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

DRAFT REPORT AND DETERMINATION

Published: 14 June 2021

NOTICE OF SECOND STAGE CONSULTATION – AMENDMENT OF THE MARKET ANCILLARY SERVICE SPECIFICATION – DER AND GENERAL CONSULTATION

National Electricity Rules – Rule 8.9

Date of Notice: 14 June 2021

This notice informs all Registered Participants and interested parties (Consulted Persons) that AEMO is commencing the second stage of its consultation on amending the Market Ancillary Service Specification.

This consultation is being conducted under clause 3.11.2 (c) &(d) of the National Electricity Rules (**NER**), in accordance with the Rules consultation procedures detailed in rule 8.9 of the NER.

Invitation to make Submissions

AEMO invites written submissions on this Draft Report and Determination (**Draft Report**).

Please identify any parts of your submission that you wish to remain confidential and explain why. AEMO may still publish that information if it does not consider it to be confidential but will consult with you before doing so.

Consulted Persons should note that material identified as confidential may be given less weight in the decision-making process than material that is published.

Closing Date and Time

Submissions in response to this Notice of Second Stage of Rules Consultation should be sent by email to mass.consultation@aemo.com.au, to reach AEMO by 5.00pm (Melbourne time) on 6 July 2021.

All submissions must be forwarded in electronic format (both pdf and Word). Please send any queries about this consultation to the same email address.

Submissions received after the closing date and time will not be valid, and AEMO is not obliged to consider them. Any late submissions should explain the reason for lateness and the detriment to you if AEMO does not consider your submission.

Publication

All submissions will be published on AEMO's website, other than confidential content.

EXECUTIVE SUMMARY

The publication of this Draft Report and Determination (**Draft Report**) commences the second stage of the Rules consultation process conducted by AEMO to amend the Market Ancillary Service Specification (**MASS**) under the National Electricity Rules (**NER**).

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

There were two key reasons noted for the consultation:

1. Whether it would be appropriate to amend the MASS to accommodate the provision of market ancillary services (**FCAS**) by distributed energy resources (**DER**) using the learnings from a trial of virtual power plant (**VPP Demonstrations**).
2. Whether to adopt a restructured, redrafted MASS following a review to improve clarity.

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**).

There was a broad range of views from Consulted Persons on the need to amend the MASS to accommodate FCAS provision from DER. Further analysis undertaken by AEMO has revealed an underlying error in the measurements captured at a slower time resolution than the MASS currently requires. The adverse consequences of this error, combined with the benefits of maintaining the measurement location at or close to the relevant connection point, and current uncertainty about the behaviour and response of DER inverters, have resulted in AEMO's draft determination to not amend the MASS to accommodate alternative measurement arrangements for FCAS provision from DER.

AEMO's draft determination sets a transitional period, until 30 June 2023, for VPP Demonstrations participants to either comply with the measurement arrangements in the MASS or exit the FCAS markets. This is based on the following considerations:

- The total fast FCAS capacity of VPP Demonstrations participants is 30 MW across four regions, so its impact on power system security is minimal and it is unlikely to affect any further MASS changes that may result from pending rule changes.
- VPP Demonstrations participants currently operating under the alternative measurement arrangements may need to make equipment and control system changes across their participating sites to be able to comply with the MASS measurement requirements for fast FCAS provision. AEMO considers that a transitional period of two years allows sufficient time to make the necessary changes.
- During the transitional period, the potential adverse impact of the measurement error at slower time resolutions will be mitigated by discounting the measured quantity, noting this applies to fast contingency services only.

Furthermore, AEMO intends to consult with industry outside of this consultation on the need for further studies of DER inverter behaviour. Specifically, this along with a number of substantive issues have arisen during the first stage consultation which AEMO would like to undertake further work on with stakeholders outside of the consultation on the MASS. AEMO has proposed to establish a Consultative Forum that would provide 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 National Electricity Market and address the concerns with DER inverter behaviour.

Submissions on the restructured MASS were largely positive, with several Consulted Persons identifying issues for further clarification. AEMO has adopted some of these and intends to make further improvements to the MASS with each future consultation, the first of which is anticipated to commence within 12 months of the conclusion of this consultation.

Along with adoption of the restructured MASS, AEMO has actioned a range of incremental improvements based on the matters put forth in the Issues Paper and the submissions received. These are:

- Clarification of MASS references to the Frequency Operating Standard.
- 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.
- New requirements and improved guidance for Regulation FCAS providers.

Other general MASS matters covered in the Issues Paper have been deferred to allow further consideration.

Additionally, AEMO has used this consultation to discuss matters related to the behaviour of non-frequency responsive FCAS with affected providers, and has proposed new actions to manage behaviour during system separation or when at risk of system separation.

AEMO's draft determination is to amend the MASS in the form published with this Draft Report.

CONTENTS

1. STAKEHOLDER CONSULTATION PROCESS

As required by clause 3.11.2(d) of the National Electricity Rules (**NER**), AEMO is consulting on the Market Ancillary Service Specification (**MASS**) in accordance with the Rules consultation procedures.[1]

AEMO's indicative timeline for this consultation is outlined below. Future dates may be adjusted depending on the number and complexity of issues raised in submissions.

Deliverable	Date
Notice of first stage consultation and Issues Paper published	19 January 2021
First stage submissions closed	11 March 2021
Draft Report & Notice of second stage consultation published	14 June 2021
Submissions due on Draft Report	6 July 2021
Final Report published	17 August 2021

The publication of this Draft Report marks the commencement of the second stage of consultation.

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

2. BACKGROUND

2.1. NER and NEL requirements

Clause 3.11.2(b) of the NER requires AEMO to have a MASS, which describes and specifies the requirement for each type of frequency control ancillary service (**FCAS**). It states:

> (b) *AEMO* must make and *publish* a *market ancillary service specification* containing:
>
> (1) a detailed description of each kind of *market ancillary service*; and
>
> (2) the performance parameters and requirements which must be satisfied in order for a service to qualify as the relevant *market ancillary service* and also when a *Market Participant* provides the relevant kind of *market ancillary service*.

The MASS may be amended at any time after following the Rules consultation procedures, as required by clause 3.11.2(c) & (d), which state:

> (c) *AEMO* may amend the *market ancillary service specification*, from time to time.
>
> (d) *AEMO* must comply with the *Rules consultation procedures* when making or amending the *market ancillary service specification*.

When considering changes to the MASS, AEMO is required to have regard to the national electricity objective (**NEO**), which is contained in section 7 of the *National Electricity Law*:

> 7—National electricity objective
>
> The objective of this Law is to promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to—
>
> (a) price, quality, safety, reliability and security of supply of electricity; and
>
> (b) the reliability, safety and security of the national electricity system.

Section 49(3) of the *National Electricity Law* states:

> (3) AEMO must, in carrying out functions referred to in this section, have regard to the national electricity objective.

[1] See rule 8.9 for the *Rules consultation procedures*.

When referring to AEMO's functions, section 49(1) includes these:

> **49—AEMO's statutory functions**
>
> (1) AEMO has the following functions:
>
> (a) to operate and administer the wholesale exchange;
>
> (b) to promote the development and improve the effectiveness of the operation and administration of the wholesale exchange;
>
> …
>
> (e) to maintain and improve power system security;

The need for FCAS arises out of AEMO's mandate to maintain power system security and AEMO operates a series of markets to procure the required FCAS. AEMO commenced the Virtual Power Plant (**VPP**) Demonstrations to identify whether power system security could be maintained or improved by the provision of FCAS by distributed energy resources (**DER**) and whether the FCAS markets could be improved to facilitate the provision of more FCAS by DER to achieve this.

The focus of the NEO is the long-term interests of consumers – that is electricity consumers overall. AEMO is conscious that changes that may directly benefit market participants, for example as producers of electricity or FCAS providers, could in some cases provide indirect benefits to some consumers. However, these need to be considered through a long term lens and across all relevant aspects of the NEO, for consumers as a whole.

There is no authoritative interpretation of the NEO other than the AEMC's Applying the Energy Market Objectives publication.[2] AEMO looks to it when seeking to apply the NEO.

The AEMC considers that:

> Changes that may be in consumers' short-term interests may not be in their long-term interests if those changes undermine incentives to make efficient investments and operational decisions over time.[3]

In the context of rapid technological change, the AEMC provides the following guidance:

> …the Commission's role is to establish market frameworks that allow the most cost-effective technologies to be deployed to minimise costs to consumers, while making sure that Australia's energy systems remain secure and reliable.

In its role as the power system operator, AEMO's primary concern is the maintenance of power system security but, in the context of the NEO, this means that AEMO must procure electricity and other services in the most cost-effective manner so as to minimise costs to consumers. These include the changing costs associated with maintaining power system security and reliability.

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 VPP to deliver FCAS in June 2019 (**VPP Demonstrations**). In its Issues Paper published on 19 January 2021 (**Issues Paper**), AEMO sought submissions on whether the trial specifications 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 the Issues Paper AEMO proposed two options for the measurement of FCAS provision from DER:

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[2] Available at: https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf

[3] AEMC, Applying the energy market objectives, 8 July 2019. Available at: https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf

- Option 1: To leave the measurement requirements in the current 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 NEO and FCAS delivery could still be verified accurately.

In addition to the DER questions, the Issues Paper presented a number of general improvements to the MASS that AEMO has identified as part of an ongoing review. This consultation seemed an appropriate time to consult on a restructured, redrafted MASS. The changes are aimed at improving its readability, accessibility, and usefulness, as described in the Issues Paper.

2.3. First stage consultation

AEMO issued a Notice of First Stage Consultation on 19 January 2021, along with the Issues Paper.

AEMO received 32 valid written submissions, and two late submissions.

AEMO also held two forums on 4 February 2021; one to address the general MASS review, the other to consider the DER issues with up to 40 organisations represented. Eight stakeholder meetings were held to discuss the submissions in more detail and also as a result of meeting requests from two Consulted Persons.

Copies of all written submissions, summaries of the meeting minutes, and a Q&A of issues raised in forums (excluding any confidential information) have been published on AEMO's website.[4]

3. SUMMARY OF MATERIAL ISSUES

Appendix B lists of all the issues arising from the proposal and raised by Consulted Persons while the material issues covered under Section 4 and 5 are summarised in the following table:

No.	Issue	Raised by
1.	Measurement Time Resolution.	Delta, Hydro Tasmania, Intellihub, Reposit Power, SwitchDin, Tesla & VIOTAS.
2.	Location of Measurement Point for FCAS provided by DER.	EQ, Evergen, Hydro Tasmania, Intellihub, Landis + Gyr, Members Energy, Reposit Power, Rheem & CET, Solar Analytics, SwitchDin, Tesla & VIOTAS.
3.	MASS readability and usability.	AGL, CleanCo, CEC, Delta Electricity, Hydro Tasmania, Infigen, Karit, Reposit Power, Shell Energy & Tesla.
4.	Clarification of references to the Frequency Operating Standard (FOS).	AGL, CleanCo, CEC, Delta Electricity, EQ, Hydro Tasmania, Infigen, Shell Energy & Tesla.
5.	Requiring non-frequency responsive facilities to deliver FCAS only when enabled up to 150% of enablement amount only.	AGL, CleanCo, CEC, Delta Electricity, Enel X, EQ, Hydro Tasmania, Karit, Reposit Power & SwitchDin.
6.	Co-ordination between FCAS and PFR.	AGL, CleanCo, CEC, Delta Electricity, Empower Energy, Enel X, Hydro Tasmania, Infigen, Reposit Power, Shell Energy, SwitchDin & Tesla.
7.	Relationship between MASS and other Instruments/Institutions	Delta Electricity, Infigen & Tesla.
8.	Requirements for Regulation FCAS.	AGL, CleanCo, Delta Electricity, Enel X, Hydro Tasmania, Infigen, Karit, Mondo, Shell Energy & Tesla.

[4] At https://aemo.com.au/en/consultations/current-and-closed-consultations/mass-consultation?submissions=4

No.	Issue	Raised by
9.	Clarification of requirements for Delayed FCAS.	AGL, CleanCo, CEC, Delta Electricity, Evergen, Hydro Tasmania, Infigen, Shell Energy, SwitchDin & Tesla.
10.	Issues associated with Pending Rule Changes and matters for Separate Consultation.	AGL, CleanCo, CEC, Delta Electricity, Empower Energy, Enel X, Hydro Tasmania, Infigen, Karit, Rheem & CET, Shell Energy, Simply Energy, Solar Analytics & Tesla.
11.	Need for a Holistic Review of the MASS	Infigen & Tesla.
12.	Leveraging Network Assets	Ausgrid, CPUE, ENA & EQ.

A detailed summary of issues raised by Consulted Persons in submissions and forums, together with AEMO's responses, is contained in Appendix B and in the DER MASS Review FAQ[5]. A summary of the meeting minutes has been published on the AEMO MASS consultation website[6].

4. DISCUSSION OF MATERIAL ISSUES – DER

AEMO needs to determine two matters concerning the participation of DER in the FCAS markets. The resulting changes to the MASS (if any) will depend on how those matters are resolved:

- What type of time resolution should measurements of Fast Contingency FCAS delivered by DER exhibit?
- Where should the measurement point be located, especially for aggregated DER?

The Issues Paper presented two options, with the differences highlighted in the following table:

	Option 1	Option 2
Measurement time resolution of power flow and local frequency for delivery of Fast Contingency FCAS	… at intervals of ≤50 milliseconds (ms) per *NMI*	… at intervals of <1 second (s) across all *NMIs* provided additional requirements met.[7]
Measurement location	*Connection point*	Inverter or controllable asset, provided additional requirements met.[8]

The submissions and AEMO's responses to the issues around the two options (and alternatives proposed by stakeholders) can be found in Appendix B. Sections 4.1 and 4.2 address the key issues.

4.1. Measurement Time Resolution for FCAS delivered by DER

4.1.1. Issue summary and submissions

The MASS requires measurements of power flow and local frequency be made at intervals of 50 ms or less for the purpose of verifying FCAS delivery. The specifications used during the VPP Demonstrations[9] permitted trial participants providing Fast Contingency FCAS to capture power flow and local frequency measurements on a time base equal to 1s from every controllable asset. These arrangements were

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

[6] Available at: https://aemo.com.au/consultations/current-and-closed-consultations/mass-consultation

[7] See section 2.3.2 of the Issues Paper.

[8] See section 2.3.2 of the Issues Paper.

[9] Available at: https://aemo.com.au/-/media/Files/Electricity/NEM/DER/2019/VPP-Demonstrations/VPP-Demonstrations-FCAS-Specification

designed to encourage participation in the VPP Demonstrations and test whether DER could be properly orchestrated to provide FCAS.

In the Issues Paper, AEMO sought submissions on whether the measurement time resolution specified in the MASS for Fast Contingency FCAS should remain at 50 ms, or if the 1 s measurement resolution trialled during the VPP Demonstrations is more appropriate.

AEMO was also open to considering alternative measurement options that could be demonstrated to meet the specified objectives.

Extracts from the major submissions on this issue are cited below.[10]

Delta:

> Delta Electricity recommends Option 1 for these reasons:
>
> - In a market where the accuracy of demand-supply predictions is reducing, AEMO are encouraged to seek the most accurate information possible.
> - The system inertia is reducing which is potentially increasing the RoCoF. 1s time sampling reduces the certainty of events between sampled data.
> - There are events that trigger on Delta's present 20ms high speed recorders that are not detected in the 4s sample set. 1s sampling will lose visibility of some of these. In addition, if units are only recording for triggered events and not maintaining a continuous 1s data set, the events may not be detected.
> - Consistency for all providers. Existing providers are meeting the existing standard. A reduced specification standard will reduce the overall standard and produce greater variability in the objective.

Hydro Tasmania:

> Based on the proposal in Option 2, the 1s sampling rate is used for the FCAS response integrity check but isn't directly used in the FCAS delivery evaluation. Instead, the actual FCAS delivery is calculation based e.g., the battery deadband and droop settings as well as the default battery performance based on the [Factory Acceptance Test] injection test.
>
> Given the chemical battery response effectiveness, this approach appears ok in general, however its suitableness may lessen if/once the VPP reaches other technologies outside of chemical battery e.g., if VPP involves in rotational sources and the initial response needs to be distinguished. To address this issue, the 100ms data appears to be a good long-term alternative as mentioned already.
>
> As the existing 50ms data resolution requirement was specified nearly two decades ago, it would be reasonable to conduct a technical review to understand the necessity of this requirement.
>
> Hydro Tasmania is happy to facilitate this analysis given Tasmania's unique power system condition e.g., small system and relatively large system frequency deviation, which provides a perfect window to understand if e.g. 100ms resolution data is sufficient for the system inertial response evaluation.

Intellihub:

> Advanced digital meters, performing the dual role of the revenue meter for the NMI, could provide the required measurement facilities for the fast raise and fast lower service. Leveraging the revenue meter for this capability is the most efficient means for measurement and validation of a response to a contingency event.
>
> The capabilities of advanced digital meters are often overlooked, particularly when seeking an innovative solution, as they are thought of simply as a means to produce a bill for the energy consumer. While for the most part, these meters are used to measure energy consumption in 30- minute and 5 minute intervals for billing purposes, these meters have capabilities far exceeding this simple use case. A standard residential digital meter of the current generation measures approximately 50 different parameters with calibrated high accuracy and updates these typically 10 times per second.
>
> A key driver for the Power of Choice reform, which commenced in 2017, was to enable innovation in the metering space. In line with this objective, Intellihub will be introducing its next generation of advanced digital meters this year. This next generation metering platform will have capabilities well beyond current generation meters. One of the design goals for this new metering platform is to come as close as possible to

[10] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

meeting the performance requirements for measurement facilities as per the current MASS without burdening the meter with additional cost. Advancements in technology have made this possible.

Figure 1: Generations of Electricity Meters

We set this goal with small scale DER in mind, to give the best possible performance at a cost compatible with VPPs. While accuracy and performance testing of our next generation meter against the MASS requirements is not yet available, we are confident in either meeting, or coming very close to meeting, the requirements in section 3.6 of the current MASS. Every new residential meter we install from the end of 2021 will have this capability as standard – it will not be an additional extra nor a special request.

Reposit Power:

3.4.1 Overestimation of energy delivered/withdrawn

Error in energy delivered into or withdrawn from a frequency deviation will affect the efficacy of an FCAS response. An overestimation of expected response from a VPP provider's offer will damage the ability of the Fast FCAS service to arrest a frequency deviation. As discussed throughout section 3 of this document, Option 2 introduces significant error into the delivery of Fast FCAS. This comes from an incorrect assumption of homogeneity across DER "type" and is compounded by the assumptions that must be made if 1Hz data is to be used for measurement.

Using this analysis Reposit estimates that Option 2 will decrease the certainty of energy delivered from a VPP to a Fast contingency event by 16%. That is AEMO would need at least 16% more Option 2 Fast FCAS MW than Option 1 Fast FCAS MW to arrest the same frequency deviation. Or in other words, Option 2 FCAS is likely to be no greater than 84% effective when compared to traditional FCAS.

Additionally, Option 2 removes the majority of the incentive for VPP providers to deliver a well-controlled, homogeneous response. This is because it assumes a well-controlled homogeneous response as part of its verification processes. As a result, VPP providers will make little to no effort to deliver high-energy FCAS responses but instead will focus on putting as much capacity into the market as possible. This is akin to the effect that solar feed-in-tariffs have had on the wholesale energy market. That is, well-controlled, reliably metered generation will be replaced by poorly controlled, poorly metered generation creating a double effect in the decrease of system security during frequency contingency events.

Even a VPP provider that is committed to enhancing system security is foiled by Option 2. A VPP provider (and AEMO) cannot detect energy under-delivery/withdrawal with 1Hz metering (see 3.3.6.3) and so has no chance of being able to rectify it. Likewise, Option 2 blinds AEMO to the actual response being delivered to a contingency event when a material proportion of a region's Fast FCAS capability is being provided by DER fitted with Option 2 metering.

Reposit asserts that should AEMO proceed with Option 2 but does not discount Option 2 FCAS, then system security will be diminished. Reposit suggests that this discount needs to be 16% (section 3.3.6.3.1). FCAS providing DER accounts for 30MW of Fast FCAS response today - 22MW of using Option 2 metering. This is a small percentage and a 16% error in this quantity is immaterial. However AEMO's own RIS has predicted up to 2.5 GW of aggregated, behind-the-meter storage within 5 years, most of it eligible for Option 2. This would be more than sufficient to saturate the FCAS markets with Option 2 DER. In this

circumstance AEMO would be forced to address this error or be faced with a continuous and material risk to system security.

SwitchDin:

Measurement Resolution for Fast Contingency Services - Frequency Measurement Accuracy

The limiting factor in delivering a solution that meets the requirement will likely be driven by integrating with hardware that is able to meet the frequency measurement accuracy of ≤ 0.01Hz error and ≤ 0.0025Hz resolution. This frequency measurement requirement is the same for Option 1 and Option 2. If AEMO chooses to proceed with Option 2 then SwitchDin recommends that consideration is given to whether this level of frequency measurement accuracy is required, or whether this can be relaxed in order to lower the cost of delivering a solution.

Measurement Resolution for Fast Contingency Services - Other Options

Consideration should be given to what measurement resolution and accuracy is required as a minimum to verify the delivery of FCAS from DER VPPs without the need for an additional HSM. This would ensure that more stringent requirements are only imposed where there is a clear need for verification at that level of resolution/accuracy. Measurement at 100ms resolution without additional HSM was included as an option within the VPP demonstrations indicating that lower resolution measurement may be sufficient without the need for an additional HSM.

In particular, alignment of FCAS measurement requirements with the future mandatory requirements of inverters (AS/NZS 4777.2:2020 Grid connection of energy systems via inverters, Part 2: Inverter Requirements) should be considered as this may result in lower cost implementation in the longer term.

Table 2.5 — Specification for measurement and calculation accuracy

Quantity	Measurement accuracy	Measurement time	Measurement range
Voltage	±1 % $V_{nominal}$	100 ms	0 to 280 V
Frequency	±10 mHz	100 ms	45 to 55 Hz
Active power	±4 % S_{rated}	200 ms	0 to 120 % S_{rated}
Reactive power	±4 % S_{rated}	200 ms	0 to ± 120 % S_{rated}
Apparent power	±4 % S_{rated}	200 ms	0 to ± 120 % S_{rated}
NOTE For the purposes of measurement accuracy, $V_{nominal}$ refers to 230 V of AS 60038.			

Source: AS/NZS 4777.2:2020 Grid connection of energy systems via inverters, Part 2: Inverter Requirements

Tesla:

Element	Tesla Position	Proposed Alternative
Frequency Injection test requirements	Frequency injection test on every different type of controllable device must be provided to demonstrate asset type performance.	Tesla supports this requirement.
All controllable units within the same VPP operate with the same type of FCAS controller	Tesla notes that this may conflict with the proposed "General" change that delayed services must be provided by switched controllers. Tesla is unsure how both requirements will be managed, particularly for VPP fleets that may use multiple technology types.	AEMO to clarity how this requirement will work in effect if all delayed services need to be provided by switched controllers.

Element	Tesla Position	Proposed Alternative
Additional metering requirements – 1 meter / 5MW	Tesla does not agree with this perspective. A 1 HSM/5MW appears like an arbitrary measure of individual system performance, as it will only provide site data for ~1/1000 systems. So using this as a rationale for the catching non-performing systems does not appear to be a sensible solution. Our primary concern with this approach will be the potential high cost of the solution (if utility spec. meters are required), the lack of affordable technologies that are proven to be MASS compliant, and the potential requisition issues if external meters need to be recovered from customer properties. … We understand that there are a number of companies that are working towards being able to provide 50ms data resolution in the future, however as none of these systems are currently registered to provide FCAS, both AEMO and VPP market participants would be taking a risk on these systems both being developed, and being deemed to comply with the MASS requirements. The lack of clarity on whether this may actually happen, and the timeframes for doing so will push VPP operators to the more expensive solutions in the short to medium term. It is also unclear as to whether these technologies will be capable of measuring frequency and power at the device terminal (as is proposed through this review process) and whether the technology is sufficiently neutral to be used by multiple VPP aggregators. A bad outcome of this review process would be if the MASS review inadvertently created a monopoly for a single aggregator or technology type.	Tesla believes that 1 meter per **technology type** per jurisdiction should provide AEMO with sufficient confidence on the asset level performance. This means that AEMO will have visibility on the performance of all systems participating in a broader VPP fleet. Tesla believes that this approach will provide more value to AEMO than the 1 meter / 5MW proposal that has been put forward in the Consultation Paper.

VIOTAS:

Measurement requirements need to be appropriate to the service being provided and, while 1s data resolution is sufficient for slower services, where participants are being paid for providing fast responses maintaining ms resolution data is an important requirement to ensure AEMO has sufficient resolution to validate response.

As the power system continues to transform, faster response services such as FFR will be required, and maintaining the highest standards of metering and verification will become increasingly important. Developments in the utilisation of ultra-fast response services are being seen in markets worldwide, as system operators work to manage their power systems with very high penetrations of non-synchronous renewable generation and reduced levels of inertia. Amending the MASS to allow potentially large volumes of controllable capacity to be deployed with low resolution measurement is likely to reduce the flexibility available as the system develops and progressively faster service requirements become increasingly prevalent.

VIOTAS believes the benefits of increasingly fast services are sufficient that there is significant merit in retaining the MASS measurement requirements, and mandating that service providers deploy the highest

> standard power meters and control systems that are capable of both faster response speeds and the associated monitoring and verification. VIOTAS believes it is important for ancillary services minimum technical requirements to be as broad as possible (enabling the widest possible range of providers) but for these to be complemented by strong price signals to incentivise the service delivery characteristics of highest value to the system. If faster responses are of higher value to the system, providers which can both provide and verify faster response should be paid more. In the Irish market for example, FFR requires full response within 2s (allowing a wide range of providers), but payment is subject to a scalar which rewards providers who can respond within 150ms threefold vs. a provider who can only meet the minimum 2s requirement. Allowing service providers to be deployed with lower standard metering systems may preclude the subsequent implementation of such market designs in the NEM, as these providers would be unable to measure or verify their performance with sufficient resolution.
>
> VIOTAS believes there is considerable merit in retaining the HSM (50ms) capability requirement for participants providing fast contingency FCAS. As the critical element of these services is delivered within 6s of a frequency event, being able to measure the frequency and power flows with high resolution during this period is a critical element of verification.

4.1.2. AEMO's assessment

Submissions on this issue were extremely diverse. The Consulted Persons who were in favour of changing the measurement time resolution to less than or equal to 1 s were, in most cases, opposed to the requirement for a high-speed meter for every aggregated capacity of 5 MW. Only 5 submissions were either supportive or silent on the requirement for a high-speed meter.

AEMO extended the first stage of this consultation to conduct more detailed analysis on the error associated with a measurement time resolution lower than 50 ms and to consider further the potential risks due to the behaviour of DER inverters following power system incidents, as highlighted in some submissions.

AEMO's assessment and key findings have been summarised in the following sections.

Hardware limitation

Support for changing the measurement time resolution to 1 s was mainly due to concerns over the need to install additional and more expensive hardware to capture data at less than or equal to 50 ms intervals.

During meetings with AEMO, Consulted Persons suggested that a 100 ms measurement resolution is currently achievable with various hardware setups currently in use, and it is likely that 50 ms will also be achievable in the near future. Some Consulted Persons also noted that a number of assets may already be capable of 50 ms sampling but that substantial testing is required to confirm this. AEMO notes that one DER FCAS Provider is currently participating in the FCAS markets with metering equipment that complies with the MASS, which calls into question the arguments that this cannot currently be achieved in an economic fashion.

AEMO also sought submissions on the cost of high-speed metering capability supported by evidence, and the cost per NMI ranged from $120 to $15,000[11] .

Alignment with AS/NZS 4777.2:2020

The newly updated AS/NZS 4777.2:2020 (effective in December 2021) specifies a DER inverter standard of measurement time, which is aimed at ensuring stable input data for utilisation in protection and control functions, rather than any data logging or measurement time resolution requirements. Data capture functionality is specific to each inverter make and model, as determined by the manufacturer, therefore, it is not appropriate to align the data sampling requirement set out in the MASS with this standard, as suggested in a number of submissions.

[11] Full particulars of submissions on the cost of implementation can be found in item 4 of Appendix B.

