# AMENDMENT OF THE MARKET ANCILLARY SERVICE SPECIFICATION – DER AND GENERAL CONSULTATION

## FINAL REPORT AND DETERMINATION

Published: **22 December 2021**

## EXECUTIVE SUMMARY

The publication of this Final Report and Determination (**Final Determination**) finalises the Rules consultation process conducted by AEMO to consider proposed amendments to the *market ancillary services specification* (**MASS**) under the National Electricity Rules (**NER**).

AEMO is required by clause 3.11.2(b) to make and publish a MASS, which AEMO may subsequently amend at any time subject to the Rules consultation procedures in rule 8.9.

AEMO commenced this consultation on 19 January 2021 and received 34 submissions in response to an issues paper on the proposed changes to the MASS (**Issues Paper**). A Draft Determination and Report (**First Draft Determination**) was published on 14 June 2021 and AEMO received a further 44 submissions in response to the Draft Determination. A Second Draft Determination and Report (**Second Draft Determination**) was published on 18 November 2021 and AEMO received a further 15 submissions in response to the Second Draft Determination.

A majority of submissions to the Second Draft Determination were supportive of AEMO's proposed changes, which were focused on amending the measurement time resolution for Fast FCAS Providers with Aggregated Ancillary Service Facilities with no inertial response, and to make some general improvements to restructure the MASS and to resolve or clarify a number of ambiguities.

In response to some submissions to the Second Draft Determination dealing with the proposed changes to the MASS applicable to DER FCAS Providers, AEMO commissioned the University of Melbourne (**UoM**) to conduct additional analysis using actual metered connection point metering data from a DER FCAS provider with high-speed measurements at every site. The additional analysis confirmed that 200 ms is an adequate measurement time resolution to verify Fast FCAS delivery from Aggregated Ancillary Service Facilities with no inertial response if data is appropriately filtered prior to assessment to identify the start of the relevant contingency event being analysed. However, it was also identified that there is a need to review the conditions on which DER FCAS providers can participate in the Fast FCAS markets. As a result, AEMO has determined that a minimum of 25 sites must be aggregated before a measurement time resolution of 200 ms is acceptable, and a discount must be applied for Aggregated Ancillary Service Facilities with less than 500 sites. In the Second Draft Determination, a minimum of 2 sites needed to be aggregated and discount applied for aggregations of 200 or fewer.

After considering all submissions and analysis, AEMO has determined to make the changes to the MASS set out in this Final Determination. In summary, the consultation outcomes affecting DER FCAS Providers are:

- A measurement time resolution of 200 ms is adequate to verify Fast FCAS delivery from Aggregated Ancillary Service Facilities with no inertial response, provided that:
  - At least 25 Ancillary Service Facilities are aggregated; and
  - A discount of 5% is applied to the quantity of Fast FCAS delivered if at least 25, but less than 500 Ancillary Service Facilities are aggregated.
- Where those conditions are not met, the minimum acceptable measurement time resolution is 50 ms for participation in the Fast FCAS markets.
- The measurement location will remain 'at or close' to the connection point of each Ancillary Service Facility.
- Transitional arrangements will apply for those participating in the VPP Demonstrations (**Trial Participants**) until 30 June 2023.

AEMO has also addressed several submissions on the general improvements to the MASS.

Allowing for the required minimum interval of 30 days after publication, the MASS amendments will take effect on 1 February 2022.

AEMO wishes to thank Consulted Persons for their engagement with this consultation throughout the year. The submissions have been crucial to assist AEMO in its deliberations in reaching this Final Determination. The general support for the proposed changes clearly demonstrates that the changes to the MASS will increase FCAS participation in the NEM and benefit consumers.

# CONTENTS

# 1. STAKEHOLDER CONSULTATION PROCESS

As required by clause 3.11.2(d) of the NER, AEMO has consulted on the Market Ancillary Service Specification (**MASS**) in accordance with the Rules consultation procedures[1]. A third stage of consultation was added to this process based on the diversity of views in submissions and the complexity of issues raised.

AEMO's steps and timeline for this consultation are outlined below.

| Deliverable | Date |
|---|---|
| Notice of First Stage Consultation and Issues Paper published | 19 January 2021 |
| First stage submissions closed | 11 March 2021 |
| First Draft Report & Notice of Second Stage Consultation published (second stage) | 14 June 2021 |
| Second stage submissions closed | 6 August 2021 |
| Second Draft Report & Notice of Third Stage Consultation published (third stage) | 28 October 2021 |
| Third stage submissions closed | 18 November 2021 |
| Final Determination and Report published | 22 December 2021 |

In addition, AEMO held stakeholder information forums on the following dates throughout the consultation period:

- 4 February 2021 (two forums)
- 23 June 2021 (two forums)
- 1 October 2021
- 8 November 2021.

At each stage, AEMO received a significant number of written submissions from Consulted Persons:

- 32 valid submissions and two late submissions on the Issues Paper
- 44 valid submissions and seven late submissions on the First Draft Determination
- 15 submissions on the Second Draft Determination.

Eight meetings were held with individual Consulted Persons to discuss detailed matters in submissions to the first stage of consultation.

All AEMO consultation materials, forum and meeting summaries and written submissions (excluding any confidential information) have been published on AEMO's website[2]. AEMO received one entirely confidential submission on the First Draft Determination, which was not taken into account in reaching any determination.

The publication of this Final Determination concludes this consultation.

Note that there is a glossary of terms used in this Final Determination at **Appendix A**.

# 2. BACKGROUND

## 2.1. NER requirements

AEMO is required by clause 3.11.2(b) to make and publish a MASS, which AEMO may subsequently amend at any time subject to the rules consultation process in rule 8.9.

[1] See rule 8.9 for the Rules consultation procedures.
[2] Available at: https://aemo.com.au/en/consultations/current-and-closed-consultations/mass-consultation?submissions=4

## 2.2. Context for this consultation

The primary driver for this consultation was to determine whether and how to amend the MASS to facilitate the ongoing participation of DER in the FCAS markets. AEMO commenced a trial of the capability of virtual power plants (**VPPs**) to deliver Fast FCAS in June 2019 (**VPP Demonstrations**). In its Issues Paper published on 19 January 2021 (**Issues Paper**), AEMO sought submissions on whether the specifications used for the VPP Demonstrations should be incorporated in the MASS.

The core questions for this consultation in relation to DER participation were directed at the measurement requirements in the MASS for delivery of FCAS, in particular the appropriate measurement time resolution[3] for capturing data for verification of Fast FCAS delivery, and the location of the measurement point. In the Issues Paper AEMO proposed two options:

- Option 1: To leave the measurement requirements in the MASS unchanged.
- Option 2: To embed the measurement requirements that were tested in the VPP Demonstrations in the MASS.

AEMO invited stakeholders to propose alternative options if they promoted the national electricity objective (**NEO**) and FCAS delivery could still be verified accurately.

In addition to the DER questions, the Issues Paper presented a range of general improvements and issues for consultation, spanning a variety of matters including improved guidance on Regulation FCAS requirements, service co-ordination, and refinement of service definitions. This was an appropriate time to consult on a restructured, redrafted MASS. The changes were aimed at improving its readability, accessibility, and usefulness, as described in the Issues Paper.

## 2.3. First Draft Determination

On the DER questions, AEMO's draft determination and report published on 14 June 2021 (**First Draft Determination**) included a draft determination that the measurement requirements in the MASS for Fast FCAS should be unchanged. That is, the measurement time resolution must be no slower than 50 ms, and the measurement location would remain 'at or close' to the connection point of each Ancillary Service Facility. This conclusion took into account University of Melbourne (**UoM**) analysis confirming significant error margins when data is captured at slower rates (up to 1 s as permitted in the VPP Demonstrations).

AEMO's draft decision to leave the measurement time resolution in the MASS unchanged was due to the power system security concerns associated with DER inverter behaviour and the verification error calculated with data captured at 1 s intervals, given AEMO's verification methodology at that time. Although the First Draft Determination acknowledged the potential for a 200 ms measurement resolution to be a good overall compromise, there was no clear justification at that stage for the further analysis necessary to confirm the implications of that change.

Given the draft determination to apply the existing MASS measurement requirements to DER, AEMO also proposed a transition period until 30 June 2023, allowing a reasonable period for participants in the VPP Demonstrations (**Trial Participants**) to bring their facilities into line with the MASS if they wished to remain in the Fast FCAS markets.

In relation to general improvements and other potential revisions to the MASS, the First Draft Determination adopted a restructured MASS which addressed incremental improvements including:

- Clarification of MASS references to the Frequency Operating Standard (**FOS**).
- Improved guidance on the co-ordination of different FCAS and Primary Frequency Response (**PFR**).
- Clarification of the relationship between the MASS and other instruments and institutions.

[3] Also referred to as 'sampling rate'.

- New requirements and improved guidance for Regulation FCAS providers.

The First Draft Determination also confirmed that consideration of some other general issues would need to be deferred.

## 2.4. Second Draft Determination

The submissions received to the First Draft Determination indicated that the general issues were largely settled. A range of clarifications and minor corrections were made in the draft MASS, but the document remained largely consistent in meaning and form to the First Draft Determination.

On the other hand, there was a broad range of views on the need to amend the MASS to accommodate the provision of FCAS by DER. Several submissions supported alternative measurement time resolutions for Fast FCAS such as 100 ms and 200 ms, and there was also a split between the submissions supportive of the measurements remaining 'at or close' to the connection points or changing to the asset level.

Based on the additional evidence submitted by Consulted Persons and UoM's Second Stage Report, which demonstrated that the difference between the errors associated with data captured at 100 ms and 200 ms was <1%, and that the verification error decreases as the number of sites within an Aggregated Ancillary Service Facility increases, AEMO decided to make another draft determination (**Second Draft Determination**) for further consultation. In relation to DER matters, the key variation from the First Draft Determination was to require a minimum measurement time resolution for Fast FCAS Providers of:

- 200 ms for Aggregated Ancillary Service Facilities with no inertial response (5% discount for verification error if the number of sites aggregated is less than 200); and
- 50 ms for all other facilities.

The Second Draft Determination confirmed that a measurement time resolution of 1 s was unsuitable due to the inability to detect detrimental under-damped oscillatory behaviour.

The transitional arrangements for Trial Participants proposed in the First Draft Determination included a discount of 20% for verification error if data was captured between 200 ms and 1 s intervals. Based on the study completed by UoM and submissions, the discount was revised to 5% in the Second Draft Determination.

# 3. SUMMARY OF MATERIAL ISSUES IN SECOND DRAFT DETERMINATION

Appendix B lists all issues arising from the Second Draft Determination raised by Consulted Persons. Material issues addressed in Sections 4 and 5 are summarised in Table 1:

**Table 1 Material Issues raised by Consulted Persons**

| No. | Issue | Raised by |
|---|---|---|
| 1. | Measurement Time Resolution for FCAS provided by DER. | AGL, EDMI, Evergen, Greenergenic, Members Energy, Public Interest Advocacy Centre (**PIAC**), Reposit Power (**Reposit**), Rheem Australia & Combined Energy Technologies (**Rheem & CET**), Shell Energy, sonnen, Simply Energy, SwitchDin, Tesla Motors Australia (**Tesla**) |
| 2. | Location of Measurement Point for FCAS provided by DER. | AGL, EDMI, EnergyAustralia (**EA**), Evergen, Reposit, Rheem & CET, Shell Energy, Simply Energy, sonnen, Tesla |
| 3. | Transitional Arrangements | AGL, Evergen, Hydro Tasmania, Members Energy, Shell Energy, Simply Energy, sonnen, SwitchDin, Tesla |
| 4. | Application of the NEO to the provision of FCAS by DER | AGL, EA, EDMI, Evergen, Members Energy, Reposit, Rheem & CET, sonnen |
| 5. | Integrity of the Consultation | EA, Evergen, Greenergenic, Rheem & CET, Simply Energy |
| 6. | MASS Readability and Usability | EA, EDMI, Hydro Tasmania, Shell Energy, Simply Energy |
| 7. | Co-ordination between different FCAS and Primary Frequency Response | EA, Shell Energy |
| 8. | Requirements for Regulation FCAS | Hydro Tasmania, Shell Energy, Tesla |

# 4. DISCUSSION OF MATERIAL ISSUES - DER

Sections 4.1 to 4.5 address the key issues raised by Consulted Persons arising out of the Second Draft Determination on the measurement arrangements for Aggregated Ancillary Service Facilities.

## 4.1. Measurement time resolution for FCAS provided by DER

### 4.1.1. Issue summary and submissions

A majority of Consulted Persons were supportive of the measurement time resolution in the Second Draft Determination. A few questioned whether the data used in the UoM analysis was adequate and whether the results accurately reflect the verification error from Aggregated Ancillary Service Facilities capturing data at intervals of ≤200 ms. These issues are addressed in section 4.5.

Extracts from submissions on this issue are cited below[5]:

AGL:

> AGL supports AEMO's proposed variations to its First Draft Determination to:
>
> - Lower the Fast FCAS measurement time resolution for aggregated Ancillary Service Facilities (200 sites) with no inertial response to 200 ms (and require 50 ms for all other facilities);
> - Apply a discount of 5% if the Aggregated Ancillary Service Facility comprises less than 200 sites
> - Implement improvements to the FCAS Verification Tool before the updated MASS becomes effective to improve its accuracy.
>
> We note the additional analysis undertaken by the UoM and consideration by AEMO that the 200 ms measurement option is sufficient to verify the Fast FCAS delivery of aggregated facilities with no inertial response. As we observed in our response to the First Draft Determination, we understand

[5] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

that this option will be much more cost-effective for a broader cross-section of inverter manufacturers.

We also consider a range of alternative options may be more effective to address system security concerns whilst also proving more cost-efficient for market participants. In this regard, we support AEMO's intent to implement improvements to its FCAS Verification Tool…

EDMI:

EDMI is supportive of the proposed amendments to the MASS for the increased market participation it will provide.

Evergen:

We note that AEMO has chosen 200 ms and assessment at the connection point. Evergen's preference was 1 s, assessed at the device level. We understand AEMO's responsibility to the NEO, and to maintaining system security, and appreciate that AEMO has adjusted its position on this issue to avoid an unnecessary compliance burden where they have found it is safe to do so.

Evergen believes there remains a strong case that good verification can occur with 1 s telemetry for certain classes of FCAS Provider - namely, VPPs comprising many individual DER, each separately metered.

Evergen will use this submission to reinforce arguments that coarser telemetry is acceptable for verification with VPP-based DER fleets doing FCAS, and highlight some shortcomings in the analysis conclusions AEMO has relied upon to arrive at 200 ms instead of 1 s.

There is a strong case for adopting DER VPP specific requirements for FCAS, that are low-cost but deliver the same verification accuracy. Introducing such requirements would allow greater participation of residential DER in Fast FCAS markets, opening up an untapped resource. We believe AEMO should move swiftly to implement such change decisively, to keep pace with rapid change across the NEM.

…

### 3. Oscillation risk

AEMO indicated in their Second Draft Determination that 1-s time resolution was unsuitable for detecting "detrimental under-damped oscillatory behaviour". This seems to be the primary reason for rejecting 1-s sampling for FCAS verification.

Evergen notes that in the study commissioned by AEMO in support of the Second Draft Determination, the UoM did not reach the conclusion that 1-s sampling was unsuitable through analysis. In fact, the UoM analytical work omitted consideration of 1-s sampling. Instead, UoM determined theoretically that 1-s sampling was unsuitable, by appealing to the Nyquist-Shannon sampling theorem.

### 3.1 Control and visibility of oscillatory behaviour

In summarising the November 8 forum, AEMO states:

> *AEMO acknowledged that it was unlikely that a few devices producing an oscillatory response from a large fleet would result in an error that AEMO could measure. Nevertheless, oscillatory responses are something AEMO looks at in many contexts in the NEM, including in the context of power system security. AEMO's objective is to keep oscillatory behaviour at a minimum. Therefore, while this behaviour may not be an issue within a large fleet or where it can be contained within a network, broader issues could surface at the grid level if the behaviour is widespread and/or significant. AEMO noted that oscillatory problems are becoming more prevalent in the NEM and AEMO needs to work to minimise this at all levels.*

Evergen accepts and agrees with AEMO's objective that oscillatory behaviour is to be kept at a minimum.

That said, any oscillatory behaviour from individual grid-connected DER will occur whether or not those DER are able to participate in the Fast FCAS market.

Given that analysis of aggregated fleet-level telemetry could not detect oscillatory behaviour from individual DER in any case, Evergen's view is that it is not in accordance with the NEO to impose additional measurement requirements on DER-based VPPs participating in the FCAS market, if

those additional requirements have no impact on minimising or even characterising the notional problem of oscillatory response from DER.

### 3.2 Minimal chance of fleet-level oscillation

Having good measurements is not the only requirement for detecting oscillatory behaviour. At the risk of stating the obvious, oscillatory behaviour will only be detected if there is actually an oscillation present. We note that AEMO and UoM both focused on high magnitude oscillation detection should an oscillation actually occur at the aggregated DUID level, but did not examine the likelihood that such an oscillation would ever manifest across a DUID composed of many devices.

In our previous submission we argued that there is little risk of a high magnitude oscillation ever manifesting at the aggregated DUID level for a many-plant DUID such as a VPP. This is because individual device-level oscillations are of no consequence to the aggregated output for the DUID. **AEMO acknowledged this point in the November 8 stakeholder forum, in response to Evergen's question**.

In our previous submission, Evergen also argued that even if every single device in a VPP were showing oscillation behaviour, if the oscillations of each device were not all in phase they would likely destructively interfere, resulting in no significant aggregated oscillation at the fleet level.

**Neither AEMO nor UoM addressed the arguments made in Evergen's submission on the First Draft Determination**.

### 3.3 Oscillation detection using 1-s sampling

Taking into account the Nyquist-Shannon sampling theorem, Evergen accepts that the sampling rate to perfectly reconstruct a continuous waveform from sampled data, where the waveform exhibits a maximum frequency component of x Hertz, requires a sampling rate of at least 2x Hertz. This theorem is often invoked in a signal processing context.

However, AEMO is not undertaking a signal processing exercise here, as though the objective were to transmit lossless information over the powerlines. AEMO is only required to detect non-compliant provisions of FCAS.

It isn't necessary to be able to reconstruct the power response at very high fidelity, it is only important to detect that an oscillation is occurring at some magnitude. So, the Nyquist-Shannon sampling theorem is not entirely relevant, and the heuristic of requiring three samples per half period is potentially excessive as a result.

UoM presented some information that seemed to show an oscillation could not be detected with a 1-s sample rate. They included two charted examples (see Fig. 2.8 from the UoM study): a response with a 1Hz oscillation, and another with a 4Hz (0.25s period) oscillation. In both cases, the 1-s sampling appears as a straight line ramp, with no detection of the oscillation.

**This occurred in their examples only because these oscillations are a harmonic (whole-number multiple) of the 1 Hz sampling rate, and they aligned sampling so that sample points occurred where the oscillation was crossing the baseline. This is a worst case scenario.**

Fig. 1 shows 1-s sampling of an oscillatory response profile with an oscillation period of 0.769 s (1.3 Hz). In this case, the oscillation frequency is not a harmonic of the sampling frequency. The result is that successive samples do not always appear at the same point in each cycle.

1-s sampling is able to provide insight into the magnitude of deviation from the base case, under these conditions. This would even work for higher frequency oscillations, provided the frequency of oscillation was not a harmonic of 1Hz.

Had UoM considered the 1-s sample rate case in their study, they may have arrived at a different method for oscillation detection, and could have revealed some success in detecting oscillations even with 1-s sampling.

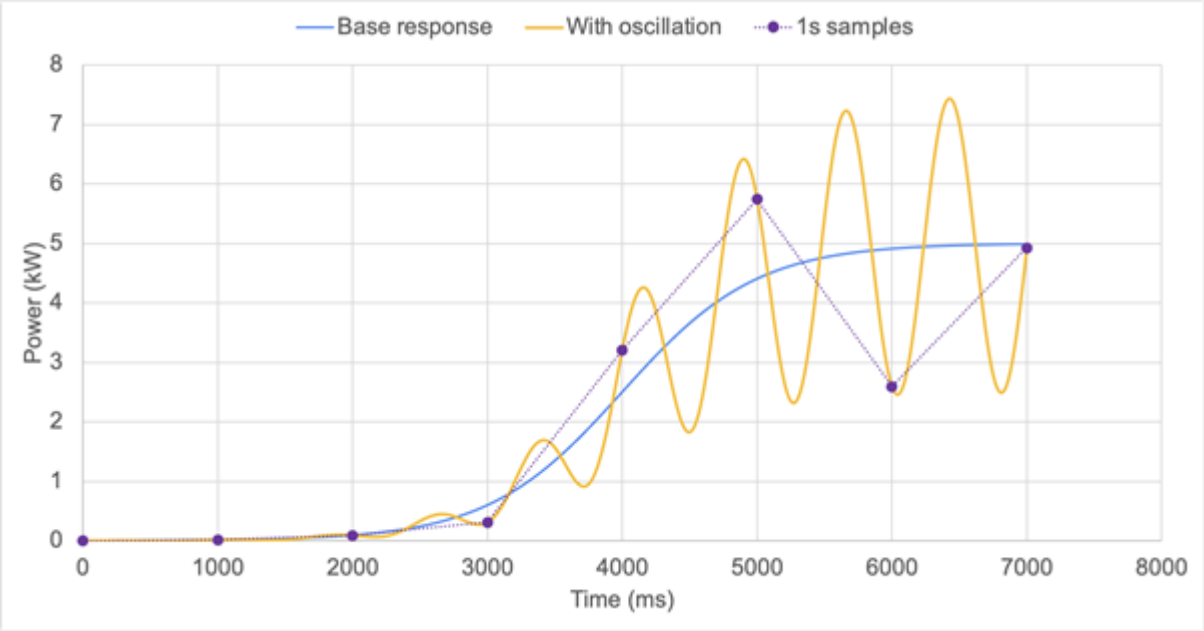



Fig. 1 - FCAS response from a 5kW device, with a superimposed oscillation of 1.3Hz. This illustrates that if the oscillation period is not a harmonic of the 1Hz sampling rate, then even 1-s sampling may provide information regarding the magnitude of any oscillation present.

In highlighting this, Evergen is not suggesting that 1-s sampling is perfect for detecting undamped oscillations. We are only seeking to emphasise that there is the possibility that 1-s sampling could detect an oscillation in many circumstances. This, combined with additional points in this section, forms a complete argument that there is, overall, very low risk presented by 1-s sampling.

### 3.4 Low Risk Overall

To sum up, the problem AEMO is seeking to avoid is that there is both:

(a) a DUID-level large-magnitude oscillation; and

(b) AEMO's verification process fails to detect it.

For these conditions to be met, the following would need to occur:

- Each device type in the DUID undergoes a high sampling rate frequency injection test. These tests show no oscillation, resulting in the DUID passing registration.
- A large number (or all) devices under the DUID would need to then subsequently incur some type of fault, resulting in each independently exhibiting oscillatory behaviour.
- The oscillations of each device would need to constructively interact with each other to produce a large-magnitude oscillation in the aggregate. This requires:
    - The period of individual device oscillations to be identical; and
    - The oscillations of each device to be in phase with each other.
- The overall frequency of the resultant aggregate DUID-level oscillation would need to be a harmonic of 1 Hz, such that 1Hz sampling had trouble identifying the oscillation.

**Evergen suggests that the probability of all of the above occurring so as to create a verification problem is low.**

Regardless of whether Fast FCAS verification can detect oscillatory behaviour, DER that exhibit such behaviour will still be grid-connected and contributing risk to power system security even if excluded from Fast FCAS markets. For this reason, **Australian standards and commissioning requirements are a more appropriate vehicle for mitigating oscillatory response from DER**, not the verification approach for the Fast FCAS market.

We would also like to reiterate comments from our submission on the First Draft Determination that there is scant evidence on the prevalence of oscillatory behaviour from DER inverters responding to

FCAS. Later in this submission (see section on real-world data) we also comment on the pitfalls of relying on individual case studies.

## 4. Benchmark for acceptable verification

The UoM study used a synthetic benchmark. This benchmark was formed by combining AEMO's own high resolution (50 ms or faster) measurements of grid frequency across real frequency disturbances, with a Frequency-Watt curve provided by Tesla to generate a benchmark FCAS power profile.

Using the "universal window" method to determine frequency disturbance time (FDT) and the trapezoidal integration method, UoM calculated the benchmark FCAS energy delivery from this profile.

When analysing various scenarios (e.g., different sampling rates, or different methods of determining the FDT) UoM compares each scenario to this synthetic, perfect benchmark to calculate verification error.

What is missing from this analysis is an indication of what is acceptable to AEMO. UoM acknowledges this:

> *"Note that a small verification error in the results reported here only shows that the Fast FCAS contribution calculated with the given settings (e.g., sampling rate, frequency disturbance time assessment method) is close to the contribution calculated with the response sampled at 20/50 ms, assuming that the 20/50 ms response with "universal window" method is the benchmark. Thus, for a given event, a small error shown in the results of this report does not necessarily indicate that the provider would have an acceptable performance in terms of FCAS delivery as recognised by AEMO. "* - UoM, p. 8

By comparing to a perfect, synthetic benchmark the relative errors for each of the scenarios considered by UoM seem larger than if they were instead compared to a benchmark of what AEMO regards as realistically acceptable, a benchmark that would unavoidably include error of its own.

AEMO has already determined and communicated to the market what it believes is an acceptable level of accuracy. This is what is described in the existing MASS, v6.0 and accompanying verification tool:

- 50 ms measurement resolution.
- 2% (of total plant output) power measurement error.
- first recorded point method for determining FDT.
- the Riemann-sums method of integration.

Rather than only comparing each scenario to the perfect case, it would be instructive to also compare each scenario to AEMO's existing benchmark, as articulated in MASS v6.0 and MASS Verification Tool.

Such a benchmark could be readily added to UoM's analysis. This could be in the form of an additional scenario as follows:

- Begin with the original synthetic profile, of 20/50 ms data.
- Resample this profile at 50 ms, and in so doing include a random error of ±2% power measurement error using the method already described in UoM's study.
- Calculate verified FCAS energy for this resampled 50 ms profile, using the first recorded point method for FDT determination, and Riemann sums for integration.
- Calculate the error spread for this resampled 50 ms profile vs the original synthetic benchmark.

The above scenario would provide an unbiased indication of AEMO's current standard of acceptable verification.

If all of the scenarios considered in the UoM study were compared to this benchmark, AEMO would have even greater justification for accepting a coarser sampling resolution requirement - particularly if national metering identifier (**NMI**)-level verification were implemented. If NMI-level verification

at 1-s were shown to be more accurate than the 50 ms resampled benchmark, that would provide a powerful argument for the suitability of 1-s sampling along with improvements to the verification approach.

## 5. Verification at the NMI level

In our submission on the First Draft Determination, Evergen showed that with an improved method of determining FDT and NMI-level FCAS verification, fleet-level FCAS verification error could be reduced to negligible values. This would apply even for sample rates as coarse as 1-s sampling. Indeed, with a sufficient number of devices, verification error could be smaller with 1-s sampling using NMI-level verification than for the current MASS's approach of 50 ms sampling and aggregated verification. UoM found essentially the same result.

However, UoM's current study did not specifically address whether NMI-level verification with 1-s measurements could be more accurate than aggregated verification at 50 ms, as suggested in the previous section of this submission. Nevertheless, we can still observe telling results in the data that has been provided.

Looking at the tables in Appendix B of the UoM Stage 2 study, and considering just the RoCoF method for choosing the FDT, we can see that the error ranges for 1-s sampling when there are just 25 NMIs are similar or smaller to the error for a single device sampled at 100 ms. See Table 1 and Table 2 below, which reproduce data from the UoM study.

Table 1. Reproduction of results from Table 7.3 of the UoM study, using RoCoF method, and the NSW event. Similar results for 1 site@100 ms and 25 sites@1 s are highlighted

| ***No. of sites*** | ***100 ms*** | | ***200 ms*** | | ***1 s*** | |
|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max |
| 1 | **-3.9%** | **3.7%** | -4.3% | 4.3% | -11.1% | 13.5% |
| 25 | -1.1% | 0.8% | -1.0% | 0.8% | **-3.1%** | **3.0%** |

Table 2. Reproduction of results from Table 7.6 of the UoM study, using RoCoF method, and the QLD event. Similar results for 1 site@100 ms and 25 sites@ are highlighted

| ***No. of sites*** | ***100 ms*** | | ***200 ms*** | | ***1 s*** | |
|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max |
| 1 | **-4.4%** | **2.9%** | -4.7% | 2.8% | -10.8% | 9.5% |
| 25 | -1.9% | 0.1% | -2.0% | 0.2% | **-3.2%** | **2.0%** |

UoM's results along with analysis in Evergen's previous submission both suggest the same thing:

**With NMI level verification and a minimum fleet size of 200 devices, 1-s sampling delivers acceptable verification accuracy, on par with what is delivered by 50 ms sampling at the aggregated DUID level.**

We understand that AEMO will require some time to develop a NMI-level approach to verification. But given:

- The inherent bias of the current approach to VPPs;
- The proven redundancy of requiring so many measurements at each individual device;
- The rapid pace of change across the whole NEM, and
- The inefficiencies of slow transitions in creating a moving target for hardware designers,

Evergen recommends that AEMO works towards implementing NMI-level verification swiftly. Evergen would be very pleased to contribute to this work and aid where we can.

…

## 6. On separate verification approaches as a general principle

Evergen's arguments above suggest that AEMO should adopt a separate approach to verification that is specific to DUIDs comprising many plants. Yet AEMO seems motivated towards one process with which to assess all FCAS providers, to maintain impartiality.

We agree that FCAS assessment should be technology independent, and the market should be open and impartial to any participant or technology that can deliver adequate response.

However, building a single verification approach only offers only a thin veneer of impartiality. In practice, different technologies have different circumstances. AEMO already recognises this, which is why the Second Draft Determination divides the market into synchronous generators for which inertia calculations apply, and FCAS Providers such as battery energy storage systems (**BESS**) for which inertia is not relevant.

As Evergen has argued both in this and our previous submission, in focussing on a verification method that uses aggregated DUID-level data, the existing MASS v6.0 is biased against DER-based VPPs as compared to single-plant DUIDs.

It is not possible to derive a completely impartial, unbiased, technology-neutral approach to verification, and AEMO can't operate under the pretense that this is possible. Instead, Evergen recommends AEMO strive for a consistent level of verification accuracy across all participants, rather than a consistent method of verification.

If a cheaper/less onerous verification approach for one technology can achieve the same benchmark for verification accuracy, that approach should be made available for that technology.

It is more in accordance with the NEO for AEMO to make principled and objective technology-specific modifications to its verification process than to create a one-size-fits-all approach, and expect many participants to incur unnecessary costs in complying with an approach that is more suited to other types of participant.

...

**8. Reasonable measurement requirements**

From a helicopter view, there is something inherently disproportionate to the idea of collecting telemetry from residential-scale BESS at the same fidelity as the telemetry gathered from a multi-MW industrial provider of FCAS.

In this section we present a case study comparing the Hornsdale big battery with a VPP of similar size to illustrate this.

**8.1 Volume of measurements required**

The Hornsdale big battery in South Australia (**SA**) is a 150MW plant, with a maximum FCAS bid of 95MW.

In order for a VPP composed of many 5kW BESS to comply with the existing same Fast FCAS as the 95MW Hornsdale facility would require 19,000 BESS and 19,000 telemetry streams. It is a huge amount of data collection, all to deliver the same level of service.

For compliance with fast market measurement requirements in the existing MASS, Hornsdale would need to provide:

20 samples/s * 65 s = 1,300 measurement records for a single frequency disturbance.

In comparison, for a 95MW VPP:

95MW from 5kW devices = 19,000 devices.

The data burden to achieve fast market compliance across all these devices would equate to:

19,000 * 20 samples/s * 65 s = 24,700,000 measurement records for a single frequency disturbance, to comply with the existing MASS.

To comply with the Second Draft Determination requirement for 200 ms resolution:

Hornsdale would need to record 325 measurements.

A 95MW VPP would need to record 6,175,000 measurements.

**8.2 Power measurement error**

Each power measurement must have an accuracy of 2% of total power.

For a 5kW device: ±100 Watt measurement error.

For Hornsdale: 2% of 150MW total battery power: ± **3,000,000 Watt** measurement error.

Summing power measurements across thousands of devices does not mean that it makes sense to sum the individual errors. Across a big enough fleet, the error distribution is normal about a mean of zero. The errors will cancel each other to an extent, and the total error across a fleet of thousands of devices will be much, much less than 100W * 19,000 = 1.9MW, diminishing close to zero.

Evergen's previous submission as well as UoM's analysis demonstrate this. It is beyond dispute that the error in aggregated measurement error across a fleet will be much smaller than a single set of measurements from one device. For this reason there is plenty of room to consider relaxing the sampling rate requirements for VPPs delivering Fast FCAS.

So both the existing and the draft MASS are biased against VPPs versus DUIDs consisting of a single plant behind one connection point, in terms of both volume of measurements required, and accuracy of measurement.

**The impact of a single 5kW (roughly) size DER on the grid is negligible, and monitoring attached to that system should be commensurate with this near negligible impact.**

We need to be serious about allowing residential DER to participate in FCAS, it will add up to be a huge reservoir of FCAS capacity. Since both the VPP Demonstrations and the one VPP external to the program have already demonstrated the viability of DER-based FCAS, then AEMO should be contemplating the idea that we will be collecting telemetry streams from hundreds of thousands of systems in the near future.

