltered offer curves for reserve and regulation may have limited usefulness.

Dispatch outcomes may be inferred by MPs based on published offer curves and reserve/regulation requirement for the corresponding period, with the key assumption that dispatch is based purely on merit order – that least cost offers are always dispatched first. However, this is not necessarily the case in practice.

As illustrated in Figure 1 below, inferred dispatch outcomes can differ from actual dispatch outcomes.

FIGURE 1: Illustration of inferred dispatch outcomes vs actual outcomes

Assume there are two units with the corresponding offers reflected below. Each price-quantity tranche is 10MW. The system-wide requirement is 25MW and the actual schedules for Unit A and Unit B are 8MW and 17MW respectively.



Real-time Schedule Quantity (1)	8	10	0	7	0	0
Inferred Merit-based Schedule Quantity (2)	10	10	5	0	0	0
Difference = (1) – (2)	-2	0	-5	7	0	0

<u>For quantities:</u>

- **Total MW difference** (in MW)
  = Sum positive differences across all tranches
  = 7 (Note that the positive and negative differences in a given period would sum to zero.)

- **Percentage MW difference** (in %)
  = Total difference as percentage of system-wide requirement
  = 7 / 25 × 100% = 28%

<u>For prices:</u>

- **Price difference** (in $/MWh)
  = Real-time price – Offer price of marginal offer based on inferred merit-based schedule

- **Percentage price difference**
  = Price difference / Real-time price × 100%

Table 1 below shows that based on March 2023 data, there are substantial differences between inferred dispatch outcomes, and actual dispatch outcomes. Hence, published offer curves have limited usefulness if used for inferring dispatch outcomes.

TABLE 1: Difference between inferred merit order dispatch outcomes based on published offer curves, and actual dispatch outcomes in March 2023

Product	Average quantity difference per period, MW	Average quantity difference per period, %	Average price difference per period, $/MWh	Average price difference per period, %
Primary Reserve[2]	48.7 MW	27.4%	$0.23/MWh	36.1%
Contingency Reserve	96.8 MW	24.8%	$13.32/MWh	65.2%
Regulation	9.7 MW	8.3%	$34.49/MWh	44.6%

4. Analysis

Referring to the original proposal to filter offers based on unit status, we assess the proposal's impact for both Use Cases 1 and 2.

4.1 Use Case 1: Monitoring changes in offer behaviour over time

Filtering offers based on unit status will likely have no positive impact on market monitoring. Furthermore, switching from unfiltered offer curves to filtered offer curves may even introduce inconsistencies when attempting to compare offer behaviour before and after filters are applied.

4.2 Use Case 2: Inferring dispatch outcomes

Filtering offers based on unit status will also not result in more "accurate" offer curves that better represent what the Market Clearing Engine (MCE) uses for determining dispatch outcomes.

The MCE is unable to distinguish units that are on outage when determining dispatch outcomes – the MCE accounts for offers but not physical unit status directly. A GRF on outage but with non-zero offers (e.g., not removed in time) will be assumed by the MCE to be able to provide ancillary services. This results in the MCE potentially scheduling that GRF to provide ancillary services (subject to other constraints modelled within the MCE, as well as economic dispatch).

Hence, removal of such offers is inconsistent with the MCE's clearing logic, which may further increase the discrepancy between inferred dispatch outcomes and actual dispatch outcomes.

Nevertheless, EMC recognises that there may be a valid underlying concern for Use Case 2 – that current offer curves (particularly for reserves and regulation) lack usefulness for inferring dispatch outcomes.

4.2.1 Why do inferred dispatch outcomes from unfiltered offer curves differ from actual dispatch outcomes?

Inferred dispatch outcomes based on merit-order scheduling invariably schedules the cheapest set of offers available.

In practice however, "out-of-merit" scheduling may occur, where some reserve/regulation offers are not scheduled by the MCE, despite having a lower offer price relative to other offers scheduled by the MCE. Potential causes can be grouped into two categories:

[2] For primary and contingency reserve, offered quantities are adjusted by reserve effectiveness

- Facility constraints modelled by the MCE that limit the facility's reserve and regulation capacity

- Co-optimisation with other products to minimise overall cost

4.2.2 Can offer curves be filtered to mirror facility constraints modelled by the MCE?

To some extent, it is possible to filter offered reserve and regulation quantities based on facility constraints modelled within the MCE.

As per Table 2 below, a set of filter conditions may be applied, to improve the accuracy of published supply curves for reserves and regulation.