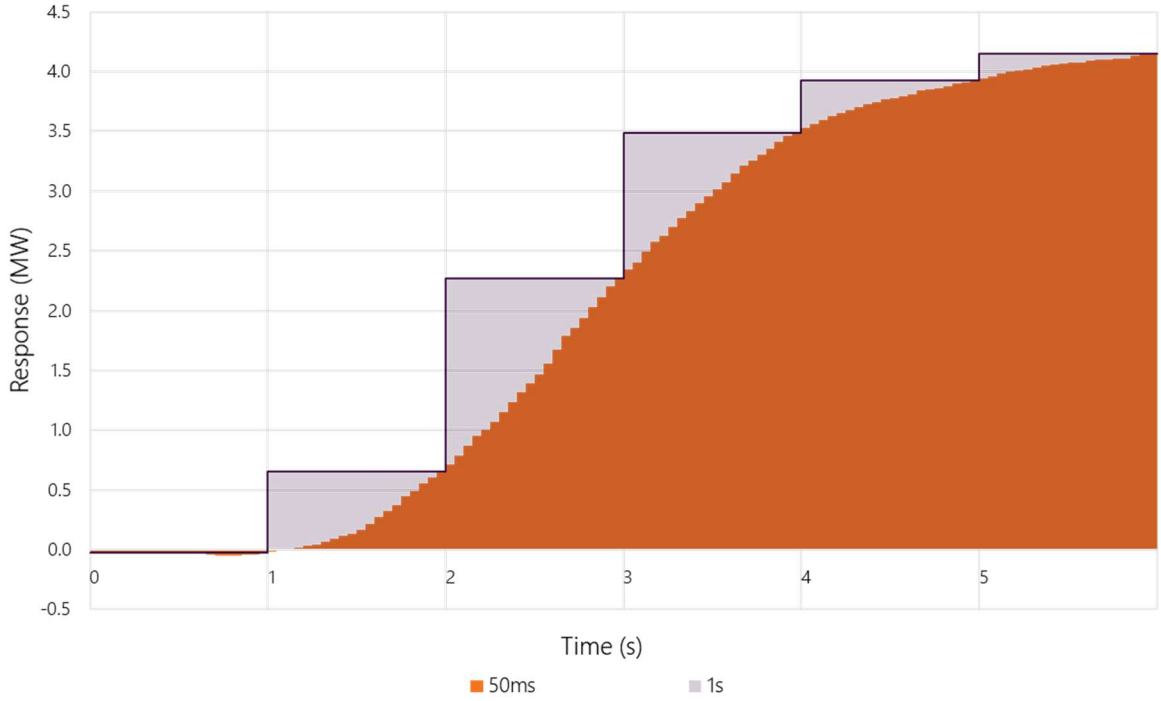
Error introduced with lower measurement time resolution

Reposit Power presented a mathematically based assessment that showed that a 1 s measurement time resolution introduces uncertainty of the order of 16% in power measurements. This uncertainty could result in an under-delivery of FCAS that is not detected due to the lack of data within those 1 s intervals. Failure to identify phenomena, such as oscillation within 1 s intervals, could lead to less energy being delivered to the grid during frequency disturbances, resulting in an extended frequency recovery period.

AEMO analysed measurement data from a DER FCAS Provider to confirm whether there is a difference in the amount of FCAS deemed to have been delivered if measurements of power and frequency are captured at 1 s intervals (as opposed to 50 ms), and to evaluate the percentage error introduced with the lower measurement time resolution.

Figure 1 presents the measurements of power and frequency from the high-speed data samples captured by a DER FCAS Provider with high-speed metering after a frequency disturbance, with data extrapolated every second.

Figure 1 Comparison of DER FCAS Provider data at measurement resolutions of 50 ms and 1 s



The purpose of Fast FCAS is to arrest a fall or rise in power system frequency following a contingency event that results in System Frequency being outside the Normal Operating Frequency Band (**NOFB**). Therefore, the amount of Fast FCAS delivered is calculated based on the change in active power over time and can be referred to as the 'area under the curve'. If the amount of Fast FCAS delivered was determined by subtracting the power flow measurement before a frequency disturbance and 6 s later, FCAS Providers could delay the start of their response and deliver a larger step change in active power just before 6 s of the Frequency Disturbance Time (**FDT**). This delay would not contribute to arresting the fall or rise in power system frequency. It is, therefore, critical that the Fast FCAS response from proportional or switching FCAS controllers can be verified over the first 6 s of a frequency disturbance.

The shaded area under the 50 ms and 1 s samples represents the amount of Fast FCAS delivered, as calculated using data at different measurement time resolutions using the Right Riemann sum method (as

used by the FCAS Verification Tool). It can be clearly observed that the 'area under the curve' is substantially larger when measurement at an interval of 1 s is used. This implies that an FCAS Provider can appear to have delivered more Fast FCAS due to power measurements being sampled at a lower time resolution.

The FCAS Verification Tool[12] facilitates the calculation of whether Contingency FCAS delivered by an ancillary service facility was delivered in accordance with the MASS. AEMO uses the FCAS Verification Tool in the first instance to assess the performance of ancillary service facilities and compliance with the MASS for the purposes of registration and verification following frequency disturbances. An adverse outcome identified using this screening tool will alert AEMO to potential under-delivery but requires further investigations to ascertain whether it occurred as a result of a failure by the FCAS Provider to provide FCAS in accordance with the MASS, or whether other factors are at play.

Using the FCAS Verification Tool to assess performance using the data underpinning Figure 1, one can see that an error of 25% is introduced for a time resolution of 1 s as compared to 50 ms, as shown in the table below:

Measurement time resolution	**50 ms**	**1 s**
Fast FCAS/MW	4.15	5.19

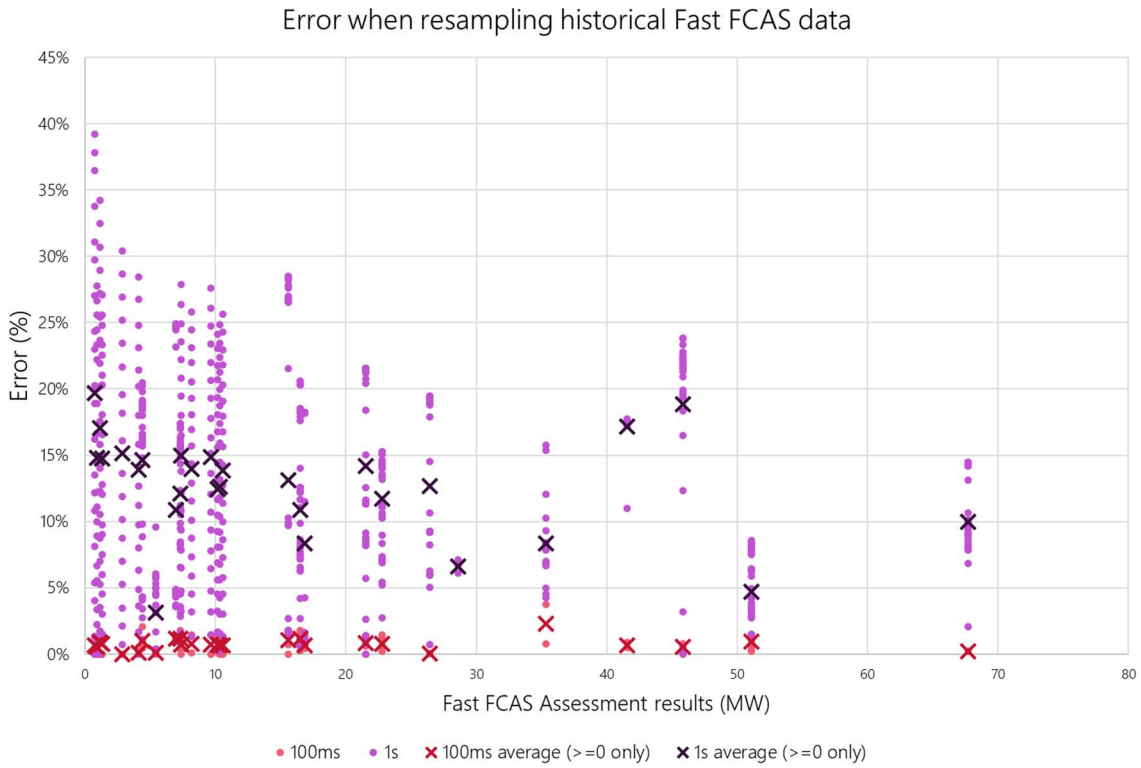
AEMO conducted further analysis on the error introduced when using measurement resolutions lower than 50ms, by evaluating the response from two DER FCAS Providers with *NMI* level high-speed *metering* capability. This analysis included 28 assessments over seven frequency events and five sets of the data provided by the two FCAS Providers for assessment during registration.

The results are summarised in Figure 2, after the data was assessed using the MASS FCAS Verification Tool, updated to use the Trapezoidal rule[13].

[12] Available at: https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/2020/external-fcas-verification-tool-v400-for-mass-v6.xlsx?la=en&hash=CE9BD3EDE1F921ABD522B6C300FF651F

[13] The Trapezoidal rule approximates the area under the curve by dividing the total area into smaller trapezoids as opposed to small rectangles for each data interval. It is considered to be a more accurate method of approximation than the Left or Right Riemann sums.

Figure 2 Average error calculation



The FCAS Verification Tool determines the FDT (t=0s) based on the first data sample of frequency outside the NOFB and this methodology is in line with the Right Riemann sum.

The maximum error introduced was 19.7% when the measurements of power were at a 1 s time resolution. AEMO also calculated the maximum error as 2.3% with measurements sampled at a 100 ms time resolution.

The University of Melbourne also completed an independent analysis[14] for AEMO for the purposes of this consultation confirming the error associated with a time resolution of 1 s. Its report indicates that the average error is 15% for 1 s data samples and 2.8% for 200 ms data samples and suggested the use of a different approach to determine the FDT, involving a 'universal window'[15] method as opposed to the 'relative window'[16] method used by the FCAS Verification Tool. Assessing FCAS delivery based on the 'relative window' approach can be shown to consistently over-estimate the delivery, and this bias increases as the sampling rate reduces. The 'universal window' approach is shown to reduce the average over-estimation bias to around 0% for 200 ms data samples and a maximum of 3% for 1 s data samples. The University of Melbourne acknowledged that:

> the universal window method considered here is for reference purposes. In practice, the actual implementation of such universal window mechanism requires further analysis to identify what procedures, requirements and possibly additional facilities would be needed to gather relevant data (e.g., to ensure timestamp synchronisation across various providers and with respect to a reference frequency disturbance identification that might be carried out by AEMO, for instance).

[14] Available at: https://www.aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/NEM-Consultations/2021/MASS/AEMO-FCAS-verification-UoM

[15] 'Universal window' assumes that a universal FDT can be defined for all FCAS Providers in each event and does not rely on the local frequency data sampled by each FCAS Provider (from The University of Melbourne report).

[16] 'Relative window' assumes the start point of the assessment window is determined by the first point sampled by the FCAS Provider when the local frequency crosses NOFB (from The University of Melbourne report).

AEMO notes that the 'universal window' approach can be beneficial in minimising the error associated with low measurement resolution, but would not have a significant impact on high resolution metering (as required by the MASS).

The University of Melbourne analysis suggested that a 200 ms measurement resolution combined with changes to AEMO's verification methodology (use of the "universal window") could be a good overall compromise. AEMO agrees that in the absence of the power system security concerns highlighted below, this approach could be considered, although it would require more conclusive information on the costs associated with different measurement options[17] and significant further work to identify all relevant issues and necessary changes to the MASS and the FCAS verification methodology. Given the potential significance of power system security and other concerns discussed in this Draft Report, at this stage AEMO has not identified a clear justification for that further analysis.

Power system security concerns

Some submissions and subsequent discussions with Consulted Persons have highlighted some of the risks associated with DER inverter performance and capability, in particular, the lack of a complete and common understanding of the behaviour of DER inverters in delivering services, such as FCAS, during local *distribution* network faults and power system disturbances.

UNSW submitted that its researchers have observed a broad range of responses from inverters following frequency and voltage variations and that certain inverter models can abruptly disconnect or undesirably curtail their output power upon application of voltage sags, phase-angle jumps, and rate of change of frequency.

PAP's submission referred to issues that need to be solved for aggregators within a distribution network, such as voltage management (voltage rise due to generation in the lower voltage levels on the network), voltage fluctuations from intermittent generation, network reliability, voltage balance between phases, harmonic mitigation, and fault identification and location.

Ausgrid's submission recommended that AEMO explore the interaction between market services and network connection arrangements with Distribution Network Service Providers (**DNSPs**) and Market Participants before finalising amendments to the MASS. Ausgrid also mentioned that DNSPs are developing and deploying dynamic operating envelopes that are likely to apply at a customer's connection point. It is envisioned that aggregators would be required to comply with the operating envelope limits at the connection point, including any limits on maximum ramp rates.

AEMO also summarised its analysis of DER behaviour during power system disturbances in a report[18] published in May 2021, which focused on DPV inverter behaviour. Future work will need to be completed following consultation with DNSPs and aggregators to explore the behaviour of other types of DER, including distributed battery installations, electric vehicles, and others.

There are a range of potential risks, and ways to manage them, associated with the behaviour of DER inverters, which are outlined below:

- **Risk:** Unexpected disconnection due to a local network fault, and potential power system security risks in frequency recovery if the unexpected inverter disconnections are not properly accounted for, resulting in a DER FCAS Provider not being able to respond to a frequency disturbance.
  - **Potential action:** Requiring compliance with AS/NZS 4777.2:2020 for all systems upon registration for FCAS. The updated AS/NZS 4777.2:2020 standard is intended to address some issues suspected to be influencing DER inverter disconnection rates, including better measurement and sampling, immunity to a broader range of plausible disturbances, and grid support capability,

[17] Information to date from Consulted Persons on the cost of high speed metering capability ranged from $120 – $15,000 per NMI

[18] Available at: https://aemo.com.au/-/media/files/initiatives/der/2021/capstone-report.pdf?la=en&hash=BF184AC51804652E268B3117EC12327A

however, the behaviour of legacy inverters is a significant concern, as well as compliance of assets tested and certified to the updated requirements.

- **Risk:** Behaviour during local distribution network and global power system disturbances posing a risk of under-delivery of FCAS due to inverter requirements, e.g. autonomous *reactive power* (Volt-Var response) support assisting voltage management in the distribution network prioritised over *active power* (FCAS response).
  - **Potential action:** Reaching industry agreement on the control hierarchy of participating DER inverters, to ensure security and reliability functions are prioritised appropriately and for this to be accounted for within aggregators' bidding. This was successfully tested in the South Australia Power Networks (**SAPN**) Advanced VPP Grid Integration Trial.[19] If adopted more broadly, VPP operators' bids into the FCAS markets would better reflect potential restrictions on FCAS enablement amount.
- **Risk**: Risks associated with large-scale, rapid *active power* injection or withdrawal from deeply embedded assets (aggregated to provide FCAS) exceeding the limits of secure distribution network operation limits.
  - **Potential action:** Coordination between DNSPs and aggregators to ensure distribution network limits are appropriately specified and prioritised within the control hierarchy of participating DER inverters. This could be through static rules or DNSPs issuing limits to aggregators on a dynamic basis. Several projects have tested flexible distribution network connection agreements and communicating dynamic operating envelopes to DER FCAS Providers, such as SAPN's Advanced VPP Grid Integration trial[20], the evolve[21] trial and Project EDGE[22]. SAPN's final report includes a section on 'Operating Envelopes during contingency scenarios' outlines capabilities and aggregator interactions with DNSPs that might be required as more DER participates in the FCAS markets.
  - **Potential action:** AEMO working with potential/existing DER FCAS Providers and DNSPs on how distribution network limits are accounted for in the registration of the aggregator as more DER operators seek to provide FCAS. The Wholesale Demand Response Guideline[23] includes a DNSP endorsement process to augment the assessment of the security impacts of aggregation, which recognises that DNSPs are best placed to assess the security risks that arise from aggregation in their distribution networks.
- **Risk:** Unexpected responses from inverters that cannot be identified using low granularity measurement, for example, if inverters deliver an oscillatory response within 1s intervals due to a voltage or frequency disturbance.
  - **Potential action:** AEMO to maintain the 50 ms measurement resolution requirement in the MASS in order to identify phenomena such as oscillatory responses.

Without careful consideration, these risks can materially impact aggregated FCAS delivery and give rise to increasingly complex consequential impacts and operational challenges, especially as aggregated DER

[19] SAPN, 2021. *Advanced VPP Grid Integration Final Report*. Available: https://arena.gov.au/knowledge-bank/advanced-vpp-grid-integration-final-report/. Pages 29-31.

[20] SAPN, 2021. *Advanced VPP Grid Integration Final Report*. Available: https://arena.gov.au/knowledge-bank/advanced-vpp-grid-integration-final-report/. Page 31, "Further analysis of the network impacts of this kind of transient response will be required to develop the business rules and technical parameters around 'emergency operating envelopes' which could be supplied to FCAS-responding plant, so that the greatest amount of additional FCAS capacity can be activated in emergencies without the risk of severe overload or tripping of other inverters or network plant."

[21] evolve DER Project. Available: https://arena.gov.au/projects/evolve-der-project/

[22] AEMO, *Project EDGE*. Available: https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/project-edge

[23] AEMO, 2021. Available: https://aemo.com.au/en/consultations/current-and-closed-consultations/wdr-guidelines.

participation grows. The submissions have also highlighted the likelihood that once operationalised, VPPs could quickly become a large proportion of Contingency FCAS in the market.

Other reforms will also lead to increasing aggregated DER participation in the energy market and the provision of network support and control ancillary services. Coordination between aggregators, DNSPs, Transmission Network Service Providers (**TNSPs**) and AEMO will be essential for enabling this future, allowing for:

- DNSP, TNSP and AEMO situational awareness of aggregated DER impacts on network assets and power flows based on an understanding of where participating devices are located.
- Specification of device-level requirements so that aggregated DER participation respects secure and reliable power system and local distribution network operation. This requires DNSPs to set location-specific restrictions (e.g. export limits, voltage regulation set points and ramp rates) and DER aggregators to configure devices to prioritise responses appropriately.
- Aggregators taking into account locational device-level requirements and reflecting this within the market bidding process, and for the locational impact of aggregated DER to be reflected in *dispatch* and operational decision-making, through appropriate representation in load estimation across different distribution network levels and at transmission connection points.

The development of fit-for-purpose coordination architectures and integration between AEMO, TNSP, DNSP and DER aggregator systems will be critical in a high DER future, especially in a world with many DER aggregators controlling assets in response to price and other signals. AEMO welcomes submissions on how this can be progressed to help address the identified risks and enable the provision of more FCAS from DER in the future.

AEMO is committed to working with industry to address the DER inverter behaviour concerns, but cannot raise the 50 ms sampling rate requirement until this work is complete. It is also anticipated that advances in high speed metering will reduce this issue as a barrier to entry.

Integrity of fast FCAS

A common thread underpinning AEMO's concerns over the dilution of the strict time resolution requirements in the MASS is the integrity of the fast contingency FCAS service. This issue is referred to by Reposit Power[24] and VIOTAS[25], and also noted by Delta Electricity[26]. In particular, this statement from Delta Electricity encapsulates the concern:

> ... the impact of poor-quality information, any subsequent greater mismatch and inaccuracy in the true supply and demand conditions and the overall impacts on frequency performance compounds the inaccuracy of supply/demand balance.

The accuracy of measurement of FCAS delivery has consequences across the whole spectrum of actions associated with the FCAS markets, from determining the needs of the power system to meet AEMO's power system security responsibilities, to economic procurement and payment for FCAS delivered and compliance with the MASS.

4.1.3. AEMO's conclusion

AEMO has concluded that it is not appropriate to change the measurement resolution for Fast FCAS.

The main reasons for this are:

- Concerns regarding the behaviour of DER inverters and whether, or to what extent, this could impact power system*/distribution* network security.

[24] See the extracts in section 4.1.1 and items 1, 2, 3 5 & 6 of Appendix B.
[25] See the extract in item 3 of Appendix B.
[26] See the extract in item 1 of Appendix B.

- The error introduced in the FCAS verification/compliance process when lowering the measurement resolution and the uncertainty of specifying the quantity of FCAS to be procured and actually delivered.

While changing the measurement time resolution requirement to 1 s may increase competition in the short term, the distortionary impact on the Fast FCAS markets does not promote the NEO. Similarly, the impact of the error on power system security does not promote the NEO. While measurement resolution of 100/200ms and changes to the FCAS assessment methodology may present a reasonable compromise, it is anticipated that in the time required to assess and confirm whether this is the case, advances in high speed metering will reduce this as a barrier to entry.

Notwithstanding the potential pathway AEMO has identified to address the errors associated with a lower data time resolution, given the power system security concerns associated with DER inverter behaviour, AEMO does not consider it to be prudent to reduce the granularity of the measurement resolution until approaches to address these concerns are implemented.

4.2. Location of Measurement Point for FCAS delivered by DER

4.2.1. Issue summary and submissions

One of the key issues to be determined by AEMO in the context of the incorporation of DER in the MASS was whether to leave the measurement location at (or close to) each relevant connection point to capture the net flow from, or to the grid, which is currently the case, or whether to create a less restrictive requirement for DER by permitting measurement at the inverter or asset level.

Submissions expressed a varied range of preferences for Option 1 or Option 2 (or a hybrid). A number of specific comments on the location of the measurement point for DER are extracted below.[27]

EQ:

> In EQ's view, there is the risk that gaming will occur if metering is moved to the inverter (which is behind the connection point). However, given the intent is that this arrangement will be for many small inverters, the ability of the aggregator to co-ordinate, for example a load increase co-incident to a fast raise generation out or vice versa, when they do not control the load at the premise is extremely remote, if not impossible.

Evergen:

- Measuring FCAS response at the connection point rather than at the battery inverter requires additional dedicated hardware and cost compared to current practice.
- All existing DER in Evergen's fleets and almost all residential DER in the country lack this hardware and would be immediately excluded from participating in VPPs offering FCAS.
- For new installs the inclusion of hardware to measure power and frequency at fast-FCAS-compatible sampling resolutions at the connection point is not a good value proposition for customers, since FCAS capability is not a key sales driver for residential DER and adding cost to the consumer by requiring additional hardware will negatively impact the speed of adoption of batteries more generally.

Hydro Tasmania:

> Hydro fully understands the challenge of specifying the measurement locations for different purpose.
>
> - In the Wide Test, for the purpose of understanding and demonstrating the battery performance, the measurement specified at the invertor / controllable device level appears practical and reasonable.
> - Whereas for the purpose of FCAS delivery evaluation, either a calculated or measured net grid response should be considered.

[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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

Intellihub:

While many of the initial VPP pilots have generally been carried out with a single controllable device at each site, often a battery, this configuration is unlikely to prevail. Going forward, it will be much more common for multiple devices at a single NMI to participate. Orchestration between these devices will take place such that the optimal device or combination of devices is used to respond to any given contingency event.

The best location to measure the response to a contingency event of a site with multiple devices is at the aggregate or net point, or in other words at the NMI. Measuring at the NMI level makes FCAS validation of sites with multiple responding devices possible and is desirable to support a broad range of use cases.

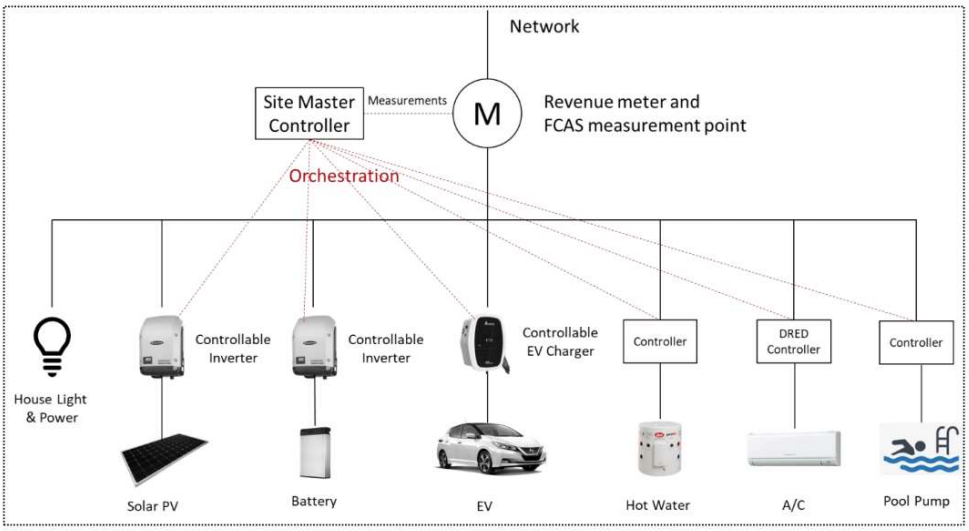


Figure 2: FCAS Measurement at the NMI permits orchestration of multiple devices

We recognise that measurement at the NMI level is not always preferable for the site owner or VPP operator, particularly for homogenous VPP configurations with a single device.

We propose that the current MASS requirement where the measurement point is defined as the NMI is retained, however we do not oppose exceptions for small DER where this is deemed appropriate.

Landis + Gyr:

In summary Landis + Gyr believe:

- The measurement must occur at the Point of Connection. Having the measurement point at any other location will introduce complexity to the settlement process when the market is looking for an aggregate response. It may also lead to perverse outcome where one device acts in a positive manner to the event whilst another device may act in a negative manner, allowing participants to manipulate the market outcome.
- The existing electricity metering system is best placed to be used as the mechanism to detect and record the response to FCAS events. The metering system not only consists of the physical meter but also the communications, data collection and data processing systems. Leveraging the metering system to also including MASS settlement data is seen as an incremental step and a cost-effective approach to the widespread types and numbers of devices that would be able to participate in the market.

Members Energy:

In the case of changing the metering point to the connection rather than the inverter/battery, we consider that costs would be significantly higher, including labour costs of site visits to install the equipment. Given the technical requirements can be adequately dealt with using the inverter/battery approach, we would affirm the connection point approach is not warranted, and would actually reduce the number of market entrants and competition, and therefore likely increase costs to consumers unnecessarily. We have formed this view after considerable experience of our market offering in NSW and Vic (compared to SA) and the current and anticipated future cost of connection point technologies.

Reposit Power:

3.4.2 Device-level metering

- Independent of the energy delivered/withdrawn error discussed above is Option 2's requirement that power flow be measured at the device rather than the connection point. This is a departure from the Connection Point measurement of response that has been used throughout the NEM from market start. The effect of this change in measurement is that error from absorbed energy (section 3.2.1) will increase by some unknown and changing amount over time.
- This absorbed energy will not contribute to the arrest of the frequency deviation, but will be assumed to be delivered to the grid. That is because AEMO procures energy in the form of FCAS offers to feed the contingency and assumes that it all reaches the grid. This is a valid assumption where FCAS measurement is conducted at the Connection Point, but it is not a valid assumption where FCAS measurement occurs behind the connection point. This is because another device behind the connection point could absorb some of that energy.
- AEMO recognise that this could occur intentionally28 and requires connection point metering (of unspecified properties) as a result. Clearly AEMO is concerned about absorbed energy, but incongruously Option 2 allows Participants to bid nameplate capacity anyway. Intention is not important to a frequency deviation, in all cases absorbed energy will damage the ability of Fast FCAS to arrest a frequency deviation.
- Allowing absorbed energy to be considered part of the FCAS response is damaging to system security unless it is compensated for by AEMO. Much like in the error in quantity of energy delivered/withdrawn introduced by 1Hz metering, AEMO is blinded to what this compensation amount might need to be. Option 2 provides no HSM that can be processed to determine the compensation factor. Instead AEMO will need to rely on the effect that absorbed energy has on Option 1 FCAS (DER and otherwise) to estimate how much more FCAS requires procuring. Reposit offers an error estimate of at least 6% informed by fleet operational data but has no data to suggest a future state.
- …

Option 2 metering will damage system security

Only precise metering of Fast FCAS response at the Connection Point can be relied upon if a high certainty of arresting high-speed frequency deviations is required for system security. Option 2's deeming approach introduces between 16-22% new uncertainty to a DER unit's contribution to arresting a frequency deviation. System security will be materially damaged where a significant proportion of Fast FCAS is provided by Option 2 metered DER (**Section 3.4**).

Rheem & CET:

- Believe 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

…

In respect to Grid flow / Connection Point (NMI) vs Appliance level metering:

- We support NET (Connection point) metering, and the requirement for FCAS providers to control the grid power flow at the NMI, and hence verification of the delivery of contingency FCAS via net power measurements at the site connection point.
- We believe that the technological challenges associated with multiple agents controlling various DER at a single site are currently too significant to be overcome in the short term. The most cost effective and robust contingency FCAS solution currently is orchestration of DER at a site with connection point metering.
- This position is based on our extensive experience at thousands of orchestrated DER sites where we use connection point (NMI) metering for the validation of HEMS orchestration of site generation, storage and loads under control. Our orchestration of smart, mixed DER is via a site edge HEMS gateway, local smart DER control interfaces, and net flow power metering to MASS - FCAS specification.
- From this experience we note a number of issues that need to be addressed:

[28] Issues Paper - January 2021 - Section 2.3.2.