Evergen recommends against a verification scheme that applies such disparate verification burdens, or one that requires such a copious and unnecessary amount of data from individual residences each with only ~5kW impact on the grid.

### 9. Alternatives for determining FDT

In our previous submission, Evergen explained the shortcomings with AEMO's existing method ("first recorded point" method). We described two alternative methods ("midpoint", "twin points average" as labelled by UoM). UoM confirmed that these methods are preferable to the existing method, and also provided a 3rd, even more accurate method (the Rate of Change of Frequency or "RoCoF" method).

Evergen appreciates that AEMO took our response seriously, confirmed it, and is now proposing to update the verification approach accordingly. Our aim in contributing is to be collaborative, and work with industry and AEMO to assist DER to participate where it is sensible to do so, and it is gratifying to jointly make progress like this.

We noted that in the forum of 8 November, that one stakeholder suggested that they had previously examined the measurement resolution question and concluded that more coarse than 100 ms was not acceptable. Even without detail on this study, and assuming it is completely robust and accurate, if this study did not make use of the RoCoF method for FDT determination nor use the trapezoidal method for integration, then it is no longer a relevant study. The same applies for any other previous studies on this issue that do not consider these new methods.

At the very least, the 2021 MASS review has uncovered these new approaches to calculation which offer improved verification at little or no cost, a win for AEMO and a win for the market.

### 10. On using real-world data

Following feedback from the November 8 forum, AEMO has recently made a broad request for additional real world data, presumably to diversify the analysis presented by UoM, which uses only synthetic data.

Given the theoretical underpinnings for AEMO's result that 200 ms is acceptable for non-intertial DUIDs such as those providing FCAS from BESS, and the additional result (which was supported by both UoM and also by Evergen's previous analysis), that even 1-s resolution is acceptable if verification is done at the NMI level, Evergen does not expect studies with new data to have any tangible impact on the results presented by UoM regarding verification error. It's possible though that AEMO might be presented with additional case studies of oscillatory response.

There is often a base assumption that real-world data is somehow preferable for assessing impacts, because it captures real world nuances that do not appear in theoretical data. There is definitely

truth to this. However, there are also drawbacks from using real world data, and Evergen would like to emphasise these here, to pre-empt some of the additional analysis that may result.

### 10.1 Measurement error

Real world data involves the taking of measurements. These are inextricably linked with measurement error. Despite the inclination to treat 50 ms real-world data as an error-free benchmark, it is simply not the case, and neglecting to properly handle this error risks skewing an analysis. As stated above, Evergen believes that the omission of a 50 ms resampled case has the effect of accentuating the error attached to UoM's considered scenarios. These scenarios would all appear to have a more muted error if compared to a 50 ms resampled benchmark that includes measurement error.

The sensitivities around measurement error become especially acute when examining individual response profiles as case studies. This is because individual case studies can no longer assume that measurement error matches the design specification of the measuring equipment. For individual case studies, whether the measurement equipment itself is faulty is a consideration, and additional analysis should be employed to verify that this isn't the case.

We are invited to treat such case studies - such as the single oscillatory response profile provided by Reposit in their first submission - on face value as being a perfect representation, ignoring any measurement error. But how can we determine whether or not the measurements were taken by a properly functioning measurement device? How do we distinguish between:

A A faultless measuring device taking measurements of a faulty inverter, where the inverter really is delivering an FCAS response with oscillatory power response

B A faulty measuring device taking measurements of a faultless inverter, where the apparent oscillations evident in the measurements are just an artefact of faulty measurement, and not something that is really happening at all.

Evergen recommends AEMO remain mindful of this when assessing the real-world data provided for this last stage of the MASS Review process.

Presentation of additional individual devices presenting oscillatory responses could be verified by replacing the measurement hardware for such devices and observing whether the same behaviour occurs. This would minimise the chance that the oscillation is an artefact of faulty measurement equipment rather than an actual inverter power output occurrence.

## 11. An assessment of current API-based DER industry capability

Evergen is not a hardware company, and we do not install additional Internet-of-things (IoT) devices for every DER we intend to orchestrate, though it is true that in the company's early years we did so. Our approach to VPP orchestration now requires no additional hardware or expense for the end user. This approach has allowed us to scale quickly to more than 6,000 DER, and ongoing rapid growth into the future.

As the DER sector has progressed, we have seen the inverter manufacturers themselves convert their products into IoT devices. This makes sense, because by allowing remote monitoring and control, hardware vendors can more readily assist end users to monitor their systems for faults, do maintenance tasks such as firmware updates, and collect data to guide future development.

We are a software-as-a-service (SaaS) company. We saw this clear and strong trend towards inverter vendors developing integrated monitoring and control capabilities. Our business model is to use rather than duplicate this capability. We make linkages between system suppliers, hardware partners, VPP owner-operators and consumers of grid services (AEMO, retailers, DNSPs) to facilitate remote monitoring, optimisation and control using the existing capabilities of inverter manufacturers.

Evergen is currently integrated with nine DER inverter companies, with more integrations under development. Our portfolio of integrations includes both residential and commercial-scale DER, both battery and solar inverters. Our roadmap includes integrations with Electric Vehicle charging stations, and other DER such as air-conditioning control systems.

We believe this approach is the future for residential scale DER monitoring and control, and therefore think that our perspective on the impact of the draft determination on FCAS capability for Evergen and its hardware partners is useful to AEMO in understanding the market impact of its

determinations. Evergen itself has the infrastructure and capacity to monitor and control devices according to the MASS requirements, provided our hardware partners are able to comply.

- Of our current partners, **none** currently offer Evergen the ability to deliver FCAS with 200 ms (5 samples/s) or faster sampling via API. In the immediate aftermath of the Second Draft Determination being made final, Evergen would be excluded from participating in the Fast FCAS market with our current hardware partners - except for our involvement in transitional period FCAS fleets.
- Should the 200 ms requirement become final, we expect that **one** of our hardware partners will be able to comply in the short term by rolling out firmware updates only.
- Two hardware partners who had already developed FCAS capability at 1-s will not be able to achieve 200 ms compliance at existing installations, even with firmware updates. There is no economic opportunity or plan to retrofit these installations with new hardware to allow 200 ms verification, so these systems would be excluded from Fast FCAS.
- Across our remaining hardware partners, some (not all) already include metering hardware compatible with 200 ms sampling. However metering hardware is but one facet of capability. None have yet communicated concrete plans for doing the additional work (local data handling, storage, comms, cloud, databases and servers, APIs) to deliver 200 ms data recording in a way that allows remote orchestration and measurements for Fast FCAS. We may see more clarity once the current MASS Review process is finalised.
- One hardware partner has indicated they are targeting 200 ms capability via API by Q3 2022.
- Several seem open/positive to exploring what might be required - they have not ruled out developing 200 ms capability, but nor have they provided any commitment.
- One of our hardware partners focuses more on C&I level battery installations. Compliance with the Second Draft Determination is less pressing, since the installation of 3rd party metering solutions is a comparatively smaller percentage of cost relative to battery costs and FCAS income at this scale.

**12. Recommendations**

Evergen recommends:

- 1-s sampling for DUIDs comprising many individual DER (eg. 200 minimum) is acceptable, provided DER types pass one or more frequency injection tests at high sample rate, to exclude DER types that have significant undamped oscillatory response as part of nominal operation, if any.
- Australian Standards and commissioning requirements are a more appropriate vehicle for controlling the potential oscillatory response of DER, rather than ineffectually using Fast FCAS measurement requirements for this purpose.
- AEMO works towards implementing NMI-level verification swiftly.
- AEMO develops DER/VPP-specific requirements for FCAS, that allow low-cost compliance but deliver the same level of verification accuracy.
- …

Greenergenic:

**Concerns around impact of oscillatory response assessment**

AEMO's approach to oscillations in potential DER response is incomplete with respect to the requirements such oscillations pose on relevant metrology, in particular sampling frequency. The UoM report correctly identifies the relevance of Nyquist-Shannon sampling theorem, suggesting that in excess of twice the oscillation rate is required as a sampling rate to accurately capture an oscillating signal – a common conclusion. The report promulgates an assessment methodology with a number of sample and application dependencies to correctly identify an oscillating signal; once identified as oscillating, the method does not provide a means to reconstruct such a signal within the accuracy requirements of the MASS.

The UoM report confirms samples provided by AEMO for relevant evaluation feature oscillations in the range 1-3 s, the lower bound of which would be adequately met by a 200 ms sampling rate. AEMO acknowledged data within a submission predating the commissioning of the UoM including data identifying a DER approved for sale in Australia (and thus falling within the scope of the MASS) having a ~6 Hz oscillation in response data. Per sampling theory described in the UoM report this response signal would not be adequately captured within the accuracy requirements of the MASS if sampling at 200 ms.

AEMO response (verbatim in third consultation forum) – "we haven't observed an oscillatory behaviour from a fleet of DER inverters" – neither addresses the evident nature of the submission provided (falling well within the scope of possibility the MASS covers) and is further inconsistent with AEMO's prior evidence base and rationale for determining sampling rate (i.e., using a single laboratory sample with synthetic error rather than "behaviour from a fleet of DER inverters"). It is further stressed that DERs covered by the MASS are not limited to inverting DERs, and that oscillation in DER response may arise from a number of possibilities not limited to inverter response (in lieu of regulation for standards conformance to these ends). No rationale is given as to why metrology requirements of the MASS should cover some classes and behaviours of DERs and not others.

Members Energy:

In summary the Second Draft Determination provides for:

- 200 ms measurement
- Measured 'at or close to' connection point
- Transition period:
  - can backfill churnout up to present limit of registration
  - transition period ends 30 June 2023
  - 5% discount for measurement frequency above 200 ms
  - no new entrants on transition requirements (they must meet ongoing requirements).

As detailed in our August submission, 200 ms is not currently achievable by our fleet, although we believe we could meet that requirement by the end of the transition period. Similarly, the requirement for measurement at or close to the connection point and the proposed transition requirements are all, considered separately, achievable in due course.

…

… in relation to under-damped oscillatory behaviour. We support their [Evergen's] contention that AEMO's concerns in relation to this issue are overstated, that 1 s measurement is adequate in practice and that 200 ms is unnecessarily risk averse and will, in practice, increase the long term risk to AEMO as described above.

This third submission to the MASS review process essentially reiterates the contents of our second submission last August. So, we draw your attention to that submission rather than repeating its technical contents here.

PIAC:

PIAC supports the Second Draft Determination to require a minimum measurement time resolution for Fast FCAS Providers of:

- 200 ms for aggregated facilities with no inertial response (5% error applies if number of sites is less than 200); and
- 50 ms for all other facilities.

PIAC commends AEMO for taking extra time to consider the issue of measurement resolution and propose a solution that better serves the interests of consumers. The minimum 200 ms resolution provides a much clearer path towards the mature VPP FCAS market needed to support AEMO's goal of the grid handling 100% instantaneous renewable energy by 2025.

Reposit:

Reposit continues to support AEMO's objectives of the MASS consultation and key areas of its First Draft Determination.[6] However, Reposit does not support AEMO's reversal of key positions in its Second Draft Determination which are based on the UoM's analysis (and evidence from other stakeholders[7]). The Second Draft Determination proposed a 200 ms minimum measurement time resolution requirement for Fast FCAS for aggregated connection points (only DER resources can aggregate connection points) compared to a 50 ms requirement remaining for all other connection points.

Reposit does not support AEMO's proposal to allow a 200 ms measurement time resolution for Aggregated Ancillary Service Facilities with no inertial response (aggregated sites) and a 5% discount applied to aggregations of less than 200 sites. This draft decision:

- Understates the risk to the power system associated with the measurement and verification of energy for Fast FCAS and is likely to negatively impact overall market operation and efficiency.
- Creates a clear and unnecessary distinction between the technical requirements for different registered participant categories based on the size of assets at the connection point.

AEMO has based its assessment on UoM's analysis of Fast FCAS performance verification and investigation of different integration rules. Reposit considers UoM's methodology is flawed which results in its analysis of verification error being skewed and understated with respect to the sampling measurement rates of 100 ms and 200 ms. These flaws include:

- The use of synthetic (not real-world) data. In calculating the verification risk associated with Fast FCAS, UoM's assessment is based on a fabricated dataset of 1000 sites based on a single Tesla Powerwall 2 (PW2). This PW2 is responding to a frequency injection test for a single contingency event under lab conditions and with a response measured by an instrument of unknown calibration, then 'fuzzed' 1,000 times with two random variables
- A case study approach being used, which is not able to generalised to an entire market for any future point in time, and in this case appears to reverse engineer outcomes. That is, the generated data set appears to have been contrived to deliver 0% (or minimal error) when down sampled to 200 ms, integrated with the trapezoidal method and RoCoF frequency detection time (FDT) method. This is inappropriate.

Given this, AEMO should not rely on UoM's analysis to identify potential errors of FCAS energy delivery measurement using different sampling rates. Any conclusions reliant on this analysis should also be reconsidered. For example, if a 50 ms sampling rate is required to reliably verify the delivery of FCAS then Reposit's view is that there is no need to make any changes to the FCAS verification tool.

Reposit appreciates that AEMO and UoM did not have other data to base UoM's analysis, this was identified by AEMO in the MASS stakeholder consultation forum on 8 November 2021 and in a subsequent email to stakeholders. In June 2021 AEMO requested Reposit provide a small number of high speed traces from inverters to examine their response profiles for power quality concerns, however, a short time later indicated to Reposit that it did not yet have the tools to use this information. As such, the requested data was not provided to AEMO.

To assist AEMO (and presumably UoM) reconsider the "additional" error created by a 200 ms sampling rate using actual site data, Reposit has provided actual data from 1,650+ NMIs in response to the frequency disturbance from two trip events including the Callide trip on the afternoon of 25 May 2021 and the 25 August trip.

While this actual data provides valuable insight, Reposit encourages AEMO to use any available data it has access to at the NMI-level or inverter-level (i.e. data window to include the period from 5 s before the frequency exceeded the normal operating frequency band (**NOFB**) to 65 s after) from the Callide trip event (or any recent trip event). Data from recent events can help to better understand the power response from aggregate Ancillary Service Facilities and determine if the verification error is within the MASS's 2% allowable error range.

[6] AEMO stated the objectives are to: resolve a number of ambiguities and make the MASS consistent with the rule requirements for mandatory PFR and determine whether any changes to the measurement arrangements in the MASS were appropriate to facilitate increased participation of DER in the Contingency FCAS markets.

[7] It is unclear from the Second Draft Determination what further evidence it used as the basis for reversing its position from its First Draft Determination.

Reposit has also conducted an identical analysis to that conducted by UoM on this actual data for both trips and provided the results in this submission. Reposit's analysis demonstrates that for the 25 August 2021 trip and for a 200 ms sampling rate and 200 aggregated sites the AEMO proposed changes result in a minimum and maximum verification error of 9.6% % and -2.7%. A minimum and maximum verification error of -6.7 % and -4% is apparent for same analysis with 1000 aggregated sites.

All calculated aggregations result in error that is outside the 2% allowable error range specified in the MASS. This analysis demonstrates an error that is much greater than that obtained from the MASS's current and accepted metering and verification standard. Effectively, the analysis demonstrates that AEMO's proposed changes would significantly degrade the certainty of energy delivered to/withdrawn from a contingency event.

While this actual data provides valuable insight, Reposit encourages AEMO to review and test its analysis and would welcome the opportunity to discuss its methodology or results at a more detailed level with AEMO and UoM. Full details of the analysis and data are in Appendix A and B.

...

## 3 Response to proposed changes in Second Draft Determination

### 3.1 Introduction

Reposit supports the two objectives of the MASS consultation as identified by AEMO "...to resolve a number of ambiguities and make the MASS consistent with the rule requirements for mandatory primary frequency response..." and "...determine whether any changes to the measurement arrangements in the MASS were appropriate to facilitate increased participation of DER in the contingency FCAS markets."[8]

This consultation has been controversial and complicated by divergent stakeholder views and interests which AEMO must balance to ensure that appropriate technical requirements are in place for all FCAS Providers, including VPP providers. However, first and foremost, AEMO must adequately consider the requirements of the power system which it is responsible for operating.

Table 1 summarises Reposit's positions on AEMO's key positions on the appropriate arrangements for DER providing Fast FCAS in both draft determinations. It should be noted that the Second Draft Determination reverses several key policy positions from the First Draft Determination based on further analysis from UoM, which Reposit considers is flawed.

*Table 1 Summary of AEMO and Reposit draft determinations key positions*

| | MASS draft determination | Reposit's position | MASS second draft determination | Reposit's position |
|---|---|---|---|---|
| Minimum measurement time resolution for Fast FCAS (sampling rate) | All FCAS providers must meet a 50 ms measurement for Fast Raise Service and Fast Lower Service | Supported | • 200 ms for aggregated facilities with no inertial response (5% error applies if number of sites is less than 200)<br>• 50 ms for all other facilities. | Unsupported |
| FCAS verification methodology changes | Not relevant | Not relevant | A combination of proposed changes to the FCAS verification methodology | Unsupported |

...

| | | | | |
|---|---|---|---|---|
| Oscillatory response | AEMO noted this as a power system security concern | Supported | AEMO ignored the possibility of any oscillations faster than once per second (1Hz) | Unsupported |

[8] Amendment of the market ancillary service specification - DER and general consultation, second draft determination, 28 October 2018, p.2.

### 3.2 Measurement time resolution for FCAS provided by DER

#### 3.2.1 UoM analysis

Underpinning AEMO"s decision to reverse its approach on the minimum measurement time resolution for Fast FCAS provided by DER are the results of UoM's analysis and further information from consulted persons. AEMO states:

> "At this stage, based on the additional evidence submitted by Consulted Persons and further analysis from the University of Melbourne, AEMO proposes to vary its draft determination to:
>
> - Require a minimum measurement time resolution for Fast FCAS providers of: – 200 ms for aggregated facilities with no inertial response (5% error applies if number of sites is less than 200); and – 50 ms for all other facilities.
> - Leave the measurement location "at or close to" the connection point."[9]

And:

> "AEMO's assessment, supported by UoM analysis, is that a 50 ms sampling rate is not required to reliably verify the delivery of Fast FCAS unless it is necessary to identify how an inertial response impacts the FCAS delivery."

UoM used the following to explore the impact of different sampling rates lower than 50 ms:

- A case study approach with six case studies
- The Trapezoidal rule to calculate the contribution of FCAS response, UoM stated this "…rule is far superior to simpler integration methods such as Riemann methods…"[10]
- The "RoCoF-based" method instead of the "first recorded point" FDT method which UoM considered is "…superior to other "relative window" methods proposed by different stakeholders when determining frequency disturbance time."[11]

Of relevance to the verification error, UoM concluded that:

- Using NMI-level data instead of aggregated response from Aggregated Ancillary Service Facilities reduces the verification error for lower sampling rates, e.g. 100 ms and 200 ms.
- Adjustments need to be made to the FCAS Verification Tool to capture the different approaches for DER and synchronous generators
- a 50 ms sampling rate should be maintained for synchronous generator responses for FCAS verification purposes.

Based on UoM's analysis AEMO concluded that "…to remove inefficient costs incurred by market participants to delivery of FCAS, the specifications in the MASS should be at a level needed for AEMO to reliably verify that the enabled amounts of FCAS are delivered, and no more onerous than required."

#### 3.2.2 Issues with verification error analysis

UoM's analysis seeks to identify "additional" verification error by exploring a range of factors affecting verification error and establish a methodology to identify potential oscillatory response.[12] Verification error has at least the following components:

- Power measurement error
- Sampling rate
- Determination of FDT
- Quantity of response that is inertial

[9] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, Second Draft Determination, 28 October 2021, p. 2.

[10] Fast FCAS Sampling Verification in Support of Market Ancillary Services Specification (MASS) consultation, p. 1.

[11] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, Second Draft Determination, 28 October 2021, p. 2

[12] The UoM, Fast FCAS Sampling Verification in Support of Market Ancillary Services Specification (MASS) consultation – Phase 2, October 2021

- Compensation factor
- Site aggregation method
- Integration rule used.

Any change in verification error (the "additional" error) is important to understand because this represents the modelled risk of any relaxing of technical standards. If AEMO modifies quantities and calculations in the MASS and this increases verification error by X%, then AEMO and consulted persons must accept that either:

1. The affected FCAS is now X% less effective
2. AEMO must procure X% more of the affected FCAS to ensure that service provision does not reduce below pre-modification levels.

Reposit believes that UoM's, and therefore AEMO's, analysis of "additional" error is incorrect for the following reasons:

- …
- The only error quantity that is relevant to the measurement and verification of contingency FCAS is worst-case error. This is because contingency FCAS must deliver under a worst-case scenario to prevent a cascading failure in the power system. The case study presents the error inherent in the dataset the case study was built on. This is not worst-case error - it is just "this-case" error.
- The use of case studies to determine whole-of-market requirements is not valid. The results obtained from an error analysis from a particular case study are not able to be generalised across all cases with any validity. The measured error in each case study is highly dependent on the nature of the contingency event and the composition and specific responses of the DUID units at the time. None of these things are able to be generalised to the entire market at any future point in time. A case-study calculates a "this-case" error, not a "worst-case" error
- The error identified in the case studies is unlikely to be the worst-case error. The Monte Carlo sampling used in the methodology is not guaranteed to identify worse-case error for a given case study. The UoM analysis only includes 500 Monte Carlo simulations – this creates an artificially low worst-case error as the likelihood of a worst-case scenario being analysed is smaller than if a reasonable number of Monte Carlo simulations were undertaken.
- The "error reduction" displayed in these case studies due to "site aggregation" is error cancellation. The lower sampling rate creates additional interpolation error above that created by 50 ms sampling. This error both overestimates and underestimates energy delivered to a contingency event. UoM and AEMO have considered that aggregation of FCAS contingency response over many sites will result in the errors cancelling and therefore create a high accuracy aggregate measurement. This would work where the negative and positive errors were aligned in time and so would cancel each other out. However, this depends on the constituent site responses being:
    - Symmetrical - the sampling happens at the same time offsets on the left and right side of the "middle" sample time. More precisely, the sampling offsetting on one side of the median response is the same as the sampling offsetting on the other side of the median response
    - Homogenous - all of the DER units do exactly the same thing at the same time. More precisely, a there are as many MWh delivered before the median constituent response, as there are after the median constituent response.
- The data UoM relied on (provided by AEMO using Tesla's data) has strong symmetrical and homogenous characteristics because:
    - The sampling poll time error was manufactured using a normal distribution i.e., it is perfectly symmetrical
    - It is a single power response, statistically fuzzed but otherwise simply repeated 1,000 times i.e., it is homogeneous.

Given this, UoM calculated the "additional" verification error using a dataset that demonstrated an unrealistic level of error cancellation. This degree of error cancellation would not occur in the real world (or using actual data) because:

- At best sampling offset is random (uniformly distributed) – there is nothing that suggests any symmetrical distribution or that it is the same at different points in time.
- DER response is not homogeneous – a homogeneity assumption is invalid and unrealistic. The UoM analysis assumes homogenous responses from the same type of units. Several factors affect DER response and can be different for different devices and can change in an unsynchronised way. For further information on homogeneity refer to sections 3.3.3 to 3.3.5 in Reposit's submission to the Issues Paper

### 3.2.3 Reposit's analysis

Reposit replicated UoM's analysis from its second report. This analysis uses:

- Actual operational data from 1,000 NMIs in a single region. This includes datasets from two recent Fast FCAS trip events, including the Callide trip on 25 May 2021 and the second on 25 August 2021. The NMIs were all responding existing NMIs in Reposit's DUID.[13] As mentioned, UoM has used a fabricated dataset based on one Tesla PW2
- 10,000 Monte Carlo simulations as conducting 500 simulations is 200 times less likely to miss the worst-case error combinations, and hence under-estimate worst-case verification errors.

Reposit's analysis is set out in Appendix A and B.

To demonstrate the verification error results using 'real-world' data Table 2 sets out the minimum and maximum verification error results for different levels of aggregation using a 200 ms sampling rate (as proposed by AEMO). This demonstrates some more specific observations that AEMO should consider, including:

- Using actual operational data for the 25 May 2021 and 25 August 2021, the verification error (for any number of sites) is more than the accepted MASS 2% verification error
- It is more appropriate to consider the verification errors identified from 25 August because this is a more typical trip event
- The RoCoF based methodology:
  - For 25 May 2021, the results demonstrate that the methodology does not work primarily due to the frequency recovering within the NOFB within 2.6 s. This is a more extreme event and demonstrates how inappropriate UoM's methodology is when using actual operational data
  - For 25 August 2021, the verification errors calculated once a significant number of NMIs have been aggregated appear to be directly proportional to the sampling period, i.e. 200 ms has twice the error of 100 ms (refer to Appendix A and B).

*Table 2 Minimum and maximum verification errors for different aggregation levels and a 200 ms sampling rate*

| No of sites | UoM (table 7.6) (%) | | Reposit – 25 May 2021 (Callide) trip (%) | | Reposit -25 August 2021 trip (%) | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| 1 | -4.7 | 2.8 | -14546.5 | 24559.6 | -8448.3 | 11379.8 |
| 10 | -2.4 | 0.6 | -18840.0 | 358348.5 | -319.6 | 14.0 |
| 25 | -2.0 | -0.2 | -46884.3 | 94542.2 | -25.8 | 3.9 |
| 50 | -1.7 | -0.4 | -628411.5 | 35471.2 | -16.3 | -0.1 |
| 200 | **-1.3** | **-0.7** | -10587.4 | 9056.8 | -9.6 | -2.7 |
| 500 | **-1.2** | **-0.9** | -2272.6 | 28517.0 | -8.0 | -3.6 |
| 1,000 | **-1.0** | **-1.0** | -33.5 | 9621.5 | -6.7 | -4.0 |

[13] The 25 May 2021 Callide data set is from 1,669 NMI responses and the 25 August 2021 trip is from 1,671 NMI responses.

For comparison purposes, using the same methodology, Table 3 shows the minimum and maximum verification error results for different levels of aggregation using a 100 ms sampling rate (as proposed by AEMO).

*Table 3 Minimum and maximum verification errors for different aggregation levels and a 100 ms sampling rate*

| No of sites | UoM (table 7.6) (%) | | Reposit – 25 May 2021 (Callide) trip (%) | | Reposit -25 August 2021 trip (%) | |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| 1 | -4.4 | 2.9 | -4377.7 | 23048.5 | -7036.7 | 7128.3 |
| 10 | -2.3 | 1.0 | -190734.0 | 5522.5 | -302.7 | 9.5 |
| 25 | -1.9 | 0.1 | -58505.3 | 79302.7 | -13.1 | 2.2 |
| 50 | -1.6 | -0.3 | -776830.7 | 22931.8 | -9.8 | 0.9 |
| 200 | **-1.2** | **-0.6** | -3873.4 | 3439.8 | -5.4 | -0.7 |
| 500 | **-1.1** | **-0.7** | -1137.0 | 3573.4 | -3.8 | -1.3 |
| 1,000 | **-0.9** | **-0.9** | -53.1 | 14272.6 | -3.8 | -1.8 |

### 3.2.4 Reposit's position

Reposit disagrees with UoM's methodology and conclusions in its second report and considers the analysis to be fundamentally flawed as demonstrated in section 3.2.3.

- The high-level observations from this analysis include:
- The fabricated input data is the source of the low verification errors identified in UoM's analysis
- 'Real-world' data (actual operational data) does not show the same level of error cancellation
- The site aggregation method behaves nominally on "normal" deviations but ceases to function under 'real-world' extreme circumstances. The Callide 25 May trip event shows some absurd results
- Error characterisation using a case study approach does not generalise.

Since AEMO based its Second Draft Determination on UoM's conclusions, it stands to reason that AEMO's proposed position on relaxing minimum metering and verification requirements for Aggregated Ancillary Service Facilities is also flawed. Reposit does not consider AEMO should rely on analysis that is based on a fabricated dataset provided by a market participant with a vested interest in the outcomes of this consultation. It is surprising that due diligence was not undertaken before AEMO or UoM sought to rely on this data.

That said, Reposit appreciates that AEMO and UoM did not have other data to base UoM's analysis on which AEMO identified in the MASS stakeholder consultation forum on 8 November 2021. To make transparent the circumstances of AEMO's request to Reposit regarding the data request – AEMO requested Reposit provide high speed traces from inverters to examine the response profiles for power quality concerns, however then indicated to Reposit that it did not yet have the tools to use this information[14]. As such, there was no point in Reposit providing the requested data to AEMO.

Reposit notes that AEMO recently published a statement in the MASS Consultation – Third stage consultation forum summary indicating that Reposit ("another stakeholder") "…had been unable to provide the data to AEMO…".[15] For the reason explained above, this was not the case. Reposit would appreciate AEMO clarifying this miscommunication in its upcoming final determination.

## 3.3 Other issues with UoM analysis and AEMO's approach

There are several UoM recommendations included in the Second Draft Determination that appear to be included to ensure the 200 ms sampling results are more favourable and can be accepted. This section identifies these and Reposit requests AEMO reconsider whether they are appropriate in light of any new analysis based on the actual data provided by Reposit or any other participant.

### 3.3.1 Oscillatory behaviours

[14] AEMO requested inverter traces to review DER unit responses. Reposit did not receive a request from AEMO to provide operational data on large numbers of sites (20+ sites).

[15] AEMO, MASS Consultation – Third stage consultation forum, 15 November 2021, p. 3.

The First Draft Determination and Second Draft Determination identifies the importance of being able to identify an under-damped oscillatory response particularly when the power system is under stress, e.g. a frequency disturbance requiring FCAS. As identified by AEMO "…measurement time resolution is directly linked to the identification of under-damped oscillatory behaviour."[16]

An oscillatory response of faster than 1.25 Hz being measured with a 200 ms sampling rate will result in energy delivery or withdrawal being over-estimated for a contingency event because a material amount of energy will assumed (not measured). This will occur because the interaction between the dips and the slower sampling time means that energy delivered/withdrawn is not identified and potentially over counted. This could have material consequences for the power system, e.g. the frequency deviation will not be addressed adequately and a UFLS event occurs.

UoM concluded that "the measurement time resolution needs to be at least one-fourth of the oscillation period to capture the maximum magnitude of the oscillation…" and "The under-damped oscillatory behaviour was able to be identified using measurements of power flow at 100 ms and 200 ms intervals."[17] The identification of an oscillatory response does not mean that it is being appropriately measured. Reposit considers that AEMO needs to reconsider any approach that does not adequately measure oscillatory responses, particularly as DER increases its future FCAS contribution. Reposit provides the following comments:

- The detection of an oscillatory response is entirely different to the measurement of an oscillatory response. Only the measurement of an oscillatory response is relevant when considering additional measurement error from lower sampling rates
- A 200 ms sampling rate will not be able to reliably measure energy delivered/withdrawn where the response contains oscillations faster than 1.25Hz. Oscillation "detection" is dependent on sampling rate in accordance with Shannon-Nyquist theory. That is, sampling rate must be 4 times faster than the fastest oscillation – as observed by UoM.
- Measurement of a 6 Hz oscillatory response should and can be tested before AEMO makes its final decision. Reposit is aware there are thousands of battery inverters BTM that display the 6 Hz oscillatory response. An analysis of the measurement (not detection) of this oscillatory response can be found in section 3.3.6.3 of its submission to the Issues Paper. It is noted that AEMO provided UoM with oscillatory responses of between 1Hz and 0.3Hz for testing in its case study analysis. There is no reason for oscillations to be limited to this range and is risky for AEMO to suggest otherwise.
- It is not valid for AEMO to ignore high-frequency oscillations. Reposit has determined that high-frequency oscillatory responses deliver less energy to a contingency event. The point is to accurately measure the energy delivered or withdrawn and this is impossible the sampling rate is not at least 4 times faster than the fastest oscillation (refer to Shannon-Nyquist theory)
- Reposit requests AEMO test a 6 Hz oscillatory response for slower sampling rates (100 ms and slower), however this would be unimportant if AEMO determines that Aggregated Ancillary Service Facilities must have a 50 ms sampling rate.

### 3.3.2 Use of trapezoidal integration rule and RoCoF based method

Reposit's analysis demonstrates that a 200 ms sampling rate is unworkable and would compromise power system security. If AEMO has identified other reasons for changing from the "first recorded point" to the "RoCoF based" method or adopting the Trapezoidal integration method instead of the right-Riemann, it should consider the benefits and costs to participants in doing so. Reposit does not see the benefit of changing these if 50 ms sampling is retained and encourages AEMO to explore the costs of making these changes with participants.

### Appendix A – Callide C Trip Analysis Results

Reposit conducted an analysis on the Callide C trip at 14:06 25 May 2021 using an identical methodology to that used by UoM in its second stage analysis.

[16] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, Second Draft Determination, 28 October 2021, p. 71.

[17] Ibid.

The source data is 50 ms-sampled, grid connection point data from 1,669 actual residential electricity storage systems, manufactured by various vendors, in the ASNAES1 DUID in NSW1.