TABLE 2: Constraints used for filtering

	Product	Filter	Rationale
1	Primary Reserve	Sum of Offer Quantity ≤ (Reserve Proportion) x (Sum of Energy Offer Quantity)	Scheduled primary reserve quantity is capped based on Reserve Proportion factor and scheduled energy quantity
2	Primary Reserve	Sum of Offer Quantity = 0 if Sum of Energy Offer Quantity < LowLoad	A GRF needs to operate above LowLoad in order to provide primary reserves
3	Contingency Reserve	Sum of Offer Quantity ≤ (Reserve Proportion) x (Sum of Energy Offer Quantity)	Scheduled contingency reserve quantity is capped based on Reserve Proportion factor and scheduled energy quantity
4	Contingency Reserve	Sum of Offer Quantity ≤ LowLoad Reserve if Sum of Energy Offer Quantity ≤ LowLoad	Scheduled contingency reserve quantity is capped at LowLoad Reserve if scheduled energy quantity is capped at LowLoad
5	Regulation	Sum of Offer Quantity = 0 if Sum of Energy Offer Quantity < RegulationMin	A GRF needs to operate above RegulationMin in order to provide regulation
6	Regulation	Sum of Offer Quantity = 0 if ExpectedStartGeneration < RegulationMin	A GRF needs to operate above RegulationMin at the beginning of the dispatch period in order to provide regulation
7	Regulation	Sum of Offer Quantity = 0 if ExpectedStartGeneration > RegulationMax	A GRF needs to operate below RegulationMax at the beginning of the dispatch period in order to provide regulation
8	Regulation	Sum of Offer Quantity ≤ Min(GenerationEndMax, Sum of Energy Offer Quantity) - RegulationMin	Scheduled regulation quantity is capped, based on how much its scheduled energy quantity exceeds RegulationMin

EMC has conducted a simulation based on the above 8 filters across ancillary service products, for the period of March 2023. As shown in Table 3 below, the filtering does not significantly improve accuracy of inferred dispatch outcomes for primary and contingency reserves. Meanwhile, there is a moderate improvement of inferred dispatch outcomes for regulation.

TABLE 3: Reductions in discrepancy between inferred dispatch outcomes and actual dispatch outcomes in March 2023

Product	Average quantity difference per period, %	Average quantity difference per period with filter applied, %	Average price difference per period, %	Average price difference per period with filter applied, %
Primary Reserve	27.4%	22.6%	36.1%	33.3%
Contingency Reserve	24.8%	23.1%	65.2%	62.3%
Regulation	8.3%	3.9%	44.6%	17.6%

4.2.3 Can offer curves be filtered to mirror the effects of co-optimisation?

In practice, there are numerous other constraints related to co-optimisation that apply. Indeed, co-optimisation constraints might result in significant discrepancies between inferred merit order dispatch schedules, and actual dispatch schedules. This is illustrated in Figure 2 below.

FIGURE 2: Illustration of co-optimisation effect

The Set-Up

- *Energy demand = 150MW*
- *Reserve requirement = 40MW*
- *GRF_A offers 100MW of energy @ $100/MWh and 50MW of reserve at $10/MWh*
- *GRF_B offers 100MW of energy @ $200/MWh and 50MW of reserve at $20/MWh*
- *Max capacity for GRF_A and GRF_B is 100MW each*

Inferred reserve schedule

- GRF_A scheduled for 40MW of reserve
- GRF_B scheduled for 0MW of reserve
- Reserve price = $10/MWh

Co-optimisation reserve schedule

- GRF_A scheduled for 100MW of energy and 0MW of reserve
- GRF_B scheduled for 50MW of energy and 40MW of reserve
- Reserve price = $20/MWh

However, such co-optimisation constraints cannot be used as filters for reserve/regulation offers, as explained below. Examples of such constraints include:

a) <u>Reserve Generation Max Constraints</u>

The sum of scheduled energy, reserve and regulation for a single facility cannot exceed its maximum rated capacity.

These constraints cannot be included as filters because GRFs are free to offer in quantities for each product that sum to more than their maximum capacity, (e.g., 100MW facility offering in 100MW for energy, 50MW for reserves and 20MW for regulation). It is not possible to filter such offers without conducting an MCE run.

b) Reserve Envelope Constraints

The reserve schedule of a generation facility is capped based on its energy schedule.

These constraints cannot be included as filters because we would need to know a facility's energy schedule (which requires an MCE run) before capping its reserve offer.

c) Combined ramping constraints for energy, reserve and regulation

A generation facility's schedule for energy and ancillary services should be feasible based on its prior schedule and ramping capability.

These constraints cannot be included as filters because we would similarly need to know a facility's schedule for energy and ancillary services (which require an MCE run) before capping its reserve offer.

These co-optimisation constraints are applied by the MCE to produce the most optimal market clearing solution at the system level. MPs are allowed to offer reserve/regulation up to their standing capabilities; the MCE will then schedule reserve/regulation from generation facilities, taking into account the constraints above. Whether and how much a facility's reserve/regulation offers can be scheduled then heavily depends on its own energy schedule, as well as the offers and schedules across all products for other facilities.