- We are increasingly experiencing a range of issues on sites with embedded DER that DO NOT support local orchestration (control) via a local standards compliant interface. For example, a closed battery system operating outside the control of the site Energy Management System (EMS) (or HEMS gateway as it may be known) can cause other DER to respond to changes in the battery charge, discharge or FCAS response, affecting the rest of the site. *Such automated actions / reactions can negate the intended FCAS response.*
- As a result of the above, we believe strongly that site level coordination of all smart DER devices is required. Where this is not the case, reliability of grid services such as the delivery of FCAS will quickly decrease.
- If site level co-ordination is to be achieved, some level of standardised open control interface across all DER will be required. These communications interface standards should be mandated on all embedded DER to enable the orchestration of mixed DER sites where multiple DER types are participating in FCAS and/or other grid services under local control.

    - Rheem and CET believe that the above approach will not only ensure reliability in the supply of FCAS and other grid services, but will also provide the best financial outcome for the site owner, as well as facilitating their ability to churn their DER assets across different energy market/DER VPP services providers. This in turn ensures competitive commercial access by Energy Market Service providers to control the site DER assets in accordance with the principles of the NEO.
    - The VPP demonstrations gave no assurances to participants that MASS clauses superseded for the VPP demonstrations would be rolled into any future rule changes. As such, it is our view that the continued commercial operation of the deployed VPP demonstrations beyond the end date should not be seen as an imperative for a relaxing of the power and frequency measurement requirements of the FCAS specification. Rather, we believe AEMO should, as a separate exercise, seek consultation on how and if the existing VPP participants in the trial should participate in the FCAS market in the future (e.g. grandfather sites, period of time to bring into compliance etc) and that this should be carried out in conjunction with both this MASS Consultation and any changes that may come from the FFR rule change consultation process.

    ...

    As per previous comments in this response paper, we see no requirement for additional power metering equipment (beyond FCAS compliant connection point metering), nor the need to change to 1s data capture.

    Regarding the difference in implementation costs of metering at the device or NMI level:

    - Capturing data at the 50ms resolution at the NMI does not incur any significant costs. The meter can either cache the data for the duration of the event or can transmit the data to a coordinating device in the local network. In either case the costs are low. There may be a case to decrease the sampling rate to 100ms to align with data transmission speeds found in Modbus/RTU implementations.
    - A typical DER installation will include a solar PV system. On installations with solar PV system, nett metering is already required to maximise self-consumption of the solar power. As stated previously, CET and other organisation have stated on record that low cost metering can satisfy existing FCAS requirements at a price comparable to existing meters being installed with solar PV and storage systems.
    - We are not aware of an existing technological solution that could overcome the unintended outcomes likely to arise from competing DER energy management systems at a single site.
    - We therefore believe that a “whole of home approach” to FCAS / site connection point (NMI) power metering verification and orchestration of all DER on site is the only cost effective and sensible solution for consumers and the grid at the present time
    - Water heating, due to its positioning as an essential appliance, represents a low cost opportunity to build a fleet of DER assets capable of responding to the Contingency FCAS and other grid services markets.

    We do not believe that there is anything prohibitive in either the cost of implementation or the technical specification requirements of the existing MASS Contingency FCAS specification.

    In summary, the growth in numbers of mixed DER sites, and in particular their participation in grid services including FCAS, is heavily reliant on the ability to successfully orchestrate all generation and load DER on a single site. This requires NET, connection point metering (NMI), and open, local standards based control, especially on embedded storage batteries.

Solar Analytics:

> We support the requirement of monitoring the enabled device rather than the power flow at the connection point alone. This provides the most precise measurement of delivery and is most consistent

with the conditions of the frequency injection test. We support the requirement to also monitor the grid power flow in order to ensure that FCAS delivery is not systematically undermined by an opposing response of other devices.

We do not see the need to also measure other generating units behind the connection point since this will be captured by the total power flow. However, we are not greatly opposed to this requirement.

We believe that in the future, greater participation in FCAS could be delivered by allowing a number of devices behind one connection point to contribute simultaneously - including PV generation and various loads, with measurement at grid flow being the primary determinant of delivery. An aggregation of many such connection points should allow the overall delivery requirement to be met, despite diversity in individual responses. However, we understand that this is outside the scope of the current review and that a further program of testing would be necessary to consider such an option.

SwitchDin:

AEMO requires that all providers of FCAS must demonstrate that FCAS have been delivered in the case of a contingency frequency event. In the context of VPPs, measurement at the controlled device level rather than the connection point for the verification of FCAS delivery is a trade off between the VPP operator having the highest level of confidence of being able to demonstrate that the required response was delivered and the VPP operator incurring additional cost for extra metering where there is more than one controllable DER resource at a single site.

As VPPs mature and integrate more controllable DER device types such as hot water, electric vehicles and air conditioners the cost of measurement at the controlled device level may become prohibitive. However, for some sites - for example commercial sites - where the DER capacity is low compared to the overall site load, measurement at the controllable device may be required to give the VPP operator sufficient confidence of being able to verify that the required response was delivered.

With this in mind, SwitchDin's position is that the default measurement location for verification of FCAS delivery should be at the connection point, but that VPP operators should be able to opt for DocuSign Envelope ID: E9E3E21D-D550-4D6F-A624-31A7953DEE7F measurement at the point of control (incurring additional cost to themselves) in cases where measurement at the connection point would give the VPP operator insufficient confidence of being able to verify that the required response was delivered.

Additional Issues/Clarification

- Number of HSMs
  - Section 2.3.2 of the MASS Consultation Issues Paper states that "At AEMO's discretion, the minimum number of HSM may be reviewed depending on the number of controllable systems and the types of systems used to deliver ancillary services under the same aggregated ancillary service facility."
  - SwitchDin's technology allows for vendor-neutral power plants to be built and as a result VPPs using our technology are likely to be made up of a wide range of DER devices from different manufacturers and different types. We would welcome clarity on what factors are likely to influence AEMO's decision on the number of HSMs required, and in particular to what extent that may be influenced by the number of discrete models/manufacturers of DER within a single VPP.
- VPP Testing Regime for Registration - Testing on Every Type of Controllable Device
  - Under the proposed amendments "a frequency injection test would be required on every different type of controllable device that responds to a frequency excursion".
  - The MASS Consultation Forum #1 Q&A Summary published on 24 February provides further clarity on the definition of a type of controllable device, specifically from Q14, "the type of controllable device refers to the different technology types and model of inverter. A hybrid inverter is considered a different type of controllable device than a non-hybrid one. A single-phase inverter would also be considered a different type of controllable device than a 3-phase inverter."
  - Device testing at this level will significantly impact the cost and practicality of implementing frequency injection testing for vendor neutral VPP providers. To further understand the impact of this, SwitchDin would welcome additional clarity on the definition of a type of controllable device, for example: do models with different power ratings but the same internal hardware and firmware count as different types of controllable devices.

Tesla:

Element	Tesla Position	Proposed Alternative
Allow measurement at the inverter or controllable device level	Tesla fully supports this proposed change.	
Power flow measurements from the controllable device and generating units behind the connection point, and the grid flow must also be captured	Tesla supports this proposed change.	
AEMO must be able to determine the non-controlled load using the data provided by the FCAS provider for compliance purposes	Tesla supports this approach, provided that load can be calculated based of the other measurement points, rather than being directly measured.	
The HSM installed for every 5 MW of aggregated ancillary service capacity must capture the power flow measurements from the controllable devices, generating units behind the connection point, grid flow, and local frequency	If the actual frequency performance is measured at the device terminal, Tesla does not understand the value in having HSM data which also captures the other data points listed.	We believe that the key high- speed data points required by AEMO are simply the power flow measurements from the controllable device and the local frequency. Measurements from other generating units or grid flow will not impact on the frequency performance of the site and do not provide additional value to AEMO if the frequency performance is measured at the device level.

VIOTAS:

VIOTAS sees potential merit in allowing providers to verify FCAS delivery using metered power data captured at the controllable device level, rather than the connection point, as proposed in the Issues Paper.

This would be particularly helpful for controllable loads which share a NMI with other variable loads not providing FCAS. For example normal demand changes from other on-site loads during an assessment period may lead to the measured response at the connection point deviating from that delivered by the controlled device. Where any such normal demand changes from other on-site loads are unrelated (i.e. not deliberately negating the controlled response), there is significant advantage in measuring and verifying service delivery at the controlled device itself. However, while straightforward this places a greater onus on trust in the provider. VIOTAS recommends that, if measurement at the controllable device level is allowed, it will remain important to require providers to measure power flow at the connection point to enable periodic validation by AEMO that the connection point response (even if with lower data resolution) matches that expected based on the controlled device's response.

VIOTAS also recommends the existing MASS is clarified to remove any potential ambiguity as to under what circumstances AEMO will enable power flow measurement at a point other than the relevant connection point. For example:

- Clauses 3.6, 4.6, and 5.6 of MASS v6 state that for all Contingency FCAS "power flow [...] must be measured at or close to the relevant connection point or, if otherwise agreed with AEMO, sufficient measurements may be provided to calculate the Generation Amount or Load Amount", however it is not clear how "sufficient measurement" is defined, nor under what circumstances AEMO will enable power flow measurement at a point other than the relevant connection point.
- Clause 2.4(i) of MASS v6 states that, for aggregated ancillary service facilities "where a relevant plant that forms part of an Aggregated Ancillary Service Facility shares a connection point with a variable load or generating unit, it is the gross power flow to or from the relevant plant that forms the aggregated response and must be directly measured." VIOTAS requests further clarification on exactly how this should be interpreted.

Regarding the additional conditions that are proposed that would apply to providers electing to capture measurements at the controlled device rather than at the connection point, VIOTAS does not believe these

are sufficiently defined, and requests that AEMO provide further clarity / explanation in this regard. For example, "Power flow measurements from the controllable device and generating units behind the connection point, and the grid flow must also be captured" implies power flow measurements at the connection point are still required. To what measurement resolution are these required? Does AEMO expect revenue metering to provide this measurement, or additional metering?

4.2.2. AEMO's assessment

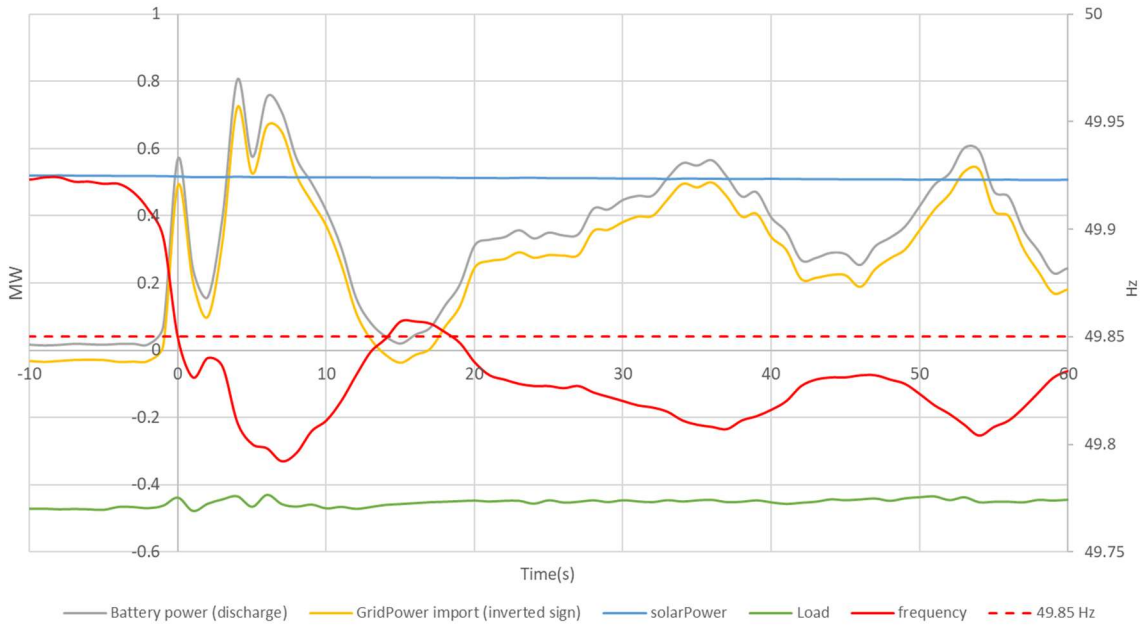
Some Consulted Persons highlighted the importance of properly orchestrating DER and ensuring that assets behind the same connection point are not operating independently of each other, which can lead to negation of the intended FCAS response if measured at the inverter level. It was also suggested that the verification of the FCAS response using grid flow will allow the combined use of different technologies behind the same FCAS measurement point, as opposed to requiring one measurement for each controllable asset.

AEMO's analysis of the FCAS response from FCAS Providers participating in the VPP Demonstrations indicates that changes in distributed photovoltaics (**DPV**) and uncontrollable load during a frequency disturbance are smoothed out on an aggregate level, and the FCAS response can be verified using aggregated measurements at the asset level or grid flow as shown in Figure 3.

Support for Option 2 to alter the FCAS measurement point to the asset level was mainly due to the requirement to install additional hardware. AEMO notes that power measurements representing grid flow are already captured by participants in the VPP Demonstrations, and provided to AEMO. As shown in Figure 3, the grid flow is sufficient to verify the amount of FCAS delivered.

It is to be expected that extra hardware would be required if there is more than one controllable asset behind a connection point and the FCAS measurement point is at the asset level, as each asset would need to be individually metered. Intellihub and Landis+Gyr noted that revenue meters could be used to capture the net flow and avoid the cost associated with additional metering equipment.

Figure 3 DER FCAS provider responding to frequency disturbance



Some Consulted Persons were also of the view that if measurements at the connection point are not used, it could result in perverse incentives to game the FCAS verification and compliance process by intentionally negating the FCAS response measured at the asset level.

Hence, AEMO is not satisfied that the measurement of power at the asset level will accurately represent the amount of FCAS delivered to the grid, especially in cases when more than one asset can be controlled. AEMO's inability to identify an FCAS shortage, or under-delivery could have a severe impact on power system security considering the amount of FCAS from DER that is envisaged in the near future.

AEMO's assessment using the data captured during the VPP Demonstrations shows that the changes in DPV and uncontrollable load are not significant on an aggregate level during a frequency disturbance. If the net flow from a NMI cannot be controlled, and one or more assets respond to frequency disturbances, the net flow will still be used to assess compliance, rather than measurements at the asset level. FCAS offers may need to be more conservative to ensure compliance, particularly if the difference between the registered maximum market ancillary service capacity and total nameplate rating from the controllable assets is small, i.e. the FCAS Provider is offering most or all of the capacity by reference to the nameplate rating of the controllable assets in the FCAS markets.

AEMO has also considered whether measurement at the asset level will be problematic when assessing compliance where more than one controllable asset behind the meter is used to deliver FCAS. Measurement at the asset level could potentially encourage technology providers to work independently, resulting in the overall FCAS response from a NMI being poorly orchestrated, or an increase in the likelihood of gaming if the FCAS response is intentionally negated by another controllable asset behind the same NMI.

In all, no supporting evidence was presented to confirm that measuring FCAS delivered by DER at the asset level would benefit the power system or improve the integrity of the FCAS markets.

4.2.3. AEMO's conclusion

After considering the issues raised and assessing the options against the NEO, AEMO proposes not to change the FCAS measurement point in the MASS. AEMO considers that power measurement at, or close to, a relevant connection point represents more accurately the FCAS delivered to the power system and minimises the risk of market distortion.

5. DISCUSSION OF MATERIAL ISSUES - GENERAL

5.1. MASS Readability and Usability

5.1.1. Issue summary and submissions

AEMO has restructured and rewritten the MASS with the aim of making it easier to read and use. Consulted Persons were asked to comment on the redrafted MASS, and to point out if there have been any material changes to the substantive provisions.

The main submissions on this issue are extracted below.[29]

AGL:

> AGL supports the proposed reformat of the MASS, including removal of repetitive service descriptions.

CEC:

> The CEC supports the intent to improve the MASS function and readability.

[29] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

CleanCo:

> CleanCo is broadly supportive of the proposed redrafting of the MASS and agrees that the new format simplifies and clarifies a range of issues.
>
> …
>
> The updated drafting in the mass appears clear and simple, and removes unnecessary duplication. These changes improve the readability of the document while retaining the intent of alien versions.

Delta Electricity:

> The draft is heading in the right direction in its structure but not in its detail. AEMO are encouraged re-incorporate all details, including re-incorporation back into the MASS the FCAS RegTool guidelines to develop the document into being a more complete specification covering all aspects of importance to designers. A document can contain an abundance of information but still be straightforward to comprehend. Understanding should become easier for the appropriately qualified engineers and designers. AEMO are cautioned against making amendments designed to make the specification simpler to understand but, in doing so, remove necessary details without which participants need to assume if not specified.
>
> The draft MASS does not have the correct purpose and scope for the Rule it is addressing.
>
> - The purpose and scope distract from the MASS also being meant to be a specification for the frequency controller and focus a reader on monitoring and recording. In the coordination of overall frequency control, recording equipment is possibly less important than control equipment. Accurate data provided by instruments specified separately for both the controller and the recorder will improve the overall objective. AEMO should seek audience with industry specialist control design consultants to obtain suggested additional frequency controller details to include in the draft.
> - The Rule requires that the MASS include "the performance parameters and requirements" which must be satisfied by the service providers. This should be applied separately to both the controllers and the recorders.
> - The Rule also refers to the use of undefined standards which should be included in or referred to by the specification and which could enhance the expectations for quality of control. If the standards don't exist, AEMO should also draft them and deliver them with the next draft of the MASS. If the FCAS REG Tool[30] is a standard it should be named as such rather than being sidelined to being a guide which weakens its purpose.
> - The word "specification" included in the Rule defines what the MASS is meant to be. An English definition is "**an act of identifying something precisely or of stating a precise requirement**." Precision requires the right amount of detail. A reduced and simpler specification may not be possible without undermining the actual purpose and therefore should not necessarily be the target for a revision of the MASS. A revision that more precisely and completely defines the requirements for control and for monitoring is recommended.
>
> The draft has made amendments in the direction of separating out specifications applicable to controllers from those applicable to the monitoring but could go much further. The structure of the whole document should focus up front on the Controller Specifications and follow later in the document with Data Recorder Specifications specifying each of these with consistent rigour and referencing required standards of instrumentation. Sections 7,8 and 9 are really aspects relating to data recorders for Contingency services.

Hydro Tasmania:

> As the primary reference of the NEM FCAS technical specification, Hydro Tasmania believes that the proposed MASS review and modification is important to continuously improve the readability and usability of the MASS, and ensure this document is up to date e.g. accommodating the changes of implementing the mandatory PFR.
>
> Hydro Tasmania is supportive for this initiative.

Infigen:

> Infigen agrees that the proposed reformatting makes for improved readability.
>
> An error has been introduced in Table 4 within the Local Frequency Measurement Range data row, where the columns of 'Margin of error' and 'Resolution' read down the page, while these should read across the page.

[30] AEMO understands Delta is referring to the FCAS Verification Tool.

Karit:

> The MASS is currently written utilising under-defined terms and complex language. Work is required to enhance the descriptive and presentation of the MASS to allow it to be more widely understood.

Reposit Power:

> Reposit supports a substantive review of the MASS. The MASS is an increasingly important document in the NEM and suffers from well-identified shortcomings.
>
> In 2020 the MASS regulated hundreds of millions of dollars of market value, and was instrumental in informing investment cases for many millions of dollars more. A substantial improvement in the MASS will immediately result in increased efficiency in investment, operation and use of FCAS and clearly promotes the achievement of the NEO. Delaying substantive improvements to the MASS for one reason or another imposes an efficiency cost on the NEM. It is important that any item delaying a substantive review of the MASS yields efficiency gains in excess of those delivered by a substantive MASS review.
>
> It should be noted that despite the shortcomings of the MASS, it does not preclude the inclusion of DER in FCAS provision. AEMO states that a substantive review of the MASS is constrained by the end of the VPP Demonstrations on 30 June 2021. AEMO states that this is to achieve a clear path to continued participation of DER in FCAS markets31.
>
> This statement ignores that the ASNAES1 DUID is composed entirely of DER. It has been operating for over a year and is a multi-MW participant in all Contingency FCAS markets. This DUID operates without the relaxations provided by the VPP Demonstrations. The existence of this DUID makes it clear that there is a clear path for DER participation in FCAS under the current MASS.
>
> This means that there is no urgent requirement to modify the MASS to allow a new, fast-growing and extremely efficient technology to provide FCAS. There is no time pressure and so a substantive review of the MASS can be completed. Reposit considers it inconsistent with the NEO for AEMO to perform an incremental review of the MASS. This is especially true if an incremental review is preferred to a substantive review so as to not delay MASS changes designed to accommodate participants that do not meet the current MASS.

Shell Energy:

> Shell Energy considers that AEMO has undertaken a thorough and considered process as it prepares for this review of the MASS. This is an opportune time to review the MASS given the scale of change underway in the market.

Tesla:

> We also welcome the General MASS review and updates to the general MASS settings, reflecting the broader technology advancements that the industry has made since the last full MASS review.
>
> ...
>
> Tesla supports the aim to simplify and clarify the MASS.

5.1.2. AEMO's assessment

The starting point for any discussion of the MASS is clause 3.11.2 of the NER; relevant provisions are reproduced here:

> (b) *AEMO* must make and *publish* a market *ancillary service specification* containing:
>
> (1) a detailed description of each kind of market *ancillary service*; and
>
> (2) the performance parameters and requirements which must be satisfied in order for a service to qualify as the relevant market *ancillary service* and also when a *Market Participant* provides the relevant kind of market *ancillary service*.
>
> (c) *AEMO* may amend the market *ancillary service specification*, from time to time.
>
> (d) *AEMO* must comply with the *Rules consultation procedures* when making or amending the market *ancillary service specification*.

[31] MASS Consultation Paper - January 2021 - Section 3.

(e) An amendment to the market *ancillary service specification* must not take effect until at least 30 days after the amendment has been *published*.

(f) In addition to the requirements under rule 4.15, a *Market Participant* which has classified a *generating unit* as an *ancillary service generating unit* or a *load* as an *ancillary service load* must install and maintain in accordance with the standards referred to in clause 3.11.2(g) monitoring equipment to monitor and record the response of the *ancillary service generating unit* or *ancillary service load* to changes in the frequency of the power system.

(g) *AEMO* must develop, and may amend from time to time, standards which must be met by *Market Participants* in installing and maintaining the equipment referred to in paragraph 3.11.2(f).

Hence, AEMO is required to publish the MASS, which must contain:

- A detailed description of each type of FCAS.
- The performance parameters and requirements to be satisfied at registration and during the provision of FCAS.

Furthermore, AEMO has opted to include in the MASS the standards for installing and maintaining the monitoring and recording equipment used by FCAS providers to monitor and record their response to changes in power system frequency.

Most submissions on AEMO's redrafted MASS were positive. The most substantive criticism came from Delta Electricity, which requested:

- Incorporation of the FCAS Verification Tool.
- The MASS should not focus on monitoring and recording at the expense of a frequency controller specification.
- The performance parameters and requirements should be applied separately to the controllers and recorders.

AEMO agrees that there is room for better specification of frequency control. We intend this version of the MASS to be a step towards this objective and AEMO will continue to improve the specification in subsequent reviews.

Hydro Tasmania's reference to the PFR as being ripe for inclusion in the MASS is addressed in section 5.4.2.

AEMO is unable to address Karit's general comment that the MASS uses under-defined terms and complex language, without specific examples.

Reposit Power considers that an incremental review of the MASS is inconsistent with the NEO, especially if it delays a substantive review. AEMO does not agree that the substantial redraft of the MASS was an incremental review. There are many issues that many FCAS providers wish to see addressed by the MASS and AEMO only has limited resources in which to assess these and then consult on any proposed changes.

5.1.3. AEMO's conclusion

AEMO will publish the MASS in the form published with the Issues Paper, and has made further changes to it as referred to in this Draft Report, including the error identified in Infigen's submission. AEMO intends to use the available time and resources in this and subsequent reviews to make incremental improvements in the readability and useability of the MASS.

AEMO agrees that there is likely a case for separating out the requirements for frequency controllers and FCAS *metering*, and will identify how best to do this following this consultation by convening an industry working group with suitable experience and expertise to consider and advise on the matter.

5.2. Clarification of References to the Frequency Operating Standard

5.2.1. Issue summary and submissions

In the Issues Paper, AEMO stated that it would be clearer if references to the FOS were more precise, by referring to particular items in the FOS, not the FOS generically.

The main submissions on this issue are extracted below: [32]

AGL:

> AGL supports the proposal to specifically reference Table A.1 of the FOS.

CleanCo:

> This clarification is useful and appropriate.

CEC:

> The CEC supports the approach to clarify that all MASS references to the frequency range NOFB would refer to the band between 49.85 and 50.15 Hz.

Delta Electricity:

> Whilst the FOS defines several different NOFBs, it is generally understood that NOFB when used without reference to islanded conditions and other operating states, means the 49.85 to 50.15Hz band. However, the MASS is a specification that ought to provide concise descriptions of the expectations for the services. Therefore, it is essential to make as many clarifications as necessary to avoid misinterpretations.

EQ:

> EQ agrees with the intent of this element of the proposal.

Hydro Tasmania:

> The information provided in the FOS Table A.1 contains the FOS in different stages responses including Containment, Stabilisation and Recovery in different system conditions and over different time frames.
>
> On the other hand, MASS as the document to implement the FOS with different market mechanisms, should reflect the connection between the 8 FCAS and the corresponding frequency control objectives.
>
> Hydro Tasmania would suggest creating one more column in the MASS summary Table 3 'Description of each FCAS', to highlight the correspondence between each type of FCAS and the FOS, and ensure MASS and FOS requirements are well aligned.

Infigen:

> Infigen agrees with the proposal to clarify variable FOS terms should refer to the specified tables unless stated otherwise. There are no other ambiguous terms within the MASS that need further clarification.

Shell Energy:

> Shell Energy agrees with AEMO's proposal to clarify references to specific frequency by referring directly to the FOS. We consider that this change will improve the current treatment of differing frequency bands relating to the NOFB.

Tesla:

> Tesla supports the aim to simplify and clarify the MASS. Also support improved specification (and greater clarity on relationship with the FOS). Containment Frequency range should refer clearly to the FOS document itself which is the Containment Band (49.5 - 50.5Hz) for Generation/Load events (mainland), avoid parallel definitions.

[32] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

5.2.2. AEMO's assessment

Submissions on this issue were generally supportive of AEMO's changes.

5.2.3. AEMO's conclusion

AEMO will retain the changes made to the draft MASS so that the relationship between MASS and FOS terms and values is as clear as possible.

AEMO does not consider the augmentation to Table 3 suggested by Hydro Tasmania is warranted. The additional entry cannot be reduced to a single item as the answer depends on power system conditions.

5.3. Requiring Non-Frequency Responsive Facilities to deliver FCAS only when Enabled up to 150% of Enablement Amount only

5.3.1. Issue summary and submissions

In section 3.3 of the Issues Paper, AEMO expressed concern over the possibility of unmanaged quantities of switched/non-frequency responsive facilities causing frequency rebound and overshoot under adverse power system conditions and especially during islanded conditions. Clearly, this eventuality could be highly detrimental to power system security. The main submissions on this issue are extracted below: [33]

AGL:

> Ensuring that non-frequency responsive facilities do not overdeliver adds complexity for participants, particularly if using blocked controls. Facilities are generally responsive to their bid/offer amount, but to prevent over-delivery, participant systems would need to be aligned with the MW level of enablement. This would require an automated software solution, linking a participant's systems with AEMO's and adjusting the MW amount every five minutes, as necessary.
>
> Requiring non-responsive facilities to have these capabilities could be a positive signal to vendors to develop more variable controllers for the market.
>
> To better manage potential over-delivery, we suggest that AEMO determine a hard limit of what constitutes 'significant over-delivery', so that participants can build systems around this limit.

CEC:

> We suggest that if AEMO has a strong understanding of the quantity of non-frequency responsive plant, and is able to model it, then AEMO should also be able to alter the amount of frequency responsive FCAS that is procured to balance this issue.

CleanCo:

> Before considering options for limiting or controlling FCAS provision by switching controllers, it is important to recognise the important role switching control plays in the contingency FCAS markets.
>
> Switching controllers are excellent at returning the frequency back to within the NOFB in the shortest timeframes. In the vast majority of situations, over-provision of response by switching providers has improved outcomes for consumers – frequency recovers faster following shocks and in a manner that is essentially free for consumers. The RIS highlighted the important role that switching providers play in terms of reducing the reserve requirement, particularly as system inertia reduces[34].