*Table 5 Minimum and maximum verification errors for different aggregation level and sampling rates with "universal window"*

| Sampling (ms) | 100 | 100 | 200 | 200 | 1000 | 1000 |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum |
| **No. of sites** | | | | | | |
| **1** | 4599.9 | -4562.4 | 7487.3 | -13582.4 | 72710.4 | -51729.7 |
| **10** | 10349.6 | -73691.6 | 282458.6 | -24503.4 | 212954.1 | -33176.7 |
| **25** | 9361.0 | -15717.9 | 13539.1 | -28138.4 | 212075.5 | -336235.8 |
| **50** | 37757.6 | -12663.3 | 23321.4 | -522565.9 | 165115.5 | -1231883.8 |
| **200** | 1553.2 | -984.2 | 3198.1 | -5535.0 | 25792.7 | -1791.2 |
| **500** | 288.2 | -1969.4 | 23652.5 | -764.2 | 60794.2 | -4961.8 |
| **1000** | 15.6 | -1741.8 | 18.6 | -4921.4 | 184.5 | -1487.7 |

*Table 6 Minimum and maximum verification errors for different aggregation level and sampling rates with "first recorded point"*

| Sampling (ms) | 100 | 100 | 200 | 200 | 1000 | 1000 |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum |
| **No. of sites** | | | | | | |
| **1** | 23345.7 | -3237.4 | 24900.2 | -12224.7 | 102173.6 | -43848.7 |
| **10** | 294265.0 | -6402.4 | 191798.4 | -22354.8 | 151007.0 | -443052.1 |
| **25** | 22390.2 | -44894.2 | 74527.4 | -16985.5 | 1287457.3 | -725.2 |
| **50** | 30184.0 | -677207.9 | 251584.6 | -3500.9 | 14933901.8 | -130.9 |
| **200** | 11185.7 | -189.3 | 41909.8 | -465.0 | 148535.1 | 13.3 |
| **500** | 46971.3 | -30.7 | 116197.8 | -5.5 | 1210034.5 | 39.4 |
| **1000** | 32832.3 | -1.7 | 62134.3 | -0.7 | 1172277.7 | 67.4 |

*Table 7 Minimum and maximum and minimum verification errors for different aggregation level and sampling rates with "RoCoF-based"*

| Sampling (ms) | 100 | 100 | 200 | 200 | 1000 | 1000 |
|---|---|---|---|---|---|---|
| | Maximum | Minimum | Maximum | Minimum | Maximum | Minimum |
| **No. of sites** | | | | | | |
| **1** | 23048.5 | -4377.7 | 24559.6 | -14546.5 | 69373.3 | -54165.2 |
| **10** | 5522.5 | -190734.0 | 358348.5 | -18840.0 | 178634.5 | -639269.3 |
| **25** | 79302.7 | -58505.3 | 94542.2 | -46884.3 | 903041.3 | -81799.5 |
| **50** | 22931.8 | -776830.7 | 35471.2 | -628411.5 | 3036364.6 | -222280.9 |
| **200** | 3439.8 | -3873.4 | 9056.8 | -10587.4 | 29448.1 | -29700.5 |
| **500** | 3573.4 | -1137.0 | 28517.0 | -2272.6 | 150456.7 | -2767.3 |
| **1000** | 14272.6 | -53.1 | 9621.5 | -33.5 | 80906.5 | -21.6 |

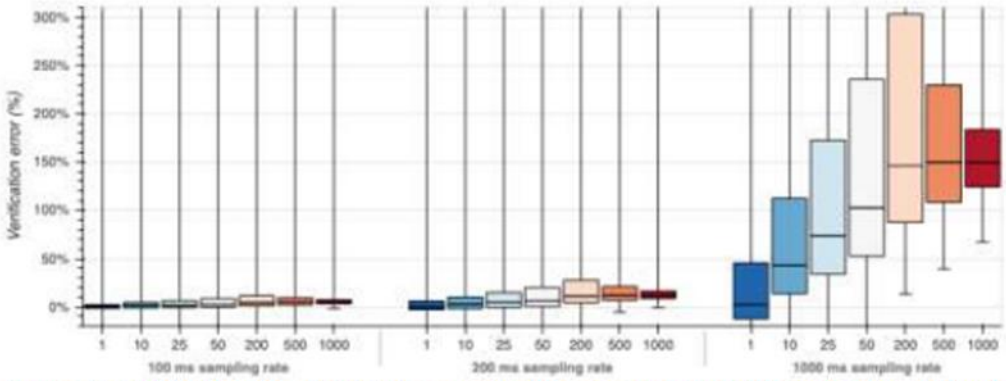



*Figure 1 Verification error (without compensation response) of different aggregation levels under different sampling rates, using the "first-recorded-point" method and trapezoidal rule*

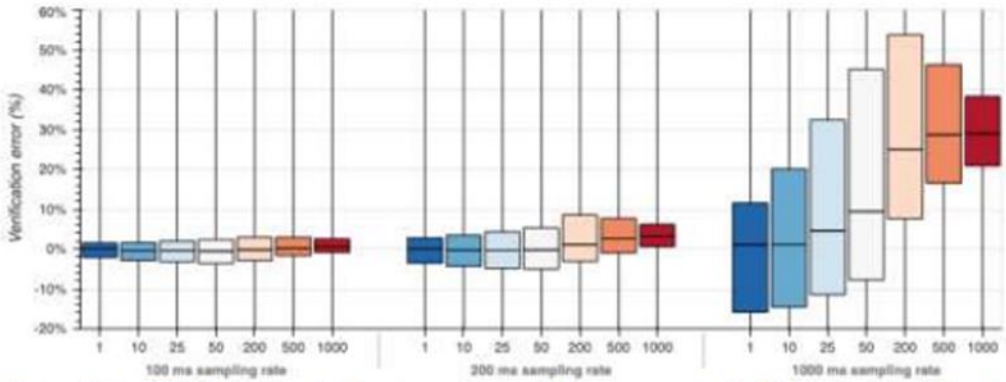



*Figure 2 Verification error (without compensation response) of different aggregation levels under different sampling rates using the "RoCoF" method and trapezoidal rule*

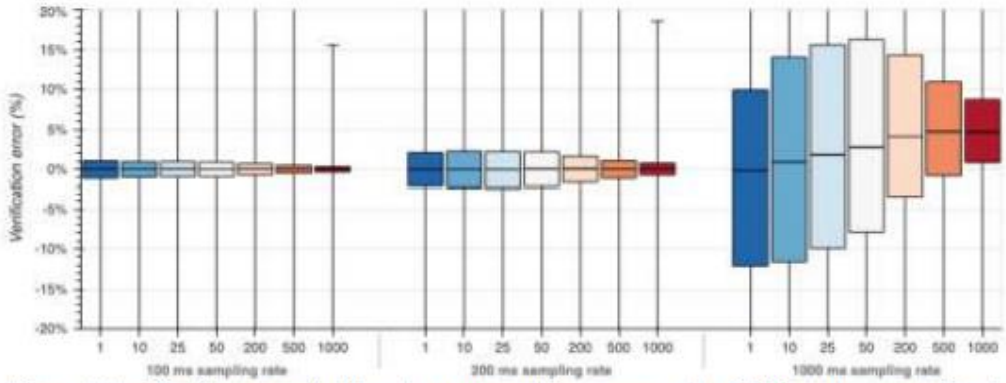



*Figure 3 Verification error (without compensation response) of different aggregation levels under different sampling rates using the "universal window" method and trapezoidal rule*

## Appendix B – 25 August Trip Analysis Results

Reposit conducted an analysis on the contingency event recorded at 18:59 25 August 2021 using an identical methodology to that used by UoM in its second stage analysis.

The source data is 50 ms-sampled, grid connection point data from 1,671 actual residential electricity storage systems, manufactured by various vendors, in the ASNAES1 DUID in NSW1.

*Table 8 Minimum and maximum verification errors for different aggregation level and sampling rates with "universal window"*

| Sampling (ms) | 100 | 100 | 200 | 200 | 1000 | 1000 |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| **No. of sites** | | | | | | |
| **1** | -2274.7 | 2299.9 | -8987.2 | 8299.8 | -31346.6 | 32181.3 |
| **10** | -7.8 | 15.2 | -24.8 | 8.8 | -141.3 | 113.9 |
| **25** | -1.1 | 1.2 | -3.0 | 3.0 | -10.9 | 8.6 |
| **50** | -0.6 | 0.5 | -1.6 | 1.3 | -3.9 | 3.8 |
| **200** | -0.2 | 0.2 | -0.5 | 0.5 | -1.9 | 1.8 |
| **500** | -0.1 | 0.1 | -0.3 | 0.3 | -1.2 | 1.1 |
| **1000** | -0.1 | 0.1 | -0.2 | 0.2 | -0.9 | 0.8 |

*Table 9 Minimum and maximum verification errors for different aggregation level and sampling rates with "first recorded point"*

| Sampling (ms) | 100 | 100 | 200 | 200 | 1000 | 1000 |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| **No. of sites** | | | | | | |
| **1** | -8215.7 | 7699.7 | -9938.6 | 12100.5 | -225400.2 | 182097.1 |
| **10** | -111.8 | 92.5 | -334.5 | 6.8 | -1037.1 | 52.1 |
| **25** | -15.2 | 1.0 | -25.7 | -0.6 | -46.3 | 12.5 |
| **50** | -10.0 | 0.2 | -18.5 | -2.6 | -28.7 | 3.0 |
| **200** | -6.5 | -1.9 | -12.2 | -4.9 | -19.3 | -4.6 |
| **500** | -5.2 | -2.5 | -10.4 | -6.1 | -16.6 | -6.8 |
| **1000** | -4.7 | -2.9 | -9.4 | -6.7 | -14.6 | -9.3 |

*Table 10 Minimum and maximum verification errors for different aggregation level and sampling rates with "RoCoF-based"*

| Sampling (ms) | 100 | 100 | 200 | 200 | 1000 | 1000 |
|---|---|---|---|---|---|---|
| | Minimum | Maximum | Minimum | Maximum | Minimum | Maximum |
| **No. of sites** | | | | | | |
| **1** | -7036.7 | 7128.3 | -8448.3 | 11379.8 | -76900.1 | 43900.2 |
| **10** | -302.7 | 9.5 | -319.6 | 14.0 | -535.7 | 81.0 |
| **25** | -13.1 | 2.2 | -25.8 | 3.9 | -45.7 | 4.3 |
| **50** | -9.8 | 0.9 | -16.3 | -0.1 | -21.7 | 0.9 |
| **200** | -5.4 | -0.7 | -9.6 | -2.7 | -14.0 | -4.1 |
| **500** | -3.8 | -1.3 | -8.0 | -3.6 | -12.8 | -5.9 |
| **1000** | -3.8 | -1.8 | -6.7 | -4.0 | -10.4 | -6.7 |

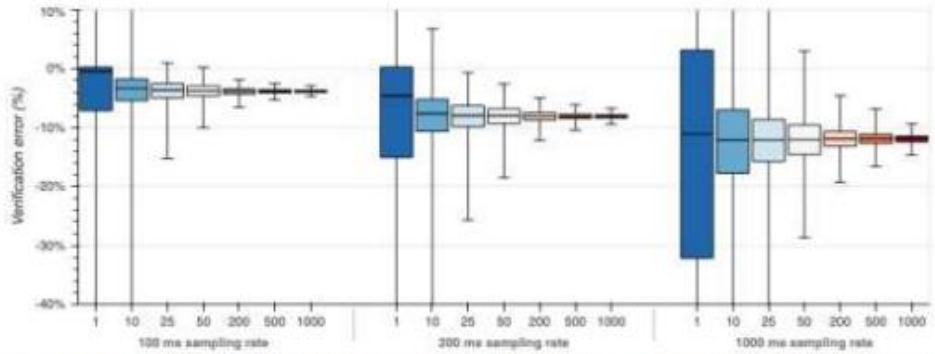



*Figure 4 Verification error (without compensation response) of different aggregation levels under different sampling rates using the "first-recorded-point" method and trapezoidal rule*

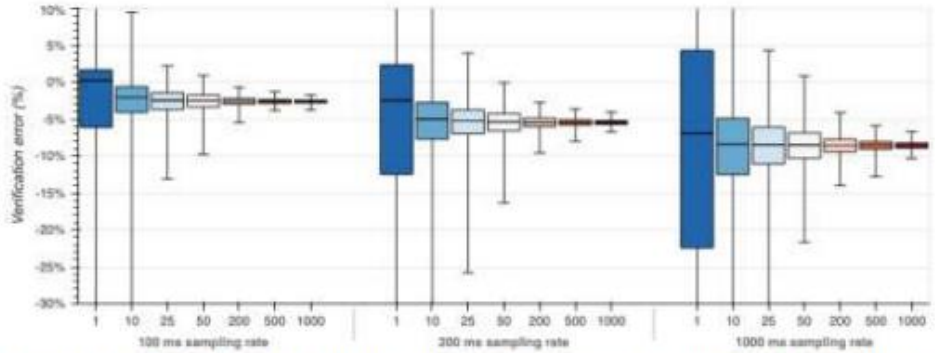



*Figure 5 Verification error (without compensation response) of different aggregation levels under different sampling rates using the "RoCoF" method and trapezoidal rule*

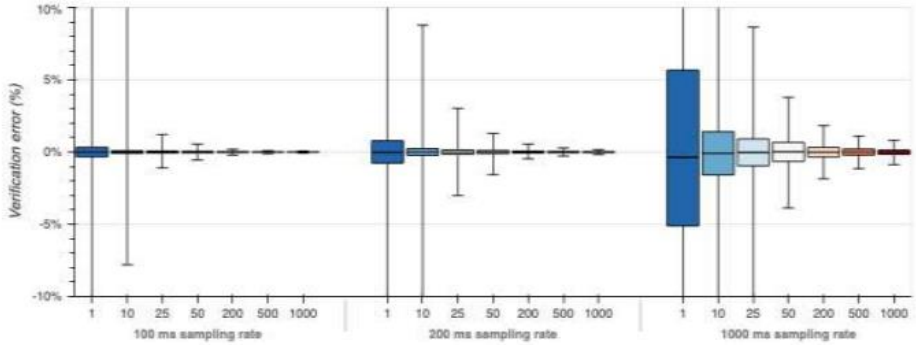



*Figure 6 Verification error (without compensation response) of different aggregation levels under different sampling rates using the "universal window" method and trapezoidal rule*

Rheem & CET:

<u>… current measurement specification requirements should remain unchanged</u>

Whilst we are aware that any decision to leave measurement specification requirements in place may have a commercial impact on some market participants, consideration should also be given to those participants that have invested in metering solutions that are compliant with the current MASS. Rheem/CET believes that, if there is negligible cost imposition (as we have shown) in the procurement of MASS compliant metering, then it is appropriate for AEMO to reject any relaxation of the current MASS.

We additionally support the original UoM report's findings that it is prudent to avoid diluting the metering specification, as this may erode the potential value of FCAS provided by DER as it reaches scale. We however do not support the latest report / findings of the UoM, as detailed below, due to our primary concerns around the data set used and analysis methodology, amongst other concerns.

<u>… there is no significant cost impediment to requiring power metering capable of measuring power flow and Local Frequency at intervals of 50 ms or less at every site (NMI)</u>

CET have a MASS compliant meter (6 Channels, 3 CT's supplied + option for an extra 3 CT's) available at a wholesale price of AU$385 (ex GST). We hope to reduce this cost in Q1 2022 when the impact of global Integrated Circuit production shortages is addressed. As a result, we do not believe that there are impediments to maintaining the current specifications to measure power flow and Local Frequency at intervals of 50 ms or less at every site NMI - i.e. at the site connection point.

We remain open to commercial discussions with any party that is having difficulties designing or procuring cost effective MASS compliant metering solutions. To this end we again wish to advise that CET contacted the Clean Energy Council (3rd August) with details of their low cost meter, with an offer to supply any members interested in purchasing the same.

Rheem/CET are also aware that other Australian companies have similar cost-effective power metering technologies available that comply with the current requirement to measure power flow and Local Frequency at intervals of 50 ms or less at every site NMI.

...

**Experience and observations specific to deployed DER assets and associated metrology:**

As stated, we have thousands of mixed DER sites across the NEM and WEM. Whilst we are yet to enter the Fast FCAS market, we offer the following observations backed by our experience:

**DER deployed asset and metrology experience:**

- Our capabilities include the design and mass rollout of our MASS compliant (50 ms) metering at thousands of mixed DER sites. We again wish to note that in our previous response we stated "CET has a MASS compliant meter (6 Channels, 3 CT's supplied + option for an extra 3 CT's) available at a wholesale price of AU$385 (ex GST). We hope to reduce this cost in 2022 when the impact of global Integrated Circuit production shortages is overcome. As a result, we do not believe that there are impediments to maintaining the current specifications to measure power flow and Local Frequency at intervals of 50 ms or less at every site NMI - i.e. at the site connection point. "
- Our experience beyond simple BESS DER extends to multiple brands of inverter, BESS, EV smart chargers, smart hot water systems, HVAC, pool pumps, heat pumps and other DER.

**Observations based on our deployed DER assets:**

- Our experience and empirical data from MASS compliant metering (from all our DER sites) concludes that there are significant variations in DER response, not only across different DER asset classes (BESS, smart water heaters etc.), but also across individual assets of the same class deployed in the field.
- Our observations are that the response from inverter based DER assets varies significantly in the field such that only high-speed metrology (50 ms preferred) can accurately capture the response and faithfully determine the energy delivered in a response to a Fast FCAS contingency event.
- Our observations are that the response of inverter-based technology is affected by temperature, BESS charge state, firmware version and local voltage, and that 200 ms metering does not capture the resulting response which may include lag and oscillation of the energy supplied as compared with the results compiled from the laboratory testing of a single/small sample of a particular DER.

...

**Recommendations - Technical**

- That the type and diversity of DER data sets that can increase the accuracy of Fast FCAS response be expanded to include other (than BESS) types of DER and be tested in parallel with metrology compliant with the current MASS. Such testing to be independently overseen.
- That such testing can be undertaken in a laboratory but the results must be confirmed via a statistically valid set of DER in a diversity of field locations – again with parallel metrology (to MASS compliance) confirming or otherwise the resultant response and the data gathered. Such testing and data to be independently overseen and verified.
- That Metrology be separately certified for MASS participation and that injection testing responses take into account accuracy of metrology in determination of a graded scale of payments (discount) that is applied based on the determined error should there be any future allowed deviation from the 50 ms measurement accuracy requirement of the current MASS.
- Metrology location: - As we have stated in our previous responses, the location of metrology should be maintained at or near to the connection point. That is, device level metering for the purposes of Fast FCAS should be precluded for reasons we have given previously in support of mixed DER sites. Again, we support AEMO's position to retain NMI level metering i.e. to measure the grid connection point net active power response. This also aligns with our March submission that Net metering (connection point metering per NMI) must be a requirement of the MASS for DER participation in the delivery of Contingency FCAS to support mixed DER sites. This approach to NMI level metering also has broad industry support, e.g. the ESB Post 2025 review in respect to DER site level interoperability and the ARENA sponsored DEIP interoperability forum.

- For any data to be useful, it is critically important that the frequency monitoring meets the MASS and that the power measurements and frequency monitoring are aligned. ***Given the frequency requirements of the MASS are not changing it will be incumbent upon the system providers to prove that the frequency monitoring and power measurements are aligned.*** If power metering is carried out at the connection point, as recommended by AEMO, but frequency monitoring is carried out at the DER, then it is essential that ***both the power metering device and the DER device both meet the MASS for frequency monitoring***.

Shell Energy:

Shell Energy is broadly supportive of the Second Draft Determination. We welcome the effort AEMO has put in to refine the MASS following the release of the First Draft Determination. In particular, we support the changes made to the measurement requirements for DER, to allow for 200 ms metering for Fast FCAS markets participation.

In response to the First Draft Determination, we considered that the proposed 50 ms metering requirement would have imposed significant costs on Trial Participants, potentially reducing the volume of Fast FCAS available to the market.

Simply Energy:

**It is appropriate to allow a measurement time resolution of 200 ms**

Simply Energy is supportive of AEMO's proposal to lower the Fast FCAS measurement time resolution for Aggregated Ancillary Service Facilities with no inertial response to 200 ms. As we have previously advised, VPP products would likely be uneconomical under a requirement to provide high speed data samples of 50 ms to participate in Fast FCAS markets.

Simply Energy agrees with the findings of the updated UoM analysis. These findings align with our previous feedback that the overall error for VPPs, where aggregation can be used, would be significantly lower than was demonstrated in the UoM's initial statistical analysis. We are pleased that AEMO took on board stakeholder feedback to undertake this additional testing before making a final determination.

…

For the benefit of new participants, it may be useful to include further detail in section 5.3.2 of the MASS to provide further clarity on there being no discount applied when either 50 ms data is provided at each connection point or more than 200 ancillary service generating units or ancillary service loads are aggregated.

sonnen:

**Moving from theory to practice**

The studies by UoM have been scoped to yield insights necessary for establishing an appropriate delivery validation framework. However, scope limitations have resulted in findings that do not adequately address all factors effecting the implementation of a practical validation framework.

Furthermore, sonnen and other stakeholders have queried how to apply the draft MASS frequency measurement accuracy specifications in practice.

To ensure the proposed validation framework is robust sonnen recommend that:

1. the RoCoF method is subjected to a sensitivity analysis addressing the impact of dynamic errors in practical frequency estimation, as utilising the derivative of frequency (df/dt) can accentuate errors that arising from poor performance in frequency tracking by certain frequency estimation algorithms. The UoM report does not provide insights into the impact on estimation of FDT and delivery quantity estimation errors arising from:
    - Frequency measurement errors due to dynamic response and power system noise impacts
    - Timing jitter in update rates
2. the MASS frequency accuracy specification be amended to codify the maintenance of accuracy under predefined power system noise and RoCoF criteria.

SwitchDin:

> Our main concern, raised within our submission in Stage 2 of the consultation process, was the requirement for 50 ms measurement of power and frequency for the verification of FCAS delivery in the Fast FCAS market. We note that this requirement has now been revised to 200 ms for aggregators which will significantly decrease the cost of compliance, ensuring that aggregators are able to access the Fast FCAS market. We would welcome clarity on whether aggregators will be required to submit aggregated or NMI level data for verification of FCAS delivery.

Tesla:

> Tesla believes that the Second Draft Determination is evidence based and provides a reasonable compromise to address the concerns raised in respect of the 1-s data used for Fast FCAS compliance purposes over the course of the VPP Demonstrations, and the existing 50 ms requirement.
>
> The 200 ms measurement resolution proposal by AEMO recognises the unique characteristics of aggregated fleets of assets and VPPs and provides a reasonable middle ground to reduce costs for new market participants whilst maintaining the integrity of AEMO's operation.
>
> Tesla supports the approach put forward by AEMO in the Second Draft Determination:
>
> - We support the 200 ms resolution for aggregated facilities (more than 200 – with a 5% error if the number of aggregated sites is less than 200) and 50 ms for all other facilities
>
> …
>
> 200 ms measurement resolution for Fast FCAS markets
>
> As noted above, Tesla supports the 200 ms measurement resolution for aggregated assets with a 5% error applied where the number of sites is less than 200.
>
> Tesla believes that the work done by AEMO to date supports the implementation of the 200 ms requirement and we agree with the statement that this change is in the long-term interests of consumers and promotes the objectives of the NEO. The "Fast FCAS Sampling Verification in support of MASS consultation – Part 2"[18] independent work undertaken by UoM was robust in supporting this position. Using 20ms frequency measurement supplied by AEMO converted to 50 ms, 100 ms, 200 ms and 1 sec synthetic power measurements with 0.7% droop setting and randomized polling for a 5kW battery by Tesla provided a replicable and verifiable analysis, separate from the FCAS assessment of a specific device or technology and focus the objective statistical analysis required to demonstrate that the verification error of 100 ms and 200 ms sampling rates reduces as the fleet grows.
>
> As Tesla noted in our previous response to AEMO, we believe that a measurement resolution less granular than 50 ms reduces costs for consumers, increases market competition and encourages more consumers to move from passive to active DER.
>
> While we support 200 ms and note that most responses to the previous consultation indicated an ability to provide data at the 100 ms or 200 ms resolution, there were also some responses that were limited to 1 s resolution.
>
> We would encourage AEMO to continue the data-driven approach they have taken on the Draft Determination as a good approach for continuing the integration of new technology types into existing markets. We would support any future work done by AEMO to consider what would need to be demonstrated for 1 s resolution to be a viable alternative to further enhance competition. This may be a role for the DER Consultative Forum (more information included below).
>
> **Tesla position: we are supportive of AEMO's position on 200 ms resolution, notwithstanding our comments on the "inertial response" caveat and the points on data used for baselining, outlined below.**

### 4.1.2. AEMO's assessment

Table 2 summarises Consulted Person's preferences for each measurement time resolution option:

[18] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/third-stage/fast-fcas-sampling-verification-in-support-of-mass-consultation-phase-2.pdf?la=en

**Table 2 Consulted Persons' preferred Measurement Time Resolution**

| Preferred Measurement Time Resolution | Consulted Persons |
|---|---|
| **≤50 ms** | Reposit, Rheem & CET |
| **≤200 ms** | AGL, EDMI, EA, Hydro Tasmania, PIAC, Shell Energy, Simply Energy, SwitchDin, Tesla |
| **≤1 s** | Evergen, Members Energy |
| **No preference expressed** | Greenergenic, sonnen |

### Summary of University of Melbourne's (UoM) First Stage and Second Stage Reports

The UoM was engaged by AEMO to provide an independent analysis of data to facilitate AEMO's determination of the optimal measurement time resolution. The work was carried out in two stages and UoM provided two reports to AEMO. Key matters from the two UoM analyses are detailed in Table 3:

**Table 3 Summary of University of Melbourne's First Stage and Second Stage Reports**

| | First Stage Report[19] | Second Stage Report[20] |
|---|---|---|
| **Purpose** | To explore the impact of a sampling rate lower than 50 ms for Fast FCAS response performance verification and investigate different integration rules in assessing the energy contribution in the Fast FCAS markets. | To explore a wide range of factors affecting the verification error and establish a methodology to identify potential oscillatory responses. |
| **Data/ Studies** | Several studies performed examining 28 response profiles provided by AEMO, recorded in the FCAS registration tests or following contingency events. | • Six case studies carried out and relevant FCAS response profiles from both DER and synchronous generators analysed. Synthetic data from Tesla was used for the analysis on the error associated with slower sampling rates and actual measured values from synchronous generators was available for the analysis on oscillatory behaviour.<br>• UoM did not consider a 1-s sampling rate in its studies on the inertial response because the number of data points captured using a 1-s sampling rate was found to be clearly insufficient to properly calculate the inertial response as UoM explained in section 3.1 of its Second Stage Report. |
| **Findings** | • AEMO's FCAS validation and assessment methodology is based on solid engineering and mathematical principles, and adjustments could be made to refine it further in light of the challenges that diverse and disperse DER providers bring.<br>• The trapezoidal rule is far more accurate at approximating area under a curve than simpler integration methods such as Riemann | • Adjustments need to be made to the FCAS verification tool so that one unified tool can be built to capture the performance of both DER and synchronous generators accurately.<br>• Increasing the number of sites will substantially reduce the verification error. For example, if a VPP aggregates 200 sites, the error distribution range is less than ±1% when using 100 ms and 200 ms |

[19] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/second-stage/aemo-fcas-verification-uom.pdf?la=en

[20] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/third-stage/fast-fcas-sampling-verification-in-support-of-mass-consultation-phase-2.pdf?la=en

| | First Stage Report[19] | Second Stage Report[20] |
|---|---|---|
| | methods. This is consistent across sampling rates.<br>• A 1-s sampling rate could introduce significant verification error and overestimate FCAS contributions as compared with a 20 ms or 50 ms sampling rate.<br>• Increasing the sampling rate from 1 s to 200 ms might significantly reduce both average error and error distribution range with the range of average errors decreasing from 15% to <3%.<br>• When using a 1-s sampling rate, local sampling of the time when the frequency exits the NOFB could consistently over-estimate the energy delivered (average error of 15%) relative to a higher sampling rate (50 ms). To mitigate this, an alternative approach could be considered that deploys a "universal" rather than a local, "relative" assessment window. | sampling rates and the "RoCoF-based" method for a single credible contingency event.<br>• The novel "RoCoF-based" method has a similar performance as the "universal window" method and is superior to other "relative window" methods proposed by different stakeholders when determining Frequency Disturbance Time (FDT). The "first recorded point" method leads to the worst results among all the three methods compared. This is particularly obvious when using 1-s sampling rate.<br>• The proposed oscillatory response identification methodology should be refined with the support of stakeholders' feedback on the numerical values to be used for key parameters, e.g., the oscillation ratio threshold currently set at 50%.<br>• Lowering the sampling rate of synchronous generators' FCAS response might introduce significant errors, in the range of ±5% for 100 ms and between -20% and +10% at 200 ms due to the inaccurate estimation of the inertial component. Therefore, a 50 ms sampling rate should be maintained when recording the synchronous generator's response for FCAS verification purposes.<br>• Additional verification errors caused by lower sampling rates could be eliminated by removing the frequency smoothing process when calculating the compensation factor for variable controllers, however, the most suitable changes to calculate the compensation factor need further consideration, as the compensation factor's purpose is to prevent the FCAS Verification Tool from under-evaluating an FCAS Provider's performance.<br>• When the response profiles of a fleet distributed across many sites are sampled at a slower rate (100 ms, 200 ms), the verification error is reduced using NMI-level data instead of the aggregated response for the assessment of the FCAS delivery. The verification error is < 0.5% for a single credible contingency event when the number of sites is ≥200.<br>• Relaxing the power measurement error from 2% to 4% might introduce significant verification error. The magnitude of the error depends on the allocation of an FCAS Provider's active power output for Fast FCAS response and other market services. |

In response to concerns raised by some Consulted Persons responding to the Second Draft Determination, AEMO commissioned a further study from UoM, the results of which are summarised here.

### Summary of UoM's Third Stage Report for this Final Determination

NMI-level data from over 1,600 sites was provided to AEMO by Reposit for frequency events on 25 May and 25 August 2021, which formed the basis of an additional round of analysis[21] to determine the errors associated with slower sampling rates.

Figure 1 shows how the frequency was already close to the lower limit of the NOFB on 25 May 2021 several seconds before it went below the trigger setting assigned to Reposit's VPP.

**Figure 1 Frequency on 25 May 2021 and 25 August 2021**


Both Reposit and UoM determined that there would be large verification errors when data at slower sampling rates is used to calculate the amount of Fast FCAS delivered. Table 4 shows the minimum and maximum verification errors associated with measurement time resolutions of 100 ms and 200 ms for the 25 August 2021 event, depending on the number of sites/NMIs considered in the UoM analysis.

**Table 4 Verification error analysis by UoM for 25 August 2021 event**

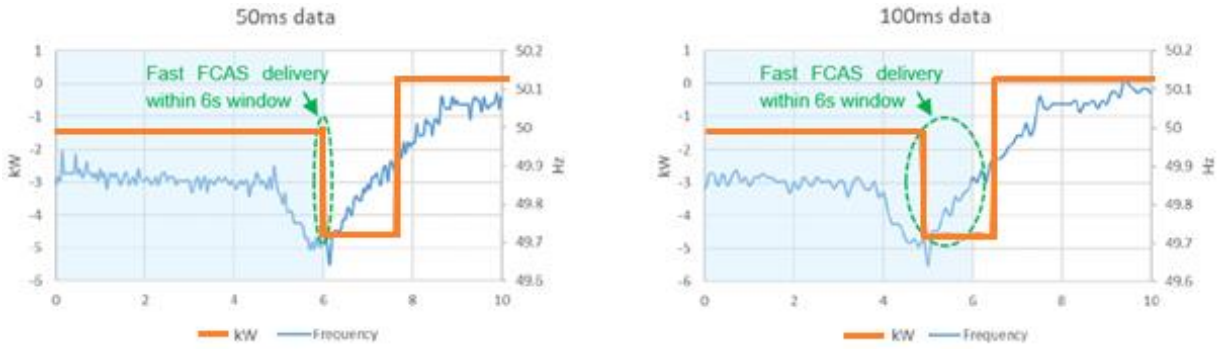
| UoM Analysis using Reposit data 25 August 2021 event | | | | |
|---|---|---|---|---|
| **Sampling (ms)** | 100 | | 200 | |
| **No. of sites/NMIs** | Minimum | Maximum | Minimum | Maximum |
| **10** | -11,092.18% | 1,270.16% | -75,255.41% | 1,643.13% |
| **25** | -5.53% | 39.01% | 0.60% | 48.63% |
| **50** | -0.55% | 19.71% | 3.67% | 30.26% |
| **100** | 1.60% | 14.33% | 6.44% | 26.51% |
| **200** | 2.26% | 12.62% | 8.05% | 22.04% |
| **500** | 3.37% | 9.27% | 10.47% | 19.43% |
| **1000** | 4.59% | 8.32% | 11.87% | 17.75% |

UoM determined that these large errors are introduced when the FDT was identified at different instances with data captured at 50 ms, 100 ms and 200 ms intervals across NMIs. As a result of the FDT being identified at a different time using data at slower sampling rates, the energy delivered is measured and

[21] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/third-stage/fast-fcas-sampling-verification-in-support-of-mass-consultation-phase-3.pdf

compared across a different assessment window. Figure 2 and Figure 3 include illustrative response profiles to show how the calculation of the energy delivered using a 50 ms measurement time resolution in comparison to a slower measurement time resolution can give very different results. As shown in each figure, the area measured can be significantly different when the start of the contingency event is determined as different times, for 50 ms and slower sampling rates, and the assessment window is consequently shifted.