Therefore, it is not possible to design a set of filters to accurately mirror the effects of co-optimisation.

In fact, it might not be desirable to remove / filter out such offers for ancillary services, as they are likely valid offers – the facility should be able to deliver the offered quantity if it is scheduled at the right energy level.

5. Consultation

The concept paper was published for consultation on 8th June 2023. Comments were received from Senoko Energy. The comments raised and EMC's response are provided below.

Comments received from Senoko Energy[3]

Senoko strongly supports information transparency, particularly in competitive wholesale electricity markets. Information transparency promotes fair competition and drives investment decisions. Market participants can make informed choices based on market conditions and dynamics when they have comprehensive and reliable information. With the publication of the offer stack, market participants can gain valuable insights into the supply and pricing dynamics within the electricity market. This transparency fosters a level playing field, where all participants have access to the same information, which is essential for fair competition. It prevents information asymmetry and reduces the potential for market manipulation, thus enhancing market integrity.

Furthermore, the publication of the offer stack enables regulatory authorities and the public to monitor and regulate the market. It provides a transparent view of the market activities, allowing them to detect and address potential anti-competitive behaviors. Regulatory oversight ensures that market participants abide by the rules and regulations, promoting fair competition and protecting the interests of consumers. In addition, consumers can gain visibility into the electricity market. Consumers can better understand the factors influencing electricity prices and the

[3] Verbatim, including underline emphasis

contribution of different generation sources. This information can help consumers make informed decisions about their energy consumption patterns, encourage energy conservation, and enable them to choose electricity suppliers based on their preferences and values.

More importantly, the availability of comprehensive market information supports investment decisions. Investors can analyze the offer stack to assess market trends, pricing dynamics, and the competitiveness of different generation sources such as electricity imports, Energy storage systems (ESS), and Renewables. This knowledge enables them to make informed investment decisions, aligning their strategies with market conditions and opportunities. Transparent access to the offer stack encourages market research, facility investment planning, and stimulates the growth of clean and efficient electricity generation. Therefore, the accuracy of the reserves and regulation offer stacks are crucial inputs for the financial modeling of any renewable projects. Minimally, Senoko believes that the reserves and regulation offer stack should undergo filtering based on the facility constraints modeled by the MCE to enhance data accuracy.

In conclusion, Senoko firmly believes that information transparency is essential in competitive wholesale electricity markets. It promotes fair competition, drives investment decisions, and enables effective regulatory oversight. By publishing a filtered reserve and regulation offer stack, the market can operate transparently and efficiently, fostering a level playing field for all participants and contributing to the growth and sustainability of the electricity market.

EMC's response

EMC agrees that information transparency is essential in competitive wholesale electricity markets – promoting fair competition, informing investment decisions and enabling effective regulatory oversight. The existing availability of reserve and regulation offer curves do provide such information transparency.

However, given the limitations explained in this paper, we could not establish a compelling case to publish *filtered* reserve and regulation offer curves, relative to current *unfiltered* reserve and regulation offer curves.

Specifically with regards to promoting fair competition and enabling effective regulatory oversight, filtering offer curves is unlikely to improve market monitoring of offer behaviour, and may even introduce inconsistencies when attempting to compare offer behaviour before and after filters are applied.

With regards to informing investment decisions, our study showed that filtering of offer curves only results in a limited improvement in inferred dispatch outcomes. This limited improvement alone is unlikely to better inform investment decisions.

6. Conclusion

Based on Use Cases 1 and 2 discussed in Section 4, there does not appear to be a compelling case to produce/publish filtered reserve and regulation offer curves.

If published offer curves are to be used for monitoring changes in genco offer behaviour over time, EMC proposes that no filtering of offer curves is needed – the current unfiltered offer curves are sufficient for such monitoring purposes. Furthermore, switching from unfiltered offer curves to filtered offer curves may even introduce inconsistencies when attempting to compare offer behaviour before and after filters are applied.

If published offer curves are to be used to infer dispatch outcomes (i.e., dispatch quantities by offer block, market clearing price), filtering to reflect some MCE constraints is possible. However, the improvement in inferred dispatch outcomes would likely be limited because:

- The number of constraints that can be used as filters are limited, limiting effectiveness
- The majority of discrepancies are likely attributable to co-optimisation effects, which are impossible to filter for without conducting an MCE run

As such, EMC proposes not to filter reserve and regulation offer curves.

EMC urges MPs to submit to their best ability ancillary service offers that accurately reflect their units' capability to provide ancillary services (e.g., after a forced outage, besides withdrawing energy offers, to also withdraw ancillary service offers).

7. Decision at the 135th RCP Meeting

The concept paper was discussed at the 135th RCP meeting; the panel unanimously supported EMC's recommendation not to filter reserve and regulation offer curves.