[33] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

[34] AEMO, Renewable Integration Study Stage 1, Appendix B: Frequency Control, March 2020

Figure 1 – Reserve requirements for loss of Kogan with increasing proportions of switched reserves

Figure 17 from RIS Appendix B

Noting the above benefits of switching providers, it is important to ensure any changes do not preclude or disincentivise switching providers from participating in FCAS markets, even the shorter 6 and 60s markets. Rules that are too strict or that preclude over-provision may simply make it too difficult for some participants to remain in the market.

If considering potential limits to switching controllers, it is also reasonable for AEMO to consider different limits for each FACS market. For instance, the limit for proportion of switching controller could potentially be stepped up between the 6s and 60s markets, with no limit on the 5 minute markets. Given the broad benefits switching controllers provide the market, it may also be appropriate to have a minimum target.

It will also be necessary to differentiate between different types of switching controllers, recognising that each has different capability. For example, Wivenhoe's generators could be programmed to target a MW output and it can reduce generation quickly once frequency recovers. On the other hand, the Wivenhoe pumps have no control over MW and, in the instance of raise services, would take some time (up to ten minutes) to re-enter the market after frequency has recovered. We expect providers in the 6 and 60s market would have a similar mix of attributes and capabilities.

...

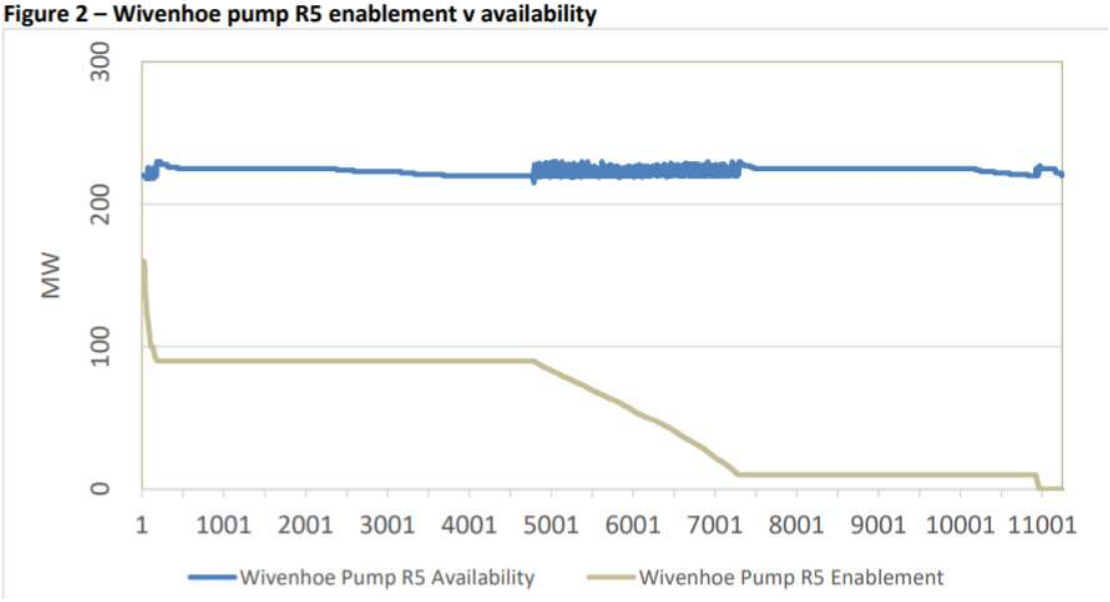
Amending control system or trading system logic to respond only when a participant is enabled is possible in most instances, depending on the age and flexibility of a participant's systems and their connectivity to MMS. Making this type of change seems simple, but it opens a range of new risks because the control system has more steps to consider when a frequency event occurs. Each of these steps is a new potential point of failure. One of the benefits of the existing system is its simplicity; the unit measures local frequency and responds if it leaves a predetermined band. Depending on the revenue they receive from FCAS markets, some participants may consider the costs of making these changes and the added risk of non-compliance outweigh the benefits of participating in the market.

...

Requiring providers to limit their response to a particular MW (or MW band) will likely preclude a significant number of switching providers from participating in FCAS markets.

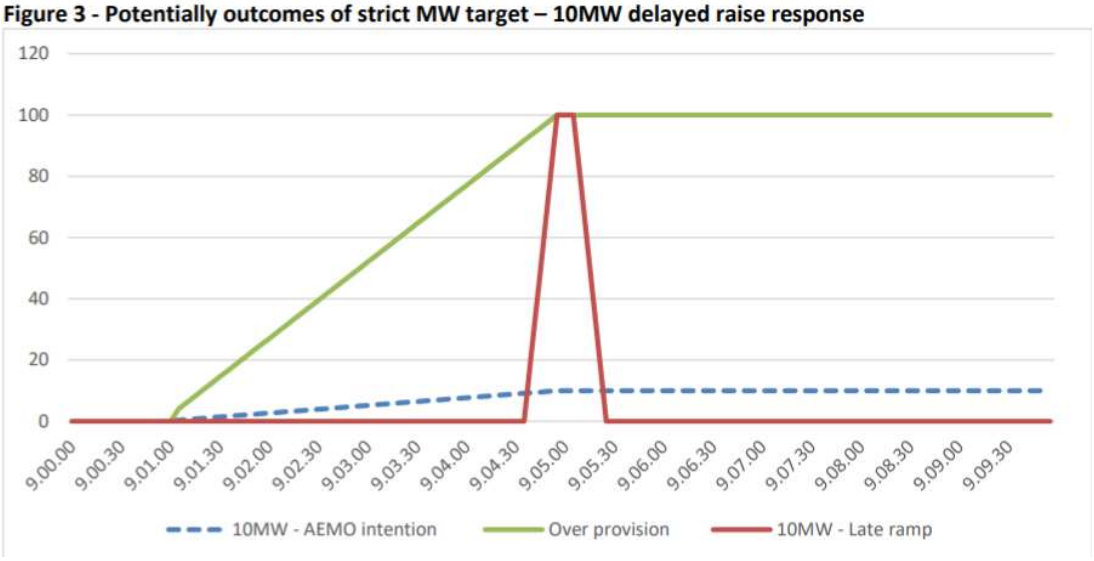
While we recognise AEMO is targeting 6 and 60s markets for these changes, we expect the below example of Wivenhoe's pumps illustrates the challenges some participants face. As noted above, CleanCo has no flexibility over the MW from its pumps; the pumps are either on or off. Even if a broad +50% target range was applied, we would not be able to offer our pump services. Figure 2 illustrates a duration curve of Wivenhoe pump enablement levels over 2020 in comparison to its likely response – the pump only could have complied with this rule 0.3% of DIs.

Figure 2 – Wivenhoe pump R5 enablement v availability



AEMO's proposal could also lead to unintended consequences. While some switching controllers may not have control over MW output, they may have control over when they respond. This could see participants delaying their start when a frequency event occurs to comply with their target. Figure 3 below illustrates two compliant options for responding to a 10MW enablement in delayed raise market (similar scenarios could happen in 6 and 60s markets). The blue line reflects how we think AEMO would like the service to be provided. The red line reflects what a switching controller with a fixed 100MW of response could provide to comply with the MASS. Importantly, compared to the over-provision option (green line) there is no reduction in the maximum output, but there is three minutes where the unit could have been providing frequency support.

Figure 3 - Potentially outcomes of strict MW target – 10MW delayed raise response



Alternative Options

While we acknowledge that response from switching units could create challenges in particular situations, we believe the alternative – prolonged under/over-frequency events while willing capable plant sit idle – appears unreasonable.

There are a few alternative options that AEMO should consider in response to this:

(a) Apply rules around following targets on a best endeavours basis, so that units that can target a particular MW (or MW range) do. This would minimise over-provision where possible, while still maintaining the largest number of participants in the market;

(b) For large inflexible units, expand their deadbands so they only provide response in the instance of more significant frequency events. While they may not respond as frequently as participants on tighter deadbands, in most instances they will also only be being paid for a small fraction of their total response;

(c) Build inflexibility into NEMDE either through –

a. optimising to enable switching providers up to their full output. Inflexible providers could nominate full/minimum response to AEMO. AEMO can, based on least cost, optimise for providers while only enabling full output from switching providers.

b. optimising dispatch based on the existing equation, but then have a secondary loop which limits enablement of switching controller based on max output.

c. optimising across raise and lower services. As prices for lower services are consistently lower than raise services, AEMO could optimise to enable more lower services in instances where there is a significant proportion of switching providers enabled for raise services.

Importantly, these options would maximise the competition in FCAS markets and provide AEMO with more options to identify the lowest cost mix of services for customers.

(d) Provide more guidance on AEMO's expectations for when FCAS response should finish. This could include clarifying when generators are to stop providing services and options for the orderly reintegration of demand side participants into the market. As a further step, AEMO could consider removing incentives that encourage the provision of frequency support after frequency has recovered. To clarify AEMO's expectations, the specification for Fast Raise Service could be amended to:

(a) twice the Time Average of the Raise Response starting at the Contingency Event Time and ending 6s from the Frequency Disturbance Time, excluding any Inertial Response; and

(b) twice the Time Average of the Raise Response between 6s and 60s (or until frequency returns to the NOFB, whichever is sooner) from the Frequency Disturbance Time, excluding any Inertial Response,

This could potentially be expanded to remove entitlement to revenue from energy after the frequency has recovered.

Delta Electricity:

The SCADA system can deliver enablements to Units and automatically select the relevant controllers for service.

Processes relying on human observation and manual arming or disarming of controllers are unlikely to be successful in supporting this objective.

A switched controller could be assigned the required MW value by automated dispatch. SCADA and Unit controller modifications would be required for this which can be expensive and which require coordinated projects between AEMO, TNSPs, participants and technical resources. Without the above, the separation between FCAS bidding, dispatch and controls means that controllers will deploy a maximum value including times when the enabled quantity is less suggesting over-delivery will be common.

Enel X:

Responding only when enabled

It is reasonable to expect FCAS providers to only respond when enabled. However, AEMO will need to consider how this proposal could feasibly be implemented by aggregated facilities when only partially enabled, and interactions with the proposal to bring the trigger ranges for switching controllers closer to the NOFB. For example, which assets should be disarmed if an aggregated facility offers 30MW of response but is only enabled for 10 MW, and what setpoints will those assets trigger at?

Some providers may need time to develop and implement this capability. We ask that AEMO take this into consideration if the proposal is introduced.

Limits on over-delivery

We understand why AEMO is concerned about the possible effects of extreme over-delivery from "non-frequency responsive" facilities, but strongly advise that some careful studies are done before deciding whether a limit is necessary and, if so, at what level it should be set.

…

NZ provides a useful example here. In 2013, the NZ system operator was asked to investigate whether the over-provision of interruptible load would cause power system security issues. The context was that the

existing interruptible load service requirements specified a minimum delivery requirement, but not a maximum, and so significant over-provision of interruptible load could occur. There was concern that this over-delivery could lead to the frequency overshooting, such that an under-frequency event would be immediately followed by an over-frequency event, and potentially lead to system collapse if the overfrequency recovery went far enough to cause generators to trip off. It seemed intuitively obvious that such a problem could occur, and would be very serious, and could be avoided by imposing restrictions on the amount of over-delivery allowed. It was expected that the study would confirm this and provide evidence to justify setting the limit at a particular level.

Transpower's investigation studied the over-provision of interruptible load under a variety of scenarios including low inertia conditions, extended contingent events and HVDC contribution.35 However, it concluded that "over-frequency due to interruptible load over-provision is not currently an issue nor is it likely to become an issue in the foreseeable future". Specifically, the study found that 25 per cent of the total system load in the North Island, and 16 per cent of the total system load in the South Island would need to be providing the interruptible load service for it to present a system security concern – an implausibly high figure, and very far above the quantities of interruptible load participating in the market or ever likely to do so.

It is necessary to allow some over-delivery, particularly for switched load sites, as there is always a level of uncertainty as to how and whether a particular site will respond. Aggregators manage this uncertainty by monitoring the sites carefully and modelling the probability distribution of the aggregated response size. They then offer into the market only the quantity they are sufficiently certain that they can deliver – i.e. a value in the lower tail of the distribution. As a natural consequence of avoiding under-delivery through this conservative approach, they will usually over-deliver by some amount.

Aggregators already have a financial incentive to minimise over-delivery, as they are only paid for what they offer and are enabled for. The risk of imposing a limit on over-delivery in addition to this incentive is that it will increase the risk of under-delivery, which presumably is not a desired outcome from AEMO's perspective. To reduce this risk, any limit should only be imposed if modelling shows that it really is necessary, and it should be set to the highest level that the modelling shows if sufficient to solve the identified problem.

EQ:

In our view, to achieve this requirement, the FCAS load needs a mechanism to be enabled or disabled by the aggregator, dependent on bid acceptance.

To achieve a FCAS delivery aligned to that bid and acceptance, the aggregator needs to have a model of the available load and be able to enable or disable in suitably sized steps to meet the requirement.

It is expected this would be base capability of an aggregator.

Note: Regarding Ergon Energy Network's load shed capability, this is possible as remote enabling in course blocks is available, as is a load estimation model recalculated each minute.

Hydro Tasmania:

Hydro Tasmania understands the system frequency control challenges in a market environment and agree to the issue of the potential over correcting issue due to the uncertainty from the nondispatched and non-frequency responsive facilities (including those with a switching FCAS response load response).

In regards the proposed solutions.

Option A: Hydro suggests make the first option to be conditional and avoid sending counterproductive signals to the generators that the market enablement status overrides technical consideration. More details are provided in the alternative. An example of the counterproductive signals was the previously seen issues with the introduction of deadbands to remove perceived conflicts of NER and AEMO requirements.

Option B: The proposal of 'the response should no more than 50%' appears somewhat arbitrary and needs to be thought through in aggregate across the power system.

Hydro Tasmania would suggest an alternative as below:

Given concern is non-frequency responsive facilities over correcting, it would be worthwhile to break down this question to different scenarios and considering a logical approach to manage this issue.

1) Based on the system studies, AEMO proposes a frequency threshold or thresholds.

2) By comparing the facility response trigger setting against the specified frequency threshold, the switching response facilities will be classified into two categories:

[35] See: https://www.transpower.co.nz/sites/default/files/bulk-upload/documents/TASC%20035%20Report.pdf

a. If the switching response is within the proposed threshold, e.g. if the setting is too close to the NOFB, it would be putting in the 'likely over correcting' category. In other words, this facility is likely to trigger and once is triggered, its response is likely to cause over correcting, thus certain action is needed.

b. If the facility setting is outside of the proposed threshold, e.g. distant from the NOFB, it would be considered in the 'unlikely' category. In other words, this facility is unlikely to trigger, if is triggered, the response is unlikely cause over correcting but just discount the proportional response. For these facilities there will be no action required.

By doing that, we can avoid unnecessary physical modification of the switching response if the facility is in the unlikely category. More importantly, it sets up a good engineering practice, as the voluntary FCAS switching response is valuable during extreme system contingencies, e.g. at the edge of emergency UFLSS. So as long as it is outside of the potential over correcting zone, having some voluntary FCAS switching response is not always a bad thing. Again, consideration should be given to the aggregate response across the power system, not focusing just on facilities in isolation.

Karit:

Devices not registered in the FCAS market may be repurposed to provide benefits in the wholesale or demand response markets. Should market events coincide then there is no guarantee that the device will not have an impact on any required frequency response. Karit's platform is designed to only allow a device to respond to the FCAS market if it has been registered to do so. However the nature of VPPs enables them to manage multiple sources of value, locking out a device from a particular market would require substitutable value to be made available.

Reposit Power:

6.1 Switching controller issues

Reposit understands AEMO's bifurcation of FCAS capability into frequency responsive and non-frequency responsive. Reposit agrees that it is largely a dispatch rather than MASS issue. As such it should be facilitated through a constraint (as it is in TAS1). The definition of the constraint, its trigger conditions and its calculation of key quantities should be made public to the market well before a similar constraint enabled in the Mainland NEM. This will allow Participants to determine the efficiency of migrating switched controlled MW to proportional controlled MW where that option exists.

Reposit supports the requirement for non-frequency responsive capacity to deliver only when enabled.

Reposit suggests that the restriction on switched controller over-delivery may result in a reduction in the certainty of FCAS delivery from some units. This is because under-delivery is managed by some Participants by constraining an FCAS offer to that part of a unit's response that is reliable. The remainder of any response is "gifted" to the system as it is not reliable enough to base an offer on.

Some existing units may offer capacity that is not reliable if over-delivery is to be restricted by some amount (50% is proposed by AEMO). This will increase the offers made by some units, but decrease the certainty of full delivery. Perversely, the restriction on over-delivery from some units will result in an increased likelihood of under-delivery from those same units. Reposit suggests that some of the most cost-effective, medium-scale FCAS in the market may be impacted by this restriction.

SwitchDin:

Ensuring that assets only respond to frequency deviations when enabled for FCAS would require each individual device to be aware of the market enablement status in real-time and to react accordingly (for example toggling FCAS delivery mode on and off). This does not present any significant technical difficulty.

…

The following would be required in order to ensure that VPPs do not deliver significantly over-deliver on their market enablement:

- Accurate forecasting of fleet power and energy availability, to determine an appropriate FCAS bidding profile;
- Real-time measurement of fleet availability and real-time, asset level control of FCAS enablement allowing a portion of the total fleet to be enabled to match market enablement.
- Forecasting the aggregated available power and energy within a VPP in order to determine an appropriate FCAS bid is a complex task that requires an accurate forecast of the constraints that may apply to individual assets depending on the time of day, weather conditions, level of solar production,

configuration/type of the inverter etc. In the absence of accurate forecasting VPPs may deliberately under-bid in order to ensure that they do not under deliver on their FCAS commitment.

- Real-time control of the VPP fleet at an asset level, via orchestration, rather than fleet-wide enablement is not currently widely available.

Do any alternative options exist to manage over delivery?

In the absence of real-time, asset level control, over-delivery could be partly reduced by allowing VPPs to bid in sub-1 MW increments. Increased granularity would allow FCAS bidding to more closely follow the actual available capacity within the VPP, particularly for smaller VPPs with registered capacity of 1-2 MW, rather than adopting an on/off response.

5.3.2. AEMO's assessment

As pointed out in many submissions, various technical challenges arise from attempting to manage the behaviour of non-frequency responsive FCAS that need to be worked through carefully so as not to cause unintended and unhelpful consequences. While the theoretical need to ultimately manage the balance of frequency and non-frequency responsive FCAS may be clear, other than in adverse conditions (particularly power system separations), there is little clear evidence of an urgent need to limit FCAS of this kind.

In Tasmania, where such limits already exist (as queried by EnelX), this was done on the advice of the relevant TNSP and is due to the unique situation in that region; it is not synchronously connected to the rest of the NEM and must contend with a relatively large contingency size compared with the rest of the NEM. FCAS needs to be carefully integrated with the protection mechanisms in place there. Note that the constraint equation F_T_NIL_MINP_R6 is active only when the dynamic response of Basslink (via its frequency controller) is limited.

In relation to over-delivery, AEMO draws attention to CleanCo's suggestion that AEMO should "apply rules around following targets on a best endeavours basis" is untenable. The AER's Compliance with Dispatch Instructions, Offers and Bids - Compliance Bulletin No. 1[36] clearly rejected "best endeavours" as a compliance benchmark and its expectation is that *Market Participants* who participate in different markets will submit offers they can comply with[37].

The further change to section 7.1(b) of the MASS suggested by CleanCo is not considered appropriate. The FCAS should be provided until frequency recovers, and frequency recovery is defined as being well within the NOFB.

5.3.3. AEMO's conclusion

Noting the various challenges identified, and the limited circumstances at present where non-frequency responsive FCAS may be problematic, AEMO will progress general limits on non-frequency responsive FCAS for *regional* FCAS constraint sets only (that is, the constraint sets that are brought in when at risk of separation, or during separation), however, AEMO will not progress:

- general limits on the proportion of non-frequency responsive FCAS during normal system intact operation, and continue to monitor developments and performance;
- a blanket requirement for non-frequency responsive FCAS to limit over-delivery, but may require FCAS Providers to limit over-delivery where they are of sufficient size and in locations where their contribution could cause overshoot and other undesired power system impacts (AEMO's draft MASS amends section 6.1.2 to encourage frequency FCAS Providers using switched controllers, where possible, to adopt a multiple block/multiple frequency trigger approach to spread provision of FCAS over a range of triggers); or

[36] Available at: https://www.aer.gov.au/system/files/Compliance%20Bulletin%20No%201%20-%20Compliance%20with%20Dispatch%20Instructions%2C%20Offers%20and%20Bids.pdf

[37] See page 8.

- a blanket requirement for FCAS Providers using switched controllers to only deliver when *enabled*, but will continue to monitor this, especially considering how the rollout of general limits for *regional* FCAS *constraints* is progressed.

5.4. Co-ordination between FCAS and PFR

5.4.1. Issue summary and submissions

AEMO proposed several improvements to how the MASS deals with the various types of FCAS and PFR and the co-ordination of local controls that impact Contingency FCAS and PFR and remote controls that impact Regulation FCAS. Relevant submissions on this issue are extracted below: [38]

Delta Electricity:

> A couple of suggestions:
>
> - AGC control time-base of 4s vs mechanical hydraulic governor response time (1-2s) and complimentary PFR or retarding Unit controller response times (5-20s) – What the AGC should do is match the DCS expectations not the mechanical governor reactions which are faster than the control time of the AGC.
> - Coordination differences between the fast and slow services of units with separated fast and slow controllers and those with a combined controller providing both services.
> - Coordination between frequency responsive and switched controllers – Should the MWs assigned by the switched controller be assigned only on top of the energy dispatch value or on top of energy dispatch value plus any proportional frequency control still active?
> - The specification should seek precision and clarity. The balance of guidance and flexibility is less important than the precision, standardisation and clarity of technical parameters, without which, the interpretative measures adopted by designers to fill in gaps in aspects of the specification will reduce overall coordination of frequency control. AEMO is encouraged to seek advice from technical design specialists as to what this specification requires. If that advice has already been obtained AEMO is encouraged to include it with the consultation papers.
>
> …
>
> AEMO are advised to think in more detail about what the specification implies by clause 2.2 regarding priority. Many controllers provide FCAS support and PFR added/subtracted to/from the AEMO delivered energy target which also includes any regulation amount AEMO is dispatching to the Unit. The implications of the clause suggest the MASS requires specific decoupling from the energy target of some frequency reactions including contingency services, when triggered, to essentially freeze the energy target at the pre-event level until frequency recovers. To the knowledge of Delta Electricity, no systems are presently built this way and if AEMO now requires them to be modified it needs to be more definite in this pursuit and seek modifications on all controllers, acknowledging also, the time it might take to achieve this alteration across the NEM. Following from other comments, the design specification would benefit from better diagrams to describe better how dispatch targets should be managed during contingency event responses.
>
> In addition, as many frequency controllers are the same controller that delivers PFR, decoupling the reaction from the dispatch signal on such controls would mean the dispatch target will be continuously stalled unless further modifications ensure the reaction to the [primary frequency control band] in droop fashion differs from the reaction to NOFB breaches that now requires suspension of the dispatch target until frequency recovers.
>
> Finally, as the delayed service is seeking recovery to 50Hz, the designs are become very complicated for words to adequately describe.

Empower Energy:

> **Is it primary or secondary response we're concerned with?**
>
> Discussions in the last MASS review meeting, which preceded the DER MASS review meeting, included a comment that Fast FCAS is not primary frequency response. Later discussions with Tesla Australia's

[38] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

engineering staff echoed this comment. A number of discussions with stakeholders to both meetings afterwards revealed some confusion in this matter - many believe fast FCAS is a primary contingency frequency response mechanism (as opposed to PFR, which is a primary regulation response mechanism).

The ambiguity of this situation is further complicated by the AEMC present conducting a response to the FFR Directions Paper which in part identifies the potential of DER assets among a new generation of (asynchronous) energy assets able to enact PFR - whether regulation or contingency - in a more technically flexible manner than assets available at the time the current MASS paradigms were designed. The outcomes of the FFR review are yet to be determined, though options are known to new market ancillary services to procure FFR FCAS or to procure FFR through existing service classifications.

Some (not all) participants in the FFR process are also represented in the current MASS DER review, and with this holistic appreciation of the development of FCAS have offered particularly valuable insight into how a transition from the status quo to could occur - the italicised below is from Tesla's submission to the AEMC's FFR process:

> *…"Whilst Tesla remains open to both design options, Option 1 (new FFR markets) would be preferable, with a layered approach to ensure consistency across system services - e.g.: first response primary* frequency *services (narrow deadband, continuous operations); adding a new FFR product (with <1 or <2s response, rewarding speed and accuracy); followed by existing contingency response (i.e. current 6s, with slightly wider deadband).*
>
> *If Option 1 is progressed, we agree with the AEMC's approach to co-optimise inertia, FFR and R6 services. Tesla also supports additional consideration on the introduction of performance factors to differentiate the quality and speed of service from different technologies and reward more 'premium' provision accordingly…"*

It would seem therefore that there exists a consensus from at least one leading vendor also involved in the VPP trial that:

- The initiatives promulgated in the VPP trial are possibly being considered as secondary contingency frequency response by at least one key stakeholder, though this matter is still a matter for conjecture, and
- That responses to primary contingency frequency response should be assessed on merit of quality and speed.

From here, the intent of the proposed MASS changes with respect to DER becomes quite confusing… because if a DER:

- Can meter power and frequency at Class 0.2 with 1Hz frequency, and
- Is intended for secondary frequency response

Then it already meets the requirements of the Slow FCAS (secondary frequency response) within the current MASS - there's nothing to change! No need for check metering, injection testing or the like. The current MASS requires 0.25Hz Class 0.2 metering for secondary response. 1Hz metering exceeds this requirement. It is difficult to understand in this instance why anything needs to be changed - let alone the design of our current fastest contingency market in a manner disincentivizing competitive response performance - for assets that currently meet secondary frequency response requirements.

…

AEMO should make clear its intent for Fast FCAS as primary or secondary frequency response moving forwards, and within this process provide transparency around a known roadmap for all activity shaping these markets in the near term. It is apparent that the DER MASS review is not a complete means to these ends.

Is the current MASS change for DER consistent with AEMO's view on FFR and FCAS?

AEMO's response to the AEMC on the matter of market design efforts for best procurement of services would tend to agree with the situation being in flux, with more effort required before an understanding of a best approach to procurement of frequency services clarifies a considered market restructure:

> *"At a high-level, AEMO notes FFR could be added as a separate Contingency FCAS in addition to the existing services but it may be more efficient to implement FFR by re-specifying existing FCAS. In either case much work is needed before being able to conclude one way or the other."*

AEMO's response does not mention efforts to re-draft the MASS with respect to DER.

Given cognisance of impending potential, significant and structural change to the very markets the DER MASS review seeks to change - it is difficult to understand why AEMO has not sought to formally align

these efforts, particularly given the close timing between them and the potential for a change to Fast FCAS to influence the design or impact of any determination on FFR.

Hydro Tasmania:

Hydro Tasmania believes it is important to establish technical co-ordination between different FCAS and other characteristics that support management of system frequency.

Given the complexity of the issue, Hydro Tasmania would encourage AEMO to consider an independent document to state the coordination specifications details, but only leave high level principal description in the MASS. This would be helpful to ensure that each section in the MASS is reasonable balanced and no significant modification of MASS is required when update or further coordination specification is needed.

In regards the coordination specification contents, Hydro would suggest AEMO considering a logical and sequential approach, including:

- PFR and SFR roles and objectives.
- PFR and SFR response characteristics and the coordination design principle.
- PFR and SFR coordination guideline. E.g. physical coordination and control settings.
- FCAS delivery evaluation coordination specification.

…

AEMO has proposed a coordination diagram in Figure 8[39]. Hydro thinks this is good starting concept, on top of that more details would be helpful to reflect the two key factors of coordination - 1) responding timing and 2) allocated Δp size after coordination.

Infigen:

Infigen has not identified any other co-ordination matters that should be addressed in the MASS, provided that the interactions between PFR / Contingency FCAS controls and AGC controls also addresses AGC targets for energy dispatch.

For clarity, it should also be noted that for some generators that provide a proportional controller response, the same controls will be implemented for both PFR and Contingency FCAS, so the PFR will be provided as a component of the overall proportional response.

Infigen have no objections to the control clarifications outlined. However, for increased clarity, Figure 8 could also include the treatment of any energy target that the plant could be subject to and how this will impact upon the FCAS facility output.