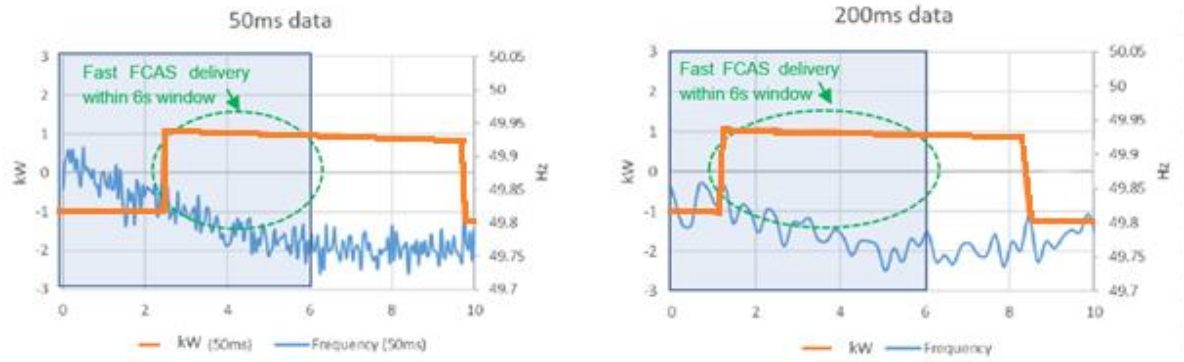
**Figure 2 Example of assessment windows based on 50 ms and 100 ms sampling rates from 25 May 2021 event**




In Figure 2, the area that indicates the assessed energy delivered (indicated by dotted green circle) as Fast FCAS within the delivery window (blue window) and the associated error with a 100 ms sampling rate has been calculated as follows:

- Using 50 ms data, the area is determined as close to 0 kWs (-0.0038 kWs) as a step change in active power is only observed at the very end of the first 6 s when the FDT is identified using 50 ms data.
- Using 100 ms data, the area is determined as -3.509 kWs as a change in active power occurs within the first 6 s when the FDT is identified using 100 ms data.
- The verification error in comparing response using 100 ms vs response using 50 ms is then determined as 922% (= (-3.509 - -0.0038)/ -0.0038).

**Figure 3 Example of assessment windows based on 50 ms and 200 ms sampling rates from 25 August 2021 event**




In Figure 3, the area that indicates the assessed energy delivered (indicated by dotted green circle) as Fast FCAS within the delivery window (blue window) and the associated error with a slower sampling rate has been calculated as follows:

- Using 50 ms data, the area is -5.26 kWs. The step change in active power is detected within the first 3 s after the FDT identified using 50 ms data.
- Using 200 ms data, the area is -7.13 kWs. The step change in active power is detected within the first 2 s after the FDT identified using 200 ms data.

- The verification error in comparing response using 200 ms vs response using 50 ms is then determined as 36% (= (-7.13 - -5.26)/ -5.26).

Fast Raise FCAS is required to arrest a drop in system frequency following a contingency event that takes system frequency below the lower limit of the NOFB within the first 6 s following the Frequency Disturbance and then provide an orderly transition to a Slow FCAS.

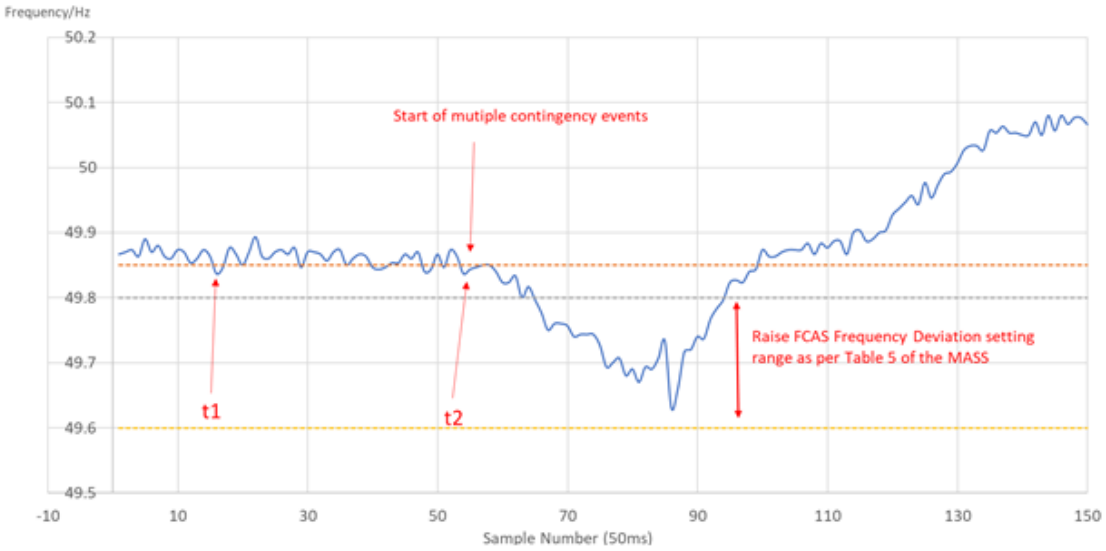
To avoid the significant verification errors described above resulting from instances of 'noise' prior to an event, or data at different sampling rates resulting in misaligned assessment windows, it is important to calculate the area indicating the energy delivered across the same assessment windows by determining the time of the contingency event across all NMIs. It is, therefore, necessary to apply a filter, referred to as the Contingency Time Identifier (**CTI**), to determine the appropriate Contingency Event being analysed. UoM's approach for the CTI consisted of using a rolling window of 50 ms data to find the first recorded point when the frequency consistently remains outside the NOFB for at least 250 ms. UoM applied the CTI to compare the errors for slower sampling rates across similar assessment windows.

The CTI methodology to identify the start point of the assessment window is demonstrated in Figure 4. The frequency trace for the 25 May 2021 event is considered in this example, as it clearly shows why the CTI is necessary to identify the relevant assessment window under some conditions, as the start of the six-second assessment window should not be before the start of the contingency event being analysed. This is shown in Appendix A of the MASS.

To identify the commencement of the contingency event for the purposes of FCAS assessment, it is necessary to apply the definition of 'Contingency Event Time' in the Glossary in section 1.2.1 of the MASS. In this example, paragraph (b) of the definition is relevant, as it applies when there is a series of step changes in frequency. The commencement of the contingency event will be at the start of the greatest rate of change of frequency, as measured by AEMO.

In this example, the frequency is already close to the lower limit of the NOFB before the start of the multiple contingency events. Without applying the CTI, the FCAS assessment would start at t1, which is not consistent with paragraph (b) of the definition of 'Contingency Event Time'. The FCAS assessment should start from t2 and the CTI is applied to identify the start point of the six-second assessment window to be closer to t2 than t1.

**Figure 4 Frequency observed during 25 May 2021 event**




In its submission, Reposit stated that it was more appropriate to consider the verification errors identified from the 25 August 2021 event because it is a more typical contingency event. AEMO agrees with this. Contingency FCAS is procured to deal with a credible contingency event, which is typically the loss of a

large generating unit or a major industrial load, as occurred on 25 August 2021, and the 25 May 2021 event is considered atypical. Furthermore, identifying the 'Contingency Event Time' and the relevant assessment window across all NMIs for the 25 May 2021 event was shown to be more difficult as the frequency was already close to the limit of the NOFB before the multiple contingency events.

Section 6.5 of the MASS states that if there is any inconsistency between the FCAS Verification Tool and the MASS, the MASS will prevail to the extent of that inconsistency. AEMO acknowledges that further discussions are required before the FCAS Verification Tool can be used in cases where there are several small/short frequency deviations to identify the 'Contingency Event Time' and the assessment windows more accurately.

The analysis of the 25 August 2021 event after applying the CTI is summarised in Table 5. The verification errors for the 25 May 2021 and 25 August 2021 events (unfiltered) can also be found in UoM's Third Stage Report.

**Table 5 Verification error analysis by UoM for 25 August 2021 event using 200 ms sampling rate and CTI**

| No of sites/ NMIs | Min | Max | Median | 2.5-97.5 Percentile | | 2-98 Percentile | | 1.5-98.5 Percentile | | 1-99 Percentile | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $P_{2.5\%}$ | $P_{97.5\%}$ | $P_{2\%}$ | $P_{98\%}$ | $P_{1.5\%}$ | $P_{98.5\%}$ | $P_{1\%}$ | $P_{99\%}$ |
| 10 | -124% | 114% | -0.89% | -4.69% | 2.80% | -4.96% | 3.06% | -5.36% | 3.41% | -5.88% | 3.97% |
| 25 | -7.26% | 7.46% | -0.89% | -3.17% | 1.37% | -3.27% | 1.52% | -3.45% | 1.69% | -3.73% | 1.93% |
| 50 | -4.70% | 3.00% | -0.89% | -2.47% | 0.67% | -2.56% | 0.75% | -2.66% | 0.88% | -2.79% | 1.01% |
| 100 | -3.36% | 1.43% | -0.88% | -1.98% | 0.21% | -2.04% | 0.27% | -2.10% | 0.34% | -2.19% | 0.44% |
| 200 | -2.77% | 0.87% | -0.89% | -1.67% | -0.11% | -1.70% | -0.08% | -1.74% | -0.03% | -1.81% | 0.04% |
| 500 | -2.01% | 0.17% | -0.88% | -1.37% | -0.39% | -1.39% | -0.36% | -1.42% | -0.34% | -1.46% | -0.30% |
| 1000 | -1.62% | -0.23% | -0.89% | -1.22% | -0.54% | -1.24% | -0.53% | -1.26% | -0.50% | -1.29% | -0.47% |
| 1500 | -1.46% | -0.33% | -0.88% | -1.16% | -0.60% | -1.18% | -0.59% | -1.20% | -0.57% | -1.22% | -0.55% |

In its second submission, Reposit stated that the RoCoF based methodology does not work for the 25 May 2021 event due to the frequency recovering within the NOFB within 2.6 s. As described under section 3.1.1 of UoM's Third Stage report, the large errors do not arise from the use of the RoCoF based methodology per se, but as a result of the different assessment windows across NMIs. The different windows are due to the misalignment of the FDT and Contingency Event Time without the CTI.

The results in Table 5 indicate that measurements taken at a sampling rate of 200ms, and when used in conjunction with at CTI, provide errors that are either consistent with the margin of error allowed by the MASS (2%), or can be brought in line with this margin of error with the application of a 5% discount to the aggregated quantity delivered. In particular, the following results are observed and considered pertinent:

- For 500 or more sites, the 1-99 percentile errors bounds are less than 2%, and the absolute minimum and maximum errors are less than or equal to 2% (rounded to 1 decimal place)
- For 25 or more sites, the 1-99 percentile errors bounds are less than 7%, and the minimum and maximum errors are between 7% and 7.5%(absolute).

- For less than 25 sites, the 1-99 percentile errors bounds may be less than 7%, however the minimum and maximum are materially larger than the combined sum of the 2% allowable margin of error and applicable discount of 5%.

**Is 1 second measurement time resolution still relevant?**

AEMO indicated in the Second Draft Determination that it would not consider a 1 s measurement time resolution further. Nevertheless, Evergen's submission, in particular, argued it is suitable for DER FCAS Providers.

The size of the verification error introduced by a 1 s measurement time resolution is reduced as the number of DER devices within an Aggregated Ancillary Service Facility increases as demonstrated by UoM's Third Stage Report. A critical problem with 1 s measurement time resolution remains, however, that AEMO cannot reliably detect a plausible range of oscillatory behaviour at that level. There is insufficient evidence in Evergen's submission to substantiate the ability of 1 s measurement time resolution to detect such oscillatory behaviour.

Evergen stated in its submission that any oscillatory behaviour from individual grid-connected DER will occur whether or not those DER are able to participate in the Fast FCAS markets. In AEMO's view, however:

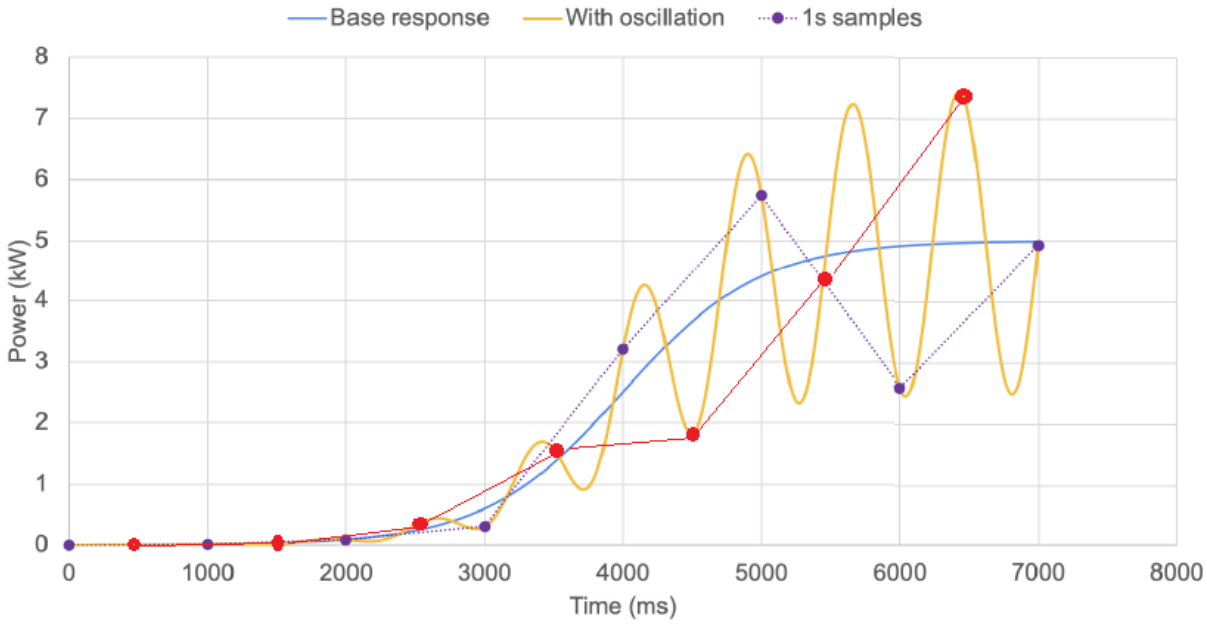
- The oscillations could be consistent with DER enabled in the Fast FCAS markets responding to a power system incident. AEMO has observed this from Ancillary Service Facilities in the past.
- Oscillatory behaviour from DER for reasons not connected with the provision of FCAS is beyond the scope of the MASS.
- Purchasing FCAS from problematic Ancillary Service Facilities means that FCAS is not purchased from other Ancillary Service Facilities, resulting in a portion of FCAS being inadequately delivered with potential adverse impacts on power system security.

Evergen's submission noted that UoM did not include analytical work in considering 1 s sampling. UoM's Second Stage Report did, in fact, include this work[22] and it was evident from the real-world examples considered by UoM that a 1 s sampling rate was not adequate to detect oscillatory behaviour when the period of the oscillatory response profile is 1 s.

Evergen considered a response profile with an oscillatory period of 0.769 s (1.3 Hz) to suggest that a 1 s measurement time resolution could detect an oscillation in many circumstances. The case study using a response profile with a period of 1.3 Hz assumes that the measurements are sampled at the right instance to capture the oscillatory behaviour. If the samples were offset by approximately 500 ms, the oscillatory behaviour would not be detected as shown in Figure 5. AEMO has superimposed the red line to demonstrate the different outcome if the samples were taken approximately 500 ms later. Hence, AEMO disagrees with Evergen's contention that 'there is the possibility that 1 s sampling could detect an oscillation in many circumstances' and that 1 s sampling is therefore low risk.

[22] See page 16 of the report. Available at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/third-stage/fast-fcas-sampling-verification-in-support-of-mass-consultation-phase-2.pdf?la=en

**Figure 5 Detection of oscillatory response with data captured at 1 s intervals**




Evergen's submission provides an example, comparing a 5 kW device and the 150 MW Hornsdale Power Reserve, to support an argument that the interrogation of measurement error for constituent devices for both is an inherently disproportionate approach. AEMO does not agree. Hornsdale Power Reserve is made up of hundreds of Powerpacks that form an Ancillary Service Facility with one connection point. It is different to a VPP that uses hundreds of DER devices over hundreds of different connection points, which may not even be connected to the same distribution network.

### Oscillatory behaviour

AEMO needs to be able to detect oscillatory behaviour from devices highly sensitive to frequency and voltage changes and, as noted by UoM, a 1 s measurement time resolution data cannot facilitate this. While the combined capacity of DER devices on the power system delivering Fast FCAS with a 1 s data resolution is immaterial at present, the number of DER devices that are participating in the Fast FCAS markets is likely to grow, and the need to detect oscillatory behaviour will become more important.

Moreover, while oscillatory behaviour from a DER fleet enabled to deliver FCAS might be smoothed out when considered in the aggregate, it can still cause harm to a local distribution network if it remains undetected. AEMO's functions include the improvement of the effectiveness of the operation and administration of the wholesale exchange and to maintain and improve power system security[23]. Neither of these objectives would be served if AEMO ignored the potential impact of oscillatory behaviour on any part of the networks comprising the interconnected power system.

Reposit and Greenergenic submitted that the 6 Hz oscillation shown on a graph in Reposit's first submission[24] should be considered by AEMO because it is from a particular type of DER approved for sale in Australia and, therefore, would fall within the scope of the MASS. AEMO notes that not all DER products available for sale in Australia automatically meet the relevant MASS requirements for Fast FCAS. DER products need to be assessed by AEMO before being allowed to participate in the FCAS markets. The example chosen by Reposit was a battery system that is excluded from Reposit's supported products list, and would not necessarily be assessed by AEMO as appropriate to participate in the Fast FCAS markets.

[23] See section 49 of the National Electricity Law.

[24] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/first-stage/submissions/reposit.pdf?la=en

A key objective of this consultation is to determine the acceptable measurement time resolution for FCAS Providers using DER to participate in the Fast FCAS markets. The ability to capture data at the specified measurement time resolution must be demonstrated when a person applies to AEMO to classify an Ancillary Service Facility, and must be maintained during operation after registration.

It should be noted that the requirements for the benchmarking/laboratory tests to assess the FCAS capability of a DER will not be modified as a result of this consultation. A measurement time resolution of ≤50 ms would still be required to verify the Fast FCAS response for every type of controllable device. AEMO will identify oscillations faster than 1 Hz from a DER product type during the FCAS assessment. The frequency injection test requirements are not specified in the MASS and AEMO is not proposing to alter the measurement time resolution for those tests.

In response to Evergen's submission that the Nyquist-Shannon sampling theorem is not entirely relevant, AEMO notes that the theorem demonstrates the minimum requirements to identify oscillatory behaviour. Moreover, the claim that oscillatory behaviour is insignificant at the DER device level does not obviate the conclusion that such behaviour could have a significant impact on a distribution network if they remain undetected. In contrast, Greenergenic stated that UoM correctly identified the relevance of the Nyquist-Shannon sampling theorem.

### Appropriateness of case study method

In its second submission, Reposit stated that 10,000 Monte Carlo simulations were conducted in it's analysis instead of 500 simulations because this is 200 times less likely to miss the worst-case error combinations, and hence underestimate worst-case verification errors. This was taken into account for the purposes of UoM's latest analysis, which was run 10,000 times instead of 500 times.

UoM's Third Stage Report considers a real-world example of the Fast FCAS response of Reposit's VPP following a power system incident. Since the studies completed using both the Tesla data and the Reposit data show that a measurement time resolution of 200 ms is adequate for Aggregated Ancillary Service Facilities with no inertial response, there is sufficient evidence to support AEMO's final determination.

### The need for further studies

In response to concerns over the type of data used in UoM's Second Stage Report, AEMO engaged UoM to conduct further analysis, similar to that carried out for the purposes of the Second Stage Report, incorporating metering data provided by Reposit.

Reposit requested that AEMO test a 6 Hz oscillatory response for slower sampling rates (100ms and slower), noting this would be unimportant if AEMO determines that Aggregated Ancillary Service Facilities must have a 50 ms sampling rate. As Reposit's case study did not involve a DER product approved for participation in the Fast FCAS markets or confirmed by Reposit to be participating in the Fast FCAS markets, there is also no apparent value in testing a random 6 Hz oscillation for slower sampling rates.

After considering the conclusions from UoM's Third Stage Report, AEMO acknowledges that:

- The current methodology to align the measurements from every NMI based on the first measurement of frequency outside the NOFB can create misalignments when aggregating the NMI-level data, particularly when frequency was already close to the limits of the NOFB prior to the contingency event being analysed. Project Match will enable AEMO to consider how NMI-level data can be aggregated to avoid material verification errors even for a high sampling rate, noting this misalignment occurs with data captured at 50 ms as well.
- The FCAS Verification Tool or user guide can be improved to assist FCAS Providers in identifying the Contingency Event Time, particularly when the frequency is already close to the limit of the NOFB before the relevant assessment window.
- A wider range of data for multiple contingency events and technology types would improve the confidence level of results of this type of analysis, particularly for aggregations with fewer sites.

AEMO agrees that further analysis might support future adjustment of the applicable discounts. Considering the limitations of work to date, AEMO has taken a prudent approach by considering both the 1-99 percentile errors bounds as well as the minimum and maximum errors from the analysis on the sampling rate using the Reposit data.

**Australian Standards**

Evergen submitted that Australian Standards are a more appropriate vehicle for managing oscillatory behaviour.

As noted on page 13 of the Second Draft Determination, the MASS and AS/NZS 4777.2:2020 serve different functions. Of specific relevance to this consultation, the measurement time requirements in AS/NZS 4777.2:2020 are 100 ms for frequency and 200 ms for active power.

**Bias in the MASS**

Several grid-scale battery systems and commercial loads participate in the FCAS markets, so AEMO does not agree with suggestions that the MASS is biased in favour of synchronous generation. It is true that the MASS was created at a time when the only type of generation visible to the transmission network was synchronous generation and that its requirements were orientated towards the type of controllers and metering that large, synchronous generation would use, however, the measurement requirements have not been a barrier to entry for grid-scale battery systems and commercial loads.

This consultation is an example of how standards can be updated to remove unnecessary barriers for technologies that involve the use of smaller, aggregated devices to deliver FCAS, without jeopardising the security of the power system.

AEMO is working on a tool through Project Match that will allow NMI-level data to be provided by FCAS Providers for FCAS assessments. Nevertheless, AEMO is committed to keeping the FCAS assessment methodology technology agnostic where possible and appropriate. All FCAS Providers participate in the same markets and the MWs from any FCAS Provider should be interchangeable with the MWs from another, regardless of which technology they are deploying.

Evergen claims in its submission that the existing and draft MASS are biased against VPPs. Certainly, the MASS is focussed on plant behind each connection point, in terms of both volume of measurements required, and accuracy of measurement. However, AEMO does not accept the proposition that as the impact of a single DER on the power system is negligible, the monitoring required should be commensurate with this negligible impact. The participation of aggregated DER in the FCAS markets will keep increasing, and this is the context in which the extent of monitoring needs to be considered. It is the orchestration of aggregated DER that is being used to provide FCAS. Individual DER of the size suggested by Evergen, 5 kW, cannot participate in the FCAS markets.

**Clarification of application of discount**

In response to Simply Energy's suggestion that AEMO include further detail in section 5.3.2 of the MASS to provide further clarity on the application of the discount, AEMO has redrafted and moved these provisions to set them better in context. They now appear in section 5.4 of the final amended MASS.

### 4.1.3. AEMO's conclusion

For the reasons specified in section 4.1.2:

- A 1 s measurement time resolution for Fast FCAS is inadequate.
- Following the additional analysis by UoM detailed in its Third Stage Report and further consideration by AEMO, a minimum of 25 sites needs to be aggregated before a measurement time resolution of 200 ms can be used to verify the delivery of Fast FCAS. The error associated with a measurement

time resolution of 200 ms is too large if the Aggregated Ancillary Service Facility comprises <25 sites, therefore, the measurement time resolution for those Aggregated Ancillary Service Facilities will remain at 50 ms.

- A discount of 5% to the quantity of Fast FCAS delivered will apply if the Aggregated Ancillary Service Facility comprises of ≥25 sites but <500 sites, reflecting the associated verification error.
- No discount to the quantity of Fast FCAS delivered will apply if the Aggregated Ancillary Service Facility has ≥500 sites. As discussed in UoM's Third Stage Report, the verification error for these types of Aggregated Ancillary Service Facility is within the margin of error of 2% for the measurements of power allowable under the MASS.
- A number of changes to the FCAS Verification Tool will be implemented to incorporate the trapezoid and RoCoF methodology to improve its accuracy.
- Table 4 in section 5.3.2 of the draft MASS has been updated to reflect the conclusions reached. The discount to be applied is now contained in a new section 5.4.

## 4.2. Location of Measurement Point for FCAS provided by DER

### 4.2.1. Issue summary and submissions

AEMO's Second Draft Determination was to maintain the metering point 'at or close' to the connection point for each Ancillary Service Facility within an Aggregated Ancillary Service Facility, to ensure the proper orchestration of DER and to verify the amount of FCAS delivered to the power system more accurately. This does not preclude the provision of asset level data by FCAS Providers in the event of a suspected FCAS non-compliance. On the other hand, the measurement of power flow from/to an asset is not a requirement of the MASS, and FCAS Providers could continue to capture that data at intervals of 1 s.

Extracts from submissions on this issue are cited below[25]:

AGL:

> AGL supports AEMO's position not to nominate a different metering point under clause 3.8.7A(c) of the NER, which means that FCAS bids will apply 'at or close' to the connection point to ensure the proper orchestration of DER and to verify the amount of FCAS delivered to the power system more accurately. As we observed in response to the Draft Determination, this approach is consistent with current market arrangements and mitigates the risk of inaccuracy and gaming between multiple parties that could otherwise impact overall system balancing.
>
> We note that Clause 5.3.2 of the Draft MASS provides some flexibility for AEMO to determine the location of required FCAS metering during the FCAS assessment process on a case-by-case basis. While we support this flexibility to accommodate the potential for measurement at individual assets in certain circumstances (for example the C&I customer segment), we would encourage AEMO to develop consistent criteria to be applied in its FCAS assessment process to ensure consistent application. We would recommend these criteria be published as part of the final MASS to provide transparency to the market.

EA:

> The proposal to retain the measurement location at, or close to, the connection point is also supported. That is, with all evidence indicating any change would only increase uncertainty in the quantity of service provision, thereby leading to market inefficiency and security risks.

EDMI:

[25] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

EDMI is supportive of the proposed amendments to the MASS for the increased market participation it will provide.

Evergen:

We understand the arguments for retaining FCAS measurement location at the connection point. While Evergen still holds the view that the risks raised by AEMO (which almost specifically relate to concerns about competing FCAS-responsive hot water systems and batteries behind the one meter) are not significant, and are readily handled by VPP operators themselves with end-user contractual arrangements, we are satisfied that measurement at the connection point will not block FCAS participation unnecessarily for DER-based VPPs.

AEMO communicated in the November 8th stakeholder forum that so long as power is measured at or close to the connection point, it would be acceptable to measure frequency at the device. This could occur provided a process was in place to ensure synchronization of samples. Having discussed this with our hardware partners, Evergen thinks this allowance reduces barriers to VPPs participating in Contingency FCAS markets under the proposed draft, and we will not further comment on this issue in this submission.

Reposit:

*Table 1 Summary of AEMO and Reposit draft determinations key positions*

| | **MASS draft determination** | **Reposit's position** | **MASS second draft determination** | **Reposit's position** |
|---|---|---|---|---|
| ... | | | | |
| Measurement at or close to the connection point | Measurement at or close to the connection point | Supported | No change | Supported |

Rheem & CET:

<u>... net metering (connection point metering per NMI) must be a requirement of the MASS for DER participation in the delivery of Contingency FCAS to support mixed DER sites</u>

We support AEMO's position to retain NMI level metering i.e. to measure the grid connection point net active power response. This aligns with our March submission that Net metering (connection point metering per NMI) must be a requirement of the MASS for DER participation in the delivery of Contingency FCAS to support mixed DER sites.

This approach to NMI level metering also has broad industry support, e.g. the ESB Post 2025 review in respect to DER site level interoperability and the ARENA sponsored DEIP interoperability forum.

As we are aware that the requirement for NMI level metering may create issues for some VPP Demonstrations fleet owners, Rheem/CET is happy to offer to help them to make their fleets compliant, at a relatively low cost and with reasonable commercial terms.

We also refer to the June 23rd AEMO consultation which included the following "question on notice":

> *"Noting that the measurement location concerns primarily seem to be around more than one device providing FCAS at the same location, is AEMO willing to consider further optionality where device or grid flow data is allowed (with grid flow data required for sites with more than 1 FCAS enabled device, and all other sites having the option)?"*

The underlying assumption behind this question is that all household DER is installed simultaneously. The reality is that consumers will often install a PV system first, and then add other DER over time. To mitigate the cost to the consumer of multiple meters and meter redundancy, it is important to mandate accessible NMI level metering with the installation of the first item of DER.

With the imminent introduction and broad adoption of Dynamic Operating Envelopes (DOE) across the NEM and WEM, it is even more critical to enable any households with DER with NMI level metering. This will be the most efficient way to secure the grid through the energy transition with as many households able to provide effective grid services such as DOE and FCAS, utilising all of the available DER within the household and avoiding both hardware (device level meters) redundancy

and individual DER within the home negating FCAS responses from other DER within the same home.

Shell Energy:

... we support AEMO's position, consistent with the First Draft Determination that measurement should be at or close to the connection point. We agree with AEMO that power measurement at the connection point (or as close to as technically achievable) is the least distortionary way to accurately measure the FCAS delivered to the power system. Recognising that the MASS allows for alternative measurement methodologies, and that AEMO may approve alternative methodologies, we consider it would be good regulatory practice to require AEMO to detail its reasons for allowing (or disallowing) alternative approaches. This is still absent from the Second Draft Determination and we note that AEMO has not addressed this issue. We encourage AEMO to factor this is as it prepares its final determination.

Simply Energy:

**We accept the proposal to leave the measurement location at, or close to, the connection point**

While Simply Energy considers that asset level metering should be sufficient to validate an appropriate response, we understand AEMO's reasoning behind not proposing a different metering point. As we have stated previously, our key concern is that requiring measurement at the connection point could preclude future innovations, such as allowing multiple parties to provide services BTM.

sonnen:

sonnen's remains strongly committed to our position that measurement of FCAS delivery by DER at the device level is the most efficient approach in the long-term interests of consumers.

AEMO's preference of measurement at the 'connection point' may improve the validation certainty of delivered quantities in limited circumstances, but this comes at the expense of failing to minimise the value of resources required to deliver a given level of output.

Tesla:

Measurement location

While Tesla supported measurement at the device level in our response to AEMO on the First Draft Determination, we are comfortable with the "connection level" approach proposed by AEMO in this Second Draft Determination and support this decision.

We appreciate the comments made by AEMO in section 4.2.3 of the MASS Draft Determination:

> *On the other hand, if a potential FCAS non-compliance is identified using the grid/net response, AEMO may request the measurements from the asset/s to confirm whether the change in active power was in line with each Ancillary Service Facility's droop setting, frequency deadband or frequency deviation trigger settings"*

We believe that this largely resolves the potential under-delivery concerns that were raised by Tesla in our previous submission regarding fringe situations where uncontrollable load or generation may interfere with AEMO's assessment of FCAS compliance.

**Tesla position: we are supportive of the recommendations made by AEMO to measure performance from data "at or close to" the connection point.**

### 4.2.2. AEMO's assessment

Most submissions were supportive of maintaining the measurement point 'at or close' to the connection point.

Table 6 gives a summary of which measurement point was preferred by each Consulted Person:

**Table 6 Consulted Persons' preferred Measurement Point**

| Preferred Measurement Point | Consulted Persons |
|---|---|
| **'At or close' to connection point** | AGL, EDMI, EA, Evergen, Reposit, Rheem & CET, Shell Energy, Simply Energy, Tesla |
| **Asset level** | sonnen |
| **No preference expressed** | Hydro Tasmania, PIAC, Members Energy, Greenergenic, SwitchDin |

There was a general consensus that the use of device-level measurements to confirm whether changes in active power complied with settings was reasonable, and would ensure that the amount of FCAS delivered to the power system would be verified more accurately.

While AEMO does not verify FCAS compliance in real-time (as sonnen correctly pointed out), AEMO must still ensure that the FCAS delivered by an Aggregated Ancillary Service Facility can be verified accurately. While this is typically performed after a power system incident, AEMO relies on FCAS assessments to identify FCAS non-compliances.

AEMO notes AGL's suggestion that AEMO publish the criteria it will use to determine how AEMO will exercise its discretion under section 5.3.2 of the MASS during the FCAS assessment process. In AEMO's experience, the assessment tends to be site-specific; the configuration and operation of the proposed Ancillary Service Facility will determine the optimal location of the measurement point. AEMO will consider how some guidance can be included in the Application Guide for Registration as a Generator in the NEM[26].

### 4.2.3. AEMO's conclusion

As there was no new information submitted to AEMO to reconsider its conclusion in the Second Draft Determination and most Consulted Persons were supportive of measurement 'at or close' to the connection point, AEMO's final determination is to maintain the measurement location 'at or close' to the connection point.

## 4.3. Transitional Arrangements

### 4.3.1. Issue summary and submissions

Based on the analysis from UoM and the proposed changes to the FCAS Verification Tool and methodology, AEMO's Second Draft Determination was to amend the discount rates for Trial Participants to 5% where the measurement time resolution used by them was >200 ms and ≤1 s.

Extracts from submissions on this issue are cited below[27]:

AGL:

> We support AEMO's determination to amend the discount rates for Trial Participants to 5% where measurement time resolution is lower than 200 ms but higher than or equal to 1 s.
>
> We also support the transitional period set out in the First Draft Determination until 30 June 2023 for Trial Participants to either comply with the measurement arrangements in the MASS for trial facilities or exit the FCAS markets.

Evergen:

[26] Available at https://aemo.com.au/-/media/files/electricity/nem/participant_information/registration/generator/nem-generator-registration-guide.pdf?la=en.

[27] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

### 7. Adapting swiftly to market realities

Table 3 shows how much change has occurred with respect to grid-connected DER in Australia over the last 10 years, and the 10 years before that. Australia now has PV installations on approximately 1 in 4 homes[28]. We have the highest penetration of installed PV per capita in the world[29].

Table 3. Showing explosive growth of Australian DER (both distributed PV and BTM BESS) over a short time frame.

| Year | Distributed PV capacity | Number of PV systems | BtM BESS capacity | Number of BtM BESS |
|---|---|---|---|---|
| 2001 | 2.8MW[30] | ~1000 or less | negligible | negligible |
| 2011 | 1236.8MW[31] | 500k[32] | negligible | negligible |
| 2021 | ~15,000MW | 3 million[33] | ~600MW | 110-150k |

Australia has enough residential rooftop PV to contribute a significant chunk of daily generation across the NEM. On the back of this rooftop PV generation, renewables have recently instantaneously accounted for over 60% of total generation power in the NEM, and 100% for just SA.

Australia is seeing ongoing huge growth, with annual installations of 2,000-3,000MW per year. We install more per year now than our cumulative total BTM rooftop capacity 10 years ago.

From a base of essentially nothing 10 years ago, Australia now has approximately 150,000 BTM BESS (extrapolating from 110,000 at end of 2020, as reported by Sunwiz), with more than 30,000 added each year at present[34]. Assuming 4kW per BESS, that means Australia has approximately 600MW of BTM battery storage, and is adding more than 120MW per year. As a limiting case, if all new batteries were FCAS capable and this growth is maintained or is exponential, then residential storage could deliver much of the FCAS market within a few short years.

This ongoing MASS determination has the potential to allow or prevent this, and so it needs to be considered carefully.

We have heard it suggested in stakeholder forums that market participants need long time horizons (e.g. 10 years) and static regulatory/administrative conditions across these time frames to be able to develop new market offerings.

This is no longer realistic. It is naive for a market participant to expect this level of certainty given the rapid change we have seen in the last 10 years. The grid will fall over unless the industry as a whole, from market participants, to network operators to AEMO and regulators, can move quickly to adapt to the level of change we are seeing.

SA provides a recent stark example of our current reality: PV installers and inverter manufacturers had to adjust within months to SA regulatory change regarding inverter connection standards and behaviour in response to extreme grid issues (e.g. voltage ride through). It's tough for industry, and it costs money, but that's where we are. It is not in accordance with the NEO to move slowly on updating requirements to accommodate short-sighted business models, if in doing so valuable new participants are excluded from the FCAS market, potentially increasing the NEM-wide costs of maintaining system security.

### 12. Recommendations

Evergen recommends:

…

- AEMO should move swiftly and implement such change decisively, to provide industry with certainty and keep pace with rapid change across the NEM.

[28] https://www.energymagazine.com.au/australian-solar-industry-reaches-historic-milestone/
[29] https://iea-pvps.org/wp-content/uploads/2020/11/IEA_PVPS_Trends_Report_2020-1.pdf
[30] https://iea-pvps.org/wp-content/uploads/2020/01/nsr_2003_AUS.pdf (table 1, page 7)
[31] https://iea-pvps.org/wp-content/uploads/2020/01/tr_2011.pdf
[32] Assuming a typical system size of 2.5kW. https://pv-map.apvi.org.au/analyses
[33] https://reneweconomy.com.au/transformational-australia-passes-3-million-mark-for-rooftop-solar-systems/
[34] https://reneweconomy.com.au/australians-installed-31000-batteries-in-2020-led-by-households/

Hydro Tasmania:

**11.3.2c Proposed application of 5% Discount Rates for VPP operators providing Fast FCAS with less than 200 assets metered at 200 ms resolution.**

- Hydro Tasmania acknowledges the review carried out by the UoM which considers (among other things) the appropriateness of applying a FCAS discount rate. Hydro Tasmania considers that this study has provided a sound reference to understand the impact of data resolution to the FCAS evaluation.
- Section 3.4 of the UoM report ("Site aggregation") states that 'increasing the number of the sites will substantially improve (reduce) the verification error'. Hydro Tasmania is unable to find an explanation from the report as to how increasing the number of assets will create a fundamental improvement to the FCAS evaluation. As such, we remain unclear how this conclusion has been reached in the analysis presented. We would encourage further clarification on this finding.
- Hydro Tasmania would like to note that, while the statistical error (probability) may decrease with a larger sample size, this may not accurately reflect physical outcomes. For instance, a VPP with a greater number of units will likely experience greater transmission losses. Therefore, we encourage further work to better understand the overall errors associated with the delivery of FCAS from VPP.
- Given the 200 ms measurement requirement is a step change to the VPPs, Hydro Tasmania would suggest that the MASS should focus on the 200 ms implementation at this stage. Delaying the inclusion of the 5% discount proposal for both participants under and over 200 sites will allow for a more conclusive decision to be reached once further information is available.

Members Energy:

Our concern is that the overall package is likely too expensive to warrant participation, given the current levels of FCAS revenue (outside of SA). We believe the overall package needs to be softened and extended; perhaps with the transition period ending a year later, participants allowed to expand their fleets beyond their current registration and new VPP entrants being allowed to meet the transition arrangements rather than the ongoing MASS requirements. This would allow:

- the increased cost of the more stringent technical requirements to be reduced slightly by ongoing technological development and increased manufacturing volumes
- time for VPPs to add demand response to their offerings to customers thus preserving profitability in the current volatile environment for FCAS revenues
- time for AEMO and state based regulators to offer residential demand response revenue opportunities to aggregators/VPPs to supplement FCAS revenues
- all while maintaining the existing connection between AEMO and VPPs, thus avoiding the upheaval and network risk associated with VPPs severing that connection with AEMO and then needing to re-establish it again in the future.

Reposit:

*Table 1 Summary of AEMO and Reposit draft determinations key positions*

| | **MASS draft determination** | **Reposit's position** | **MASS second draft determination** | **Reposit's position** |
|---|---|---|---|---|
| ... | | | | |
| Transitional arrangements | VPP trial participants will need to comply with MASS measurement requirements by 30 June 2023 | Supported | Same as draft determination, noting that AEMO has proposed changes to minimum measurement requirements | Unsupported |

...

| | | | | |
|---|---|---|---|---|
| Discount arrangements | For VPP participants covered by the MASS transitional arrangements, a discount to be applied to the Fast FCAS quantities provided<br>• 20% if data captured was between 200 ms and 1 s intervals<br>• Less than 50 ms but higher than or equal to 200 ms, a discount of 20% applies | Unsupported | a 5% discount applied to reflect the verification error when less than 200 sites. | Unsupported |

Shell Energy:

> We also suggested that the proposed transitional arrangements should apply permanently, to allow supply with metering in the 50-200 ms range to continue to participate with a 5% discount applied to the quantity of FCAS delivered. We are pleased to see that AEMO had adopted this concept in the Second Draft Determination. This change from the First Draft Determination should allow for increased participation of Trial Participants in Fast FCAS markets.
>
> We consider that the proposed requirements to allow a measurement time resolution of 200 ms for Aggregated Ancillary Service Facilities with a 5% discount applied when the number of sites within an aggregate is less than 200, is a reasonable approach that efficiently balances the need for appropriate metering resolution, costs on participants and the risk of measurement error. Further, we support the use of a transitional period to 30 June 2023 to allow for Trial Participants to comply with the new measurement requirements.

Simply Energy:

> Simply Energy agrees with AEMO's proposal to apply a 5% discount to the quantity of Fast FCAS measured when there are less than 200 aggregated sites and the measurement time is more than 50 ms. This proposal is aligned with the UoM's analysis and is a more reasonable approach than disallowing aggregations of fewer than 200 sites from participating in Fast FCAS markets.
>
> ...
>
> **The proposed VPP Demonstrations Transitional Arrangements will provide certainty**
>
> In the context of the other proposals in the draft determination, Simply Energy is comfortable with AEMO's proposal to apply a discount of 5% to the quantity of Fast FCAS measured at all connection points in a Trial Participant's fleet until 30 June 2023. As the final MASS has been delayed, Simply Energy proposes that AEMO consider whether the transitional arrangements should instead conclude two years after the final MASS becomes effective.
>
> Trial Participants have invested significantly in their trials, such as in application programming interfaces, sales channel costs, up-front and ongoing customer benefits, and device charges. Simply Energy provided AEMO with detailed information on the average revenues and costs of our VPP offer in our submission to the First Draft Determination. To comply with the revised MASS, Trial Participants will need to incur additional expenses to retrofit sites within the current fleet. For that reason, it is critical that Trial Participants can continue to earn revenue from participation in Fast FCAS markets while transitioning their fleets to the requirements of the revised MASS. We consider that 30 June 2023 provides Trial Participants with sufficient time to ensure their fleets are compliant.
>
> AEMO's proposal to apply a 5% discount is more methodologically sound than its previously proposed 20% discount. While we still consider a discount is unnecessary (as the current fleet does not impact the overall provision of FCAS in the market and the security of the system), we are

comfortable that the 5 per cent discount is consistent with other aspects of the draft determination and is based on the UoM's analysis.

Simply Energy still believes there is a strong case to grandfather the existing VPP fleet under the VPP Demonstrations FCAS Specification. If AEMO were to significantly move away from the proposals in the Second Draft Determination, we would be keen to revisit that discussion with AEMO before the final MASS comes into effect.

sonnen:

AEMO has not made a substantive justification for continued support of the VPP Demonstrations framework. The current and future value transferred away from other Market Participants has been glossed over, and over time the consequential lessening of competition has not been quantitatively addressed. The VPP Demonstrations has failed to substantially inform the development of the MASS, as such it serves no continued purpose.

> **sonnen strongly reject any proposal to implement a VPP Demonstrations Transitional Arrangement.**

**The renewable energy transition is occurring too quickly and the regulatory update cycle too slow for good policy to be developed by iteration.**

The MASS update consultation has been vastly more successful than the VPP Demonstrations in engaging with current and future DER FCAS providers. sonnen acknowledge the detail and breadth of input from stakeholders and the significant effort of AEMO staff and consultants in engaging with submissions.

Despite the significant effort of all those involved, many conclusions informing the draft determine are based on substantially incomplete and/or qualitative assessments.

> **sonnen is strongly of the view that further analysis is required to deliver a robust determination that will drive efficient investment in the provision of FCAS from DER. The determination of the DER elements of the MASS update should be delayed until the gaps in quantitative analysis can be addressed. The renewable energy transition is occurring too quickly, and regulatory update cycle too slow, for good policy to be developed by iteration.**

sonnen are not satisfied that AEMO has achieved justifiable and workable conclusions with respect to:

- Optimising the available DER from residential consumers
- Establishing a level playing field to encourage new entrants and support innovation

These failures risk increasing FCAS costs to consumers and reducing the benefits that resource diversity brings to improving power system resilience.

SwitchDin:

In addition we note that the discount applied to existing Trial Participants is reduced from 20% to 5% …

We strongly support these changes and thank AEMO for commissioning the additional modelling required to support these decisions following the stage 2 consultation process.

Tesla:

- We support the 200 ms resolution for aggregated facilities (more than 200 – with a 5% error if the number of aggregated sites is less than 200) and 50 ms for all other facilities

…

**Transitional period**

Tesla appreciates AEMO releasing the VPP Demonstrations Guide to Transition (Draft) document (**Transition Guide**). This is a helpful document for industry in transitioning from the VPP Demonstrations trial. There are still areas of the transitional arrangements that we believe would be supported by further clarification from AEMO, these include:

- Transitional arrangement boundaries - AEMO should clarify the boundaries and any limitations (other than time) to the "transitional period". For instance, can AEMO confirm that if a market participant "separates load" as per the Transition Guide, then this separated load will no longer be considered as transitional. We understand that the separated load would need to be fully compliant with the MASS, however the definition of "transitional" also has relevance to the ESCOSA VPP licencing requirements in SA.
- New DUID – if all NMIs are moved across from the existing VPP Demonstrations DUID to a new DUID, does AEMO require a separate "plant" list, or can this be done through a back-end AEMO transfer of systems.
- Droop curve – AEMO has indicated that the droop curve applied to VPPs may be subject to review. How will this change be managed? Will it be subject to consultation and how will any change to droop curve affect existing participants?
- Ongoing compliance data requirements – will AEMO continue to require data to be provided on an aggregated basis for compliance purposes or is a move to NMI level data (to address oscillation risks) anticipated. How is AEMO thinking about collecting compliance data? Is there the possibility of reinstating the API?
- Measurement location – for VPP operators who continue to use the transitional arrangements, does compliance data need to be provided "at or close to the connection point" (as per the Second Draft Determination) or should it be provided from device level data (as per the VPP Demonstrations).
- NMIs – is there a limit on the number of NMIs that can be registered under the transitional arrangement. AEMO notes that it is possible to replace NMIs to address customer churn. Tesla asks AEMO to clarify whether there is a cap on the total number of NMIs that can be added to a transitional DUID, provided that the total MW capacity does not change (e.g., can a market participant theoretically add an extra 1000 NMIs to a 2MW registration provided the total MW does not change).
- Definition of "plant" – AEMO uses the term "plant" throughout the Transition Guide. Can AEMO clarify that in this respect "plant" refers to the devices that will be providing the FCAS response?

**Tesla position: Tesla believes that the Transition Guide should be updated to provide further information to industry which addresses the points above.**

### 4.3.2. AEMO's assessment

#### Grandfathering

The only submission still seeking the grandfathering of the VPP Demonstrations was from Simply Energy, which stated that 'there is a strong case' for it. As the submission did not provide evidence to substantiate Simply Energy's view, AEMO has concluded that there is no basis to depart from the position explained in the two draft determinations.

#### Discount

A majority of submissions were supportive of AEMO's draft determination to apply a 5% discount to the measured quantities of Fast FCAS from Aggregate Ancillary Service Facilities. Rheem & CET suggested a graded approach. The discount is intended to ensure that all Fast FCAS Providers deliver what they are paid to deliver. The only real issue is whether 5% represents a realistic estimate of the quantity of Fast FCAS under-delivered if the measurement time resolution is >50ms and ≤1s. Table 7 shows the errors associated with a measurement time resolution of 1 s using the Reposit data for the 25 August 2021 event. As described in section 4.1.2, the CTI is required to determine the start of the contingency event and the relevant FCAS assessment window.

**Table 7 Verification error analysis by UoM for 25 August 2021 event using 1 s sampling rate and CTI**

| No of sites/ NMIs | Min | Max | Median | 2.5-97.5 Percentile | | 2-98 Percentile | | 1.5-98.5 Percentile | | 1-99 Percentile | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | $P_{2.5\%}$ | $P_{97.5\%}$ | $P_{2\%}$ | $P_{98\%}$ | $P_{1.5\%}$ | $P_{98.5\%}$ | $P_{1\%}$ | $P_{99\%}$ |
| 10 | -258% | 324% | -1.91% | -15.35% | 13.99% | -16.21% | 14.83% | -17.34% | 16.46% | -18.80% | 18.27% |
| 25 | -20.57% | 28.46% | -1.91% | -10.03% | 6.92% | -10.45% | 7.48% | -11.02% | 8.02% | -11.74% | 8.87% |
| 50 | -14.80% | 10.36% | -1.88% | -7.61% | 4.14% | -7.91% | 4.46% | -8.22% | 4.80% | -8.71% | 5.44% |
| 100 | -9.93% | 7.59% | -1.89% | -5.96% | 2.35% | -6.18% | 2.56% | -6.41% | 2.87% | -6.72% | 3.20% |
| 200 | -7.49% | 4.14% | -1.88% | -4.75% | 1.05% | -4.90% | 1.20% | -5.08% | 1.35% | -5.33% | 1.56% |
| 500 | -6.50% | 1.92% | -1.88% | -3.75% | -0.06% | -3.84% | 0.03% | -3.96% | 0.14% | -4.12% | 0.28% |
| 1000 | -4.72% | 0.99% | -1.88% | -3.19% | -0.58% | -3.25% | -0.52% | -3.33% | -0.46% | -3.41% | -0.35% |
| 1500 | -4.07% | 0.08% | -1.88% | -2.93% | -0.83% | -2.99% | -0.78% | -3.05% | -0.71% | -3.14% | -0.62% |

Hydro Tasmania queried the basis on which UoM concluded that an increase in the number of DER assets improves accuracy as it might not reflect reality, and cited transmission losses as a reason. AEMO confirms that measurement of FCAS delivery occurs 'at or close' to the connection point and it is appropriate to apply the discount at the same point; transmission losses are not explicitly considered when determining the FCAS quantities. The latest UoM analysis does not support the contention that the conclusion based on statistical error might not reflect physical outcomes. As noted under section 3.1.1 of UoM's Third Stage Report, when considering a larger number of sites and aggregating the FCAS delivery, the potential over-estimation and under-estimation of the error from individual NMI responses tend to cancel each other, leading to a narrower distribution.

Reposit submitted[35] that the application of a discount 'creates a clear and unnecessary distinction between the technical requirements' for different categories of FCAS Provider based on the size of assets at the connection point. AEMO agrees that the distinction is clear, but not that it is unnecessary. The discount accounts for the size of the Fast FCAS that would not otherwise be measured adequately using a measurement time resolution between 50 ms and 1 s.

The discount rate for aggregated ancillary service facilities participating in the Fast FCAS markets outside the transitional arrangements is discussed separately in Section 4.1.2.

### Length of Transition Period

There was some positive commentary on the appropriateness of 30 June 2023 as the end of the period within which Trial Participants need to either meet the MASS or exit the Fast FCAS market, but most submissions were silent on the issue.

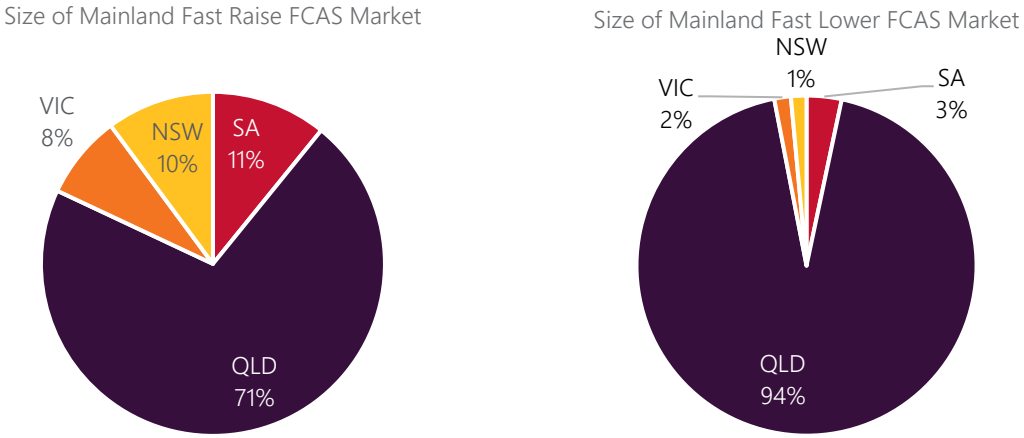
The only submission seeking an extension was from Members Energy, which is discussed in the next sub-section.

[35] See the extract in section 4.1.1.

sonnen submitted that there should be no transitional arrangements and that further analysis is required before good policy outcomes can be achieved. sonnen was concerned about the wealth transfer that will continue until the transitional period ends. This raises the question of whether Trial Participants have a material impact on Fast FCAS revenues. Between 1 December 2020 and 1 December 2021, Trial Participants received only 0.85% of payments for Fast FCAS provided in the mainland regions. The only region in which >1% of revenue was earned by Trial Participants is SA, and even there, it is around 10%. Figure 6 demonstrates the relative size (by revenue) of the Fast FCAS markets by mainland region, which shows quite clearly that the biggest market, by far, is in Queensland, in which there are no Trial Participants.

Hence, if the capacity of Trial Participant Fast FCAS is capped, the size of any wealth transfer is, in the overall scheme of things, immaterial.

**Figure 6 Size of Fast FCAS Markets by Mainland Region (by Revenue)**




### Other aspects of Transitional Arrangements

In addition to seeking an extension to the transition period, Members Energy sought an expansion of the VPP Demonstrations by permitting Trial Participants to expand their fleets and allowing new DER Providers to join. The reasons for Members Energy's submission on these issues were focussed on the profitability of DER Providers. AEMO explained in the Second Draft Determination that the profitability of a group of industry participants is not a determinative factor in considering whether a proposal is consistent with the NEO.

### Speed of Regulatory Change

Both Evergen and sonnen commented on the length of this consultation, albeit from different perspectives.

While AEMO acknowledges that the rapid pace of technological change necessitates a rapid regulatory response, the realities of the NEM are these:

- Where the NER do not authorise the implementation of new technologies or changes to current operations necessitated by new technologies, someone will need to submit a request to the AEMC to amend the NER.
- New rules made by the AEMC will often, and appropriately, require AEMO to establish and maintain procedures, guidelines and the like, to address the finer technical or operational detail to implement the new rule or changes to the NER.

While the National Electricity Law prescribes the procedures and timeframes[36] for making a rule, the reality of rule change consultations is that these times vary considerably depending on many variables including their relative prioritisation by the AEMC, complexity, urgency, controversiality and diversity of stakeholder views. The time taken to complete the last 10 substantive rule change requests is tabulated below.

**Table 8 Last 10 AEMC Rule Change Consultations**

| Rule Change | Submitted | Initiated | Final Determination | Commencement Date[37] |
|---|---|---|---|---|
| **NEM settlement under low, zero and negative demand conditions[38]** | 8 Feb 21 | 22 Apr 21 | 17 Jun 21 | 1 Sep 21 |
| **Settlement under low operational demand[39]** | 15 Feb 21 | 22 Apr 21 | 7 Oct 21 | 10 Oct 21 |
| **Implementing a general power system risk review[40]** | 26 May 20 | 14 Jan 21 | 3 Jun 21 | 10 Jan 22 |
| **Prioritising arrangements for system security during market suspension** | 26 May 20 | 17 Dec 20 | 17 Jun 21 | Rule not made |
| **Participant derogation – financeability of ISP Projects (ElectraNet & TransGrid)** | 23 Oct 20 | 5 Nov 20 | 8 Apr 21 | Rule not made |
| **Semi-scheduled generator dispatch obligations[41]** | 24 Sep 20 | 15 Oct 20 | 11 Mar 21 | 11 Mar 21 |
| **Generator registrations and connections** | 15 Dec 18 | 8 Oct 20 | 21 Oct 21 | 24 Oct 21 |
| **Prudent discounts in an adoptive jurisdiction[42]** | 10 Aug 20 | 8 Oct 20 | 17 Dec 20 | 17 Dec 20 |
| **Transparency of unserved energy calculation[43]** | 1 Aug 19 | 24 Sep 20 | 19 Nov 20 | 17 Dec 20 |
| **Reallocation of national transmission planner costs[44]** | 20 Aug 20 | 3 Sep 20 | 29 Oct 20 | 29 Oct 20 |

The following observations can be made:

- The date a rule change request is submitted is not the date the consultation process commences; the shortest time between submission and initiation in the sample is around two weeks, while the longest is 22 months.

[36] See Division 3 of Part 7. Note that there is flexibility to extend those timeframes.
[37] Where there is staged commencement of different parts of a rule, the date in this column is the first of those commencement dates.
[38] Consulted on as an urgent rule under the National Electricity Law.
[39] Consulted on as an urgent rule under the National Electricity Law.
[40] Consulted on using the 'fast track' process under the National Electricity Law.
[41] Consulted on using the 'fast track' process under the National Electricity Law.
[42] Consulted on using the expedited process under the National Electricity Law on the basis that it was non-controversial.
[43] Consulted on using the expedited process under the National Electricity Law on the basis that it was non-controversial.
[44] Consulted on using the expedited process under the National Electricity Law on the basis that it was non-controversial.

- Seven of these requests were treated under some type of expedited process, which is available under the National Electricity Law.
- The length of consultation is the period between initiation and a final determination, and it varies between 35 days and 12 months.
- Two of these rule change requests resulted in no rule being made.

It is also necessary to factor in the time taken by a proponent to prepare a rule change proposal, which in AEMO's experience can take many months, especially if the subject matter is complex.

Then, if the rule requires AEMO to publish or amend procedures etc., minimum consultation procedures typically apply under clause 8.9 of the NER, also with prescribed timeframes. The time taken by AEMO to complete consultations on the last 10 substantive new or amended NEM procedures etc is tabulated below.

**Table 9 Last 10 Consultations on AEMO Procedures etc.**

| Procedure etc | Initiated | Final Determination |
|---|---|---|
| **Congestion Information Resource Guidelines** | 10 May 21 | 20 Oct 21 |
| **Electricity Demand Forecasting Methodology** | 18 Dec 20 | 21 Sep 21 |
| **NEM Customer Switching** | 17 Oct 19 | 9 Sep 21 |
| **B2B Procedures v3.7** | 31 May 21 | 20 Sep 21 |
| **ISP Methodology** | 1 Feb 21 | 30 Jul 21 |
| **Inter-Network Test Guidelines** | 17 May 21 | 23 Sep 21 |
| **Baselines Eligibility Compliance and Metrics Policy** | 18 Dec 20 | 20 May 21 |
| **Supply scarcity procedures** | 21 Jan 21 | 3 May 21 |
| **Electricity Market Participant Fee Structure Review** | 18 Aug 20 | 26 Mar 21 |
| **Wholesale Demand Response Guidelines** | 22 Oct 20 | 25 Mar 21 |

The shortest consultation timeframe seen in this sample is around 3.5 months[45], while the longest was almost 11 months, which was a consultation that necessitated a third round of consultation, much like the MASS consultation.

All this indicates that regulatory change in the NEM is never swift. To suggest that AEMO can make substantive changes swiftly ignores the realities of the regulatory framework and the diversity of stakeholder interests that must be considered for due consultation to occur. Despite AEMO's best intentions, when complex issues come to the fore, even procedural change takes time and sometimes requires the additional step of seeking a change to the NER.

### Transition Guide

AEMO notes Tesla's comments on the Transition Guide, which is not part of this consultation. The comments will be addressed by the appropriate AEMO team.

[45] For the supply scarcity procedures. AEMO received no submissions in either round of consultation.

### 4.3.3. AEMO's conclusion

For the reasons specified in Section 4.3.2:

- The transitional arrangements will become effective on the same date as the updated MASS. These arrangements will conclude on 30 June 2023.
- Based on UoM's Third Stage Report, the margin of error of 2% for the measurements of power allowable under the MASS, and the combined capacity of 31 MW from Trial Participants, the discount rate for Trial Participants has been maintained at 5% where the measurement time resolution is ≥200 ms.

## 4.4. Application of the NEO to the provision of FCAS by DER

### 4.4.1. Issue summary and submissions

AEMO concluded in the Second Draft Determination that its substantive draft determinations had been subjected to a robust assessment that aligned with the long-term interests of consumers consistent with the NEO. Extracts from submissions on this issue are cited below[46]:

AGL:

> As we observed in our response to the First Draft Determination[47], to determine appropriate technical specifications for business-as-usual operations, AEMO needs to effectively balance the system security needs with the strategic intent to facilitate DER participation. We consider that the Second Draft Determination generally strikes the right balance.

EA:

> The proposal to change the measurement time resolution to 200 ms is supported. This is based on the updated modelling provided by the UoM and information from other stakeholders in response to the First Draft Determination. These additional analyses show a measurement resolution time of 200 ms will likely provide a 'Goldilocks' solution that strikes an optimal balance between commercial and technical imperatives. That is, by promoting innovation and competition to increase value to customers without materially increasing associated measurement error.
>
> A measurement time resolution of 200 ms contrasts favourably with other proposed solutions including:
>
> - a 1 s setting which would materially increase measurement error compromising system security and obviating the gains from increased competition;
> - a 50 ms approach which would do little to support competition and the development of new energy services; and
> - a 100 ms alternative which, although having similar measurement error, would once again limit the number of potential service providers.

EDMI:

> We note that the previous Fast FCAS reporting interval of 50 ms was prohibitive from a hardware perspective – very few devices are available to support this requirement. Revision of the requirement to a 200 ms reporting interval will enable MASS participation using a much larger range of devices, inclusive of EDMI's currently deployed fleet of PoC NEM meters. As household DER and battery technology continue to reduce in price, this increased participation capability will impact positively on the operation of the NEM. EDMI believes that leveraging the experience of established market

[46] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

[47] See AGL Submission to AEMO's Amendment of the Market Ancillary Service Specification (MASS) (6 August 2021), Available at https://thehub.agl.com.au/articles/2021/08/agl-recommends-aemos-market-specifications-better-support-der-participation-in-fast-fcas-markets.

participants and their current proven infrastructure provides a robust utility-grade solution that will enhance grid security and resilience at an optimal price point.

Evergen:

In this submission we would like to reiterate that we firmly believe that the move from small numbers of large generators dispatching power, to many thousands of inverter connected devices doing so as part of a harmonious system requires new ways of thinking and new approaches to system orchestration. The huge pace of change in our grid continues unabated. The impact of rooftop PV is tangible and readily visible at the grid-wide level.

Our focus as an industry should be on developing a flexible and resilient energy system that can support accelerated decarbonisation and electrification of transport. The world is looking to Australia for leadership in innovation in this space, we believe the Second Draft Determination is a good step in the right direction, but the opportunity exists to act even more decisively and unlock the full potential of the residential scale DER around the country to keep pace with the transformational changes happening in this space.

…

Evergen … appreciate that AEMO took our previous submission seriously. It is gratifying to be able to share insights to assist AEMO and the industry generally.

We think the Second Draft Determination represents a positive outcome for the MASS to date. It is positive that together we have all come to a point where we are revising the verification process and accommodating DER, without losing accuracy.

Evergen reiterates that we firmly believe that the move from small numbers of large generators dispatching power, to many thousands of inverter connected devices doing so as part of a harmonious system **requires new ways of thinking and new approaches** to system management.

Members Energy:

In summary, we believe the Second Draft Determination is overly conservative in its settings for VPPs, both existing (part of the VPP Demonstrations) and new entrants. We believe this runs the risk that the VPP industry's growth will be retarded at a time when it should be nurtured. This, in turn, risks VPPs withdrawing from the FCAS market and, therefore, becoming invisible to AEMO and DNSPs while they pivot their business models to demand response offerings.

We believe demand response will become increasingly important to VPPs, AEMO and DNSPs in the coming years, particularly as electric vehicle charging grows. If existing VPPs have disconnected from AEMO due to unnecessarily expensive technical requirements now, AEMO will need to reconnect with them in the future or risk their demand response activities remaining invisible. Providing greater support to the fledgling VPP industry now, via measured technical requirements for FCAS participation, avoids this possible disconnection and subsequent reconnection – a much preferable scenario for all stakeholders.

…

In summary, drawing on our expertise in the VPP space relating to marketing and overall management of our VPP, we believe AEMO's Second Draft Determination is too technically risk averse and runs the significant commercial risk of decreasing visibility of DER by driving VPPs away from their current connections, both technical and commercial, with AEMO. As electric vehicle charging increases its impact on the network in the future, this commercial risk will have significant technical implications for AEMO's management of the network. While these future risks could be mitigated by network control means at that time, essentially curtailment, to do so would threaten the social licence AEMO has built up through the VPP Demonstrations. We believe a strategy which lowers overall risk for AEMO would be to have a slightly increased technical risk appetite now, by softening the Second Draft Determination and extending the transition period, resulting in significantly lower overall risk in the future by maintaining and increasing AEMO's visibility of DER in a way which values residential consumers' contributions throughout the energy transition.

Reposit:

As AEMO is aware, it is important that it carefully considers its obligations under the NEL and NER with respect to any consultation. In considering changes that lower existing technical requirements for DER participation, AEMO's primary concern is in maintaining power system security and any relaxing of technical standards must ensure this is maintained and provide a positive long-term benefit to consumers consistent with the NEO.

Reposit considers that the proposed changes with respect to measurement and verification will, in the long term, erode power system security and cost consumers more in managing any impacts. Reposit's analysis (using actual data) demonstrates that a 200 ms (and 100 ms) sampling rate does not accurately and reliably measure Fast FCAS delivery. In the long term, if the amount or quality of the service is not delivered, this will be more costly for consumers as greater amounts of Fast FCAS will need to be purchased to arrest remaining frequency deviation.

As such, Reposit requests that AEMO reconsiders its proposed position based on an analytical (rather than case study) approach. The current case study approach does not create results that can be generalised to the entire market. It is also prone to the manipulation of key parameters so as to derive a favourable outcome for Aggregated Ancillary Service Facilities with lower sampling rates for Fast FCAS.

## 2 Context

### 2.1 Purpose of Fast FCAS

Fast FCAS is provided to arrest a material change in system frequency following a contingency event that takes it outside the NOFB. It must be provided within the first 6 s of a frequency disturbance.

Currently, for Fast FCAS, a market participant providing this service must be capable of measuring power flow and Local Frequency at intervals of 50 ms or less at every site (as represented by a NMI).

### 2.2 AEMO's responsibilities

AEMO has two key responsibilities under the NEL that are relevant for this consultation, including:

- Promoting the development and improving the operational and administrative effectiveness of NEM
- Maintaining power system security.

In assessing changes to the MASS, AEMO must consider the NEO and power system security. AEMO must ensure FCAS Providers have appropriate and accurate metering in place to ensure the service needed has been provided and participants are appropriately compensated for the service provided. The inherent risk is that insufficient FCAS is delivered to, or withdrawn from, the grid at times when this service is needed to arrest a frequency disturbance.