Switching Controller Trigger Ranges

AGL:

AGL's preference is that switched controllers are not part of frequency control within the NOFB. On this basis, we support the narrower trigger ranges, which remain outside the NOFB.

CleanCo:

CleanCo notes the considerable benefit switching controllers provide in terms of stabilising and returning frequency to within the NOFB[40]. As such, any proposals to limit or control switching controllers should be undertaken in a way that still encourages them to take part in the market.

…

Decreasing the deadbands for switching controllers appears at odds with the problem AEMO is trying to solve in 3(a) [of the Issues Paper]. Decreasing deadbands will see switching controllers react to frequency issues more often and potentially increases the likelihood over overshoot. Notwithstanding this, CleanCo recognises the significant improvement in frequency performance since PFR has been implemented across the NEM, a tightening of deadbands could likely be achieved with limited impact to most switching controllers. Any impacts that do occur could be dealt with through higher offer prices.

Delta Electricity:

Delta Electricity considers Delayed controls should be set wider than any faster services. The trigger ranges proposed in the Draft that narrow Delayed FCAS activation to tighter values of 49.85 and 50.15 are

[39] Figure 8 is in the Issues Paper.

[40] AEMO, Renewable Integration Study Stage 1, Appendix B: Frequency Control, March 2020 - See Figure 17.

not recommended. Generally switched control ought to be considered a secondary back-up to frequency responsive controls.

In typical installations, the switched controllers have been applied in the Delayed service only, which by existing MASS design are set outside the operational levels of Fast and slow services and are only be required where 6 and 60s responses have been inadequate. The Delayed switched control follows in more stepped correction to hopefully prevent further deterioration of conditions and avoid the deployment of more disruptive protective measures such as load shedding.

Enel X:

The [Issues] paper notes that frequency performance has improved markedly because of the mandatory PFR rule change and that there now is a disparity between the work expected of a proportional controller and a switching controller. AEMO argues that those with proportional controllers that remain at wider dead bands (0.15 Hz) because they haven't made PFR changes yet, or are not affected by the PFR rule, are responding to contingency events more often than switching controllers set to wider response settings.

It's not clear why AEMO is proposing changes to the trigger ranges for switching controllers on the basis that something "appears unjustified". And, as AEMO notes, frequency performance has improved markedly since PFR implementation, so excursions outside the NOFB are rarer. The [Issues] paper includes very little detail on why this is being proposed, and no data to support its claims. Clearer explanation of the system security or market implications that this is having is needed before proposing solutions.

Frequency set points should not be used to make sure that providers are used more often or more equally. Rather, they should reflect what frequency AEMO is comfortable for the system to deviate to in a contingency event and the amount of response that is needed at each set point to arrest and restore system frequency. Bringing all providers in closer to the NOFB would mean they provide a frequency response more often. This would increase many providers' costs, which will be reflected in their offer prices. It could also result in frequency overshoot and make the system more vulnerable to a significant contingency event.

If AEMO does decide to tighten the trigger ranges for switched controllers, we ask that this not be applied retrospectively. Existing switched providers and their constituent loads have made investments and decided to participate in the market based on the frequency set point agreed with AEMO. Requiring that the set point be changed will change the investment case and may therefore change a providers' incentive to continue participating in the market.

Other options that AEMO could explore in the context of concerns about the "frequency responsiveness" of switched controllers include:

1. Increasing the granularity of the trigger set points assigned to switched loads to enable a portfolio of switched loads to mimic a proportional response more closely.
2. Assigning larger switched loads to lower frequency set points, and smaller ones to higher set points, to minimise any potential for frequency overshoot.

Hydro Tasmania:

Hydro Tasmania would suggest maintaining the trigger range in Tasmania region, in order to accommodate the frequency deviation caused by the Basslink power flow reversal.

Shell Energy:

AEMO's proposal to introduce additional requirements on switched controller response creates some challenges, particularly for suppliers with older control systems to comply. Older systems are designed to provide a binary response, based on the setting of a switching relay which continues to be active regardless of whether the provider has been enabled for the provision of FCAS or not. In addition, in general, they are not capable of providing a part response. While new digital control systems should be able to facilitate the proposed changes, there would be a cost involved with replacing existing systems. We consider it preferable for the NEMDE to be required to consider if the switched frequency responsive load is a binary outcome (i.e. 0 or 100% only) and not part enable that load when selecting loads to be enabled for frequency response.

Shell Energy considers the proposed switching controller trigger ranges to be reasonable. However, given the difference between the frequency response settings on the mainland and in the Tasmanian region, it is unclear how switched frequency response service providers in the Tasmanian region could continue to be enabled to provide switched frequency response on the Mainland.

SwitchDin:

The proposed revised trigger ranges and deadbands do not present any additional technical challenges as the droop curve maintains the same gradient. However any significant increase in the number of expected frequency events per month may require increased orchestration by VPP operators to ensure that individual sites do not exceed agreed acceptable limits of use.

Proportional Controller Deadband to be Set at ≤0.1 Hz

AGL:

The Issues Paper provides that "[t]he FOS states that AEMO should restore frequency to be within the NOFB, not its edge." We disagree with AEMO's view that the edges of the NOFB are outside of the NOFB.

Proceeding with this change to the MASS will require settings changes for all FCAS providers, along with reworking FCAS registration amounts for these units so that the registered MW amount does not exceed a unit's response capability. The FCAS trapeziums, that co-optimise energy MW with FCAS MW will also require recalibration.

The costs to generators of a change to ±0.10Hz will be significant, not dissimilar to the costs incurred by generators in implement mandatory PFR settings. The difference is that mandatory PFR, including the deadband setting, went through an AEMC rule change process, while AEMO's proposal to rework contingency FCAS settings will not be subject to the same level of scrutiny.

We anticipate market distortion on a number of fronts arising from this change. Firstly, generators would be providing additional MW to the system within the NOFB, which is not the purpose of FCAS markets. A future PFR market, which the AEMC is currently considering, could be eroded as an overlap in frequency deadbands between frequency response services could distort price signals in the separate markets for these services.

In addition, we would anticipate increased costs to generators for providing contingency FCAS, due to increased cycling at smaller frequency excursions. These costs would ultimately be passed through to customers through higher wholesale prices. Alternatively, to avoid incurring additional costs, proportional controllers would simply disable frequency response when not enabled for FCAS. This would be of detriment to the power system, which currently benefits from this 'free' frequency control.

Finally, in the absence of a decision from the Reliability Panel narrowing the contingency band from the existing ±0.15Hz, we firmly disagree with the proposal to require proportional controllers to set contingency FCAS deadbands at ±0.10Hz.

CEC:

The paper also notes that the FOS states that AEMO should restore frequency to be within the NOFB, not its edge. The MASS indicates that frequency response should be maintained (or at least not withdrawn) until frequency recovers, defined as ±0.1 Hz, inside the NOFB. We suggest that as the PFR settings established in 2020 indicate AEMO's willingness to use three decimal places, that ±0.145Hz may be suitable rather than ±0.1Hz.

CleanCo:

Similar to above [regarding switching controllers], tightening deadbands for proportional controllers could probably be achieved with minimal impact, particularly given the recent improvement frequency performance.

Delta Electricity:

Clarifying that the controller must continue to operate until recovery is appropriate if that is what is required for good frequency control relative to the FOS. However, for many existing designs it also determines the activation value and the frequency deviation point that determines the effective proportional droop reaction in MWs.

The specification needs to be clearer about this (e.g. wording of 6.2.3 in the draft still implies where the control should commence). AEMO should consider the impact from controller designs that choose to include hysteresis in activation between an initiation point at 49.85Hz, for example, and a recovery point to 49.9Hz. If both are configured with a droop response applicable to the relevant frequency value, the response will be different depending on whether frequency is deteriorating or recovering. Such complexity could contribute to oscillatory reactions and is probably best avoided in fast and slow frequency responsive controllers as it adds to the complexity of coordination. It would be better if the FOS NOFB meant what it has meant previously as being the point where frequency controllers are meant to operate but the simpler compromise to cater for possible detection delays in controllers is to have the controller set at the

frequency recovery band initially but permit its variation out to the NOFB as long as the recorded MW response quantities remain compliant with MASS expectations.

Additionally, if participants are using the same controller to deliver PFR, the practical deadband for these FCAS will be much tighter. Does the MASS permit this in all places particularly when proportional response at ±0.15Hz deviation will be much larger from a large machine with a ±0.015Hz deadband vs a one with a ±0.1Hz deadband?

Hydro Tasmania:

Hydro Tasmania understands the consideration of revising the maximum allowable proportional controller dead band to ±0.1 Hz, so that the FOS requirement and the MASS technical specification aligns.

However, given the recent efforts on implementation of PFR which we believe supports this desired outcome, a conscious decision needs to be made about the completion of this change and the remaining shortfall. Thus Hydro Tasmania proposes AEMO defers the ±0.1Hz change in the MASS until the PFR implementation is fully completed and assessed.

This is critical for the participants to ensure that there is a sufficient and stable frequency margin between the NOFB and contingency bands, thus permanent dead band reduction e.g. from ±0.15Hz to ±0.1Hz could possibly be made once assessed post mandatory PFR is implemented.

Note: The ±0.1 Hz deadband requirement will not be applied for the PFR variation and exemption units.

Infigen:

The purpose of the MASS is to action the FOS. While AEMO has raised a theoretically correct point (deadbands at the edge of the NOFB cannot bring the frequency back into the NOFB), Infigen is not aware of any modelling indicating that this change is necessary to achieve the FOS.

Similarly, AEMO has not considered the costs and benefits of moving deadbands to 0.1 Hz rather than the edge of the NOFB. More frequent activation of resources will increase the cost of provision, which will ultimately be borne by consumers. There may need to be a greater role for the Reliability Panel in the MASS to ensure consumers are protected.

We also note this potentially conflicts with the proposal below to require Delayed FCAS providers to be switched controllers.

We note that frequency recovery within the NOFB (to ±0.1Hz or some other deviation from 50Hz) has been shown to be adequately supplied by PFR to date, highlighting the value of this service that should be compensated through market mechanisms. Regulation FCAS and the 5-minute dispatch of energy should also be considered for their role in frequency recovery within the NOFB to ensure that they are being utilised appropriately. Any change in requirements for proportional contingency FCAS deadbands should not be made due to adjustments made for PFR for other generators – it should be made if there is an ongoing concern around the delivery of contingency FCAS within the NOFB.

Reposit Power:

Many of the same issues that AEMO is attempting to address with the frequency responsive/non-frequency responsive bifurcation come into play here. Reposit asserts that AEMO is able to alleviate all of these issues with a considered application of frequency settings across units. These settings cannot be identical across units and so issues of equity arise. This is one of the reasons AEMO must work to demonstrate a fair and unbiased treatment of Participants in FCAS markets. A Participant that is trusting of AEMO is likely to carry an increased load for some time provided that they are sure that AEMO are not intentionally providing advantage to their competition.

Shell Energy:

AEMO indicates that Contingency FCAS response may be weak or withdrawn as frequency approaches the edge of the NOFB. Under current arrangements this is entirely to be expected, as it is a function of AEMO procurement of contingency response to only procure sufficient services to restore frequency to the edge of the NOFB. The inclusion of load relief in the procurement calculation further reduces the procurement of contingency services to restore frequency to within the NOFB. If AEMO is concerned by this, then they should adjust their procurement to reflect the required recovery to within the NOFB rather than just the edge.

AEMO is proposing that the MASS require proportional FCAS controllers not affected by the Interim Primary Frequency Response Rule to have frequency deadbands no wider than ±0.1 Hz. Shell Energy queries whether it would be acceptable for response to trigger at ±0.15 Hz but sustain recovery until ±0.10 Hz. This may be achievable with modern control systems on asynchronous service providers. We consider

> that this approach would still provide AEMO with the desired response but at a lower implementation cost.
>
> We contest AEMO's assertion that a general deadband specification of ±0.15 Hz or ±0.1 Hz is unsuitable for managing frequency. AEMO's assertion has not been demonstrated in reality. In the case of a wider deadband, the speed and level of response are as important as the setting of the deadband. We add that the AEMC is currently considering market provision of regulation PFR so that AEMO's proposed requirements in Section 3.341 would also apply to service providers providing contingency but not regulation PFR.
>
> ...
>
> Shell Energy also seeks clarification on the proposed requirement that all controllable units within the same VPP must operate with the same type of FCAS controller. While we believe AEMO is suggesting that the controllers must all be either proportional/variable or switched, we have concerns this may be implying that the controllers must have identical hardware or that any devices within the VPP must also be identical (e.g. same battery and inverter type). Shell Energy accepts the rationale for the controller alone needing to be either proportional/variable or switched but would oppose more onerous requirements to create homogenous VPPs using identical hardware.

Tesla:

> Workable for utility-scale BESS and should provide AEMO greater clarity on response quantities from assets not providing PFR. Tesla agree that the level of non-frequency responsive FCAS providers is a serious issue for the NEM, particularly for frequency overshoot when non-enabled providers respond. Tesla support the requirements for active market enablement, as well as non over responding more than 50%.
>
> Tesla supports and reiterates the statement: "all frequency response would be measured as contributing to Contingency FCAS."

5.4.2. AEMO's assessment

Guidance on FCAS co-ordination and priority

Support for providing increased guidance on control co-ordination and interaction was widespread. Submissions highlighted the need to clarify the role of primary vs secondary frequency control, and where PFR sits in relation to FCAS. AEMO notes the spectrum of views on how prescriptive AEMO should be in the MASS, and whether a case exists for some other document to provide this guidance.

AEMO accepts that FCAS Providers should not ignore AGC when Contingency FCAS controls are active, as this is unworkable where PFR and Contingency FCAS controls are active within the NOFB.

AEMO noted several ideas in the submissions on how guidance could be further improved and proposes to add their feasibility to the agenda of an industry working group to address.

Switching Controller Trigger Ranges

In response to Enel X's concern that AEMO might make any changes to controller trigger ranges retrospective, AEMO notes clause 3.11.2(e) of the NER, which states that amendments to the MASS cannot take effect until 30 days after they have been published. Section 6.1.4 of the MASS already specifies the range of conditions whereby trigger settings might be revised retrospectively.

AEMO notes the possibility of unintended consequences of further narrowing the trigger range, especially in Tasmania.

Proportional Controller Trigger Ranges

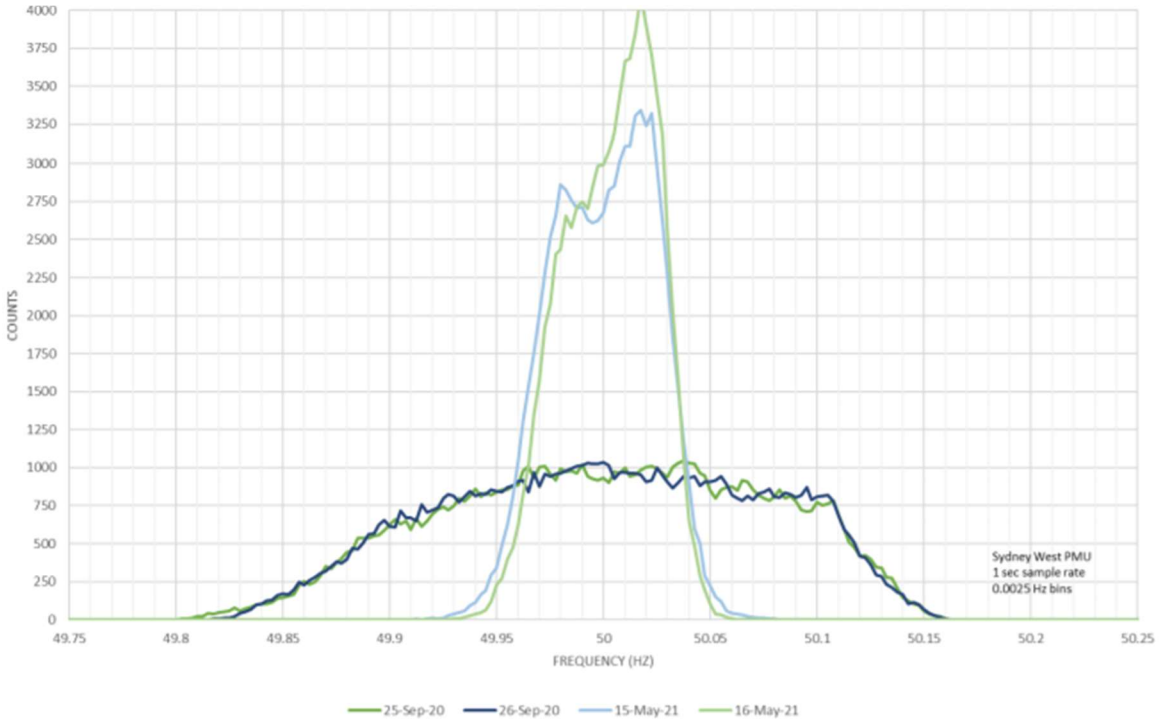
AGL disagrees that taking power system frequency to the edge of the NOFB does not achieve AEMO's objective of bringing it within the NOFB. Infigen, on the other hand, agrees that AEMO has a point. Frequency is constantly changing; AEMO cannot bring frequency back to be within the NOFB if Contingency FCAS acts to bring it only to the very edge of the NOFB, and no more. It is the frequency

[41] See the Issues Paper.

response that is holding frequency at the edge of the NOFB; once it is withdrawn, frequency will fall or rise once more. This is the key reason why some overlap into the NOFB is required for good control co-ordination.

More generally, as discussed in section 5.5, the FOS places requirements on AEMO (rather than FCAS Providers) to configure and procure FCAS that is expected to meet the performance requirements of the FOS (and a range of other NER requirements relating to power system security). Therefore, it is entirely appropriate for AEMO to set FCAS parameters to the settings it considers are necessary to meet the FOS and NER requirements. Following implementation of the National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5 (**Mandatory PFR Rule**)[42] AEMO's experience thus far indicates that the typical frequency distribution in the NEM (i.e. frequency under typical non-contingency conditions) will sit somewhat outside the 'prevailing deadband' of the primary frequency controls in the power system. Having implemented the Mandatory PFR Rule across a significant proportion of the NEM's scheduled and semi-scheduled generation, the prevailing deadband in the NEM might now be considered to be ±0.015 Hz. The typical frequency distribution, however, sits within approximately ±0.05 Hz, a multiple of the prevailing deadband. Prior to implementation of the Mandatory PFR Rule, the NEM's frequency distribution tailed off at some point outside of the prevailing deadband of ±0.15 Hz – see Figure 4, which is extracted from AEMO's most recent PFR Implementation Report[43]:

Figure 4 NEM Frequency Histogram



This experience also seems quite consistent with the modelling presented by Dr Undrill in his report to AEMO in support of AEMO's rule change request that resulted in the Mandatory PFR Rule[44].

AEMO understands and appreciates that FCAS Providers must, in some cases, undertake considerable work or incur cost to adjust frequency response settings with proper due diligence. Therefore AEMO agrees that, in light of the fact that the majority of impacted generators have already made changes to their control

[42] https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response

[43] https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2021/pfr-implementation-report-v15-18-may-21.pdf?la=en

[44] https://www.aemc.gov.au/sites/default/files/2019-08/International%20Expert%20Advice%20-%20Notes%20on%20frequency%20control.pdf. See Figures 7.1 through 7.5, in particular.

systems to comply with the Mandatory PFR Rule, further changes to proportional controller deadbands can be delayed until rule changes associated with PFR are made.

AEMO agrees with Hydro Tasmania's suggestion that it defers the ±0.1Hz change in the MASS until the PFR implementation is fully completed and assessed.

5.4.3. AEMO's conclusion

AEMO has made the following changes to the draft MASS:

- Section 10.3 includes Figure 8 from the Issues Paper.
- Section 2.2 now states that there is no priority in the provision of different types of FCAS.
- AEMO will retain the switching controller trigger ranges as they are but will change the 'default' settings in Table 5 and Table 6 to the narrowest settings within the applicable ranges. This sends a clear message that facilities using switching controllers should consider that they are likely to be required to apply the narrowest setting. Rearrangement of already assigned trigger points will be in accordance with the current arrangements.

AEMO will defer a decision on refining and clarifying trigger ranges (and service termination settings) for proportional controllers until the rule changes associated with PFR are made.

5.5. Relationship between MASS and other instruments or institutions

5.5.1. Issue summary and submissions

Several submissions queried the relationship between the MASS, the FOS and the Reliability Panel.

Each submission on this issue is detailed below:[45]

Delta Electricity:

> Inclusion of a reference to a document that details how the AEMO AGC interacts with Unit dispatch participates in frequency control should be considered.

Infigen:

> The MASS is a technical document reflecting technical requirements; however, it has material impacts on costs to consumers and generators. As such, it may be necessary to create a stronger link between the MASS and the Reliability Panel, including how the FOS is actioned.

Tesla:

> The existing FCAS registration route for grid-scale BESS is not transparent or consistent. Market participants continue to seek guidance on what is practicable; where responsibilities lie (AEMC vs AEMO vs Reliability Panel); where technical requirements are defined (NER vs MASS vs FOS); and what change processes are required (e.g. rule change or not).

5.5.2. AEMO's assessment

AEMO's understanding of the relationships is based on its understanding of various requirements in the NER:

- The functions of the Reliability Panel are listed in clause 8.8.1(a) of the NER. One of those is to review and, on the advice of AEMO, determine the power system security standards. The FOS is one of the

[45] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

power system security standards[46]. When doing so, the Reliability Panel must follow the consultation process in clause 8.8.3(d) to (l) of the NER[47].

- The latest version of the FOS has a commencement date of 1 January 2020[48].
- The FOS specifies various frequency bands, including the NOFB, which are then used to specify the required power system frequency outcomes following specified events.
- AEMO's functions in section 49 of the National Electricity Law include the maintenance and improvement of power system security[49]. Chapter 4 of the NER elaborates on this function extensively. The general requirement in clause 4.3.1 of the NER restates AEMO's primary responsibility is to maintain power system security. There are many provisions that elaborate on what this entails; in the context of power system frequency, clause 4.4.1 is the most relevant:

> **4.4.1 Power system frequency control responsibilities**
>
> *AEMO* must use its reasonable endeavours to:
>
> (a) control the power system frequency; and
>
> (b) ensure that the frequency *operating standards* are achieved.

- Hence, the FOS details the power system frequency performance indicators AEMO is required to meet. This is reinforced by clause 4.8.16 of the NER, which requires AEMO to report on power system frequency performance by reference to specified measures. Clause 4.8.16(b), in particular, requires AEMO to report quarterly on several factors, including:

> (2) *AEMO*'s assessment of the achievement of the *frequency operating standard*, including (where applicable) an analysis of how and why the *frequency operating standard* was not met;

- A fundamental design characteristic of the NEM is that AEMO is required to procure energy and market ancillary services through *spot* markets and will only intervene where market mechanisms fail to assure power system security[50].
- AEMO is required to procure market ancillary services (commonly referred to as FCAS) through a *spot* market in accordance with clause 3.4.1(a)(2) of the NER. What constitutes a market ancillary service is specified in clause 3.11.2(a) and defined in Chapter 10 of the NER.
- All of these provisions coalesce in clause 3.8.1(a) of the NER, which summarises the function of *central dispatch*, which AEMO is required to operate for the NEM to function in accordance with the NER:

> (a) *AEMO* must operate a *central dispatch* process to *dispatch scheduled generating units*, *semi-scheduled generating units*, *scheduled loads*, *scheduled network services* and *market ancillary services* in order to balance *power system supply* and demand, using its reasonable endeavours to maintain *power system security* in accordance with Chapter 4 and to maximise the value of *spot market* trading on the basis of *dispatch offers* and *dispatch bids*.

- Hence, to meet the FOS, AEMO is required to purchase FCAS through the FCAS markets and the MASS specifies the requirements that each FCAS must fulfil to meet AEMO's requirements.
- AEMO has discretion in specifying the quantity of each type of FCAS it requires to achieve the objectives of Chapters 3 and 4 of the NER, namely, the operation of the wholesale exchange in a way that maintains power system security and meets the FOS.

---

[46] See sub-paragraph (2). The FOS is defined in Chapter 10 of the NER as being one of the power system security *standards*.

[47] See clause 8.8.3(c2)

[48] Available at: https://www.aemc.gov.au/sites/default/files/2020-01/Frequency%20operating%20standard%20-%20effective%201%20January%202020%20-%20TYPO%20corrected%2019DEC2019.PDF.

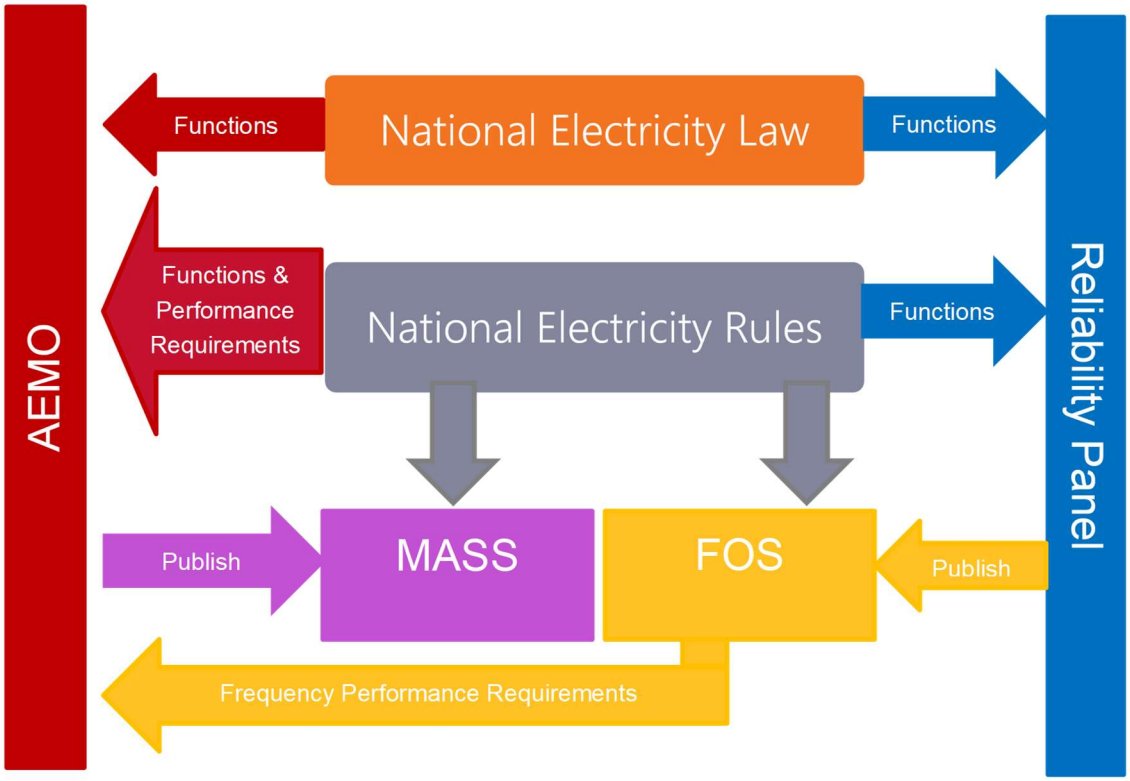
[49] See also section 4.2.2.

[50] See, for example, the intervention process in clause 4.8 of the NER.

- The quantity of each FCAS AEMO procures is not a matter that is required to be addressed in the MASS. There is no obligation on AEMO to consult with industry on how those quantities are determined, and we do not consider that a consultation requirement would be appropriate. Ancillary service constraint sets may need to be adjusted in operational timeframes to ensure power system security is not compromised.

These relationships are depicted diagrammatically in Figure 5.

Figure 5 Relationship between MASS and other Instruments and Institutions



Any Consulted Persons who consider these relationships inappropriate would need to seek a change to the NER.

5.5.3. AEMO's conclusion

The MASS does not require any changes to address this issue.

5.6. Requirements for Regulation FCAS

5.6.1. Issue summary and submissions

AEMO proposed a number of requirements for 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 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 – smaller bid sizes specified for facilities with very clean output.
- Maximum Control Response Delay (**CRD**) – must be no more than 150 s.

- Minimum Ramp Rate – to be set at 3 minutes to facilitate delivery of full amount within a dispatch interval (**DI**).
- Required measurements – AEMO specified the data required to be sent to AEMO via the SCADA system.
- Transitional Period – AEMO proposed a one-year transitional period to the new requirements
- Testing Cycle – AEMO proposed a 2-year testing cycle.