While there are other sources of risk to be managed, AEMO manages the energy delivery risk through the MASS' technical requirements. For Fast FCAS, AEMO specifies these technical requirements including specifying quantities and calculations. Through the MASS AEMO must specifically manage the delivery risk associated with energy delivered to, or withdrawn from, the power system when a contingency event occurs and a frequency disturbance follows. It is therefore critical there are appropriate measurement and verification arrangements to understand the service delivery risk and that error in that delivery risk is appropriately accounted for and managed.

### 2.3 DER Integration and participation

As noted in previous MASS submissions, Reposit has been successfully providing and operating Contingency FCAS from DER (including as a VPP) provider under the existing MASS technical requirements since December 2018. This commercially operating VPP continues to grow and does not rely on any future relaxation of technical standards.

The VPP Demonstrations specified alternative measurement requirements to encourage more VPP providers to participate and test capabilities to deliver Contingency FCAS. Since Reposit's VPP and DER meets the existing metering and verification requirements, Reposit saw little to no value in participating in these trials. Participating in these trials would have incurred unnecessary costs (e.g. developing APIs) which would be borne by customers.

Reposit continues to question why other participants are not focussed on meeting accepted power system requirements instead of diluting them to meet commercial imperatives – this values the short-term over the long-term benefits for customers. While the VPP Demonstrations may have

identified some learnings, they have insufficiently tested the impact of relaxing verification and measurement requirements.

...

### 3.4 NEO Analysis

AEMO's assessment of how its proposed changes meet the NEO is set out in section 4.5.2 of its Second Draft Determination. AEMO used the AEMC's Applying the Energy Market Objectives to guide its application of the NEO. In doing so, AEMO (supported by UoM's analysis) identified how it considers specific NEO variables apply to its determination, including price, quality, reliable supply, system security and safety. Additionally, AEMO identified various other NEO components that apply, including consumers, services not assets, long-term changes that may undermine incentives to make investment and operational decisions, and technology.

AEMO noted that "the specifications in the MASS should be at a level needed for AEMO to reliably verify that the enabled amounts of FCAS are delivered, and no more onerous than required."[48] Table 4 summarises AEMO's position on measurement time resolution for Fast FCAS by DER and specified by the NEO variables and components identified by AEMO. The table also includes Reposit's response and assessment taking into account it has undertaken using UoM's methodology and actual data from 1,650+ NMIs for two recent contingency events.

[48] Ibid., p.148.

*Table 4 Summary of AEMO's assessment against NEO variables and components and Reposit's response*

| Specific NEO variables | Summary of AEMO's NEO position on measurement time resolution for Fast FCAS by DER | Reposit's response |
|---|---|---|
| Price | *Lower barriers to entry lead to lower consumer prices:*<br>- Lowering the Fast FCAS measurement resolution for aggregated ancillary service facilities with no inertial response from 50 ms to 200 ms can remove inefficient costs and minimise barriers to entry, which could lead to lower prices for consumers through increased competition | • Inefficient costs involved in participating in Fast FCAS have not been demonstrated. Noting that cost has not been a barrier to entry for many DER participants (evidenced by growing levels of participation outside of the VPP trials) and the metering required is not expensive and available from several suppliers<br>• Lowering the technical requirement for aggregated ancillary service facilities (suggested by some stakeholders as a barrier to entry) will lead to increased prices (not lower prices) in the long-term for consumers because the increase in verification error (X% to Y%) will result in more FCAS being required to ensure a frequency disturbance is addressed<br>• AEMO must quantify the cost and benefit to consumers before determining that a slower sampling rate meets the NEO. For example, project the amount of Fast FCAS that is expected from DER in the next 10 years, multiply this by the increased error and the average Fast FCAS price to determine an approximation of the long-term cost or benefit to consumers.<br>• AEMO must also quantify the additional cost that 50ms metering adds over and above 200ms metering on a whole-of-market basis.<br><br>Lowering barriers to entry in this circumstance leads to lower quality service which in turn leads to higher prices for consumers. AEMO also needs to consider that reducing the cost to participants at the expense of consumers is simply a transfer of wealth from consumers to participants. |

| | | |
|---|---|---|
| Quality | *Reliable verification:*<br>- 50 ms sampling rate is not required to reliably verify the delivery of Fast FCAS unless it is necessary to identify how an inertial response impacts the FCAS delivery<br>- 200 ms sampling rate can adequately verify Fast FCAS delivery.<br><br>*Verification assessment*<br>- From aggregations of more than one site with changes proposed changes to the FCAS verification tool and the discount can minimise the error to a level that minimises the impact on the quality variable | • The increase in verification error does not mean the quality of FCAS diminishes, instead it is the quantity provided to the NEM that diminishes from a DER provider with a 200 ms sampling rate.<br>• The need to make changes in the verification assessment (and tool) is deemed necessary because a slower sampling rate is proposed, which is of a lower quality than currently required by the current MASS.<br>• The RoCoF method and other techniques are being proposed to compensate for the lower quality sampling rate and increased verification error.<br>• It is inefficient for AEMO to make these changes to enable DER FCAS providers when there will be an increase in the verification error beyond the accepted 2% verification error in the current MASS.<br><br>This is likely to result in the need for more Fast FCAS and hence greater cost to ensure the service level does not reduce. |
| Reliable supply | AEMO noted that the proposed 200 ms sampling rate allows FCAS markets to remain secure and reliable | • An increase in the verification error affects the amount of energy delivered or withdrawn into the power system.<br>• An under-estimation or over-estimation will affect the expected response from a DER FCAS provider.<br><br>This has the potential to impact supply at a time when power system security is already under significant distress |
| System security | As above | As above |
| Safety | AEMO noted that this is not a differentiating factor for the consultation | If insufficient Fast FCAS is provided to address a frequency disturbance following a contingency event and this leads to under-frequency load shedding and potentially, blackouts it may cause safety concerns affecting customers, e.g., traffic lights not working, CPAP machines not working. |
| Consumers | AEMO noted that the changes are in the long-term interest of consumers and argued that more competition leads to lower prices to the benefit of all consumers FCAS | • It is theoretically correct that competition leads to lower prices.<br>• It is theoretically possible that in the race to lower prices services to customers diminishes as a result.<br>• The increase in costs to consumers of more appropriate metering to ensure appropriate verification of Fast FCAS has been evidenced to be very low.<br>• For existing assets to contribute to new services like FFR, the metering will need to be improved to allow this service to be provided. |

| | | |
|---|---|---|
| | | • If the quality of the service is diminished, then more service will need to be procured to meet the same power system security needs.<br><br>Lowering the sampling rate and changing the verification methodology to ensure certain assets can participate in the short-term is a false economy and will result in consumers paying more in the long-term. |
| Services | AEMO noted that the approach allows the most cost-effective technologies to be utilised to provide services | • AEMO's proposed approach is to 'codify' the lower standards allowed, but not adequately tested, for in the VPP trials to apply for DER of the future.<br>• If AEMO accepts a higher verification error (Reposit calculated between 4% to 7% for a 200 ms sampling rate using the 25 August trip, refer to Appendix B) then AEMO needs to consider the cost effectiveness of purchasing more service to mitigate the consequential risk to power system security.<br><br>The most cost-effective technologies that meet the established standards are needed to ensure consumers do not pay more for services in the long-term |
| Long-term changes may not be appropriate where they undermine incentives to make efficient investment | AEMO did not make a direct comment, however noted that the proposed change is technology neutral and maintains a flexible framework that allows cost-effective technologies to be deployed. | • Based on its analysis, it is far from clear how increasing the risk to the power system and the likely increase in cost to procure services to mitigate that risk is in the long-term interest of consumers.<br>• AEMO's proposed approach undermines the investment decisions made by DER providers that meet the MASS requirements.<br>• AEMO's proposed approach may encourage investment in products that overall diminish power system security. |
| | | • Customers are unlikely to be able to understand the implications of not having the technological capability to provide new services requiring higher speed metering prior to making this investment decision.<br>• AEMO's proposed approach may encourage more customers to invest in products without metering capable of providing new services like FFR and hence reduce competition for future services<br>• AEMO's proposal undermines the incentive to make efficient investment, demonstrating AEMO's willingness to lower standards to encourage participation of DER and make de facto policy decisions ahead of the AEMC.<br><br>A precedent for participants with slower metering who are likely to argue for slower metering requirements and other techniques to compensate should not be set. This will increase risks to the power system and result in the parties paying for these risks that are not best placed to manage them, i.e. at the expense of consumers. |

Rheem & CET:

... AEMO would increase the opportunity for consumer participation in the future energy market, not just by those that can afford batteries and solar PV, but also across a far greater socio-economic spectrum.

If the energy market is to be truly democratised, it is extremely important that any changes to the NER and associated technical specifications for participation in grid services (such as FCAS) are made with the consumer at the centre of the solution. This will ensure that current and future investment in smart DER by households continues to be made. Fundamental to this approach will be that new rules do not favour a particular technology, technology class, or technology manufacturer, and that technology neutrality is not impeded by barriers to entry in creating or modifying the NER.

sonnen:

**Optimising the available DER from residential consumers**

sonnen's remains strongly committed to our position that measurement of FCAS delivery by DER at the device level is the most efficient approach in the long-term interests of consumers.

AEMO's preference of measurement at the 'connection point' may improve the validation certainty of delivered quantities in limited circumstances, but this comes at the expense of failing to minimise the value of resources required to deliver a given level of output.

AEMO has not provided quantitative analysis demonstrating the 'expected'[49] cost of uncertainty in delivery (for example, the amount of additional FCAS enablement, if any, required to address uncertainty) exceeds the benefit of reduced hardware and installation costs from measurements at the device.

In addition to the absence of quantitative evidence to support AEMO's conclusions, sonnen has listed in Table 2 further responses to AEMO's evaluation.

| AEMO's evaluation | sonnen's comments |
|---|---|
| FCAS is necessary for the power system to manage disparities in supply and demand on a continuous basis. AEMO needs to know how much energy is being produced and consumed at all times, and these measurements are taken at the connection points. | AEMO do not have access to real-time connection point data for most distribution network connected loads/generations. AEMO rely on aggregate data (such as bulk supply point data) to manage disparities in supply and demand. AEMO have not demonstrated the relevance of this statement to distribution network connected DER. |
| In certain circumstances, they could counter each other's contribution to FCAS, negating any benefit to the power system which, as DER penetration grows, could have a significant impact. | No quantitative based assessment has been provided by AEMO to demonstrate that potential counter-productive behaviour of other BTM devices might increase to the point of 'significant impact'.<br>No 'efficient frontier' has been described balancing lower cost of FCAS provision with the level of risk posed by other devices that are detrimental to the value of FCAS provided. |

Table 2. Location of measurement point for FCAS provided by DER

**Clear and unambiguous technical requirements for stakeholders to develop hardware**

DER hardware developers typically have product development cycles of 3 years or longer. Changes to technical requirements and/or interpretation of technical requirements create risks for DER hardware developers such as sonnen. sonnen is concerned that the MASS frequency measurement accuracy specification is open to various interpretations.

**Frequency Measurement Accuracy for FCAS delivered by DER**

[49] Expected or probability weighted outcome rather than low probability maximum risk limit.

As AEMO have disregarded sonnen's concerns regarding the cost impact of frequency measurement accuracy expressed in our prior submission[50] we are restating and elaborating on our earlier feedback.

During the 2nd stage consultation AEMO sought feedback from stakeholders on the cost of high-speed event recorder solutions suitable for DER installations. Cost estimates varied greatly, and sonnen's previous submission attributed the likely cause of widely varying engineering cost estimates to stakeholders forming different views on the required robustness of frequency estimates under noisy and high RoCoF conditions.

sonnen has observed behaviour within our VPP clusters consistent with local power system noise impacting frequency measurements. To ensure delivery of a dependable distributed FCAS resource sonnen's VPP controller continuously examines quality indicators in the 1 s data stream from batteries to remove devices from the resource pool that may not provide a predictable FCAS response. sonnen has observed in its fleet, battery installations with sporadic poor quality frequency measurements that persist after hardware exchanges. In these instances, sonnen have concluded that real world network conditions are having a significant impact the performance of frequency measurement algorithms.

Frequency measurement does not escape the classical engineering optimisation paradigm:

- Low cost, robust, and accurate. Choose any two.

Many low-cost frequency measurement implementations, such as those suggested by other stakeholders … risk failing to maintain adequate accuracy (error ≤0.01Hz) under high RoCoF, in the presence of noise or voltage waveform distortions

Delivering a high update rate (i.e., 50 ms), high RoCoF tolerant, fast settling, and robust frequency estimate that maintains adequate accuracy under dynamic and noisy conditions requires both a suitably responsive estimation algorithm utilising high sample rates in conjunction with digital filtering and conditioning logic to remove implausible estimation artifacts (particularly those introduced by impulse noise sources).

Sophisticated frequency measurement algorithms, digital filtering and state estimation algorithms typically rely on more costly Digital Signal Processing hardware.

Sophisticated instrumentation, such as the high-speed recorders utilised by Trial Participants to provide a reference 50 ms frequency record achieve adequate settling of frequency estimates within 50 ms, but at a high cost that cannot be replicated on distributed installations.

The proposed revised MASS does not provide adequate guidance on the need to maintain accuracy of frequency measurements under dynamic conditions typically experienced during contingency events. The 'standard ramp' described in the MASS does not reflect actual contingency events.

AS/NZS 4777.2:2020 inverter frequency response time and accuracy requirements are not a reasonable proxy for MASS requirements and address separate needs

Standards such as IEEE C37.118.1-2011 targeting grid synchrophasor measurement have attempted to address frequency measurement performance under dynamic power system conditions and may provide guidance on how AEMO can specify dynamic performance expectations.

**Recommendation**

1. Amend revised MASS to specify the power system conditions that the frequency estimate error must be maintained at less or equal to 0.01Hz. sonnen require a response to this matter to avoid wasting development costs.
2. Establish a public record of measurement devices that have demonstrated compliance with MASS measurement accuracy specifications to reduce the incidence of duplicate testing of performance.

[50] MASS Consultation – Third stage consultation forum – summary of discussions 4.2 – 'AEMO noted that it had not considered revisiting the accuracy requirements for frequency, noting that Trial Participants had not raised this as a barrier to entry in FCAS markets and it had not been raised in submissions.'

### 4.4.2. AEMO's assessment

Several Consulted Persons submitted their views on AEMO's consideration of relevant factors in its assessment of its draft determination against the NEO. The most extensive submission on the NEO was from Reposit, so AEMO has framed its response largely by reference to Reposit's submission.

An assessment against the NEO depends on the quality of information AEMO can use to conduct it. If new, or better, information is provided to AEMO, the results of its assessment could change.

After reviewing the concerns raised by some Consulted Persons about the use of the data from Tesla for the purposes of UoM's Second Stage Report, AEMO commissioned UoM to complete further analysis using data provided by Reposit.

AEMO's assessment and responses to the material issues raised in submissions on each of the NEO considerations are set out under the sub-headings below.

#### Price

- To Reposit's suggestion that AEMO has not demonstrated that the current costs of participating in the Fast FCAS markets are inefficient, AEMO considers that it is not necessary to demonstrate inefficiency, merely that the alternative is likely to be more efficient.
- Suggestions that AEMO is permitting under-delivery of Fast FCAS are not substantiated. All metering equipment exhibits error, including meters capable of capturing data at 50 ms intervals. Hence, some degree of error will always be tolerated. AEMO has used the UoM analysis to understand the degree of additional error that a slower measurement time resolution will introduce and has accounted for the estimated additional error by introducing a 5% discount on Fast FCAS delivered. The measurement error at a measurement time resolution of 50 ms is not at issue in this consultation; AEMO was concerned with assessing the error margins at slower sampling rates representing a change from the existing 50 ms requirement.
- It is not necessary to quantify the costs and benefits for the purposes of an assessment against the NEO, nor is it practical where there is a wide variation or limited verifiable information on cost estimates. The cost-benefit analysis that AEMO carries out, of necessity, is high-level and carries a degree of informed judgement.
- Likewise, it is not feasible to quantify the incremental cost of 50 ms metering over 200 ms metering for similar reasons. AEMO's assessment has taken into account reasonable information indicating that the overall trend is one of reducing metering technology cost.

#### Quality, Reliable Supply and Power System Security and Safety

(Many of the arguments raised under this heading are also related to the price factor.)

- Reposit suggested that a measurement time resolution of 200 ms is of lesser quality. This infers that the measurement is not adequate for the purposes of FCAS delivery, with which AEMO does not agree. AEMO has expended significant effort to identify whether, to paraphrase Evergen's submission, there exists another measurement time resolution that avoids a compliance burden if quality, reliability and safety are not compromised. The views of Consulted Persons on whether any of these are compromised appear largely aligned with their position and interests in the market. As the independent market and system operator of the NEM, AEMO has a responsibility to assess and form its own view on these issues based on available evidence and technical analysis. To assist in this task, AEMO engaged the independent expertise of UoM. AEMO's resulting final determination is that 200 ms, subject to applicable conditions and discounts, is an adequate time resolution to measure FCAS delivery with no discernible impact on quality or reliability of supply, power system security or safety. It follows that AEMO does not consider it plausible that a 200 ms measurement time resolution could impact supply to the extent of causing load shedding and blackouts, as suggested by Reposit.

- Whether the additional Fast FCAS that AEMO needs to acquire to cover a 5% deficit materially increases the cost of FCAS to consumers remains to be seen. Currently the relative capacity of DER in the Fast FCAS markets is minimal, even in SA, as shown in Figure 7.

**Figure 7 Relative Capacity of Trial Participant Facilities in Fast FCAS Markets**


The MASS is a living document and AEMO will be monitoring how DER FCAS Providers perform as the volume of FCAS from DER increases. Even in SA, which has the highest penetration of DER Fast FCAS Providers using home battery systems, they represent <10% by capacity, so an error of 5% in measurement is 0.05% of total capacity, namely <2 MW. Should any of the assumptions on which AEMO's final determination prove to be incorrect, AEMO will address those in a new consultation.

In relation to Trial Participants, Figure 6 in section 4.3.2 demonstrate that the market share of Trial Participants by revenue is immaterial, and under the MASS transitional arrangements will not expand further from mid-2021.

- In theory, the application of a discount, when compared to no discount being applied, would tend to increase the cost of FCAS to consumers. AEMO is satisfied that, in the near term, this potential increase is immaterial and cannot reasonably be considered a substantive factor in assessing the MASS amendments against the NEO. Importantly, the use of a discount to facilitate use of an appropriate slower sampling rate can be expected to result in greater participation, which should have a downward influence on FCAS costs.
- In contrast with Reposit's submission, Members Energy comments that AEMO is being 'overly conservative' that the Second Draft Determination imposes 'unnecessarily expensive technical requirements' to the extent that DER FCAS Providers are likely to exit the FCAS markets. On the balance of information available to AEMO, it appears unlikely that this change will cause a significant decrease in the overall participation of DER in the FCAS markets.
- sonnen's submission commented on an AEMO statement in the Second Draft Determination regarding AEMO needing to know how much energy is being produced and consumed at all times. sonnen noted AEMO doesn't have access to real-time data from most distribution network connections and has not demonstrated the relevance of this statement to DER. However, AEMO's statement was made in the context of the need to manage a supply-demand balance at all times, which necessitates the provision of data continuously that reflects movements in supply and demand. A lack of real-time distribution network data from every connection point is not relevant to a discussion on the need for accurate measurements (for ex post review) for specific connection points where FCAS are delivered. Any counter-productive behaviour BTM could impact the FCAS markets as the size of DER participation in the FCAS markets grows. Although there is no quantitative analysis of

its impact, it is a known issue for batteries and controllable hot water systems behind the same connection point meter, as noted by Rheem & CET in their first stage submission[51].

- sonnen's further statement that it has seen battery installations with sporadic poor quality frequency measurements after hardware exchanges potentially having a significant impact on the performance of frequency measurement algorithms is noted, and something that AEMO will have to monitor.
- In response to sonnen's first recommendation, AEMO notes that Table 4 of the MASS already specifies an error margin of ≤0.01 Hz.
- AEMO considers that sonnen's second recommendation that AEMO should establish a public record of measurement devices that have demonstrated compliance with MASS measurement accuracy specifications to reduce the incidence of duplicate testing of performance has merit and, in light of the fact that AEMO needs to commence a fresh MASS consultation, will consider how it can undertake the necessary work to achieve this in 2022.
- sonnen considered there is insufficient guidance in the proposed revised MASS regarding the need to maintain accuracy of frequency measurements during certain contingency events and that the standard frequency ramp specified in the MASS does not reflect actual contingency events. AEMO acknowledges there is little guidance for conditions that are very different to those specified in the MASS, such as the standard frequency ramp e.g. events with very high RoCoF. AEMO would be interested in feedback from providers following this consultation on how this may be better specified. In this determination, AEMO will leave the requirements unchanged. However, it may take into account the nature of high RoCoF events when assessing compliance.

### Consumers

- Reposit implies that AEMO's objective is seeking to lower prices (potentially at the expense of the quality of services to customers), or to facilitate greater participation by certain DER at the expense of existing FCAS Providers. AEMO disagrees. The nature of the NEM is changing and AEMO needs to find new ways to address the resulting challenges without compromising current standards. The measurement time resolution required by the MASS has been the same since market start when the FCAS markets were served by fewer, larger, synchronous generating systems. The market is in a state of transition to a high proportion of non-synchronous generating plant, and it is timely for AEMO to consider whether a slower, and potentially less costly, measurement time resolution can achieve substantially the same outcomes. Indeed, AEMO would be remiss in not adopting a less costly option if one were to be found, what EA calls a 'Goldilocks' solution, striking an optimal balance between commercial and technical imperatives. Clearly opinions vary on whether the same outcomes can be achieved and, as previously noted, AEMO's task is to make an unbiased assessment.
- Because of the wide variation in costs submitted by Consulted Persons, it is not practicable for AEMO to test the veracity of Reposit's suggestion that the increase in costs to consumers by reason of DER FCAS Providers having to meet the 50 ms measurement time resolution is low.
- Any issues associated with FFR will be addressed in the next MASS consultation.

### Services

- Reposit suggests that AEMO is codifying an inadequately tested standard that is lower than the current standard. As noted earlier, opinions on whether the standard is being lowered vary significantly across the full spectrum.
- Using the data captured for the 25 August 2021 event, Reposit calculated a verification error between -2.7% to 9.6% for a 200 ms sampling rate from 200 sites and an error between -6.7% to -4% from

[51] Available at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/first-stage/submissions/rheem-and-cet.pdf?la=en.

1,000 sites. The maximum errors calculated by UoM without the application of the CTI are even greater than the errors calculated by Reposit. For example, when data is captured at 200 ms intervals, the maximum error calculated without the CTI for 200 sites is 22.04% and 17.75% for 1,000 sites. Once the start of the relevant contingency event is correctly identified using the CTI, the maximum error calculated for 200 sites is 0.87% and -0.23% for 1,000 sites. The UoM analysis using the data from Reposit shows that a measurement time resolution of 200 ms is not a lower standard when the aggregate consists of a sufficient number of sites/NMIs, as the maximum error is consistent with the MASS' error margin of 2%.

**Long-term changes not appropriate where they undermine efficient investment incentives**

- Standards need to be adjusted to take into account new technologies and better ways of doing things. The MASS has been through 6 versions since 2001. Since then, the NEM has seen the addition of the Tasmania region, the introduction of wind generation, abolition of the Snowy region, reconfiguration of non-market ancillary services and other reforms that could have impacted the assumptions made by owners of generating plant when they entered the FCAS markets, with lengthy investment horizons. None of these seem to have undermined investments in generating plant, as indicated by the growth in volume and diversity of connection generation in the NEM (refer NEM Generation Information[52] published in November 2021).
- Both market developments and the numerous federal and state government investment incentives over the past two decades have significantly changed the market and, more recently, challenged fundamental assumptions about the nature of the power system. These have given rise to the need to maintain the power system's resilience as more traditional generating plant retires, some earlier than expected due to economic outcomes. AEMO must respond to the changes by developing new ways of dealing with the issues new technology gives rise to and this consultation is an instance of that.
- The possibility of consumer investments being impacted because they are unlikely to understand the implications, is not a matter that AEMO can address. AEMO publishes extensive information about the markets it operates and constantly strives to makes them easily understood. Any business that misleads consumers about the prospective returns of their investments may need to answer to the competition regulator.

### 4.4.3. AEMO's conclusion

After reviewing the submissions on this issue, AEMO is satisfied that its previous assessment remains valid, and the substantive outcomes of the consultation are consistent with the NEO.

## 4.5. Integrity of the Consultation

### 4.5.1. Issue summary and submissions

Several Consulted Persons raised issues around the integrity of the consultation. Extracts from submissions on this issue are cited below[53]:

EA:

> EA appreciates AEMO's additional efforts to investigate whether MASS settings are appropriate in light of ongoing technological and operational change. In particular, extending the consultation timeframe to undertake further analysis on measurement time resolution in response to

[52] Available at: https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/generation_information/2021/nem-generation-information-nov-2021.xlsx?la=en

[53] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

significant stakeholder feedback. This is a noted and welcome contrast with some other previous AEMO initiatives such as the Settlement Under Low Operational Demand rule change. We strongly encourage AEMO to continue with this open, flexible and collaborative approach to consultation and engagement. It will only lead to more robust, efficient and timely industry outcomes.

Evergen:

Thank you for taking our previous submission seriously and taking the time to undertake further investigation into some of the arguments we presented. We put a lot of effort into contributing, and it is gratifying to be able to share our insight to assist AEMO and the industry generally. The most recent draft issued by AEMO represents a positive outcome for the MASS process to date. It is positive that together we have all come to a point where we are revising the verification process and accommodating DER, without losing accuracy.

Greenergenic:

AEMO's current determination of a 200 ms sampling rate for aggregates of DERs over 200 units is based on a UoM study using data supplied by AEMO, which by AEMO's admission concerns data used in Tesla's Application Note as submitted through the second round of the MASS consultation.

It is of material interest that:

- Despite being verified as a data source by AEMO in the third MASS consultation forum, Tesla is not mentioned or explicitly cited in the UoM report.
- Both Tesla's Application Note and the UoM study around sampling rate use similar methodologies, are structured similarly in execution and come to the same conclusions with respect to DER MASS sampling rate specifications per VPP aggregate numbers.
- The UoM report very clearly limits the scope of findings to the data provided, offering the following conclusions and recommendations:
    - (MoU report, pp 32-33, item 4) "Note that this conclusion is fully derived from the analysis of the data provided by AEMO; *studies with more diverse data may be needed to demonstrate the benefits of using NMI-level response profiles for FCAS verification*", and
    - (MoU report, pp 33, recommendation 4) "When verifying the response of a fleet distributed across multiple sites, if the trapezoid rule and RoCoF-based method are used, using NMI-level data with 200 ms sampling rate can achieve a relatively good performance, for example, in the range [-1.3%, 0.2%] for the 200 sites with response equal to a maximum of 5kW FCAS enablement per site analysed in this report. *It is worth noting, though, that this recommendation is derived based on the data provided by AEMO for the studies conducted here, and further studies would be required to be able to provide more definite recommendations.*"

  The stipulations of these conclusions and recommendations contrast significantly in intent with AEMO's interpretation:

    - (AEMO 'Third stage of consultation – stakeholder forum summary') "*However, irrespective of the technology types, if the sample size is large enough, the UoM analysis shows that the error can be significantly minimised*"

The conclusion cited in AEMO's summary is not corroborated in the UoM report prepared for AEMO.

Tesla's source data appears as an Application Note in their original second-round response (Appendix B) with an updated version having modified methodology (with increased error concluding the appropriateness of a 200 ms DER MASS sampling specification rather than the 100 ms specification concluded in the original submission). The updated Application Note was accepted by AEMO 18 days after the deadline for responses. As AEMO has refused (in writing) to accept revised submissions from others that are less overdue (e.g., from this author), it may be surmised that the decision to accept Tesla's revised Application Note is discretionary in nature. AEMO has provided no rationale for this decision.

The use of laboratory source data and synthetic error in estimating the frequency response behaviour of a DER fleet is critical in determining the net response error underpinning analysis and

conclusions on the efficacy of reduced metrology requirements in frequency response service delivery. AEMO has, to these ends:

- Not demonstrated a process by which the statistical risk methodology employed by UoM was tested, accepted and/or validated,
- Not demonstrated that any alternative methodologies were computed and presented for comparison, or
- Not demonstrated that the error simulation method is reflective of response behaviours inherent to internal or external error sources characteristic of DERs within the regulatory scope the MASS.

The use of normal distributions to estimate fleet response characteristics is especially concerning from a number of perspectives, including (but not limited to):

- The assumption that responses are symmetric around a mean creates error cancellation (thus minimising net error),
- The implication that responses meet requirements of the Central Limit Theorem sufficient to justify the use of a normal distribution requires (at a minimum) that samples be independent, random variables – this is not a requirement met in mixed DER fleets, or in fleets where prevailing error sources within a DER fleet are not randomised (e.g., ESS SoC), and
- The implication that average system behaviours should be used to quantify power system capabilities under contingency conditions is not a best-practice assumption. This approach is not generally used in power system design, and is not common to any other system security facility in the NEM.

In the third-round consultation AEMO was not able to describe a fair, industry-inclusive and transparent process by which data was sought for UoM's study on sampling rates. AEMO could not describe a process by which other stakeholders were afforded opportunities to contribute to suitable data. Such data sources may have included (but are not limited to):

- Injection test data; a possibility extending to DERs beyond inverting devices (whether manufacturer-supplied or independently commissioned)
- Data from production VPPs or DERM vendors having devices within the scope of the DER MASS review under management capable of analogous response,
- Data from overseas market initiatives (some of which AEMO used to inform some of the FCAS arrangements trialed in the VPP Demonstrations),
- A series of simulated results from first principles encompassing practical DER device considerations within the scope of the MASS's remit.

It is not credible to suggest that these methods were not known or not available to AEMO; of the more significant opportunities an established Distributed Energy Resource Management (DERM) solution provider has appropriate market registrations meeting the current MASS (though AEMO as the market operator) in significant numbers as to not require any synthetic estimation of fleet response to frequency events. Their dataset – as is known to AEMO – extends significantly beyond the two frequency trip events evaluated in the two studies cited. Rationale for not using such datasets was not provided by AEMO.

It is inevitable that any frequency response data unique from that supplied to UoM for analysis would increase error inherent in results used to inform the specific conclusions AEMO has sought to incorporate in the current draft MASS. This is not a subjective conclusion; it is statistics.

**Concerns around data request requirements**

AEMO's subsequent data request to MASS stakeholders (11th November) placed a number of requirements on data that would have clearly excluded the source data supplied to the UoM report. No rationale is provided for this asymmetry in stakeholder management.

AEMO has mentioned in the third-round consultation and relevant Summary of Discussion that Project MATCH may provide a channel for stakeholders to submit relevant data. The existence of Project MATCH – in addition to AEMO's extraordinary data request on 8-day notice - suggests AEMO is aware of the need for better data to inform more robust conclusion to these ends, and has

strategically resourced accordingly to close a gap in knowledge relevant to the current MASS review. To request data that has been available for some time (potentially at low to zero cost) through a specific, future, out-of-scope project channel is a curious use of process - particularly so relative to current MASS review objectives.

AEMO has placed a significant emphasis in this review process on transitional arrangements for VPP Demonstrations customers. The VPP Demonstrations were a government-funded initiative to (among a number of intended outcomes) demonstrate an easier way of delivering Contingency FCAS from DERs by way of decreased access barriers. It is difficult to understand why - nearly three years and thousands of trial NMIs later - the outputs of the trial's design do not have among them the very data necessary to unequivocally prove that which the trial seeks to achieve. Original requirements of the VPP Demonstrations (being managed by AEMO) stipulated clear requirements for high-speed, MASS-compliant metering. AEMO's current technical conclusions are not based on trial data. It is noted that, on a per-NMI basis, Tesla is significantly represented among participating trial DERs.

...

**Concerns around vendor capabilities**

AEMO disclosed during the third-round consultation that some DER vendors were unable to meet a sampling rate requirement of less than 200 ms in the context of changes to the MASS. AEMO omitted this detail from their stakeholder forum summary document. AEMO has not detailed how this information affected decisions around draft MASS sampling rate specifications.

**Conclusions**

The present situation shadows a significant body of directionally-correct work intended to extend Australia's leading position as an enabler of active DER through advanced market design. It's important that processes to evolve our rules remain fair: there is certainly scope to create and develop fair, equitable, competitive market rules for grid services enabling the participation of world-leading volumes of active DERs across current and future types - inverting and otherwise - from a growing number of vendors providing value-adding solutions to customers living the world's highest-penetration DER market.

With an impending new MASS review just around the corner in 2022 - one inclusive of considerations towards FFR (which may redefine ancillary service markets and according value distributions) - it may be prudent to pause further modification to the MASS within this review pending a more robust approach to analysis, source data and related process driven by learnings from current experience. DER participation is a complex issue, particularly in our wide, deep and storied market. Evolution in market design is certainly important to maximise net consumer value against evolving opportunity. Similarly, it is paramount to seek excellence in what precedents are set in processes supporting change such that expectations and outcomes from change initiatives are reflective of all interests towards best, competitive ends - to do otherwise undermines our best collective intent.

There are many practical ways to lower access barriers to DER participation in FCAS. We therefore suggest that AEMO reconsider modifications to the current MASS for DER implications in the next MASS review, wherein various learnings may be considered in a more complete manner.