The main submissions on each issue are extracted below: [51]

Generally

Delta Electricity:

> Control system and SCADA modifications would be required for this which can be expensive, use resources with limited availability, require considerable testing periods post implementation and require coordinated projects between AEMO, TNSPs, participants and technical resources.
>
> The MW adjustment (some of the PFR) deployed by a computerised proportional frequency controller, can be accurately sent to AEMO. PFR delivered by mechanical-hydraulic controllers can be calculated and provided but in AEMOs 4s AGC the data would not be useful. By the time the AGC has considered and adjusted, the PFR from the mechanical-hydraulic governor will have changed significantly. The time-frame of the response of the AGC should target only that part of a controller it can reasonably expect to react to which for many machines will only be the computerised portion of the control, of which the actual amount can be communicated to AEMO in the SCADA data set.
>
> The currently designed Regulation FCAS dispatch is particularly difficult to deliver during energy ramping because of AEMO's delivery of the dispatched quantity on the energy dispatch signal. Some of the proposed requirements are difficult to meet because of this design. AEMO could separate the FCAS regulation target and send it to each Unit separately where it could be delivered with more assurance by Frequency controls instead of via MW setpoint controls.
>
> Ramp rate limitations often occur due to ambient temperature and fuel constraints. It is better that the FCAS regulation dispatch observe the applied Unit ramp rate and restrict the maximum possible regulation FCAS dispatch to suit the ramp rate rather than the specification trying to enforce that a Unit should maintain enough ramp rate to deliver any amount up to the maximum registered Regulation FCAS in 3 minutes.

Enel X:

> We do not have any comments on the proposed regulating FCAS requirements. However, we encourage AEMO to open the regulating FCAS markets to all capable participants, including small-scale and aggregated behind-the-meter batteries.
>
> In the development of the final rule for the Ancillary services unbundling rule change, AEMO noted that the existing MASS did not accommodate aggregated dispatch for the purposes of providing a regulating raise or lower service. The AEMC noted this comment in the final determination and recommended a review of the MASS to address this. It was the intention of that rule change to unbundle the provision of all ancillary services from the provision of energy, not just the contingency services.
>
> Section 2.4 of the current MASS suggests that aggregated assets can be used to provide regulating FCAS, but none do because the requirement is that the provider have AGC and SCADA capability. This is a significant barrier to entry for aggregated assets. The service is therefore provided entirely by scheduled energy market participants. The lack of access to the regulating FCAS markets also reduces the incentive for behind-the-meter battery providers to invest in a proportional controller over a switching controller.
>
> As we saw when the contingency FCAS markets were unbundled, removing barriers to the regulating FCAS markets will increase competition and lower prices. And, increasing access to the regulating FCAS markets is likely to become even more important as the traditional providers (e.g. Yallourn) exit, more renewables connect, and the need for service increases. We therefore encourage AEMO to explore:

[51] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

- how to establish a baseline (other than an energy market dispatch target) from which an aggregated provider could be dispatched up/down for regulating FCAS
- alternatives to AGC signals and SCADA that would enable aggregated providers to participate.

Hydro Tasmania:

In the current proposal, the regulation FCAS requirements seems only relate to AGC - the secondary frequency response, however given the reality that now governor response are also involved in the frequency regulation, Hydro would firstly suggest AEMO clearing the Regulation FCAS definition and scope in 3.5 [of the Issues Paper], then regulation FCAS requirement.

Infigen:

Infigen is in general agreement with the proposed requirements and settings listed in Section 3.5 [of the Issues Paper], with the following comments and concerns:

…

- The Local PFR measurement should include any response provided for contingency FCAS, and instead represent the MW output of the facility based on its total local frequency response;
- AEMO should provide further commentary on the use of these required measurements and why they are required within the context of providing regulation FCAS (e.g. battery state of charge information). This will help identify if AEMO's proposed use of data supplied by a facility could create unforeseen issues; and
- If possible, AEMO should provide the feedback from the independent AGC experts which lead to them determining the proposed regulation FCAS requirements for greater transparency.

Shell Energy:

At the first instance, Shell Energy considers that it is incumbent on the MASS to provide a clear definition of what regulation (AGC) frequency response actually is. As the Paper notes, the current MASS states that providers must act in an accurate and timely manner, however the definition of what service is actually required to be provided is not set out in the MASS. In addition, the definition of accurate and timely is left to AEMO's discretion. Clearly, this creates a situation with little clarity or transparency for participants.

We therefore welcome AEMO's approach to better define the requirements of Regulation FCAS (notwithstanding the need for an overall definition).

Telemetered Data Rate

AGL:

The proposal that data from each regulating facility be updated at least every 4s with no more than 8s data latency is not achievable by DER or smaller stations. These smaller regulation FCAS providers are unlikely to have control systems that can operate to these requirements. Upgrading these systems would likely require significant cost.

Maximum and Minimum limit duration (s) – AEMO proposes that within the telemetered data requirements, battery-based facilities indicate how long a maximum and minimum AGC control limit can be sustained based on the battery state of charge. We would need to review this proposal further, but our initial view is that this requirement would be difficult to meet for DER battery facilities.

CleanCo:

CleanCo supports provision of real-time data to AEMO to facilitate closer monitoring of regulation FCAS provision.

…

Appropriate and achievable.

CEC:

The proposed telemetered data rate of 8s is inconsistent with other similar systems and appears unjustified. TNSP and AEMO's systems such as AGC do not always meet this requirement, so it appears inconsistent to require this for regulation FCAS.

Energy Locals:

...

5. New Regulation FCAS

The requirement for no more than 8s of data latency is inconsistent with the delays already seen in TNSP and AEMO systems. We don't believe these arbitrary limits add value when it's simple for AEMO to measure regulation FCAS response on a storage fleet vs traditional generators.

Hydro Tasmania:

Adequacy:

Hydro believes the proposed measurements have reasonably captured the need for regulation FCAS performance evaluation.

Achievability:

While most of proposed measurements are already available or provided to AEMO, Hydro would like to point out that it can be challenging to extract the PFR response other than the existing approach established in the contingency FCAS space e.g. using machine terminal power minus the inertial response.

Hydro suggests considering PFR determination as a stand alone topic.

Infigen:

Infigen is in general agreement with the proposed requirements and settings listed in Section 3.5 [of the Issues Paper], with the following comments and concerns:

Further clarifications on the data latency requirement should be provided, namely whether the maximum 8s data latency is in reference to the internal control systems or external communications between the facility and AEMO. If it is in reference to external communications, then these are typically outside of the control of individual participants and the responsibility of TNSPs and/or AEMO, which would limit the ability for participants to rectify latency issues;

Shell Energy:

AEMO proposes no more than 8s data latency. We urge AEMO to recognise that this may be beyond a participant's control if the cause of the latency is AEMO or AEMO's agents' systems.

...

AEMO also lists a range of data that facilities providing Regulation FCAS will be required to convey to AEMO in real time. AEMO is requesting that all of these values be provided through SCADA with a latency of no more than 8s. As above, this may be beyond the provider's control if AEMO or AEMO's agents' systems are causing the latency. We have additional comments on certain required measurements:

- Ramp rate (MW/min) – AEMO states that providers would be expected to ensure that the telemetered ramp rate can cover changes in energy dispatch, plus any Regulation capacity cleared in NEMDE. We disagree with this requirement. Instead, AEMO's enablement of secondary AGC frequency response must be based on the bid ramp rate, any change in a provider's energy dispatch target, plus secondary AGC frequency response. A generator utilising all its bid ramp rate to meet a change in energy dispatch targets should not be enabled for secondary AGC frequency response in the same direction as the change in energy dispatch target.
- Maximum AGC control limit (MW) – AEMO is requesting providers include the maximum available MW capacity for AGC-issued control requests as facilities may have additional capacity above that reported as maximum availability that is not currently available to AGC control but is available to the plant operator (e.g. overload capability). We would like to see AEMO provide justification for this request as it is unclear to Shell Energy why this is strictly necessary when a provider has already provided advice in the form of maximum availability in the dispatch offer. There may be a case for this data to be provided if it is to ensure AEMO procures only the capable quantity from a service provider.
- Local PFR (MW) – AEMO is requesting the current MW equivalent of any local PFR as extracted from the local plant controller or equivalent. Again, it is unclear why this should be required or how it would be measured. As such, we wish to see a clear justification for the reasoning behind requesting this data.
- Minimum limit duration (seconds) – For batteries, AEMO requests the duration the Minimum AGC control limit can be sustained for the current state of battery charge. Essentially, AEMO is requesting dynamic feedback of storage levels. We consider that it is the responsibility of the BESS operator to submit dispatch offers and bids based on storage capability and not on AEMO to decide a BESS's

capability or how it should be utilised. Clause 4.9 of the NER make it clear that BESS operators would have to do this in any case. It is therefore unclear why AEMO requires this data.

Tesla:

... there are several elements ... that we feel are not warranted and could be amended slightly to improve the experience for technology providers and customers. Specifically, Tesla questions the need for the following:

...

General

Consider alternatives to the proposed "no more than 8 second latency" requirement, considering delays in AEMO/TNSP SCADA systems on large generators typically exceed 20s.

Tesla Position	Proposed Alternative
1. The "no more than 8s data latency" is not workable. It is inconsistent with and ignores the delays in TNSP and AEMO's own systems (i.e. AGC suffers delays ~ 30s or more). 2. ... 3. Providing local PFR (MW) telemetry to AEMO may be problematic for batteries, as this value isn't readily available on the SCADA system (it exists locally at inverter) and operates at a faster time scale. It is unclear what value this provides. 4. For maximum limit duration (batteries) this is a good initiative, it is unclear how this will be implemented in dispatch however. More information and industry feedback on this requested.	• An alternative solution is to use timestamps as applied at each generator's RTU for generator originating SCADA data. AEMO/TNSPs also need to continue addressing these delays on their own systems directly. ...

AGC Controllable

AGL:

We have no concerns with the proposed requirement that a regulating facility must demonstrate its response to AGC-issued control requests as either setpoint targets or as raise/lower controls.

CleanCo:

Appropriate and achievable.

Shell Energy:

AEMO proposes that for setpoint controlled facilities, the minimum change of the control request (setpoint change deadband) must be no larger than half the facility's allowed minimum bid size. Shell Energy disagrees and recommends that the level of change should be no greater than 20% per minute of the facility's enabled quantity. This is to ensure that the MASS does not inadvertently require the service provider to exceed its stable bid ramp rate.

Minimum Bid Size

AGL:

AEMO's proposal for minimum bid sizes of 2MW for batteries and 5-10MW for thermals appears intended to manage the accuracy of plant output measurements, and we understand this concern. We also consider that this could potentially reduce overall regulation FCAS supply, while increasing costs for providers.

CleanCo:

Appropriate and achievable.

CEC:

> The proposed minimum bid size of 2MW is not supported. It is possible for batteries to provide a clean output well below the 2MW threshold identified within the [Issues] paper. We suggest AEMO consider the minimum bid size further and conduct deeper analysis as required.

Infigen:

> Infigen is in general agreement with the proposed requirements and settings listed in Section 3.5 [of the Issues Paper], with the following comments and concerns:
>
> …
>
> AEMO's motivation for implementing a minimum bid size for different generators should be provided, detailing the clear need for the minimum bid sizes and how these were calculated. The implementation of minimum bid sizes may also cause perverse market outcomes if every generator has a minimum cleared level, while also adding complexity to the co-optimisation of regulation FCAS and other services would be introduced to the NEM;

Mondo:

> … the proposed minimum bid size of 2MW is not supported. Inverter-based resources should be able to provide a bid size of 1MW, which would take advantage of the full capability of new generation plant.

Shell Energy:

> AEMO proposes that batteries or other inverter-based resources have a minimum bid size of 2MW, with other facilities having larger minimum bids, e.g. 5 or 10MW. We do not consider that AEMO has adequately explained why a change from the current minimum bid size is required. We consider that Regulation services minimum requirements should be the same for all technologies.

Tesla:

Tesla Position	Proposed Alternative
5. … 6. The 2MW limit is arbitrary and inconsistent with "no less than half the bid size" (i.e. 1MW/2 = 500kW). 7. …	… • Remove arbitrary limits, and/or recognise technology differences - it is much easier to observe a clean 1MW regulation response on a battery than it might be to observe a 5MW on a thermal plant.

Maximum CRD

AGL:

> We support the proposed requirement for a maximum CRD value of 150s.

CleanCo:

> We recognise AEMO needs to be cautious in setting limits that could significantly reduce competition but, on face value, a control response delay of 150s may be too generous. Regulation FCAS is designed help manage small deviations in the demand/generation balance within the DI. Allowing a 150s control response delay could essentially render regulation FCAS meaningless for the first half of each DI.
>
> We are also a little concerned that a longer control response delay is contributing to AEMO's position on the minimum ramp rates issue below, which CleanCo has reservations about.
>
> If AEMO is concerned that setting a CRD <150s would preclude too many providers, it could consider offering a premium for those with a lower CRD. This would incentivise providers to improve their CRD over time and reward those generators that are more likely to provide services up to their enablement level within a DI.

Shell Energy:

> AEMO proposes allowing a maximum time of 150s. We consider this to be an acceptable delay, provided it is 150s from the time the AGC output change request is received at the facility.

Minimum Ramp Rate

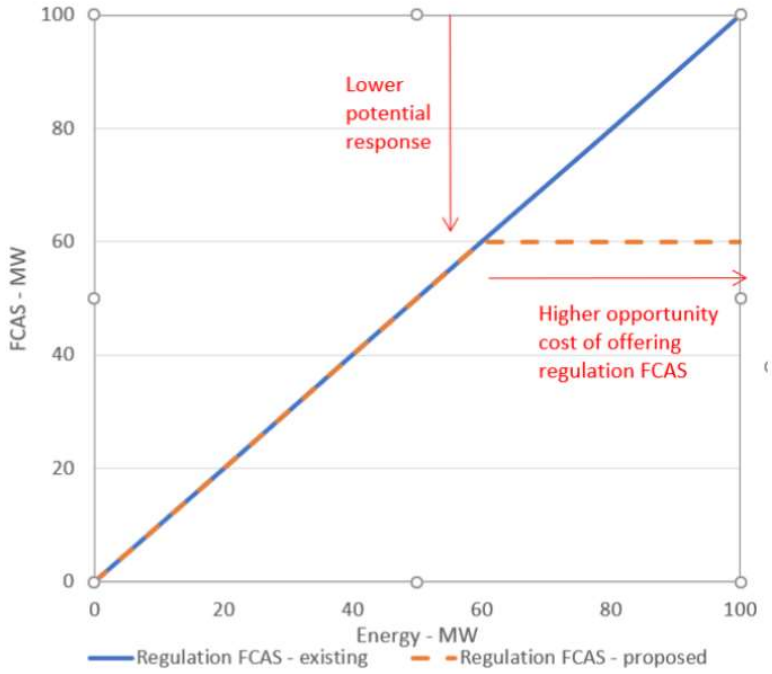
AGL:

> We suggest that a minimum three-minute ramp rate requires much more thought and analysis. This change would require recalculation of regulation FCAS capability NEMwide, which is a significant task for generators. Our initial observation is that a three-minute ramp rate would artificially limit the regulation FCAS capabilities of some generators but may broaden the pool of enabled providers.

CleanCo:

> CleanCo suggests … that a three-minute ramp requirement may be too short.
>
> …
>
> CleanCo recognises AEMO's preference for providers to be able to achieve their full enablement even if a frequency event occurs later in a DI. However, we have reservations AEMO's proposal, particularly the requirement to be able to meet the regulation FCAS enablement within three minutes. The proposal will complicate the bidding/dispatch process and increase the opportunity cost of supplying of regulation FCAS. All other things being equal, consumers would be worse off under the proposed model than under the existing model.
>
> Figure 4 provides an example of this issue. The opportunity cost of a generator providing regulation FCAS is that it will not be dispatched for additional energy.
>
> Under the existing framework, there is a one for one relationship and the trade-off is relatively simple; a plant with a 20MW per minute ramp rate, can offer 100MW of regulation FCAS and additional 100MW of energy. AEMO can then optimise between FCAS and energy based on whatever outcome is best for consumers.
>
> Under the proposed framework, the plant would only be able to offer 60MW of regulation FCAS. The opportunity cost of being enabled for this 60MW is that it will still forgo a potential 100MW of additional energy. To stay whole, the generator would have to increase its regulation FCAS price by 66%. The total cost to consumers would remain about the same but they would receive less total response for the cost, particularly where frequency events occur earlier in the DI.

Figure 4 – Higher opportunity cost and lower response under proposed model



Notwithstanding CleanCo's above reservations, we recognise AEMO's intent to improve the link between remuneration and likely response. Two options that could improve consumer outcomes for regulation FCAS would be:

(a) Consider a premium for generators with lower control response delay (as proposed above); and/or

(b) If implementing the three-minute target response, ensure NEMDE optimises between regulation FCAS and energy to ensure there is no increase in opportunity cost. In the above example, the generator could then be enabled for 60MW of regulation FCAS and up to 40MW of additional energy).

…

Other than ramp rate (as discussed above) these the SCADA requirements appear broadly appropriate. CleanCo is able to determine PFR and communicate it to AEMO separately. We understand AEMO already has real time access to most of the data points requested, although some additional internal testing/review may be necessary to ensure this is fit for purpose.

Shell Energy:

AEMO proposes that the telemetered value for the facility's ramp rate should be large enough that the market cleared Regulation FCAS capacity can be fully deployed in 3 minutes without exceeding the telemetered ramp rate. Shell Energy agrees with the concept and rationale. However, we believe that the obligation should be on AEMO not to enable regulation secondary frequency response above the level which can be achieved by full deployment within 3 minutes. The obligation should be on AEMO to procure to meet this requirement rather than a service provider to alter settings to meet this requirement.

Transitional Period

AGL:

One-year would not be sufficient for all existing regulation FCAS providers to meet the revised requirements. Smaller participants may be able to meet this timeframe, but those with larger portfolios, like AGL, would have difficulty rolling out the changes fleetwide within a year.

The bar AEMO is proposing to set for regulation FCAS is high and participants will need to assess whether it is possible for their plant to meet the requirements, and whether the costs of doing so are worth it. Should a generator proceed with implementation, verification and testing will be required before they can be enabled in the market.

Noting further proposed changes around contingency FCAS and the ongoing AEMC reforms around PFR and FFR, we would anticipate a drop-off in regulation FCAS providers with a one-year lead in time.

CleanCo:

A 1-year phase in is possible but may be challenging. Changing SCADA communications to AEMO will require coordination between the generator, TNSP and AEMO, and will need to be undertaken during an outage. Given the 100+ units registered for regulation FCAS, it may be challenging to get this completed within a year.

Delta Electricity:

Outages, budgets and planning will be required and for many participants this extends the period of time it may take to consider the revised specification, obtain estimates for the cost of modifications, consider the economic viability of the project and modify and test revised controllers. 2-years is recommended as a minimum.

The implementing resources are often resource constrained which can also extend the delivery time.

Hydro Tasmania:

Hydro would suggest the Regulation FCAS implementation is scheduled after the mandatory PFR project.

As for the time frame, it would be helpful if the implementation can be carried out in multiple stages based on the size of the machine (similar to the PFR). This will allow the participant like Hydro Tasmania (fleet includes 50 units or 29 production lines) have sufficient time to plan and implement.

Infigen:

Infigen has no issues with the above timelines for implementing and testing the proposed regulation FCAS requirements.

Testing Cycle

AGL:

Our view is that regulation FCAS is being 'tested' every 4 s because issues will become apparent in real time. Accordingly, we consider that AEMO should have the ability to challenge instances of poor or unexpected performance at any point, as is presently the case with contingency FCAS.

> Based on the current FCAS market structure, our suggestion would be for a four-year testing cycle for technology types that are able to test their response, noting that some cannot. Should the AEMC chose to implement PFR procurement through a 'primary regulating service', which would downgrade regulation FCAS to a secondary service, any testing regime should take account of this changed market structure.

CleanCo:

> Our view is that closer monitoring is preferable to periodic testing in that it identifies issues in real-time and allows AEMO to focus its efforts on the plant with worst performance while minimising the burden on well-performing plants.
>
> …
>
> CleanCo considers an automated monitoring framework would be more appropriate and valuable than periodic physical testing. An automated testing framework is better because it (a) avoids costly manual testing processes (b) identifies issues in real time, including hardware or software failure that may otherwise go unnoticed until the next physical test. Automated monitoring would also allow AEMO to focus its efforts on the plant with worst performance while minimising the burden on well-performing plants.

Delta Electricity:

> Testing could be at wider periods. e.g. AVR[52]s are not tested at this frequency. But participants may also observe defective performance in shorter time frames and, if so, ought to be required to report and correct. AEMO may also be able to perform the tests without notice in which case AEMO could do that at whatever cycle it chooses but are encouraged to approach such testing in coordinated fashion with the participant to seek improvement in performance if required.

Hydro Tasmania:

> From Hydro perspective, the real challenges is to accommodate all 50 units within the 2 years testing cycle (e.g. averagely 2 units per months) and then repeat this pattern in monthly basis.
>
> Alternatively, Hydro would suggest if the proposed tests can be integrated in normal operation, for example, using inbuilt data logging facilities where available in response to market signals and adding small ramp up and down test signals in the AEMO regulation target and introduce the power bias via the global AGC channel.
>
> By doing that, Hydro believes that:
>
> - The entire AGC channel can be tested and better identify the regulation response performance in different sections.
> - Testing downtime and cost can be significant reduced.
>
> While at this stage it is believed that AMEO still needs time to work out the testing details, Hydro would like to express an interest to facilitate the potential trails.

Karit:

> Karit supports the implementation of a regular testing cycle as long as it does not inhibit the ability of the FCAS provider being able to generate suitable returns from their investments. Any testing regime should be established on the same basis as the initial testing regime established for provisioning a site to participate in an FCAS regime.

Tesla:

> … recommend be implemented via operational AGC regulation response via a defined 5-minute test period (without taking out of market). Test data can be provided by Participant via high speed data for correlation with AGC signal data. This minimises the cost to the Generator and consumers for compliance.

5.6.2. AEMO's assessment

Generally

Submissions were supportive of the idea of better defining the purpose and requirements of Regulation FCAS, though there was a wide range of views on how this might be done and whether AEMO's proposals were appropriate. Through this consultation, AEMO has identified a subset of workable requirements that

[52] Automatic Voltage Regulators.

might be implemented now, and deferred others for further consideration. Those suitable for implementation now are:

3. Requirements for telemetered data fields along with a specified data rate and latency.
4. Requirement to demonstrate AGC controllability and a floor on acceptable AGC setpoint change deadband.
5. A minimum Regulation FCAS bid size.
6. A maximum control response delay (**CRD**).
7. Specification of a Regulation FCAS testing cycle.

To be deferred are:

8. Minimum ramp rate requirements.
9. Some of the proposed telemetry requirements.

Submissions also raised matters not specifically drawn out by the Issues Paper, including EnelX's query about how Regulation FCAS from facilities that are not scheduled or AGC-capable might be implemented. Regulation FCAS is controlled via AGC, and all calculations are internal to it. Instructions are sent out every four seconds from AGC over SCADA. AEMO appreciates that the installation of AGC response capability is a significant hurdle for facilities that are not otherwise required to have that capability. However, it is difficult to imagine a suitable alternative. If there is a workable way to implement Regulation FCAS through other means, AEMO would welcome further discussion on evidence-based proposals. Consulted Persons should be mindful that any major change to infrastructure and systems (including flow-on effects on other processes like Causer Pays[53]) is likely to be costly and the benefits of any investment in an alternative must be assessed against the NEO.

Telemetered Data Rate, Latency and Data Fields

AEMO agrees that factors external to an FCAS Provider's communications system cannot be taken into consideration when seeking to impose an 8s latency. Minimising latency is an important part of improving the efficiency of Regulation FCAS but the reality of the current communications infrastructure supporting the SCADA system means there are practical limits on what can be achieved at this time.

AEMO intends to use potential improvements in Regulation FCAS performance to support an analysis of the case for upgrading SCADA infrastructure, and in particular, direct connection between AEMO and FCAS Providers' SCADA systems.

There appears to be no significant impediment to pursuing the requirement of having the capability to telemeter data at a rate no slower than once every four seconds.

In terms of the required data fields that would need to be provided by facilities providing Regulation FCAS, some submissions questioned the need for sending limit duration data (effectively 'state of charge') and others noted difficulty in providing local PFR action (i.e. separate to energy and regulation duty). Particularly, submissions sought explanation of how AEMO's intended use for this information.

Limit duration data could potentially be used by AGC to improve AGC efficiency, by re-allocating regulating duty automatically if energy limits were reached. Reporting of PFR action allows further optimisation of AGC; it allows AGC to understand why a facility is at a particular output level and take this into account when controlling the facility. This is especially useful for pulse controller facilities as AGC needs to have an understanding of their expected PFR (or Contingency FCAS) action to best co-ordinate regulating duty on those facilities.

[53] See the Causer Pays Procedure available at: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/20170106-causer-pays-procedure.pdf?la=en

Nonetheless, AEMO accepts that these two data requirements are neither readily available, nor necessarily able to be fully utilised by AGC immediately. Given this, AEMO will defer any action on the proposed requirements to telemeter limit duration data and local PFR action. The other proposed data requirements will be included in the draft MASS.

AGC Controllable

Submissions were supportive of the MASS requiring Regulation FCAS Providers to demonstrate the ability of their facilities to action AGC controls and for the change in output to be clearly discernible from any noise and oscillation in the telemetered output. This would be proved through the normal testing conducted when any new facility registers for participation in the Regulation FCAS markets, or when they undergo testing.

While agreeing with this principle, Shell disagreed with requiring setpoint-controlled facilities to have a setpoint change deadband no larger than half a facility's allowed minimum bid size. Instead, Shell recommended that it should be no greater than 20% per minute of the facility's enabled quantity so that a Regulation FCAS Provider would not be driven by AGC to exceed its stable bid ramp rate.

AEMO appreciates the basis for Shell's concern, however, AGC would not exceed the stable bid ramp. AGC is designed to respect the telemetered ramp rates at all times. If an AGC output change request is less than a facility's setpoint change deadband or ramp rate, that output change is not actioned, and the AGC request is not allocated to that facility.

Minimum Bid Size

Of the submissions received on this topic, there were some concerns about:

- The justification for a minimum bid size (Infigen, Shell).
- The appropriateness of a blanket minimum bid size in MW (AGL, CEC, Mondo, Shell, Tesla).

There is currently no minimum bid size for Regulation FCAS other than the general requirement to offer whole MWs, which sets an effective floor of 1 MW. This is below the general noise in output for most large generating units and, notably, is lower than the minimum AGC change threshold for some.

Both these factors mean that very small quantities of Regulation FCAS cannot be discerned or measured, or, even worse, in the case of minimum AGC thresholds, cannot even be used. This means that AEMO cannot validate or provide any real confidence in amounts smaller than 1 MW being delivered to the power system.

Hence, a minimum bid size for Regulation FCAS is required. Implementing a minimum quantity on the dispatch side (i.e. within the NEM Dispatch Engine [**NEMDE**]) would require non-linear constraint equations that increase complexity, solve time and risk. Therefore, a better solution is to implement limits in the bid validation, which is an existing pre-processing stage which checks a variety of conditions to ensure bids are well formed.

AEMO accepts that a blanket minimum bid size (e.g. 2 MW or 5 MW) does not take into account the range facilities used to deliver Regulation FCAS and how it might affect different facilities. In particular, AEMO agrees that a 1 MW change on a 5 MW facility will be far more discernible than a 1 MW change on a 500 MW facility.

Taking these issues into account, AEMO has developed an approach based on the registered capacity of a facility. A 1% of registered capacity threshold has been adopted, which can be applied in a technology-agnostic manner. In effect, a Regulation FCAS Provider must not bid a quantity less than the greater of 1% of the registered maximum capacity of the facility used (rounded to the nearest MW), or 1 MW. This means a facility with a registered capacity of less than 150 MW will continue to be able to offer 1 MW. A facility that is between 151 and 249 MW would not be able to offer less than 2 MW in any bid tranche. A large

facility, say 500 MW, would not be able to offer less than 5 MW. Offers below the relevant threshold would be filtered out by the bid validation process.

Maximum CRD

Submissions supported the concept of setting a maximum CRD and agreed the proposed value of 150s was achievable. CleanCo noted that even this was, perhaps, too generous and could be driving a desire to manage ramp rates better.

AEMO generally agrees with CleanCo and suggests the establishment of a maximum CRD might be the first of a series of actions aimed at achieving a more consistent response rate and clearer guidance on the acceptability of AGC performance. The ultimate suitability of a CRD will be related to the frequency behaviour of the power system, which changes frequency direction more quickly will require a faster response rate than one that moves quite slowly. This will be monitored and the case for further amendments to the maximum CRD will be examined again.

Minimum Ramp Rate

Submissions highlighted a range of concerns with specifying a minimum ramp rate that achieves the full bid Regulation FCAS quantity in less than 5 minutes. For example, it was noted that this might require re-assessment of registrations and may result in considerably less Regulation FCAS capability at some facilities. This has not been well assessed at this stage.

AEMO remains of the opinion that 5-minute Regulation FCAS ramp rates tend to be an impediment to the efficiency of Regulation FCAS, however, there are some initial actions that might achieve efficiency gains sought by this proposed change. One clear action is setting a maximum CRD as described above; a shorter CRD means more of the Regulation FCAS can be realised within a DI.

A second action is to clarify that telemetered ramp rates must not be set lower than bid ramp rates, and to do so is a non-compliance with the Regulation FCAS offer. AGC will use the most limiting of the telemetered and bid rates, so that a real *plant* limitation would be immediately actioned – this is for safety, stability and overall Regulation FCAS performance reasons.

A third action is to find a way to reduce churn in the dispatch of Regulation FCAS. For example, if there is no objective cost difference, NEMDE might arbitrarily choose to dispatch different facilities for different amounts of Regulation FCAS over a series of DIs. If a very small 'cost' were to be applied to changing Regulation FCAS dispatch allocation (called a 'transition cost'), NEMDE would not make these arbitrary decisions. Of course, if the overall objective cost could be reduced to re-allocating Regulation FCAS (e.g. due to cheaper offers), NEMDE would still re-allocate. While this action is promising from a theoretical standpoint, considerably more work needs to be done to assess how it could be implemented without any unintended consequences.

Transitional Period

Submissions on the need for and length of a transitional period can be summarised as:

1 year	>1 year	2 Years	Other
Infigen	AGL, CleanCo	Delta Electricity	Hydro Tasmania

Clearly the required length of a transitional period is related to the number and complexity of the changes required. AEMO is progressing only a subset of Regulation FCAS changes. Taking this and the submissions into account, AEMO has settled on a transitional period of 18 months for FCAS Providers to achieve compliance with the new Regulation FCAS requirements.

Testing Cycle

Submissions on the proposed change to the testing cycle can be summarised as:

2 Years	>2 years	4 Years	Other
Karit	Hydro Tasmania	AGL	CleanCo, Delta Electricity, Tesla

AEMO considers that there is a balance to be reached when requiring routine testing, as opposed to testing after changes to plant that could impact on the provision of FCAS. Moreover, there is a cost imperative on FCAS Providers with each test, and so routine tests should not be required too frequently.

Several submissions suggested that AGC is continually 'testing' facilities and so the need for a testing cycle is diminished or entirely unnecessary. While AEMO agrees that AGC can, to a certain extent, track a facility, it is difficult to separate AGC response from PFR, Contingency FCAS action, or even energy market ramping in a live, dynamic power system. Therefore, to truly assess the performance of a facility to Regulation FCAS controls and to ensure the AGC's facility-specific controls satisfactorily match the facility characteristics, it is necessary to undertake a series of more controlled tests. These tests would require the facility to maintain a relatively flat profile, and involve assessing facility response to AGC control requests with PFR controls both disabled and enabled, as practicable. For these reasons, the normal feedback cycle of AGC cannot substitute entirely for controlled testing.

Taking into account the submissions and the amount of effort required from both AEMO and FCAS Providers, AEMO has settled on a 3-year testing cycle, but added requirements for re-testing following changes to *active power* controls, major overhaul of facilities, or following AEMO's request for AGC tuning.

5.6.3. AEMO's conclusion

Telemetered Data Rate, Latency and Data Fields

Requirements related to telemetered data rate, latency and data fields have been set out in section 10.4 of the draft MASS. The telemetered data latency requirement of 8 seconds will apply only to an FCAS Provider's internal systems. That is, external communications and processing delays will not be subject to this limit. The telemetered data rate requirement has been set at 4 seconds. Required data fields has included all of those identified in the Issues Paper except the limit duration and local PFR, which AEMO regards require further consideration.

AGC Controllable

AEMO has introduced a requirement under Section 10.4 of the draft MASS for Regulation FCAS units to maintain a control system where an AGC control request is clearly discernible from noise in the facility's output. This applies only to control requests exceeding the Setpoint Control Deadband, an existing AGC setting that for each facility sets the minimum change in output (in MW) AGC may request from that unit. The Setpoint Control Deadband must be set greater than or equal to half of the facility's Minimum Bid Size as defined by Sections 10.1 and 10.2 of the draft MASS.

Minimum Bid Size

Sections 10.1 and 10.2 of the draft MASS have been amended to include a minimum bid size requirement of the greater of 1 MW or 1% of a facility's registered maximum capacity. FCAS Providers will be allowed 18 months from the date of the final determination to ensure compliance with these new provisions.

Maximum CRD

AEMO has specified a maximum CRD of 150 seconds under section 10.4 of the draft MASS.

Minimum Ramp Rate

AEMO will not proceed with a general minimum ramp rate at this time. Instead, AEMO will implement two actions (Setting a minimum CRD and clarifying requirements for telemetered ramp rates) and will commit to investigating the feasibility of including a Regulation FCAS 'transition cost' in NEMDE to minimise arbitrary churn in Regulation FCAS *dispatch*. Further actions on ramp rate will be subject to the impact these changes make.

Transitional Period

AEMO has set a transitional period of 18 months from the date of the final determination for FCAS Providers to ensure compliance with the new Regulation FCAS requirements.

Testing Cycle

AEMO has included new Regulation FCAS requirements in the draft MASS in line with the actions set out in section 5.6.2 and determined that routine tests should be carried out every 3 years, however, FCAS Providers will have 8 weeks from making certain changes to plant that could affect the provision of Regulation FCAS.

5.7. Clarification of Requirements for Delayed FCAS

5.7.1. Issue summary and submissions

While AEMO did not consider that this was an appropriate time to change the MASS to improve the Delayed FCAS requirements, it invited views on how they could be improved.

The main submissions on this issue are extracted below: [54]

> AGL:
>
> Our view is that delayed FCAS is an area that needs more investigation, and we propose further discussion of this within a technical working group.
>
> Preliminarily, we consider that limiting delayed FCAS providers to switched type only will likely decrease the existing supply pool significantly. We appreciate that it can be difficult to coordinate switched and proportional controllers, which may encourage AEMO to limit delayed FCAS to one type.
>
> However, in our view, switched controllers, in this context, raise power system security concerns. Enabling switched controllers for delayed FCAS can lead to system instability when these providers over- or undershoot and cause unexpected frequency outcomes. Conversely, proportional controllers that are set to maintain a very tight deadband, close to 50Hz, could better provide delayed FCAS without such system stability risks.
>
> Ultimately, we think there needs to be detailed consideration of potential adverse power system security outcomes that could arise from this proposal prior to changing the MASS.

CleanCo:

> [... implications ... of clarifying that Delayed FCAS controls may be of a switched type only (rather than also proportional), and, whether other factors in addition to those outlined in section 3.6 need to be considered.]
>
> This may be appropriate given the capability of switching controllers to return frequency back to 50Hz, but CleanCo has not investigated this closely.

[54] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

CEC:

The CEC is comfortable with the proposed direction in the paper; however, we suggest that the noted potential to utilise AGC to trigger a specific shift in base power output should not be progressed. Instead, this should be implemented via logic based on local frequency measurement only.

Delta Electricity:

Switched controllers are preferred for the delayed services but in a slow recovering system, frequency responsive proportional controls may still be active and the total response will need to be coordinated.

Some switched controllers may be ramping the provision in from a zero amount to an assigned MW value (control value not market enabled) over a five-minute period and then ramping down over the next five minutes. Is this acceptable or should the switch be an abrupt 'On' and 'Off' of switched MWs when required?

Evergen:

Limiting the delayed FCAS markets to switched control only will impact VPP value streams or drive VPPs to offer switched control across all markets to maximise participation.

…

Evergen notes that although VPPs may typically be configured to provide either switched or proportional FCAS response, AEMO does not allow a single DUID to include devices from both types of response simultaneously. For this reason, limiting Delayed FCAS to only switch-based control would mean either:

1. VPPs would be incentivised towards offering switch-based control across all markets to participate in all contingency markets, or
2. reduced profitability (and therefore a higher barrier to entry) for VPPs that offer proportional control, and are thereby excluded from the Delayed markets.

Hydro Tasmania:

Hydro would agree that synchronous machine droop responses end up with steady state error, thus an additional response outside of droop compensation is needed to bring the system frequency back to 50Hz. To achieve a suitable 'switched' response, a bias in the base assumptions is essentially needed.

Infigen:

From Infigen's perspective, the implication of Delayed FCAS being provided by switched type only controls would mean that battery facilities under their current configurations would be unable to provide this service. Given the high penetration of battery systems in the contingency FCAS markets (~26% from the Quarterly Energy Dynamics Q4 2020 report) and the increasing share that batteries will have into the future, the cost impacts of excluding this capacity from a subset of the contingency FCAS markets would need to be thoroughly investigated and justified in any decision made.

Again, we suggest that this needs to be considered in the context of a more holistic MASS review – clearly defining the FOS, and undertaking quantitative and qualitative analysis of the services required. Further factors should also be considered alongside those raised in the consultation paper. These are:

- Re-examining the problem statement issued by AEMO in the context of mandatory PFR implementation, with generator deadband settings for a number of facilities being much tighter than the acknowledged +/-0.15Hz.
- Considering the enablement of the delayed FCAS response alongside the other mechanisms that AEMO has available for recovering frequency within 5 minutes, including PFR, regulation FCAS and the dispatch of the energy market, to provide an adequate frequency recovery at least cost to the market.
- AEMO providing a clear definition of the switched type responses it would accept for a delayed FCAS response, to allow for potential providers to innovate and develop a least-cost solution if required.
- Whether the MASS should specify that the role of delayed FCAS is to return frequency to 50Hz in the context of both:
  - Existing additional services, including PFR, regulation FCAS and the dispatch of the energy market, that could be procured by AEMO to return frequency to 50Hz, such that the obligation to return frequency to 50Hz should not only rest with delayed FCAS; and
  - returning frequency to 50Hz may not be required to maintain system stability, and a new frequency return requirement could be established (such as +/-0.1Hz to be aligned with other frequency return requirements.

Reposit:

AEMO is correct that a proportional controller is unable to correctly deliver the Delayed service under the current MASS. The nature of the control means that frequency cannot be restored to 50Hz by a proportional controller. At first glance it would seem that proportional controllers should not be dispatched into Delayed. This would be technically correct, but would not contribute to the efficient restoration of 50Hz operation after a contingency event.

Shell Energy:

AEMO begins its discussion on requirements for Delayed FCAS by referring to the purpose as defined in section 5.1 of the MASS which is "*to return System Frequency to 50 Hz within the first five minutes of a Frequency Disturbance that resulted in System Frequency being outside the normal operating* frequency *band*". As such delayed FCAS should be seen as a frequency restoration service as opposed to a frequency control or RoCoF control service. To enable restoration of frequency to 50 Hz, AEMO should procure sufficient services to restore frequency to 50 Hz following the largest credible contingency. It is unclear this is always the case. We also recommended that AEMO consider a change of name for the delayed contingency FCAS to frequency restoration contingency FCAS to more accurately describe the intent of the service.

AEMO suggests a "switched" response is necessary to achieve frequency restoration to nominal frequency. Alternatively, AEMO indicates that frequency restoration could be provided via and AGC type response. We question AEMO's views in this area. Latency delays with AGC dispatch particularly around the cutover between DIs when the issue of the new dispatch targets, including new AGC targets, can be significantly delayed may result in delays to an AGC type service restoring frequency. We believe the service would be best achieved by a known level of response at known trigger levels.

The frequency trigger outcomes could potentially be used to trigger the appropriate levels of additional restoration response to match the level of frequency deviation as opposed to a reliance on service providers delivering the exact amount of response. However, to achieve this the NEMDE would need to know the exact trigger level at which every restoration service provider was set. This could be a difficult requirement. Instead, it may be easier for the MASS to stipulate that the facility ceases to provide response when 50 Hz is achieved or alternatively, maintain the enabled level of response for up to a 10 min duration in the event that 50 Hz is not achieved. We consider the required response should not be expected by AEMO to exceed the enablement amount nor should it be expected to substitute for the publication of incorrect dispatch targets by AEMO following an islanding event where AEMO should be considering automation of their systems in line with the recommendations of the Queensland and South Australia Islanding event on 25 August 2018,[55] for which no implementation date has been indicated by AEMO.

AEMO also queries whether AGC controls should be aware of the Delayed FCAS controls at a plant. Shell Energy does not support this outcome as the AGC system could then incorrectly rely on services that were not enabled for restoration FCAS dispatch during the current DI and seek to utilise a service that is not actually available during a frequency restoration period. As discussed previously, there are inherent latency issues under AEMO's direct control which delay AGC effectively responding to a frequency event.

Despite our disagreement on certain issues, Shell Energy ultimately agrees with AEMO's suggestion to pursue future work to better understand the impacts of altering the MASS requirements for Delayed FCAS. However, at the first instance, we contend that AEMOs need to consider this need for future work when setting the revised switched frequency response controller set point values.

SwitchDin:

We would appreciate clarity on whether a single VPP fleet could be registered as both a proportional service and a switched service if able to demonstrate the required response for each service. This could allow VPPs to choose to bid in as either a switched or proportional service and, in particular, not specifically exclude VPPs normally providing a proportional service from accessing the Delayed FCAS market if also registered as a switched service.

[55] Recommendation 2 - Final Report – Queensland and South Australia system separation on 25 August 2018 – pp 8.

Tesla:

Tesla Position	Proposed Alternative
Tesla is open to exploring this option further, and note that proportional response (primary frequency control) in the delayed service is not meeting the intention of what is really a reserve service (secondary frequency control). Delayed response could be provided by a switched linear ramp response which is more beneficial to the power system than a switched (step) response and would only require minor programming in local RTAC for batteries). Delayed response via AGC could also be provided for Scheduled Generators (utility projects) as it would allow regulation to continue via addition of AGC Energy/Reg/Delayed into one signal, however note that this would not be appropriate for DER response.	Batteries can use logic to implement based on local frequency measurement or AGC for Scheduled Generators only

5.7.2. AEMO's assessment

Submissions raised a number of concerns about altering the requirements of Delayed FCAS. The proposal to only allow switched controllers to provide Delayed FCAS might be excessive and unnecessarily reduce the availability and variety of suitable responses. The idea to command the response via AGC would be problematic due to the uncertain and variable timing involved in AGC signals and would also require various changes to the AGC software to accommodate. For example, submissions pointed out that sustained PFR with a very narrow deadband (such as the 0.015 Hz deadband typically applied under the Mandatory PFR Rule), would similarly act to help return frequency very close to 50 Hz, so should be considered and valued where appropriate. This is consistent with the overall principle (also codified in Table 7 of the draft MASS under 'Calculation Method') to recognise and value all frequency response as contributing to the provision of Contingency FCAS.

AEMO emphasises that the general principle of the purpose of Delayed FCAS is to return frequency to 50 Hz (or very near it) rather than to the edge of the NOFB, however because of the range of possible control methods that could be suitable, AEMO considers it premature to amend the MASS to address this.

5.7.3. AEMO's conclusion

AEMO will conduct further work on this matter, potentially assisted by an industry working group, to clarify how Delayed FCAS should support the return of frequency to its nominal value of 50 Hz, rather than to the edge of the NOFB. The aim is to find a workable and fair approach that can be codified the next time the MASS is open for consultation.

5.8. Issues Associated with Pending Rule Changes and Matters for Separate Consultation

5.8.1. Issue summary and submissions

In the knowledge that the AEMC is currently considering changes to the NER to introduce a FFR and other issues that will impact the FCAS framework, particularly the MASS, AEMO invited submissions on any high-level issues that might need to be considered in, or could be excluded from, this MASS consultation.

Submissions on other issues in this category are extracted below: [56]

[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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

AGL:

At present, the MASS excludes inertia from a unit's contingency response. The FFR rule change being considered by the AEMC is in part, targeted at managing low power system inertia, in the absence of a specific inertia market or similar. Should the FFR rule be made, we support corresponding changes to the MASS to value and price inertial response as part of contingency FCAS.

… AEMO should not make changes to the MASS that would cause deadbands of different frequency response services to overlap, as this would distort the price signals for those services.

CleanCo:

The MASS should be adjusted to allow reward for inertial response. This could be reconsidered if the or the ESB implement a formal inertia market or incentive framework, but this is likely to be several years off.

CEC:

The CEC strongly supports the implementation of FFR markets to encourage the speed and quality frequency response that new technologies, such as batteries, can provide to the power system. We support AEMO continuing to work with the AEMC to provide the technical advice needed to appropriately design such markets. Where possible, any changes to the MASS that can be made through this review that will expedite the implementation process for FFR markets should be prioritised.

Delta Electricity:

FFR services may need to include for control and monitoring data at a rate faster than 1s sampling.

The combination of services and the incorporation of PFR into the MASS in combination with or separated from Regulation FCAS. These two are a theoretical combination because each is continuously operating during dispatch. However, many contingency FCAS systems utilise the same controller as does the mandatory PFR which means there is a technical challenge and contradiction between the objectives of continuous PFR and that of the more sparsely employed contingency services making the occasional delivery of the latter likely to be affected by the constant delivery of the former. Redesigning the MASS to employ the present frequency responsive controllers as PFR instead of 6s and 60s FCAS is one solution.

A redesign of Regulation FCAS could also see a faster and more reactive delivery using the same frequency controller as present PFR and many frequency responsive 6/60s Contingency FCAS systems. This redesign would need AEMO to separate Regulation FCAS delivery signals from the energy dispatch signal and send it separately to each unit where it can be channeled into frequency controls instead of MW setpoint controls.

Empower Energy:

AEMO has undertaken to research a number of possibilities around DER FCAS integration. Whilst not the sole source of knowledge available in this space, the VPP Trial has resulted in a leading body of knowledge being made publicly available and has rendered a number of conclusions unequivocal, particularly around the value potential of DERs in modern, competitive balancing and ancillary service markets. A number of paradigms for control and participation were similarly explored that have much value to all stakeholders in this space moving forwards.

At the present time this knowledge needs to be condensed in a way that is executable in constructs befitting a regulated market guided by objectives supporting low consumer costs, increased access and no favouritism to any actors or approaches involved.

It is accordingly incorrect to, by default of immediate and specific experience, conflate the terms of the VPP Trial with market rule changes moving forwards. To do so places real limits on the outcome potential of the VPP Trial in a manner ultimately inconsistent with its best intent.

A better Option is required than that presented that uses the knowledge acquired in the VPP Trial in addition to other, broader experiences with relevant DER market participation activities to create a fair, accessible and effective solution moving forwards.

We therefore request the following:

- That AEMO undertake efforts to ensure that FFR and DER considerations to the MASS are aligned, resulting in a clear, duly communicated understanding as to the nature of any frequency response sought by the proposed changes to the MASS,
- That AEMO release a formal determination as to whether the proposed MASS changes concern a primary or secondary contingency frequency response, and to propose any regulation changes as necessary on the merits of the intent of the response type,

- That AEMO extends the VPP Trial to continue the contribution of relevant DER assets in contingency FCAS in new ways within a trial environment, whilst decoupling their stakeholder interests from MASS review timings, and
- That AEMO provides an additional Option or Options for MASS review with respect to DER participation in FCAS, or provides a single Option that encompasses a broader range of stakeholder interests in the DER space and affording better outcomes across a wider range of market stakeholders.

Enel X:

MASPs to become DRSPs

While not covered in the consultation paper, it may be helpful to note that come October 2021, the MASP market participant category will be superseded by the Demand Response Service Provider category. This should be reflected in the revised MASS.

...

Interim arrangements for FCAS provision from DER

There is no reason for AEMO to wait for the energy storage rule change to conclude before bringing the interim arrangements for the provision of FCAS by DER into the MASS. The rule change request is considering a much broader range of issues, and the question of bi-directional flows from ancillary services facilities forms a small, supplementary part of it. And, as noted by AEMO in that rule change process, AEMO already has the power to give effect to this by defining an umbrella term, e.g. "ancillary services facility" in the MASS. It would make sense to include the interim arrangements in the MASS through this review.

Hydro Tasmania:

[Hydro Tasmania] still of the view that inertia needs further consideration due to its emerging importance in the NEM.

...

Better connection with the market.

While the current MASS well covers the FCAS definition, measurement requirements, control specifications, evaluated calculation details, etc. There is very limited information available in regards how FCAS demand is specified/calculated and how each individual stage of FCAS procurement is coordinated to achieve overall system frequency control.

Hydro believes that MASS is the right document to include a high level FCAS demand and procurement specification principle, but then should be underpinned by a dedicated document (or in the Appendix) with detailed technical explanations, so that more transparent and objective guidance can be established and allow improvements for both AEMO and market participants.

...

Accommodate and coordinate with the new potential changes from inertia, FFR and the ongoing PFR are the major questions that need to be addressed in the MASS or at least considered.

So in this iteration, apart from the content changes as specified, it would be worthwhile to have a review in regards the ancillary services technical specification documentation structure, e.g. to what level, the contents should be reflected in the MASS, what are the interrelated/dedicated documents with what details are needed.

Infigen:

...Infigen believes that the following non-exhaustive list of topics should be discussed (in addition to those identified in the consultation paper):

- Integration of new market services (such as FFR and PFR) within the MASS, as well as discussing the 'scope' of the MASS in incorporating potential new markets. The MASS is not a suitable document to specify potential new markets such as inertial response or operating reserves;
- How the quantity of services to be procured by AEMO are determined, particularly of regulation FCAS and the "overlap" of services (see Infigen's submission to the AEMC[57]);

[57] https://www.aemc.gov.au/sites/default/files/documents/rule_change_submission_-_erc0263_erc0295_-_infigen_energy_-_20210207.pdf

Karit:

> The delivery of FCAS by the management of distributed resources should be a key focus of the MASS as this approach shifts more of the cost onto the customers of the power system or those who extract value from the distributed assets and reduces the risk of concentrated resources creating power system security issues. A focus on distributed assets also more appropriately reflects the ongoing evolution of the power system.

Rheem & CET:

> Believe that the findings arising from this consultation should inform the outcomes of the ERC0296 FFR market ancillary services rule change consultation.
>
> *Relationship Between MASS and FFR Consultations*
>
> We are concerned that the FFR consultation appears to focus on Embedded Storage Batteries, whilst ignoring other forms of cost effective smart DER (e.g. loads such as smart, grid interactive water heaters) and their potential participation in the Contingency FCAS and other grid services markets. This approach would appear to be at odds with the NEO guidelines and principles58.
>
> We would therefore propose further consultation to ensure technology neutrality in the formation of any proposed FFR rule changes. To that extent we would offer our expertise and insights, to join the relevant ERC0296 committee(s) to share our views and knowledge, and to ensure fair and equitable outcomes for consumers who choose to offer their DER assets for participation in the provision of grid services such as Contingency FCAS.
>
> Whilst the above issue is resolved, we would ask AEMO to make no changes to the MASS and to consult again once requirements for FFR are finalised.

Shell Energy:

> Shell Energy considers that AEMO has undertaken a thorough and considered process as it prepares for this review of the MASS. This is an opportune time to review the MASS given the scale of change underway in the market. However, we note that there are rule changes ongoing which would influence the outcome of this MASS Review, notably the FFR and PFR rule changes under consideration by the AEMC. The results of these rule changes will need to be factored into the MASS if necessary. We recommend that as part of this review AEMO consider what changes will be required to the MASS in the event a decision is made to introduce a market for the provision of FFR.
>
> …
>
> Shell Energy notes that there is a range of other work ongoing relating to frequency control, notably the FFR and PFR rule changes. Shell Energy provided a submission to the AEMC on these rule changes (sent as ERM Power) in February 2021. We recommend that as part of this consultation AEMO should consider what amendments to the MASS would be required to implement a dedicated very fast contingency response service in addition to maintaining the existing 6s service. We note work has already been undertaken in this area and supplied to the AEMC. This could be set out as a discussion paper as an appendix to the draft and final reports to promote discussion now so as to facilitate a prompt response should a rule change be made. The Appendix could set out the amendments to the MASS that would occur if a new very fast (sub one second59) contingency response market is added to the Rules. This would allow its quick implementation without the need for additional consultation.
>
> …
>
> Shell Energy believes that there are a range of changes required to the MASS as part of this review, and that the MASS should be drafted to be ready for the possibility of very fast (sub one-second) services should the AEMC make a rule change to introduce very fast FCAS into the NEM.

Simply Energy:

> *Amendments to the MASS are critical for future VPP development*
>
> …
>
> As previously noted, there would be significant benefits to consumers from the continued development of VPPs. However, without amendments to the MASS (and the continuation of the interim arrangements to

[58] "Promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity", and; "Promote competition - by minimising barriers to entry so that more FCAS providers can compete in the market".

[59] As set out in AEMO's advice to the AEMC which was discussed at the AEMC FFR TWG on Thursday 4 March 2021.

recognise bi-directional flow from ancillary service loads to deliver FCAS[60]) it is unlikely that retailers and aggregators will find it economical to invest in VPPs. In addition, participants that are part of AEMO's VPP demonstrations will not realise the benefit of their investment in the trial. Simply Energy considers that the continued development of VPPs is in line with the NEO as VPPs can provide lower energy prices for consumers, additional value for consumers from their BESSs, and increased reliability and security of the electricity grid.

...

Incorporation of the fast frequency *response rule change*

As noted in the issues paper, the AEMC is currently consulting on a rule change request on FFR. However, the AEMC is still many months away from making final recommendations on FFR and has only recently sought stakeholder feedback on high-level options.[61] Due to the uncertainty around the final FFR rule change, it is difficult to provide AEMO with feedback on how the MASS may need to be amended in response. Ideally, the MASS amendments would incorporate the AEMC's final recommendations on FFR, including any additional, changes to technology requirements.

Solar Analytics:

Need for further review

...we would welcome a further review and iteration of the MASS in the near future in order to address other opportunities to reduce barriers to entry and/or increase efficiency with respect to DER participation in contingency FCAS markets. Such opportunities include:

1. Reducing the minimum droop settings for small battery systems so that greater capacity may be enabled, up to the full cycle capacity of a battery
2. Reducing the minimum bid/enablement increment below integer MW so that greater utilisation of smaller VPPs is possible
3. Allowing for participation by DPV systems, either as a generator response, measured at the inverter, as a combined battery/PV response, measured at the inverter, or as a combined battery/PV/load response, measured at a connection point

Tesla:

Support AEMO expediting its work to consider how FCAS timing requirements and associated specifications should be revised to incorporate FFR as a separate service. Optimally this could be done by a new FFR market (R1/R2?) to replace existing FAST R6, with consolidation of R6/60 into SLOW market, which would have minimal disruption and require no change to the NER.

Tesla understands there is potential for FFR to be implemented through the MASS immediately - as ESB and AEMC explore reforms to incorporate an additional co-optimised product over the longer-term, support AEMO undertaking this work in parallel.

There is significant room within the NER definitions to redefine the desired response timeframes and still retain the defined terms of fast raise, slow raise, and delayed raise - the NER is not specific about the nature of these contingency responses and defers to the MASS

Updating the fast FCAS contingency response from 6s to <2s could allow much higher enablement from fast-response assets and value the response provided in the initial seconds. This could be framed as an 'opt-in' service to avoid changing existing generator settings.

For proportional controllers, an effective droop increase to allow full power output at 49.5Hz (50.5Hz) is considered appropriate based on closer frequency control in the NOFB post PFR, With mandatory PFR for batteries outside 15mHz this would potentially mean a 485mHz range to reach full power (.97% droop) which would allow full registration of the nameplate value for existing and new batteries, facilitating an increase in high quality proportional FCAS supply at low marginal cost to meet the objectives of the NEO.

It is important that if a high speed market is introduced, the MASS registration takes the full nameplate capacity of the System into account without artificial limits due to the droop. Tesla also question the appropriateness of switched controllers in this market, noting that high speed markets are required to recover the frequency as well as overshoot due to load drop/switched controllers.

Inertial response should be excluded from any FFR market, with the focus being on Primary Frequency Control, with a preference for proportional controllers

[60] AEMO 2019, Interim arrangements for FCAS provision from DER – policy on classification of loads as ancillary service loads, December

[61] AEMC 2020, Directions Paper – Frequency Control Rule Changes, December

This approach will also ensure both utility-scale and VPP assets are able to design and develop hardware and software requirements to be future proofed

...