**Appendix A: Open matters**

We would note that the following email requests to Mass.Consultation@aemo.com.au remain unanswered:

- An email sent on the 4th of November ahead of the third MASS Consultation forum seeking to understand who would be presenting limited an ability to form questions on notice,
- An email sent on the 11th of November in response to AEMO's extraordinary request for frequency response data, raising concerns around (summarised):
    - The terms of the data request and what processes would be used to qualify, parse and select data for evaluation,
    - The limitations placed around sources (that do not apply to source data AEMO has used in existing studies),

- The lack of information around any processes used to compare any results arising from use of supplied data,
- Whether or not the method employed by the UoM were open to challenge, and
- Whether or not AEMO considered the 8-day deadline afforded to this request to be fair given both the extensive period afforded to the procurement and use of a single laboratory sample in AEMO's current assessments and the request for NMI-related data necessitating some time in the management of any consumer data rights and related, adjacent issues,

- An email sent on the 16th of November in response to AEMO's Summary of Discussion of the third stakeholder review offering to amend some key inaccuracies and omissions in AEMO's record of events as communicated to the MASS stakeholder base. Critically, the following matters are omitted from AEMO's Summary of Discussion:
  - Concerns raised around AEMO's lack of process in adequately seeking DER frequency response data from known and available sources to better inform review of sampling rates,
  - Concerns raised from a stakeholder with diverse DER fleet experience that known asset behaviours are not reflected in the methodology chosen for assessment, and
  - AEMO's admission of understanding that some DER vendors are known to be unable to meet a MASS metrology requirement under 200 ms.

No rationale or explanation is given for the lack of response or the cited omissions from record. The latter are considered a serious matter given AEMO's Summary of Discussion forms both a matter of record within AEMO's consultation processes and a reference upon which stakeholders may use through the submission process.

Reposit:

Reposit believes that UoM's, and therefore AEMO's, analysis of "additional" error is incorrect for the following reasons:

- The dataset provided by AEMO to UoM is not based on actual operational data. The 1,000 sites data provided to UoM is a fabricated dataset based on a single Tesla Powerwall 2 (PW2). This PW2 is responding to a frequency injection test for a single contingency event under lab conditions and with a response measured by an instrument of unknown calibration, then 'fuzzed' 1,000 times with two random variables - measurement error and poll time
- The analysis is based on a fabricated dataset provided by Tesla, who has a vested interest in the MASS requiring a lower sampling rate.

Rheem & CET:

We have significant concerns with respect to the process, transparency, technical evaluation, and applied governance procedures that guided AEMO in arriving at the Second Draft Determination, with our concerns extending to how the decisions were informed by the new UOM report / findings. As such, we cannot support the conclusions adopted by AEMO that have informed it.

…

Taking into consideration the issues that we have raised in our response, we do not see how a fair, technically accurate, and open due process can occur to inform a final determination of the MASS under the timeline and conditions currently stated by AEMO.

Further, with the wide variation in DER types, combined with the considerable and unknown variation in responses due to functional, operational and status conditions of DER that is available now, and in the future, we believe a prudent and responsible approach by AEMO would be to maintain accurate metrology and sampling (i.e. the current MASS) until such time as better characterisation is available from large and diverse deployments of DER to better inform any changes (if required) to the MASS.

As such we believe that the MASS determination should be put on hold (i.e., The current MASS retained) until such time as the issues raised and the recommendations made by ourselves and many other stakeholders can be fully explored.

...

**Process and transparency:**

Having considered the AEMO notice of "Third Stage Consultation – Amendment of the market ancillary service specification – DER and General Consultation", AND having attended the "MASS Consultation Stakeholder Forum" - third stage, on Monday November 8th 2021 we wish to raise the following technical and process/governance related concerns:

- That the conclusions and recommendations informing the Second Draft Determination have come from a single source of data and a single VPP trialist.
- That only one vendor was approached for data.
- That the data represents only one class/type of DER asset, i.e. BESS.
- That the single source of data is derived from lab tests on a single BESS.
- That the single BESS test has been used in the creation of 1,000 points of simulated connection point responses.
- That a subjective artificial error was injected to produce the data for 1,000 NMI simulated connection point responses and that a normal distribution was applied, the results of which we contend is not reflective of real field data.
- That the simulated data (as provided by AEMO to UoM) was the basis of the further analysis carried out by UoM, which then formed the recommendations for the "minimum measurement time for Fast FCAS providers" based on the "calculated" error, and as the data was lab produced, and the error was injected into a normalised distribution, then there was no other result that UoM could obtain than a finding consistent with the "calculated" error, being the same as that which was injected into the sample BESS in the laboratory.
- That during the third stage MASS Consultation Forum on Monday November 8th, AEMO disclosed that some VPP vendors were unable to meet a 100 ms measurement sampling accuracy. As such we are concerned as to what part this issue may have played in informing the Second Draft Determination i.e., to propose a relaxation of the current MASS to allow for a 200 ms sampling window.
- That there are NEO implications within the process adopted by AEMO, including questions around data source, vendor independence, governance, interoperability etc, that have informed the processes and outcomes at AEMO in arriving at the Second Draft Determination.

**Recommendations - process, transparency, interoperability and governance**

- That vendor independence and transparency form the basis of further required MASS determination processes and testing, to be underpinned by independently audited governance processes in arriving at a final draft determination.
- In our previous responses we provided an overview of our MASS compliant metering solution and associated pricing. We note that whilst a number of respondents were made aware of our metering solution offering, there continues to be wild and unsubstantiated varying cost estimates put forward as to ongoing costs associated with providing MASS compliant metering at new DER sites, and costs associated with upgrades to metering at VPP sites that cannot meet the current MASS (50 ms) requirement. Further, there were particularly concerning representations made for the installation component of MASS compliant metering on both single and three phase sites with some estimates in the thousands of dollars. We wish to raise that we are in receipt of a quotation clarifying the installation costs for metering solutions that was provided to both AEMO and the CEC by a Tier 1 installer of DER solutions, Service Plus Australia, during the previous consultation process. However, we can find no reference to the quotation in the Second Draft Determination. That quotation clarified the installation costs of both MASS Compliant and non-MASS Compliant Metering across single and multiphase sites. The Service Plus quotation confirmed that across thousands of sites the average installation costs for existing sites (i.e. a metering upgrade) were between $250 and $350 for single phase and $350 and $ 450 for three phase sites. On new sites (i.e. metering installed at the same time as a Solar PV or BESS installation) prices could be reduced by $100.

- We are aware that AEMO has previously indicated BTM DER interoperability is not within the scope of the MASS review. However, as it relates directly to the costs incurred by consumers, the representations of metering / metering installation costs made by respondents to participate in VPP's, AND this directly relates to the assessment of DER VPP solutions under the NEO, we wish to make the following observations for AEMO's consideration:
- It is our experience having integrated and orchestrated thousands of DER sites with multiple DER types (inclusive of multiple BESS DER solutions) that those that support open, local, standards based connectivity afford consumers the best pricing, and the best connectivity orchestration options with other DER. This approach is consistent with ARENA's DEIP program (including the DER Interoperability and DER Dynamic Operating Envelopes (DOE) working groups), and the ESB / energy market regulators' desires for a future fully integrated open source 2-sided market.
- Further we fully support the ANU led, Australian IEEE2030.5 working group which has developed the Australian IEEE2030.5 Implementation Guide, now in the Standards Australia processes.
- We would contend that outcomes of the MASS would be better aligned with the NEO should Fast FCAS MASS solutions support a mix and match of DER type with MASS compliant metrology. As open connectivity would also enable Home Energy Management Systems (HEMS) orchestration all DER types BTM, AEMO's support would thus enhance grid security of supply.
- We believe that open, standards based local control and interoperability BTM is absolutely necessary to a secure grid. Hence the requirement for Fast FCAS DER to support full local (at the Customer site) behind the connection point interoperability is in our opinion in line with testing a MASS Fast FCAS solution against the NEO.

...

**Concluding remarks:**

Taking into consideration the issues that we have raised in our response, we do not see how a fair, technically accurate, and open due process to inform a final determination of the MASS can occur under the timeline and conditions currently stated by AEMO.

Given the wide variation in DER types and the considerable and unknown variation in responses due to functional, operational and status conditions of DER that are available now or likely to be in the future, we believe a prudent and responsible approach by AEMO would be to maintain accurate metrology and sampling (i.e. the current MASS) until such time as better characterisation is available from a large number of diverse deployments of DER.

As such we believe that the MASS determination should be put on hold, with the current MASS being retained, until such time as the issues raised and the recommendations made can be fully explored.

Simply Energy:

Overall, Simply Energy supports the Second Draft Determination and is pleased that AEMO has clearly considered stakeholders' feedback on the First Draft Determination. AEMO's proposed approach is a good compromise that would support continued investment in the market, particularly in the continued development of VPPs. Simply Energy considers that the Second Draft Determination is based on solid data that has been well analysed. Stakeholders have been comprehensively consulted during the MASS review and we believe that AEMO has received sufficient stakeholder feedback to conclude this review before the end of 2021.

...

At AEMO's stakeholder forum on 8 November 2021, some stakeholders questioned the data underpinning the UoM's analysis. Our understanding is that despite the data being provided by Tesla, the data was sourced from AEMO and could have been provided by AEMO to the UoM without Tesla's assistance. Specifically, we understand that the data was 20 ms frequency measurements supplied by AEMO, converted to 50 ms, 100 ms, 200 ms and 1 s synthetic power measurements using NOFB and 0.7% droop assigned to all VPPs, sampled randomly. As we noted in our previous submission, we are concerned about the influence of stakeholders who have not been

involved in the VPP Demonstrations and the outcomes from the trials. As the data is unbiased, we believe that these stakeholders have unfounded criticisms of the UoM's analysis.

We note that AEMO has again asked stakeholders to provide data to aid its assessment (email on 11 November). Simply Energy does not consider there is significant benefit in delaying this review further so that AEMO can engage the UoM to undertake further analysis on potentially biased datasets provided by stakeholders. However, if AEMO were to propose moving away from its draft proposal based on analysis of any additional datasets, we would expect AEMO to publish a third draft determination to allow affected stakeholders to provide feedback on the reliability and accuracy of that analysis.

### 4.5.2. AEMO's assessment

Of the six submissions that commented on the integrity of the consultation, three were positive. AEMO has provided detailed responses on the three that were not, and the issues raised have been broken down for ease of response.

#### Bias

The following statements in these submissions appear to imply that the consultation has been biased in some way:

1. The data used by UoM for the purposes of the Second Stage Report was biased because it had been fabricated by Tesla.
2. AEMO was selective in its acceptance of late submissions/data.
3. The summary of the third stage consultation forum[54] is selective in detailing what was discussed.
4. AEMO's draft determination to require 200 ms measurement time resolution responded to certain OEMs' inability to achieve higher sampling rates.

AEMO will address each of these in turn:

**1. Was the data used by UoM 'fabricated'?**

Reposit alleges that the data used by UoM for the purposes of the Second Stage Report was 'fabricated'. This is incorrect and misleading.

Analysis data is not 'fabricated' simply because it is not actual metering data. The data was comprised of the calculated FCAS response from 1,000 NMIs polled at different times to reflect the fact that power measurements are not polled at the same time across all NMIs.

Based on the feedback and concerns of some Consulted Persons, AEMO commissioned UoM to repeat the analysis with actual metering data provided by Reposit, and a summary of its findings can be found in section 4.1.2.

The metering data acquired as part of the VPP Demonstrations was inadequate in assisting with determining the optimal measurement time resolution as all Trial Participants had opted for 1 s resolution. AEMO had understood from discussions in another context that Reposit was unable to share NMI-level data at 50 ms resolution, therefore, it did not pursue a request for this data in connection with the MASS consultation. AEMO acknowledges there may have been a misunderstanding, and Reposit did provide NMI-level data following the Second Draft Determination. That data has been valuable in corroborating earlier findings and identifying appropriate modifications as seen in UoM's Third Stage Report.

[54] Available at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/third-stage/mass-consultation-forum-summary-of-discussion.pdf?la=en.

Rheem & CET refer to 'governance' concerns, which AEMO understands are related to an apprehension of bias around the data used for the purposes of UoM's Second Stage Report. They were concerned that:

- The conclusions and recommendations informing the Second Draft Determination came from a single source of data.
- That single source of data was a Trial Participant.
- The data represents only one class/type of DER.
- The data was derived from lab tests on a single BESS, which was used to create 1,000 points of simulated connection point FCAS responses.
- A subjective artificial error was injected to produce a normal distribution, in statistical terms.

At the time of the UoM second stage analysis, AEMO had no other credible sources of data. The data was based on a mathematical calculation of the required FCAS response from a proportional FCAS controller with a deadband of ±0.15Hz and a droop of 0.7%. Acknowledging that this was a single source, it is noted that over 60% of FCAS capacity from market participants with residential battery systems come from this type of FCAS controller. The 'artificial error' introduced was, in fact, the action taken to account for the fact that data is not polled at the same instance across all NMIs. It would have been inappropriate to assume otherwise.

**2. Selective acceptance of late submissions/data**

Greenergenic alleges that AEMO accepted an updated Application Note from Tesla 18 days after the deadline for responses on the First Draft Determination, but refused to accept a less overdue submission from the same author representing Empower Energy earlier during the consultation. In fact, Empower's submission in the first stage of consultation was accepted, considered and responded to, even though it was late and therefore not technically 'valid' under rule 8.9 of the NER.

Tesla's Application Note was initially provided to AEMO with its (on-time) submission. An updated version of the Application Note was published on the MASS consultation webpage along with 6 other late submissions[55]. The additional information in the updated Application Note had no impact on AEMO in making its draft determination.

**3. Third stage consultation forum summary incomplete**

Greenergenic was concerned about inaccuracy and omissions from the 8 November 2021 forum summary. AEMO engaged an independent facilitator to chair the forum and to complete the summary. There was no suggestion that a transcript of proceedings or full formal minutes would be produced, and it was made clear at the forum that discussions were not a substitute for written submissions. Opinions will differ as to whether any particular person's comments/queries were material or distinct enough to warrant separate inclusion in a summary, but AEMO is satisfied that the published summary captures the key points of discussion fairly.

AEMO considered all correspondence received on this subject, and concluded that the published Consultation Forum Summary is not inaccurate and required no update.

**4. AEMO's changed its conclusions in favour of OEMs unable to meet <200 ms resolution**

Both Greenergenic and Rheem & CET's submissions could be read to imply that in settling on a 200 ms measurement time resolution, AEMO was influenced by a desire not to create barriers for OEMs that cannot meet a measurement time resolution of <200 ms. This is not the case.

A measurement time resolution of 200 ms was identified as a potential acceptable compromise in the First Draft Determination, but at that stage the additional analysis required to confirm the impacts and

[55] See https://aemo.com.au/en/consultations/current-and-closed-consultations/mass-consultation.

necessary consequential changes was not considered justified. Based on submissions to the First Draft Determination, AEMO reconsidered this and commissioned further work by UoM.

AEMO explained in the Second Draft Determination that the UoM analysis concluded that there is no additional benefit in specifying a measurement time resolution of 100 ms over 200 ms, as the difference in the errors associated with both was less than 1%, irrespective of the number of NMIs in a fleet, as shown in UoM's Second Stage Report. Based on this assessment, requiring a 100 ms measurement time resolution would have presented an unnecessary barrier to entry.

**Transparency**

Greenergenic states that there is a lack of transparency because the UoM report does not specify that Tesla was the data source. Greenergenic has also submitted various criticisms of the UoM methodology, pointed out its limitations and that AEMO's conclusions and recommendations are not 'corroborated' by the UoM report. Greenergenic would not have been in a position to express those views had the analysis not been transparent.

As to identifying the source of the data used in the analysis by UoM for the purposes of its Second Stage Report, AEMO notes that it stated that the data was provided by a DER FCAS Provider on page 72 of the Second Draft Determination. There is no independent source from which AEMO could obtain data relevant to the FCAS markets, so AEMO does not understand Greenergenic's statement that it is 'of material interest' that 'Tesla is not mentioned or explicitly cited in the UoM report'.

The 'open matters' in Appendix A of Greenergenic's submission make several additional points relating to transparency:

- The failure to respond to an email seeking to know who would be presenting at the next forum is of no relevance to the integrity of the consultation process. No one other than AEMO has presented at the forums associated with this consultation and AEMO does not understand how this could have limited Greenergenic from submitting questions on notice. AEMO also notes that Greenergenic's representative attended and asked questions during the forum, so this does not seem to have affected its participation.
- Concerns raised in Greenergenic email on 11 November 2021:
  - Data request requirements for further analysis

    AEMO had specified that the data had to be from an FCAS Provider using DER to provide Fast FCAS. By definition, their DER would be MASS-compliant, which means that the data would comply with the MASS. As such, there should be no suggestion that any qualification or parsing process would apply.

    AEMO does not agree that there has been no information about any processes used to compare results from data used in any analysis for the purposes of this consultation. On the contrary, this consultation was extended to conduct additional analysis as a direct result of issues raised by Consulted Persons. Several reports have been published, as well as analysis by Consulted Persons.

    UoM was engaged to provide independent analysis and its process and methodology were clearly outlined in each report. While it is important to replicate the results with different source data and different processes/methodologies, in this case, there are limited sources of data.

    AEMO is satisfied that the applied methodology and process involving different data strongly support its determination on the key issues surrounding the measurement of Fast FCAS provided by DER, and the consultation process has been thorough and robust. It is, of course, impossible to resolve every issue raised in a manner that satisfies every Consulted Person, and AEMO must make its independent decision on the material issues.

– Consideration of other risk methodologies

  UoM's methodology has been reviewed and challenged by several Consulted Persons. AEMO has considered the critiques of the methodology and addresses concerns elsewhere in this document. Section 2.4 of UoM's Third stage report has also stated Monte Carlo simulation is widely considered as a state-of-art methodology for risk analysis and is suitable to provide a better picture of possible verification errors given a certain dataset.

– Response period to AEMO's data request

  AEMO considered an 8-day period for seeking data from Consulted Persons reasonable given the nature of the request. Tesla previously provided its data in a shorter timeframe, and Reposit was able to share its NMI-level data with AEMO before the due date. This was possible because AEMO did not request any information that would allow the consumer or the NMI to be identified.

#### 4.5.3. AEMO's conclusion

While inferences of bias and lack of transparency were made in submissions, AEMO does not consider they were substantiated for the reasons explained in Section 4.5.2.

# 5. DISCUSSION OF MATERIAL ISSUES – GENERAL

## 5.1. MASS Readability and Usability

### 5.1.1. Issue summary and submissions

There was a significant diminution in the range of issues addressed in submissions dealing with the general issues around the MASS. Extracts from submissions on this issue are cited below[56]:

EDMI

> From a technical and measurement point-of-view, EDMI agrees with views expressed in previous submissions regarding FCAS Settling Time requirements. With reference to Table 4 of the 2nd draft MASS, EDMI agrees that "The time required for the measurement to remain within 99% of final value after a step change from zero" should be clarified with respect to frequency measurements.

EA:

> EA appreciates the clarification that references to the NOFB should be interpreted as applying only under normal operating conditions. We also support the drafting changes to use the term 'Variable Controller' more consistently. Finally, we thank AEMO for incorporating our suggestion to add the definition of 'Settling Time' to Table 4 in Section 5.3.2. All are welcome improvements to MASS clarity and utility.

Hydro Tasmania:

> Hydro Tasmania has reviewed and proposed amendments throughout the MASS consultation process. In our view, the changes enacted by AEMO throughout this process have significantly improved readability and useability of the MASS…
>
> …
>
> **Other general comments**
>
> Hydro Tasmania notes a slight disparity in the terminology used between the frequency references in figure 1 (power system frequency) and figure 6 (Local Frequency). Hydro Tasmania queries whether

[56] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

these terminologies are considered interchangeable, or are defined differently. In the event that these terms are defined differently, Hydro Tasmania considers that it would be beneficial to clarify.

In addition, Hydro Tasmania would like to note that, while the delay FCAS (5 mins) are categorised as Contingency FCAS, they are effectively implemented by AGC instruction. Therefore, if the Contingency FCAS is referred in the governor response path as shown in figure 1 and 6, we recommend that AEMO amend the schematic to be 'Contingency FCAS (6s and 60s only)' to avoid confusion.

Shell Energy:

Shell Energy welcomes AEMO's decision to revise the descriptions of Regulating Raise service and Regulating Lower service in Table 3 of the draft MASS to clarify that provision of Regulation FCAS involves controlled deviation from an Ancillary Service Facility's reference trajectory or basepoint. We are also please to observe AEMO's addition of a statement in the draft MASS "the total expected change in output is subject to enabled quantities of each FCAS and a facility's PFR obligations where applicable". We consider these additions provide additional clarity to the MASS.

…

Shell Energy also remains concerned with regards to the verification of Contingency and Regulation FCAS response and its interaction with narrow band PFR. While the verification methodology allows for the declaration of a "Contingency Event Time" by AEMO, and the use of the "reference trajectory", both of these only consider an outcome absent the specific frequency disturbance and any AGC response.

The verification process fails to include any narrow band PFR which may have already been provided in the lead up to the frequency disturbance event. As such, the verification methodology appears to fail to account for any Contingency FCAS or Regulation FCAS which may have already been consumed by narrow band PFR. We recommend the verification methodology be amended to clearly indicate that the use of Contingency FCAS and Regulation FCAS by narrow band PFR is also included as compliant response in the verification calculation. Excluding narrow band PFR from the calculation creates an unmanageable compliance risk for FCAS Providers as the magnitude of narrow band PFR is unknown at any time and cannot be included in an FCAS Provider's energy or FCAS dispatch bids. The alternative to including narrow band PFR in the verification methodology would be for narrow band service providers to limit narrow band PFR so as to ensure sufficient headroom, foot room or stored energy is maintained to ensure contingency or Regulation FCAS dispatch compliance.

Simply Energy:

**AEMO could make some further improvements to the clarity of the MASS**

The current drafting has 16 references to 'Plant' however in the context of DER providing ancillary services this term could be interpreted to be referring to either the site's connection point or the individual DER. The MASS does not describe the intent of this term and without being aware of the background the reader may draw their own conclusions as to its meaning.

…

Also for the consideration of new participants, it may be worthwhile including AEMO's expectations of an aggregated FCAS Provider when they also intend to participate in both FCAS and wholesale energy markets. The lack of clarity in the proposed version of the MASS may result in response verification issues at a later stage.

SwitchDin:

In addition we note … further improvements in the readability of the MASS.

We strongly support these changes and thank AEMO for commissioning the additional modelling required to support these decisions following the stage 2 consultation process.

### 5.1.2. AEMO's assessment

#### References to the FOS

EA noted in its submission that 'references to the NOFB should be interpreted as applying only under normal operating conditions'. That is not correct. AEMO intended that NOFB be interpreted as being range of frequencies in the 'normal operating frequency band' as specified in Column 2 of Table A.1 of the FOS.

To remove any ambiguity, AEMO has amended the definition accordingly.

#### Definition of Settling Time

EDMI's submission documented a lack of clarity in the definition of Settling Time adopted in the Second Draft Determination; an issue that others, including sonnen, had raised earlier in this consultation. AEMO appreciates the continued attention to the issue and agrees that the definition was inadequate for frequency measurement as a 'step change from zero' in frequency terms is nonsensical. An updated definition is included in the revised MASS.

#### References to AGC

Hydro Tasmania's submission has highlighted an issue concerning the use of the term 'AGC'.

As a policy, AEMO incorporates in relevant NER-defined terms in its procedures and guidelines. 'AGC' is defined in the NER, but on further consideration, the definition is not as clear as it could be. Moreover, there are some Market Participants who operate their own internal AGC systems, including Hydro Tasmania.

AEMO intended that all references to 'AGC' in the MASS mean the AGC system operated by AEMO. Therefore, in this instance, it should be clarified that 'AGC' means AEMO's AGC.

To respond to Hydro Tasmania's concern, Contingency FCAS is not implemented by AGC instructions emanating from AEMO. Consequently, there is no need to amend Figures 1 and 6.

#### References to plant

AEMO has reviewed the references to 'plant' and agrees that they would benefit from clarification.

#### Verification of FCAS and PFR

Shell Energy's comments on verification of FCAS delivery have been incorporated into section 5.2.

### 5.1.3. AEMO's conclusion

AEMO has made the following amendments to the MASS in response to these matters:

- Revised the definition of NOFB in the MASS, now defined as: "The normal operating frequency band, that applies under normal operating conditions, namely being the values specified in Column 2 of Table A.1 in the FOS."
- Revised the definition of Settling Time in Table 4 of the revised MASS has been updated to read: "The time required for the measurement to remain within 99% of final value after a step change from pre-contingency conditions".
- Replaced the NER-defined references to 'AGC' to a term defined in the MASS Glossary in section 1.2.1, to mean the AGC system used by AEMO.
- Reviewed the references to 'plant' and made appropriate clarifications.
- Further minor edits were made for clarity and readability.

## 5.2. Co-ordination between different FCAS and Primary Frequency Response

### 5.2.1. Issue summary and submissions

The Second Draft Determination addressed three key issues:

- FCAS Co-Ordination and Priority – changes were proposed to sections 2.2 and 10.3 of the draft MASS to address this concern, and introduced new definitions in Table 1.
- Proportional Controller Trigger Ranges – AEMO proposed to defer any decision on refining and clarifying trigger ranges (and service termination settings) for proportional controllers until the rule changes associated with primary frequency response (**PFR**) are made.
- Switching Controller Trigger Ranges – AEMO proposed to set the default setting to the narrower end of the existing ranges.

Extracts from submissions on these matters are cited below[57].

EA:

> As noted in our earlier submission, adjusting frequency response settings can have significant costs. We, therefore, support not making any decisions on proportional controller ranges or including PFR settings until the final PFR rule change is made. Doing so will minimise any cost impacts by avoiding having to change Frequency Settings both before and after the PFR ruling.

Hydro Tasmania:

> **6.1 Frequency Deviation Settings Provided by Switching Controllers**
>
> Hydro Tasmania suggests that the Default Frequency Deviation Setting in Tasmania should remain unchanged (see Table 6 below).
>
> **Table 6 Frequency Settings for Tasmania**
>
> | Level | Raise FCAS Frequency Deviation Setting (Hz) | Lower FCAS Frequency Deviation Setting (Hz) | Frequency Rate of Change Multiplier |
> |---|---|---|---|
> | Frequency Deviation Setting range | 49.50 Hz to 48.75 Hz | 50.50 Hz to 51.25 Hz | 0.875 |
> | Default Frequency Deviation Setting | 49.~~5125~~ Hz | 50.~~5825~~ Hz | 0.875 |
>
> Subject to the system inertia and PFR conditions at the time, Tasmania system frequency deviation introduced by the Basslink power flow reversal could reach 0.4 - 0.6Hz, occasionally up to 0.8Hz. On this basis, we consider the existing default setting reasonably reflects the Tasmania system frequency condition, and therefore, suggest the current definition be maintained. Hydro Tasmania also notes that the current Default Frequency Deviation Settings are asymmetric, and query whether this was intentional, or a slight error in the MASS.
>
> **10.3 Compliance Monitoring and action and Appendix B**
>
> In principle, Hydro Tasmania considers it appropriate to coordinate the provision of FCAS of all kinds. However, this principle isn't always upheld. For instance, when the automatic generation control (**AGC**) instructions are contradictory to the Contingency FCAS response. As currently drafted in section 10.3 and the example provided in Appendix B, the MASS would direct generating units to respond to AGC instruction, even if its correction direction is in conflict with the Contingency FCAS response.

[57] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

Hydro Tasmania considers the MASS could be improved by addressing this conflict, and mitigating adverse impacts on the power system, such as:

1. Likely interference with PFR resulting in undesired system frequency recovery delay; and/or
2. The introduction of uncertainty to the fast Contingency FCAS evaluation, alongside an opposite AGC instruction, which could discount a governor response, subsequently resulting in an under delivery of Contingency FCAS.

To achieve the harmonious operation between each of these functions, it is important that the AGC regulation correction direction be in phase with the Contingency FCAS response, thereby assisting with, rather than resisting power system frequency recovery.

Shell Energy:

... we continue to remain concerned about what appear to be conflicting requirements between sections 2.2 and 10.3 relating to the provision of combined PFR, Contingency FCAS response and Regulation FCAS response. In our view, the wording in the MASS continues to lack clarity.

Section 2.2 indicates that there should be no priority in the delivery of FCAS types, yet this section then indicates that "Unless directed by AEMO to do otherwise, subject to clause 4.9.4 of the NER, an Ancillary Service Facility providing Regulation FCAS should follow AGC instructions at all times, noting that AGC instructions are subject to Local Frequency as outlined in 10.3."

Section 10.3 then indicates that "Occasionally, the direction of the Contingency FCAS or PFR response may oppose an AGC control signal;" and that this should not be unexpected. It is therefore unclear as to whether AEMO wants FCAS providers to follow AGC instructions at all times. Fortunately, the Second Draft Determination makes the issue somewhat clearer by indicating" The aim of the MASS amendments is to establish that frequency co-ordinated control means that AGC instructions are subject to frequency. This means that AGC instructions are specified as if frequency is at 50 Hz, but may be offset by local controls (if those controls are active) if frequency is not at 50 Hz." We understand this to mean that responding to Local Frequency via automated narrow band PFR, or if the frequency deviation is large enough, via any enabled Contingency FCAS response, should take priority to following an instruction to alter energy output received via the AGC system. If our understanding is reflective of AEMO's intent, then we consider additional changes are required to the MASS to clearly indicate AEMO's intent.

...

Finally, we note that AEMO is awaiting the outcome of the PFR rule change before making any decisions on proportional controller trigger ranges. While there is still uncertainty on the precise timeframes of the PFR rule change, the AEMC's scheduled date for completion of the PFR incentive arrangements rule change is 9 December 2021. AEMO proposes to publish the final MASS by 22 December 2021 meaning that no sooner will the MASS be finalised than changes may be necessary to accommodate the PFR rule changes.

### 5.2.2. AEMO's assessment

#### FCAS co-ordination and priority

AEMO acknowledges the submissions indicating that the MASS would benefit from further clarity in sections 2.2 and 10.3. AEMO has modified section 10.3, particularly drawing on information in Shell Energy's submission. AEMO wishes to clarify that AGC instructions should be interpreted as if the frequency were at 50 Hz, and therefore any active local Contingency and PFR controllers should apply an 'offset' to the AGC instruction. AEMO understands how Consulted Persons might have interpreted this objective, as drafted in the MASS published with the Second Draft Determination, as frequency response having priority over AGC response.

AEMO also notes Hydro Tasmania's concerns regarding the possible 'interference' of AGC with Contingency FCAS response. AEMO's assessment notes two distinct matters:

- On the matter of how this might affect FCAS verification, the AGC trajectory is one of the factors considered in defining the 'reference trajectory' of the Ancillary Service Facility – that is, the trajectory the Ancillary Service Facility would have been expected to follow if there had not been a need for a Contingency FCAS response. Therefore, FCAS Providers should not be concerned that following AGC (subject to frequency, following the guidance in sections 2.2 and 10.3 of the MASS) would result in a Contingency FCAS compliance risk.
- On the matter of whether the 'interference' represents a risk to FCAS effectiveness, AEMO understands the points made. On balance, the revised MASS is preferable to retaining the 'Contingency FCAS priority' approach of the existing MASS, because:
  - AEMO retains full control over when to 'block' AGC commands and can co-ordinate the desired behaviour. AEMO's AGC contains the capability to pause issuing controls that are counter-frequency and can configure this to particular frequency settings on a per-control area or even per-facility basis. Therefore, AEMO can monitor aggregate FCAS behaviour (as part of its power system security responsibilities) and can control this centrally. The potential blocking of controls needs to be carefully balanced with the need to control Ancillary Service Facilities to dispatch targets and to meet power system security reasons, for example where a satisfactory transmission constraint equation applies.
  - AEMO cannot grant discretion to FCAS Providers as to when they are not required to follow AGC: that is a matter that is addressed in clause 4.9.3A(c) and 4.9.8 of the NER. They are required to respond to dispatch instructions immediately where they are issued by AGC and there are very limited circumstances where they might not, such as where compliance would, in the FCAS Provider's reasonable opinion, be a hazard to public safety or materially risk damaging their equipment.

These issues notwithstanding, frequency response co-ordination is a complex matter and AEMO will continue to monitor performance and any potential issues can be addressed in future proposals to amend the MASS, if the need arises.

### Proportional controller trigger ranges

The submissions on this issue are noted.

AEMO must commence a new consultation to make changes to the MASS necessitated by the National Electricity Amendment (Fast frequency response market ancillary service) Rule 2021 No. 8[58], and in due course the PFR incentive arrangements rule shortly after concluding this consultation, where this issue will be considered.

### Switching controller trigger ranges

Hydro Tasmania's comments on the proposed default switching controller trigger values are noted. AEMO agrees that, in general, it is better to avoid setting frequency triggers in the area commonly seen during Basslink reversals, which often results in deviations of ±0.5 Hz and sometimes larger.

AEMO also thanks Hydro Tasmania for drawing attention to the asymmetry in the default trigger values for Tasmania and can find no historical evidence for why this asymmetry exists.

AEMO has, therefore, set the default trigger values to ±0.875 Hz for Tasmania, which removes the asymmetry and preserves the intention of the MASS. AEMO will further monitor frequency behaviour and compile statistics of potential triggering before looking to make changes to these parameters.

[58] Available at https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

### 5.2.3. AEMO's conclusion

AEMO has amended sections 2.2 and 10.3 to further improve clarity, and introduced new defined terms to support the changes relating to FCAS co-ordination and priority.

AEMO has amended Table 6 in section 6.1.1 of the MASS to remove the asymmetry in the default switching control trigger for Tasmania, while preserving the intention of the existing MASS.

## 5.3. Requirements for Regulation FCAS

### 5.3.1. Issue summary and submissions

In the Second Draft Determination, AEMO refined certain requirements for Ancillary Service Facilities providing Regulation FCAS:

- Telemetered Data Rate – data must be updated at least every 4 s with no more than 8 s data latency.
- AGC Controllable – the Ancillary Service Facility must demonstrate its response to AGC-issued control requests as either setpoint targets or as raise/lower controls (setpoint control is preferred wherever feasible).
- Minimum Bid Size – the larger of 1 MW or 1% of the registered maximum capacity of the relevant Ancillary Service Facility was retained.
- Maximum Control Response Delay (**CRD**) – the requirement that it be no more than 150 s was retained.
- Minimum Ramp Rate – Consistent with the First Draft Determination, AEMO did not specify any particular minimum.
- Required measurements – AEMO determined that the required telemetered measurements will be agreed between AEMO and the Regulation FCAS Provider.
- Transition Period – AEMO proposed a one to two-year transitional period to the new Regulation FCAS requirements
- Testing Cycle – Following concerns raised by Consulted Persons, AEMO made two changes to the test requirements set out in section 10.6 of the draft MASS:
    1. The general test cycle should be 4 years.
    2. The applicable timeframes should refer to when an FCAS Provider must initiate contact with AEMO to plan and conduct tests.

In response to these matters, submissions were received on only some of these issues, which are cited below[60].

Hydro Tasmania:

> **10.4(a) Ancillary Service Facility – Control Request Feedback**
>
> Hydro notes there is a new item 'Control Request Feedback' proposed in Section 10.4(a). From its definition provided in Table 1, Hydro Tasmania has difficulty in understanding the requirement for older hydropower units that utilise pulse control facilities, and feel it may be impractical for the facilities if the pulses are accumulated in a physical position of governor components (i.e. setter motor shaft position), where digital feedback is not available.
>
> Hydro Tasmania would therefore encourage AEMO to provide further clarification of the requirement, and provide an explanation of the technical driver behind it. Hydro Tasmania would

[60] Note that submissions quoted in this document are in this font; a footnote in this font indicates that the footnote is copied from the submission. In the interests of saving space, AEMO has shortened some comments, removed repetitive content, replaced descriptions in the submissions with acronyms and standardised the use of other terms that are defined in the Glossary.

welcome the opportunity to engage with AEMO directly on this matter and identify a potential solutions.

**10.4(e) Control Response Delay (CRD)**

Hydro is aware that a new technical requirement associated with a time constant of 1st order transfer function has been proposed to measure the AGC response time delay in Section 10.4(e) of the MASS.

While the MASS indicates the details are still to be determined, Hydro Tasmania would like to clarify at a high level, whether this measurement will include both AEMO and participant AGC from end-to-end, or solely participant AGC alone.

**10.4 (f) Maintain at all times a Setpoint Change Deadband greater than or equal to half of the facility's minimum Regulation FCAS offer quantity as defined in Sections 10.1 and 10.218.**

Hydro notes the requirement in 10.4(f), which states that 'Ancillary Service Facility must have a control system that can maintain a Setpoint Change deadband'. However, as per the definition in Table 1, the Setpoint Change Deadband is a value set in AEMO's AGC. Hydro would like to clarify how this Deadband setting can be appropriately maintained by a participant's Ancillary Service Facility, when this value is physically set in AEMO's AGC.

Further, Hydro would encourage AEMO to provide further clarity regarding proposed configurations. In particular, Hydro queries why the Setpoint Change Deadband has to be greater than or equal to half of the facility's minimum Regulation FCAS offer. Further clarity on this point will ensure that participants understand the rationale for this requirement, and implement accordingly.

**10.6 Regulation Tests**

Hydro notes that the draft MASS proposes to extend the regulation facility routine test cycle from 2 to 4 years. We consider a 4 year interval to be reasonable. However, as mentioned in our previous submission (5th August 2021), this will be challenging for Hydro to effectively conduct testing of all ~50 Hydropower units in this timeframe.

Hydro is concerned that this obligation may result in increased downtime and increase costs associated with testing requirements. While the regulation tests details are still to be determined, Hydro Tasmania would like to engage with AEMO in developing the regulation tests approach and ensure the regulation tests can be carried out through the entire hydro fleet in a practical and cost-effective manner, whilst maintaining a robust process that can reasonably demonstrate Ancillary Service Facilities are performing as required.

Shell Energy:

AEMO has addressed our concerns about the Setpoint Change Deadband and the behaviour of AGC regarding the ramping of facilities. This is reflected in the addition of a detailed description of how NEMDE caters for bid and telemetered ramp rates is contained in AEMO's guide "FCAS Model in NEMDE". AEMO has also added a footnote to section 10.4 of the draft MASS, which states "AEMO's AGC will control facility output within the ramping rates telemetered to AEMO by the facility" to clarify how AGC uses telemetered ramp rates. Shell Energy thanks AEMO for addressing these issues and supports their inclusion in the MASS.

Tesla:

In respect of the introduction of the CRD requirements and the requirement in 10.4(e) that this is "no greater that 150 ms"[61], Tesla believes that AEMO could feasibly request a far quicker response from Regulation FCAS Providers. AEMO may wish to consider whether 15 s is a more reasonable response time.

[61] AEMO assumes this is a typo and that Tesla intended for this to mean '150 seconds', not '150 milliseconds'.

### 5.3.2. AEMO's assessment

#### Control request feedback

Hydro Tasmania sought more information regarding AEMO's rationale for requiring a 'Control Request Feedback' data feed from Regulation FCAS providers.

The purpose of this data item is to ensure that AEMO's AGC is aware of the facility's intended change in output. It is essentially an acknowledgement to AEMO's AGC that the facility has received the signal requests and intends to move to that output. In the case of a pulse-controlled or Raise/Lower-controlled facility, when AEMO's AGC receives a Control Request Feedback that agrees with what it has sent, it will stop sending further pulses for that control action. This results in more efficient AGC behaviour for AEMO, and minimising overshoot or unnecessary control actions at the provider's end.

Noting that different facilities, and especially older facilities, may have different technical capabilities, AEMO included wording in section 10.4 of the MASS indicating that providers must 'transmit an agreed set of control parameters including Controlled Quantity, Control Request Feedback […]'. The wording 'agreed set of control parameters' was included to allow some flexibility, specifically where particular facilities may not have the physical capability to deliver one of the data items exactly as specified. AEMO will work with providers operating unusual and/or older generation equipment to establish the best option for that facility. In Hydro Tasmania's specific case, AEMO will discuss options with Hydro Tasmania appropriate to their systems.

#### Maximum Control Response Delay (CRD)

AEMO wishes to clarify that the maximum allowable CRD of 150 s is an end-to-end value; it includes all time taken from the moment AEMO issues a signal to the time the Ancillary Service Facility reaches the required power output change. While some of the time involved in relaying and actioning signals is not within the direct control of an FCAS Provider, this has been acknowledged and built into the requirement, which should be perfectly achievable and, in any case, is a minimum of what is needed for effective operation of AGC.

AEMO notes Tesla's point that the maximum allowed CRD could potentially be a much faster value and considers that the advantages and disadvantages of specifying a significantly faster CRD should be subject to a targeted investigation once the proposed set of Regulation FCAS changes have been deployed and operational experience has been gained.

#### Setpoint change deadband

AEMO notes Hydro Tasmania's queries on the following:

- AEMO's rationale for setting out requirements for Setpoint Change Deadband
- How an FCAS Provider can ensure that the Setpoint Change Deadband is always set appropriately, given it is a setting applied by AEMO within its AGC software.

These queries have helped AEMO to identify an error in the Draft MASS; the wording was intended to be 'no greater than', not 'greater than'. The intention of the Draft MASS is hopefully clear in the Second Draft Determination (see section 5.6.2) and was interpreted as intended by several submissions. As the Second Draft Determination also points out (see page 59), AGC cannot issue control requests to facilities unless the control request exceeds the setpoint change deadband. So for example, if a facility has a minimum Regulation bid size of 4 MW, then this is the amount the facility could feasibly be enabled for. The Setpoint Change Deadband requirement therefore ensures that the facility can be issued Regulation control requests down to 2 MW so that the 4 MW enablement can actually be used. If the same facility were to have a setpoint Control Deadband of 5 MW (i.e. greater than the minimum bid size), then AGC would be unable to use the 4 MW of enabled Regulation FCAS at that facility. Therefore in order to ensure that all

procured Regulation is usable, it is necessary and highly appropriate to require a suitable Setpoint Change Deadband.

Regarding Hydro Tasmania's second query, a provider can ensure that the Setpoint Change Deadband is set appropriately by checking with AEMO. The value is normally set during an agreed AGC tuning exercise for the facility. AEMO and the participant will agree the value in correspondence when a facility undergoes AGC tuning. Participants will not be held responsible in the event of any change to their Setpoint Change Deadband at AEMO's end unless agreed between AEMO and the participant.

#### Testing cycle

Hydro Tasmania's submission on the length of the testing cycle and its ability to test its fleet in a time and cost-effective manner is a matter that should be addressed separately by Hydro Tasmania, not through this consultation. AEMO would be pleased to work with Hydro Tasmania to develop a reasonable approach.

AEMO also noted commentary relating to what exactly providers would need to do to undertake testing, especially as the testing would require significant co-ordination input from AEMO. AEMO has therefore clarified the testing process in 10.6 of the MASS to clarify that providers must notify AEMO of their intention to test within the specified timeframes, not necessarily initiate or complete the tests, which will naturally be subject to a variety of scheduling constraints to be worked through between the provider and AEMO.

#### Transition period for new Regulation FCAS requirements

The transition period for the new Regulation FCAS requirements has been given a firm end date of 22 December 2023. This provides a two-year transition period, increased from AEMO's original proposal of one year.

#### Other requirements

Submissions did not include material feedback on the other new Regulation FCAS requirements.

### 5.3.3. AEMO's conclusion

#### Control Request Feedback

Minor amendments have been made to the MASS to address points raised.

#### Maximum Control Response Delay (CRD)

The definition of Control Response Delay in the MASS has been revised to make clear that the requirement is an end-to-end value, and therefore includes delays both internal and external to the participant.

#### Setpoint Change Deadband

A typo relating to the Setpoint Change Deadband requirement has been addressed in the MASS as per the discussion in section 5.3.2.

#### Testing Cycle

The Testing Cycle for Regulation FCAS providers has been retained at four years, and the requirements around how to engage with AEMO regarding the testing have been clarified in section 10.6 of the MASS.

#### Transition period for new Regulation FCAS requirements

All providers of Regulation FCAS must comply with new requirements, as identified within the MASS by 23 December 2023.

### Other requirements

No further material changes have been made to other Regulation FCAS requirements.

## 6. FINAL DETERMINATION

Having considered the matters raised in submissions, AEMO's final determination is to amend the MASS in the form published with this Final Determination, in accordance with clause 3.11.2 of the NER. As specified in clause 3.11.2(e), amendments to the MASS must not take effect until at least 30 days after publication. AEMO has therefore determined an effective date for the amendments of 1 February 2022.

# APPENDIX A. GLOSSARY

| Term or acronym | Meaning |
|---|---|
| [number] ms | millisecond |
| [number] s | second |
| AEC | Australian Energy Council |
| AEMC | Australian Energy Market Commission |
| AGC | Automatic generation control system |
| Aggregated Ancillary Service Facility | As defined in the MASS. |
| Ancillary Service Facility | As defined in the MASS |
| API | Application programming interface |
| ARENA | Australian Renewable Energy Agency |
| BESS | Battery energy storage system |
| BTM | Behind the meter |
| C&I | Commercial and industrial |
| Contingency FCAS | Any of the following:<br>• fast raise service;<br>• fast lower service;<br>• slow raise service;<br>• slow lower service;<br>• delayed raise service; and<br>• delayed lower service |
| CTI | Contingency time identifier |
| CRD | Control response delay |
| Deadband | The frequency band within which an Ancillary Service Facility will not provide frequency response in accordance with the applicable Contingency FCAS requirements or PFR requirements |
| DEIP | ARENA's Distributed Energy Integration Program |
| Delayed FCAS | Delayed raise service and delayed lower service |
| DER | Distributed energy resources |
| DI | dispatch interval |
| DNSP | Distribution network service provider |
| DOE | Dynamic operating envelope |
| DUID | Dispatchable Unit Identifier |
| EA | EnergyAustralia |
| ESB | Energy Security Board |
| ESS | Energy storage system |
| Fast FCAS | Fast raise service and fast lower service |
| FCAS | Frequency control ancillary services, referred to as market ancillary services in the NER – effectively, Contingency FCAS and Regulation FCAS |
| FCAS Provider | A Market Participant in one or more FCAS markets |
| FCAS Verification Tool | An Excel spreadsheet published by AEMO to assist market participants to calculate FCAS delivered by their plant |

| Term or acronym | Meaning |
|---|---|
| FFR | Fast frequency response |
| Final Determination | This document. |
| First Draft Determination | AEMO's draft determination and report published on 14 June 2021. |
| First Stage Report | The UoM's report submitted to AEMO in June 2021, which AEMO relied on in reaching the First Draft Determination. |
| FOS | Frequency operating standard |
| Frequency Disturbance | An occasion when the power system frequency moves outside the NOFB |
| Frequency Disturbance Time (FDT) | As defined in the MASS |
| Frequency Settings | As defined in the MASS |
| Hz | Hertz |
| Issues Paper | AEMO's Issues Paper titled: Market Ancillary Service Specification Consultation – January 2021 |
| Local Frequency | The frequency of the electricity delivered by an ancillary service generating unit or consumed by an ancillary service load, measured in Hz |
| Lower FCAS | Any of the following (terms defined in the NER):<br>• fast lower service;<br>• slow lower service; and<br>• delayed lower service. |
| MASS | Market ancillary service specification |
| ms | millisecond |
| MW | megawatt |
| NEM | National Electricity Market |
| NEMDE | The NEM dispatch engine |
| NEO | The objective specified in section 7 of the National Electricity Law, which is to:<br>… promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to—<br>(a) price, quality, safety, reliability and security of supply of electricity; and<br>(b) the reliability, safety and security of the national electricity system. |
| NER | National Electricity Rules |
| NMI | National metering identifier |
| NOFB | Normal operating frequency band |
| NSP | Network Service Provider |
| OEM | Original equipment manufacturer |
| Option 1 | See the description in section 2.2 |
| Option 2 | See the description in section 2.2 |
| PFR | Primary frequency response |
| PIAC | Public Interest Advocacy Centre |

| Term or acronym | Meaning |
|---|---|
| Project Match | Project MATCH aims to establish a robust monitoring and analysis toolbox to better understand the behaviour of distributed energy resources (DER) and implications for power system security. It will investigate DER behaviour during power system disturbances and seeks to support secure power system operation under high penetrations of DER. |
| Mandatory PFR Rule | National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5 |
| Raise FCAS | Any of the following:<br>• fast raise service;<br>• slow raise service; and<br>• delayed raise service |
| Regulation FCAS | Any of the following:<br>• regulating raise service; and<br>• regulating lower service |
| Reposit | Reposit Power |
| Rheem & CET | Rheem Australia & Combined Energy Technologies |
| RIS | AEMO's Renewable Integration Study |
| RoCoF | Rate of change of frequency |
| s | second |
| SA | South Australia |
| Second Draft Determination | AEMO's draft determination and report published on 28 October 2021. |
| Second Stage Report | The UoM's report submitted to AEMO in October 2021, which AEMO relied on in reaching the First Draft Determination. |
| Slow FCAS | Slow raise service and slow lower service |
| Switching Controller | A control system that delivers a specific amount of FCAS by either switching generation or load on or off (as applicable) in response to parameters specified by AEMO |
| Tesla | Tesla Motors Australia |
| Third Stage Report | The UoM's report submitted to AEMO in December 2021, which AEMO relied on in reaching this Final Determination. |
| Trial Participant | A participant in the VPP Demonstrations |
| UoM | University of Melbourne |
| VPP | Virtual power plant |
| VPP Demonstrations | Program of work designed to inform changes to regulatory frameworks and operational processes so DER can be effectively integrated into the FCAS markets |

# APPENDIX B. SUMMARY OF SUBMISSIONS AND AEMO RESPONSES

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| 1 | Various | **Measurement Time Resolution for FCAS provided by DER**<br>See section 4.1.1. | See sections 4.1.2 and 4.1.3. |
| 2 | | **Location of Measurement Point for FCAS provided by DER**<br>See section 4.2.1. | See sections 4.2.2 and 4.2.3. |
| 3 | | **Transitional Arrangements**<br>See section 4.3.1. | See sections 4.3.2 and 4.3.3. |
| 4 | | **Application of the NEO to the provision FCAS by DER**<br>See section 4.4.1. | See sections 4.4.2 and 4.4.3. |
| 5 | | **Integrity of the Consultation**<br>See section 4.5.1. | See sections 4.5.2 and 4.5.3. |
| 6 | | **MASS Readability and Usability**<br>See section 5.1.1. | See sections 5.1.2 and 5.1.3. |
| 7 | | **Co-ordination between different FCAS and PFR**<br>See section 5.2.1. | See sections 5.2.2 and 5.2.3, |
| 8 | | **Requirements for Regulation FCAS**<br>See section 5.3.1. | See sections 5.3.2 and 5.3.3. |
| 9 | AGL | **Consultative Forum**<br>AGL supports AEMO's intent to utilise its Consultative Forum as a vehicle for collaboration between AEMO and interested stakeholders to raise, prioritise, and progress issues relating to the development of market ancillary services in the NEM and address the concerns with DER inverter behaviour. We agree with AEMO's view that the Consultative Forum should primarily address technical issues (including power system security concerns, inverter behaviour, the impact on distribution network limits, the application of AS/NZS4777 2:2020) and be attended by technical experts. | AEMO is grateful for the support shown for the consultative forum. Further detail about this will be communicated to industry early in 2022. |

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| | | AGL also welcomes AEMO's publication of a roadmap alongside its Second Draft Determination to indicate proposed work to be carried out in considering the provision of more FCAS by DER into the future. The roadmap will provide a useful starting point for AEMO to develop solutions to a range of complex challenges associated with DER participation in FCAS provision in collaboration with technical industry experts. | |
| | EA | EA supports the Consultative Forum initiative. This includes both the proposed topics of investigation and the indicative roadmap set out in Appendix D. Beyond facilitating further consideration of technical concerns, this should also make future MASS updates easier and swifter. | |
| | Evergen | We recognise the challenging role that AEMO has, and maintain our position in wishing to collaborate with AEMO and others to advance thinking in this area. | |
| | Rheem & CET | … we would welcome involvement in a Consultative Forum as proposed by AEMO as a means of engaging stakeholders and better informing AEMO in its deliberative processes. | |
| | Tesla | **DER consultative forum**<br>As per our comments in the response to the previous MASS Draft Determination, Tesla is very supportive of AEMO's proposal to establish a DER Consultative Forum. We would reiterate our support for establishing this forum and believe that it should be set up as a matter of priority, particularly as AEMO looks to finalise the approach taken for collecting compliance data on an ongoing basis.<br>We largely agree with AEMO's approach to keep the Consultative Forum technical in nature, though we do think it is important for AEMO to clearly link the different work-streams with the various DER policy priorities as well. This will reduce duplication of effort and ensure that the insights garnered in the Consultative Forum are used to their best effect.<br>Tesla supports the Roadmap set out by AEMO. We also believe that the following points should be considered: | |

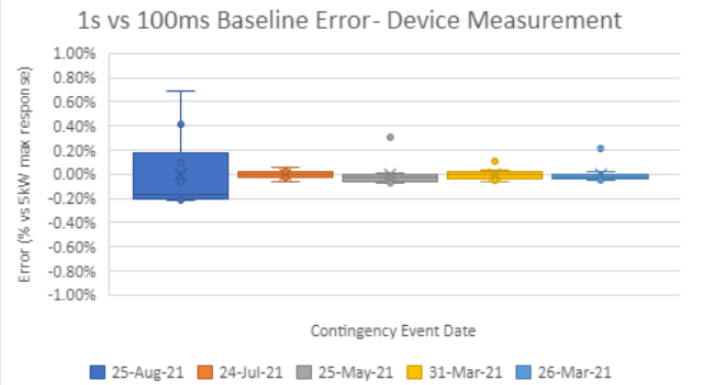
<table>
<tr><th>No.</th><th>Consulted person</th><th>Issue</th><th>AEMO response</th></tr>
<tr><td></td><td></td><td>• The DER Consultative Forum could also be used to formalize AEMO's and DER provider/ VPP data-sharing arrangements and continue to address any residual concerns regarding oscillatory behaviour from particular DER assets.<br>• It would be helpful for AEMO to provide more detail on what goes into each line item of the Workstream.<br>• For each workstream clear terms of reference should be set, and it would be helpful for AEMO to set out at the start the technical inputs and data sharing requirements from each participant.<br>• The UoM independent analysis has been helpful in the MASS Review. We recommend that AEMO considers which workstreams require independent analysis and<br>• engage the appropriate parties early.</td><td></td></tr>
<tr><td>10</td><td>sonnen</td><td>Creating a privileged class of participants<br>sonnen is the only Market Participant that operates under both the VPP Demonstrations and the MASS frameworks which provides sonnen an unique and informed perspective on AEMO's proposals.<br>Both sonnen VPP clusters utilise identical hardware and VPP coordination capabilities but deliver vastly differing market opportunities (Table 1).<br><table><tr><th>VPP cluster Regulatory Framework and jurisdiction</th><th>Market registration</th></tr><tr><td>VPP Demonstrations, NSW</td><td>6 Contingency FCAS</td></tr><tr><td>MASS framework, SA</td><td>2 Lower Contingency FCAS</td></tr></table>Table 1. Comparison of VPP Demonstration and MASS opportunities for identical resources<br>Comparing an equivalent number of aggregated batteries under each framework, and the technical and jurisdictional regulatory benefits afforded to Trial Participants the value of market revenue streams is vastly different.<br>For each day the VPP Demonstration framework is permitted to exist, value is transferred to a privileged class of Market Participants</td><td>The combined FCAS capacity from Trial Participants in total is 31 MW. Considering the quantity of FCAS that could be enabled, AEMO considers the transitional arrangements to be fair and gives them time to transition to the MASS. As noted in sections 4.3.2 and 4.4.2, the total Fast FCAS market share of Trial Participants is immaterial and should not distort the FCAS markets until the end of the transition because their capacity is capped at mid-2021 levels.</td></tr>
</table>

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| | | at the expense of those who compete on the level playing field provided by the MASS.<br>…<br>**Establishing a level playing field to encourage new entrants and support innovation**<br>sonnen encourages AEMO to take away the 'training wheels' and let DER compete on a level playing field with other FCAS Providers.<br>sonnen is strongly of the view that given the significant pace of the renewable energy transition occurring at a distribution and transmission network level any transitional arrangements for Trial Participants will hinder the recognition of DER as a genuine solution to the challenges facing the broader market.<br>Under the VPP Demonstrations framework AEMO has no obligation to place the investment of incumbents ahead of new entrants. sonnen committed resources to the VPP Demonstrations without commitments to future market access. The VPP Demonstrations existed to support informing the evolution of the MASS but has failed to be an effective tool for doing so.<br>While sonnen disagrees with AEMO's decision to abandon the distinguishing features of the VPP Demonstrations specification (for example measurement point location), we strongly believe the transitional mechanism will distort the market in favour of the incumbent Trial Participants at a critical time for the development of the industry.<br>If the proposed Transitional Arrangement is implemented sonnen expect it will be sound commercial behaviour for participants to replenish their portfolios to the point that there are sufficient assets to ensure the registered capacity in the Fast FCAS is constantly available to the market.<br>Given that value derived from Fast FCAS is typically higher than the Slow and Delayed FCAS, those Trial Participants with underutilised registered capacity will gain a greater marginal net benefit from placing a new asset into a VPP Demonstrations cluster than an FCAS Provider would receive for an identically performing asset.<br>Broader availability of low-cost, proven, and robust MASS compliant high speed event recorders and supporting IT infrastructure solutions | |

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| | | will address this gap over time, however market share lost to privileged Trial Participants in the interim reduces the prospects of competitors reaching commercial scale.<br>The greater marginal benefit will assist Trial Participants to maintain marketing and sales momentum while others are developing MASS compliant solutions. MASS compliant FCAS Providers will be at a competitive disadvantage until the Transitional Arrangements terminate, or the VPP Demonstrations clusters completely utilise their registered capabilities. | |
| 11 | AGL | **Inertial response**<br>We recommend AEMO also prescribe the meaning of inertial response in the MASS, in order not to create any barriers to aggregated DER assets providing inertia market services into the future, should that be necessary as the NEM continues to evolve. While further technical work will be required to support the provision of inertia services from aggregated DER, the MASS should not inadvertently establish an additional barrier. We recommend AEMO incorporate the language used in the UoM's analysis, that describes inertial response by reference to the physical properties of "synchronous machines" rather than inertia as a market service. | The references to "inertial response" in Table 4 should be capitalised, so that they are interpreted in accordance with the Glossary in Table 1. The correction has been made.<br>The term "Inertial Response" is not used in the NER but the definition incorporates the NER-defined term "inertia". At present, there are no "inertia market services" in the NEM. Should this change, it will be necessary to revisit the issue, but AEMO does not intend to pre-empt something that is not known at this stage. |
| | Tesla | Tesla notes that the current wording of the 200 ms requirement for "*aggregated facilities with no inertial response*". Our understanding of the description of inertial response (per the UoM analysis) is that this refers to the physical properties of "synchronous machines". As such in this context it is used as a physics term, rather than as a reference to "inertia" as a future market service.<br>We think that this is an important distinction for AEMO to make considering the AEMO Application of Grid Based Inverters in the NEM" White Paper that was released in August this year . That paper highlights the ability of inverter-based technologies to contribute to system inertia (when operating in grid forming mode). The White Paper also notes:<br>*This does not exclude the potential of smaller distributed energy resources (DER) to provide capabilities in line with the applications discussed in this paper.* | |

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| | | As with the development of all new market or grid services, Tesla deems it prudent to ensure that DER are not inadvertently excluded from accessing these future markets or contracted services, provided they are technically able to meet all requirements.<br>**Tesla position: AEMO should clarify that "inertial response" in this respect refers to the physical properties of synchronous machines and is not intended to exclude VPPs from being able to provide future inertia market services if the market deems that necessary. We recognise that further work will need to be done to ensure that VPPs set up to support system inertia will also need to demonstrate that this does not interfere with MASS compliance and the ability to fully deliver on FCAS bids**. | |
| 12 | Tesla | **Baselining data requirements used by AEMO**<br>The one concern that Tesla has with a transition to 200 ms resolution for aggregated assets, is whether that same data resolution is required over the 5 s preceding an FDT. AEMO has noted that conditional logging is appropriate for providing compliance data, which Tesla is fully supportive of as it significantly reduces the overall data storage requirements associated with logging and storing millions or billions of datapoints for a fleet of assets. Where logging at 200 ms is triggered by a change in frequency, capturing the 5 s preceding an event at the same data resolution is challenging. Where data needs to be logged at 200 ms at all times to provide the same resolution for the 5 s prior to an FCAS event, it may undermine the allowance of conditional logging.<br>Tesla's understanding is that the average value of these measurements is only used to calculate a baseline for the purpose of Fast FCAS assessment, noting the potential challenges associated with capturing the 5 s prior to a frequency event using the same measurement resolution (under a conditional logging approach), Tesla has undertaken further analysis to determine whether 200 ms (or 100 ms data) provides any additional benefits when compared to 1 s data. Note that this analysis has been undertaken purely for the assessment of measurement resolution needed to establish a baseline. Tesla accepts AEMO's position on 200 ms data resolution for the duration of the event and the 60 s following an event. | An assumption in Tesla's analysis of the error resulting from the calculation of the baseline is that the total change in active power from each system is 5 kW for the events analysed.<br>The error calculation should have instead considered the FCAS response required at the time based on the droop setting and local frequency measurements following a frequency disturbance, which would result in an increase of the error. Due to the improvement in frequency performance, system frequency tends to remain closer to the NOFB following a power system incident. An error in the baseline can have an impact on the verification of FCAS compliance particularly when the amount of FCAS delivered by the variable controllers is only a small percentage of the enablement amount<br>It has not been demonstrated up to this stage of the consultation that the determination of the baseline using 200 ms would be barrier to entry in the FCAS markets.<br>AEMO also notes that further analysis and consultation would be required before such a change could be reflected in the MASS, and AEMO must conclude this consultation within the timeline previously advised. |

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| | | Tesla ran an analysis using the 100 ms battery power measurements of 10 sites registered under VSSEL1V1 during five contingency raise events. We concluded that using 1 sec measurements instead of 100 ms measurements would have led to an over-estimation of the FCAS delivered no greater than 11 Watts per Powerwall, that is 0.22% of the 5kW expected response at 49.5Hz. The average value of the fifty 100 ms measurements over the 5 s preceding the FDT is the benchmark against which the average value of the five 1-s measurements is compared.<br>Given that there are ten 100 ms measurements in a 1-s interval, there are ten possible distinct average values of the 1-s measurements, each of which produces a different error compared to the 100 ms benchmark. The figure below shows the results of this analysis, with the 0.22% baseline error mentioned previously observed for the 25th of August event (most negative value). It is worth noting that for contingency raise events, a positive error would lead to an underestimation of the FCAS delivered. Indeed, the maximum error observed was 35 Watts per Powerwall (or 0.70% of 5kW) on 25th August, from an average 1-sec baseline of 1.275kW vs the average 100-ms baseline of 1.240kW. This is due to the same phenomenon as the one observed by UoM in their study of the FCAS window assessment methods, where the 1-sec measurements may capture the very beginning of an FCAS response at certain devices depending on which ms the frequency excursion happens vs which ms the 1-s measurement happens.<br>For context for this analysis, Powerwalls have demonstrated in the Frequency Injection Tests that they respond to Frequency Disturbances within about 250 ms, as mentioned in our previous submission. It is also important to note that this open loop inverter-based response does not rely on a meter's power measurements and that the baseline used by the control loop which provides FCAS is the amount of real power injected/absorbed ms before the FDT. | |

| No. | Consulted person | Issue | AEMO response |
|---|---|---|---|
| | |  <br>In addition to the analysis above, Tesla notes that a ≤200 ms measurement speed over 5 s will provide 25 measurements for Fast FCAS, while AEMO is satisfied with 5 measurements for Slow and Delayed FCAS which require ≤4sec measurement speed over 20 s. Tesla would suggest that AEMO considers a 1-s measurement speed requirement over the 5 s preceding the FDT, which will provide 5 measurements for baselining purposes.<br>**Tesla position: Tesla recommends that AEMO consider using 1 s resolution for the 5 s prior to an FCAS event (for baselining purposes) and 200 ms during and after the event. We suggest that AEMO consider data from Tesla and other Trial Participants to verify our modelling above.** | |
| 13 | Tesla | Tesla supports the ongoing clarification from AEMO in respect of the incorporation of the Interim Arrangements for DER[62], which clarifies that both imports and export flows from ancillary services generating unit and ancillary services load can be used for FCAS purposes. | |
| 14 | Hydro Tasmania | Lastly, with the new 200 ms data in place, Hydro Tasmania would like to clarify whether the existing regional high speed data logger (50 ms) will remain relevant, or become redundant following these amendments. | The 50 ms high speed logger was only required for Trial Participants capturing data at 1 s intervals. It will not be required if measurements at 200 ms intervals are captured. |

[62] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/New-Participants/Interim-Arrangements-for-FCAS-from-DER.pd

<table>
<tr><th>No.</th><th>Consulted person</th><th>Issue</th><th>AEMO response</th></tr>
<tr><td>15</td><td>Hydro Tasmania</td><td>6.1 Frequency Deviation Settings Provided by Switching Controllers<br>Hydro Tasmania suggests that the Default Frequency Deviation Setting in Tasmania should remain unchanged (see Table 6 below).<br>Table 6 Frequency Settings for Tasmania<table><tr><th>Level</th><th>Raise FCAS Frequency Deviation Setting (Hz)</th><th>Lower FCAS Frequency Deviation Setting (Hz)</th><th>Frequency Rate of Change Multiplier</th></tr><tr><td>Frequency Deviation Setting range</td><td>49.50 Hz to 48.75 Hz</td><td>50.50 Hz to 51.25 Hz</td><td>0.875</td></tr><tr><td>Default Frequency Deviation Setting</td><td>49.5125 Hz</td><td>50.5825 Hz</td><td>0.875</td></tr></table>Subject to the system inertia and PFR conditions at the time, Tasmania system frequency deviation introduced by the Basslink power flow reversal could reach 0.4-0.6 Hz, occasionally up to 0.8Hz. On this basis, we consider the existing default setting reasonably reflects the Tasmania system frequency condition, and therefore, suggest the current definition be maintained. Hydro Tasmania also notes that the current Default Frequency Deviation Settings are asymmetric, and query whether this was intentional, or a slight error in the MASS.</td><td>Covered in Section 5.2</td></tr>
<tr><td>16</td><td>EA</td><td>Delayed FCAS and FFR<br>We also support the decision to consider Delayed FCAS and FFR as part of the next MASS consultation. This will allow for more time for further, considered deliberation given their noted technical complexities.</td><td>Noted.</td></tr>
</table>