Tesla Position	Proposed Alternative
Support AEMO ensuring all response contributes towards contingency obligations (and associated uplifts of contingency FCAS enablement levels) AEMO has repeatedly stated that procurement volumes for FCAS will not be changed due to PFR as they are seeking to achieve different things. Need to provide participants comfort by embedding/codifying this – to ensure investment signals for FCAS reliant BESSs are maintained and future projects avoid uncertainty from price and volume risk. Agree on including AGC signal (per figure 8) and adding proportional control to this value, however note that currently AGC is ignored outside the NOFB so there will need to be a transition period to allow this logic change. Tesla is in agreement that this is necessary, as there have been several events where AGC has been locked out due to system frequency failure to return to the NOFB (however accept that this will be less frequent post PFR).	Also provide more certainty on FCAS procurement volumes

5.8.2. AEMO's assessment

Consulted Persons raised different issues, which are summarised in the following table:

Issue	Submission
DER Issues	Karit, Solar Analytics
Incorporate Interim arrangements for FCAS provision from DER into the MASS	Enel X, Simply Energy
Allow reward for inertial response	AGL, CleanCo
Encourage speed and quality of response	CEC
Expedite implementation of FFR	CEC, Hydro Tasmania, Infigen, Rheem & CET
Incorporate PFR into MASS	Delta Electricity, Hydro Tasmania, Infigen
Redesign Regulation FCAS	Delta Electricity
Incorporate MASPs	EnelX
Expedite Energy Storage Rule Changes	EnelX
Inclusion of FCAS Demand and Procurement Principles	Hydro Tasmania, Infigen
Accommodate potential changes to Inertia Framework	Hydro Tasmania
Review MASS Structure	Hydro Tasmania

The issues raised can be considered thematically as follows:

DER Issues

As detailed in section 6.1.3, AEMO intends to conduct further work addressing the issues affecting DER FCAS Providers.

Incorporating the Interim arrangements for FCAS provision from DER into the MASS

Under the Interim arrangements for FCAS provision from DER[62], AEMO recognised the provision of FCAS through the export from a load connection point.

Enel X and Simply Energy considered that the MASS should be updated to recognise the bi-directional flow of ancillary service loads when delivering FCAS.

Consistent with the interim arrangements, AEMO is proposing to update the MASS to clarify that import and export flows from both an ancillary service generating unit and an ancillary service load can be used for FCAS purposes.

Amending the MASS pre-emptively

AEMO is not in a position to make changes to the MASS to accommodate potential FFR, inertia or energy storage rule changes without reasonable certainty as to how proposed NER changes will be settled by the AEMC or their commencement date. Moreover, in the absence of a power to address services that are not part of the FCAS framework in the NER, such as FFR or inertia, AEMO cannot incorporate them into the MASS, while PFR is not a type of FCAS.

Changes to the NER are usually accompanied by transitional provisions that require AEMO to amend instruments affected by the rule change. Under the *National Electricity Amendment (Wholesale demand response mechanism) Rule 2020*, for example, references to a MASP can be updated to Demand Response Service Provider without consultation. AEMO proposes to await the outcome of any process by the AEMC to amend the NER before finally determining the extent of any required changes to the MASS.

Recognise and reward speed and quality of response

On 22 April 2021, the AEMC published the draft *National Electricity Amendment (Fast Frequency Response Market Ancillary Service) Rule 2021* and determination, dealing with FFR.[63] The proposed transitional rules will require AEMO to revise the MASS within 18 months of the date the rule is made, to specify the detailed description and performance parameters for FFR.

Consequently, AEMO will not address FFR during this consultation but will initiate another consultation at the appropriate time, which should also address the need to recognise and reward the speed and quality of response.

Redesign Regulation FCAS

The version of the MASS published with the Issues Paper focussed on clarifying the Regulation FCAS requirements and recognising how they should be co-ordinated with Contingency FCAS and PFR. Further changes to the Regulation FCAS markets could be considered in the near future and would, ideally, take into account any changes to the PFR framework and the FOS. Significant changes to the nature of Regulation FCAS are probably best investigated outside the limited bounds of a MASS consultation and would need to be based on compelling evidence to justify the amount of work involved for both AEMO and FCAS providers.

Incorporate PFR into MASS

While there is a relationship between PFR and FCAS, PFR is not a type of FCAS and so its specification is outside the scope of the MASS.

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

[63] Available at: https://www.aemc.gov.au/sites/default/files/2021-04/FFR%20market%20ancillary%20services%20-%20Draft%20Determination_22APR2021.pdf

Inclusion of FCAS Demand and Procurement Principles

As noted in section 5.5, it is not appropriate for the FCAS demand and procurement principles be included in the MASS.

Review MASS Structure

The structure of the MASS has been reviewed and revised extensively in preparation for this consultation and will continue to evolve as more changes are in the pipeline.

5.8.3. AEMO's conclusion

AEMO has amended the definition of "Aggregated Generation Amount", "Aggregated Load Amount", "Generation Amount" and "Load Amount" in the draft MASS to clarify that FCAS may be provided using import or export flows for any ancillary service facility, aligned with the intent expressed in the Interim arrangements for FCAS provision from DER[64].

Apart from various references to PFR in the MASS for the sake of clarification, AEMO has amended Table 7 in section 6.3 of the MASS to make it clear that frequency response provided while meeting PFR obligations will be recognised as contributing to an FCAS Provider's Contingency FCAS obligations.

6. OTHER MATTERS

6.1. End of VPP Demonstrations

6.1.1. Issue summary and submissions

AEMO's draft determination is not to amend the MASS measurement requirements to accommodate a lower time resolution or vary the location of the measurement point for FCAS Providers using DER to provide FCAS.

The VPP Demonstrations will end immediately prior to the effective date of the MASS amendments resulting from this consultation, and it is apparent that participants in those demonstrations will not be in a position to meet the MASS by that date. There was only one submission on this issue:

DEMSA:

> For those VPPs registered in the VPP Demonstrations Program and currently providing FCAS under the interim specification, it is important that there be continuity beyond the Program's end date of 30 June 2021. The Division therefore supports incorporating the interim specification in the MASS (option 2) to the extent that AEMO is satisfied of the robustness of that specification, including delivery verification, such that the ancillary services market can operate effectively as VPP resources continue to grow. Should that not be possible by 1 July 2021, the Division encourages AEMO to consider extension of alternative measurement arrangements for VPPs under section 7.3 of the MASS until additional data and analysis from the current trials can inform the appropriate measurement specification to include in the MASS.

6.1.2. AEMO's assessment

AEMO considers that the impact of FCAS provision by existing VPP Demonstrations participants in accordance with the VPP Demonstrations FCAS Specification will not adversely affect power system security as the total capacity will be capped at 30MW. A reasonable time should be afforded to those participants to make necessary changes to their portfolio to meet the MASS if they wish to continue providing Fast FCAS.

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

Moreover, AEMO proposes to address the estimated under-delivery error for Fast FCAS due to lower measurement time resolutions than 50ms (discussed in section 4.1.2 of this Draft Report) by applying a discount to the amounts delivered.

6.1.3. AEMO's conclusion

AEMO proposes to permit DER FCAS Providers who participated in the VPP Demonstrations to continue to participate in the FCAS markets until 30 June 2023 based on the VPP Demonstrations FCAS Specification, subject to the transitional arrangements included in the draft MASS published with this Draft Report. A discount will be applied to the quantity of fast FCAS measured as delivered depending on the measurement time resolution as follows:

(i) where the measurement time resolution is lower than 200 ms but higher than or equal to 1 s, a discount of 20% is applied, and

(ii) where the measurement time resolution is lower than 50 ms but higher than or equal to 200 ms, a discount of 5% is applied.

Further arrangements will be made for consultation outside of the current MASS to determine how to progress DER participation in the FCAS markets.

6.2. Need for a more holistic review of the MASS

6.2.1. Issue summary and submissions

Some submissions were seeking a more holistic review of the MASS.

Each submission is detailed below: [65]

Infigen:

> … there needs to be a holistic review of the MASS considering the overlap, definition, and procurement quantity of existing FCAS markets, future FFR and PFR markets, role of proportional and switched controllers, alongside a review of the FOS. As compliance with the FOS should be delivered through the services outlined in the MASS, the alignment of the FOS and the MASS is critical for ensuring that the power system is able to operate in a secure manner.
>
> Within this holistic review, Infigen believes that the following non-exhaustive list of topics should be discussed (in addition to those identified in the consultation paper):
>
> - Integration of new market services (such as FFR and PFR) within the MASS, as well as discussing the 'scope' of the MASS in incorporating potential new markets. The MASS is not a suitable document to specify potential new markets such as inertial response or operating reserves;
> - How the quantity of services to be procured by AEMO are determined, particularly of regulation FCAS and the "overlap" of services (see Infigen's submission to the AEMC66);
> - Whether the MASS is the appropriate forum to consider the Maximum frequency response rate and Area based limitations on FCAS concerns raised by AEMO in section 3.7 of the consultation paper;
> - How the process of re-registering facilities that provide contingency FCAS could be improved to allow for dynamic changes in the registered capacities to better balance periodic shortfalls in contingency FCAS market supply (particularly in islanded conditions); and
> - Appropriate scaling of registered contingency FCAS capacities through volume-weighted responses

[65] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

[66] https://www.aemc.gov.au/sites/default/files/documents/rule_change_submission_-_erc0263_erc0295_-_infigen_energy_-_20210207.pdf

Tesla:

> In January 2019, AEMO formalised droop requirements for all future BESS projects in guidance: "Unless an alternative droop limit is specified by AEMO, the minimum allowable droop setting of any BESS is 1.7%, regardless of its capacity"
>
> We understand there may be some battery systems (including VPPs) operating with 0.7% droops and so inconsistent application of droop limits must be addressed if it has not already. Refer to alternative droop suggestion above.
>
> AEMO must also clarify (or potentially codify) the calculations used in the MASS (as used by HPR to justify >57MW registration (with PFR) for R6 and R60).
>
> Causer pays:
>
> - For regulation FCAS we understand AEMO continues to review contribution (causer pays) factor procedures and cost recovery processes and as part of this process must ensure that fast responding BESS technologies are not unfairly penalised due to interim registration requirements (e.g. multiple DUIDs) and the technology's dual dispatch classifications as a scheduled generator and market customer
> - An immediate clarification to remove these perverse outcomes should ensure the battery system as a whole is viewed as not contributing to a deviation in frequency if either its load or generation side has been enabled and is providing regulation services accurately.

6.2.2. AEMO's assessment

AEMO undertook a review of frequency management in the NEM as part of its Power System Requirements Reference Paper[67], which goes some way to establishing the holistic needs of the power system, and forms a reference point from which further MASS changes are likely to be developed alongside changes to the NER.

Registration

Registration issues are outside the scope of the MASS, however, the submissions will be drawn to the attention of relevant AEMO staff.

Causer Pays

Interactions with the Causer Pays Procedure[68] are out of scope of the current MASS consultation, however, the submission will be considered in preparation for its next review and consultation.

FCAS procurement methods and limits

FCAS procurement methods and limits are generally outside the scope of the MASS, however AEMO will consider the information in submissions in its future decision making. Note that Section 5.5 also examines AEMO's obligations concerning FCAS procurement.

6.2.3. AEMO's conclusion

Due to the nature of this consultation, with tasks that must be achieved within limited timeframes, AEMO suggests that holistic review is better achieved as a separate exercise, which can then inform any desirable changes to the NER or other regulatory instruments. Nonetheless, AEMO will seek to take reasonable opportunities to improve the MASS in line with a holistic view of the frequency control framework, while noting that changes to the NER impacting FCAS will occur in the foreseeable future. AEMO hopes that an industry working group, to be convened following this consultation, will guide the development of the FCAS framework. A particular target area would be the design of the up and coming FFR markets.

[67] Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power-system-requirements.pdf

[68] Available at: https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/20170106-causer-pays-procedure.pdf?la=en

AEMO has included a provision in Table 7 in section 6.4 of the draft MASS stating that one of the principles of Contingency FCAS measurement is that it includes all frequency response, whether it is inside or outside of the NOFB. This is consistent with the approach that was fleshed out in a previous MASS consultation[69].

6.3. Leveraging Network Assets

6.3.1. Issue summary and submissions

Submissions on this issue are extracted below: [70]

Ausgrid:

> Ausgrid is generally supportive of a framework that allows for greater participation of diverse resources in the FCAS markets and support a review of the suitability of measurement and verification of services provided by DER. However, we would highly recommend that AEMO explores the interaction between these market services and network connection arrangements with network businesses and other stakeholders before finalising the amendments to the MASS.
>
> Network businesses are in the process of developing and deploying dynamic operating envelopes that are likely to apply at a customer's connection point to the network. It is envisioned that aggregators would be required to comply with the operating envelope limits at the connection point, including any limits on maximum ramp rates. An alternative arrangement with AEMO for a subset of market services could introduce additional complexity for a VPP operator. It is also unclear if a move away from connection point obligations to an inverter obligation is consistent with the technology neutral services model being contemplated in the ESB's Post 2025 market design.
>
> Notwithstanding these considerations, we agree that lowering barriers to entry is key to unlocking additional competition in these markets. In addition to establishing alternative arrangements for smallscale DER, AEMO should consider how the new arrangements could apply to frequency services provided from network assets. For example:
>
> - community batteries, which are currently being trialled by DNSPs such as Ausgrid and United Energy, have the potential to offer a wide range of services, including frequency support services; and
> - dynamic voltage management that can provide frequency support but does not have a network connection point or associated NMI.
>
> We encourage AEMO's review to consider how the MASS needs to evolve to ensure that network assets can be leveraged, with appropriate oversight, to provide services that improve customer outcomes and result in lower overall costs across the supply chain.

CPUE:

> In addition to the proposed MASS amendments, we strongly encourage AEMO to consider how the new arrangements could apply to frequency services provided from DNSP-owned grid-scale DER (such as energy storage) and other network-led initiatives. Currently, DNSPs are not allowed to participate in FCAS markets as they cannot be registered as a market participant. This prevents DNSPs from extracting the full value from their grid-scale energy storage or dynamic voltage management (DVMS) systems—both of which can provide services into the FCAS markets, increase competition in these services and reduce costs for consumers through revenue sharing arrangements. As such, we encourage AEMO to develop arrangements for DNSPs to provide frequency services into the NEM, either through bilateral contracts or changes to market participation requirements.

ENA:

> Consideration should also be given to how network assets can provide frequency services.
>
> AEMO should consider the introduction of DOEs by networks, as this will have significant implications of Aggregators if not taken into account.
>
> …

[69] See https://aemo.com.au/consultations/current-and-closed-consultations/primary-frequency-response-under-normal-operating-conditions

[70] 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 replaced descriptions in the submissions with acronyms that are defined in the Glossary.

ENA and our members are supportive of measures to ensure that wider power system security and reliability are maintained. This includes a review of how more forms of customer owned DER may provide FCAS when required are incentivised to participate.

Networks are actively researching, and testing DOEs through various trials[71,72,73] as an integral part of network operations in the future.

Implementation of DOEs by Networks will have significant implications for AEMO and Aggregators in future FCAS market participation, particularly if AEMO proposes to have alternate arrangements for market services that will significantly increase complexity for Aggregators.

We would also like to highlight the potential for other forms of network assets to help provide alternate forms of frequency support. These may include community/network batteries7475, or forms of dynamic voltage management which DNSPs are using to operate their increasingly dynamic networks.

While it not likely to affect the near-term, we encourage AEMO to consider how the convergency of Network assets and the MASS will affect industry participant in the future.

EQ:

AEMO should explore further options

However, neither option put forward in the Issues Paper enable Energex's and Ergon Energy Network's current load control capability to participate. Therefore, EQ suggests that further exploration of options would be beneficial.

EQ suggests that one alternative could include the further relaxation of the measurement requirements, for example, zone substation monitoring, modelling based on local measurement and verification and/or new local and lower cost measurement where applicable.

With respect to the aggregation of smaller services, we do not believe it is economically prudent to provide the level of metering required under the current Rules.

It is unclear how the requirement for HSM can be provided for every 5 MW of aggregated capability unless that metering is aggregated metering from the distributed injection points. This would appear to negate the objective of not requiring the HSM. It is our view that removing barriers to entry for lower cost services can only aid in reducing the cost to serve for this capability.

Energex and Ergon Energy Network maintain an audio frequency load control system that controls customers' hot water, pool pump and air conditioning loads. Elements of the customer's load could be made available (subject to meeting legal requirements) to the FCAS market in the fast and slow raise services. For example, Energex and Ergon Energy Network have approximately 900MVA of connected load under control spread across customers throughout Queensland. It is therefore not practicable to provide HSM of this load at a customer level or at a 5MW level.

Energex and Ergon Energy Network maintain SCADA metering at all Zone and Bulk Supply substations that will record MW metering with sequence of events (msec) time stamping based on a deadband delta from the previous reading (DNP3) that can be used to demonstrate the delta in load co-incident to the digital signal of the relevant controller (local frequency trigger).

While Energex and Ergon Energy Network have significant load that could be utilised in the FCAS market, current metering and the proposed VPP metering requirements make this prohibitive.

6.3.2. AEMO's assessment

The ability of DNSPs to participate in the FCAS markets is outside of AEMO's control. Changes to the NER are required before DNSPs can participate in the FCAS markets and DNSPs should sponsor such a change proposal if that is what they desire.

6.3.3. AEMO's conclusion

AEMO will not amend the MASS to address DNSP participation in the FCAS markets.

[71] https://arena.gov.au/news/australias-largest-virual-power-plant-ramps-up-in-south-australia/
[72] https://arena.gov.au/projects/sa-power-networks-flexible-exports-for-solar-v-trial/
[73] https://www.talkingenergy.com.au/64816/widgets/321357/documents/190166
[74] https://ausgrid.com.au/In-your-community/Community-Batteries
[75] https://unitedenergy.com.au/baysidebattery/

6.4. Confidential Submissions

6.4.1. Issue summary and submissions

AEMO received one submission containing confidential information. This restricts AEMO's ability to incorporate and test that information in reaching a determination.

6.4.2. AEMO's assessment

While Consulted Persons are entitled to make confidential submissions, AEMO's ability to make a determination based on confidential information is limited. Submissions that are relevant to AEMO's decision-making need to be disclosed in sufficient detail to give Consulted Persons the opportunity to understand the information AEMO has relied on and address any issue they consider relevant.

6.4.3. AEMO's conclusion

AEMO has not relied on any confidential submission in making any determination about the contents of the MASS.

7. DRAFT DETERMINATION

Having considered the matters raised in submissions and at meetings/forums, AEMO's draft determination is to amend the MASS in the form of **Attachment 1**, in accordance with clause 3.11.2 of the NER.

Finally, it should be noted that clause 3.11.2(e) of the NER states:

> (e) An amendment to the market ancillary service *specification* must not take effect until at least 30 days after the amendment has been *published*.

Subject to additional time AEMO intends to provide for certain changes to be made by FCAS Providers and the extension to the VPP Demonstrations, the amended MASS will take effect on the date that is at least 30 days after the date of the final determination.

8. CONSULTATIVE FORUM

A number of substantive issues have arisen during the first stage consultation which AEMO would like to undertake further work on with stakeholders outside of the consultation on the MASS.

AEMO requires significant input from industry to understand these and other emerging issues, including with respect to the integration of DER into ancillary services and markets. AEMO is proposing to establish a Consultative Forum that would provide 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 National Electricity Market and address the concerns with DER inverter behaviour. This Consultative Forum would be asked to establish issue specific working groups which would be tasked with progressing issues and providing advice back to the Consultative Forum for consideration and action.

Stakeholders are invited to register an expression of interest to participate in this Consultative Forum in their submission to the draft determination or by emailing Mass.Consultation@aemo.com.au. Draft terms of reference will be circulated prior the first meeting of the Consultative Forum for feedback from participants.

APPENDIX A. GLOSSARY

Terms defined in the NER have the same meanings in this Draft Report. For readability of this document, they have not been italicised, however, they are italicised in the draft MASS.

Term or acronym	Meaning
[number]ms	Millisecond
[number]s	Second
AEMC	Australian Energy Market Commission.
AGC	Automatic generation control system.
ASL	Ancillary service load.
BESS	Battery energy storage system.
C&I	Commercial and industrial.
CEC	Clean Energy Council.
Contingency FCAS	Any of the following: • fast raise service; • fast lower service; • slow raise service; • slow lower service; • delayed raise service; and • delayed lower service
CPUE	CitiPower Powercor and United Energy
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.
Delayed FCAS	Delayed raise service and delayed lower service.
DEMSA	Department of Energy & Mining - SA Government
DER	Distributed energy resources.
DI	dispatch interval
DNSP	Distribution Network Service Provider
DOE	Dynamic operating envelope.
DPV	Distributed photovoltaics
ENA	Energy Networks Australia
EQ	Energy Queensland
ESB	Energy Security Board
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.

Term or acronym	Meaning
FCAS Verification Tool	An Excel spreadsheet published by AEMO[76] to assist Market Participants to calculate FCAS delivered by their plant.
FFR	Fast frequency response.
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.
HSM	High speed meter/metering.
Hz	Hertz
IPFRR	Interim primary frequency response requirements.
Issues Paper	AEMO's Issues Paper titled: Market Ancillary Service Specification Consultation – January 2021.[77]
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): • fast lower service; • slow lower service; and • delayed lower service.
MASS	Market ancillary service specification.
MMS	AEMO's Market Management System
ms	millisecond
MW	megawatt
NEMDE	The NEM dispatch engine.
NEO	The objective specified in section 7 of the National Electricity Law, which is to: … promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to— (a) price, quality, safety, reliability and security of supply of electricity; and (b) the reliability, safety and security of the national electricity system.
NER	National Electricity Rules.
NOFB	Normal operating frequency band.
Option 1	See the description in section 2.2.
Option 2	See the description in section 2.2.
PAP	Planet Ark Power/eleXsys Energy

[76] At: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/market-ancillary-services-specification-and-fcas-verification-tool

[77] Referred to as a 'consultation' paper by various Consulted Persons.

Term or acronym	Meaning
PFR	Primary frequency response.
Mandatory PFR Rule	National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5.
Raise FCAS	Any of the following: • fast raise service; • slow raise service; and • delayed raise service.
Regulation FCAS	Any of the following: • regulating raise service; and • regulating lower service.
Rheem & CET	Rheem Australia & Combined Energy Technologies
RIS	AEMO's Renewable Integration Study
RoCoF	Rate of change of frequency.
RTU	Remote terminal unit.
SAPN	South Australia Power Networks
SCADA	Supervisory control and data acquisition.
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.
TNSP	Transmission Network Service Provider.
UFLSS	Under Frequency Load Shedding Scheme.
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	**Choice of Option for FCAS measurement requirements for FCAS delivered by DER** **AGL** AGL supports implementing Option 2, which would embed the measurement requirements tested in the VPP Demonstrations into the MASS. VPPs are typically comprised of residential and C&I sites. At present, we do not consider it is appropriate to require all VPP sites to have HSM installed, akin to those in place at grid scale generators. **Ausgrid** Ausgrid is generally supportive of a framework that allows for greater participation of diverse resources in the FCAS markets and support a review of the suitability of measurement and verification of services provided by DER. **CEC** The CEC welcomes the proposal to relax metering requirements so that Virtual Power Plants (VPPs) can participate in Contingency Frequency Control Ancillary Service (FCAS) markets without the prohibitively expensive cost of metering. However, the proposed requirement for high-speed metering for every 5 MW per region is not supported. The rationale for the 5 MW per region threshold is unclear and the expense might not be justified. We understand that high speed meters cost between $10,000 and $15,000, comprising $5,000 to $10,000 per meter (depending on type), $2,500 for the cost of installation, and $2,500 for additional works such as provision of additional space in a new subboard and independent network connection and setup. We suggest AEMO consider one high speed meter per technology type per region, rather than for every 5 MW per region. **CPUE** **There are benefits to amending the measurement requirements in line with the learnings from the AEMO's VPP demonstrations** The learnings from AEMO's VPP trial demonstrated the benefits of DER responding to FCAS events and as such, we strongly support the amendment to allow DER to meet the measurement requirements by capturing power flow and local frequency with a resolution ≤1s across all NMIs rather than ≤50ms. … We propose the following further recommendations regarding the proposed amendments. • Droop setting—the current MASS rule limits the maximum frequency response rate from proportional controllers to 1.7% droop setting. We recommend using 0.7% droop settings as applied in the VPP demonstration trial for small-scale DER systems. • High resolution metering—based on the current recommendation, the VPP proponent is required to install a high-resolution meter for every 5MW capacity. It is recommended clarity is provided on the rationale behind this decision. Our recommendation is to revert to the proven VPP trial requirement for high-resolution metering i.e. one HSM per region, as we believe this is sufficient to validate the performance.	The two options presented by AEMO in the Issues Paper are as follows: 1. Do nothing. 2. Amend the MASS by relaxing the measurement requirements for FCAS delivery by DER, as follows: a. Power flow and local frequency measurements can be taken with a resolution of <1s. b. For every 5 MW of aggregated FCAS capacity within a region, measurements to be taken by HSM with a resolution of <50ms on a common timescale. c. Measurements can be taken at the inverter or controllable asset level, provided they capture grid flow, as well. AEMO was also open to considering alternative options from the industry if they promote the NEO, and FCAS delivery could still be verified accurately. Consulted persons who were not fully supportive of Option 2 have been listed under the Hybrid preference below.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		• Relocation/decommissioning of assets installed on low voltage (LV) distribution networks – our understanding is a VPP facilitator is only required to re-register NMI's if they are intending to increase the capacity (MW) of the VPP. This will avoid the need to register and re-register NMI's frequently due to customer churn. AEMO will validate the NMI's to confirm the maximum capacity of the VPP. However, it is recommended that further clarity is provided on how AEMO will treat the relocation/decommissioning of a VPP asset installed on a low voltage (LV) distribution network. Since the VPP facilitator is managing the risk of an underperformance, it is recommended AEMO treat this similar to a customer churn. **Delta Electricity** AEMO are encouraged to think carefully about metrological details. For the control of frequency there is little value in encouraging competition if the services obtained are not coordinated due to too great a mismatch in measurement technique, control response speed and accuracy. Coordination of controls depends initially on ensuring like-for-like data for the control signal, frequency, and the dispatch signal process confirming the correct target reaches the Unit output. Full coordination also depends on the correct engineering parameters and suitable metrology of a comparable performance and quality being demanded by the specification. Making the specification easier for some suppliers by broadening the accuracy base in value or resolution will not bring about an overall coordinated result. For example, as the specification has in recent past removed the calculations that confirm performance into a guide, it is now less certain in instructing a participant how to build a spreadsheet that evaluates the participant's performance. Perhaps this is AEMO's intention in that there are some technical advisers in the market that think the FCAS controls as currently specified and guided do not adequately provide the required reactions to coordinate frequency. Inaccuracy for the centralised controller which can result in less coordination for frequency control has many sources including: • Data source instrumentation differences (accuracy of device, accuracy of source transformer, settling time), • Data conversion differences (A-D conversion resolution, time-stamping conventions, delta error interpolation of data), • Telecommunication defects, drop-outs or inadequacy, • Time-base of the centralised controller and mismatched coordination between the unit controllers and the centralised controller because of transient reactions that occur within the time-frame particularly apparent on Units that have mechanical-hydraulic controllers in partnership with computer controllers that following instructions from the centralised controller to set the Unit output and • Intermittency in the prime-moving source energy compared to predicted (wind speed, Solar irradiance, specific energy of fuel). Whilst higher quality instrumentation can be expensive, the impact of poor-quality information, any subsequent greater mismatch and inaccuracy in the true supply and demand conditions and the overall impacts on frequency performance compounds the inaccuracy of supply/demand balance.	**Table 1 Option Preferences for integrating DER into Contingency FCAS Markets** **Option 1:** Delta Electricity; Reposit Power; Rheem & CET; Viotas **Option 2:** AGL; DEMSA; Evergen; Mondo; Origin Energy **Hybrid:** CEC; CPUE; Energy Locals; EQL; Hydro Tasmania; Landis + Gyr; Members Energy; PAP; Shell Energy; Shinehub; Simply Energy; Social Energy; Solar Analytics; sonnen; Tesla **Other:** Empower Energy; Intellihub; Karit **No preference:** Ausgrid; ENA; SwitchDin; UNSW Seeking Consulted Persons' preference was a way of eliciting reasons for and against each option, and AEMO was provided with a wealth of information, reproduced in items 1 to 7 in this Appendix B. The high number of submissions in favour of a different option is notable as is the variety of proposed variations. AEMO's determination not to amend the MASS to relax the *metering* requirements for DER has been informed by

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		As the variability of frequency reflects the balance in the system between supply and demand, it is important that all instrumentation that provides information on the supply and demand quantities, and the frequency of electrical system, be measured in a consistent way to a common specification. AEMO can reduce some of the variability in the response and performance of FCAS systems by producing in the next MASS draft an improved and more directing specification on the instrumentation signalling and quality expected. **DEMSA** The Division supports revising the MASS, where necessary and appropriate, to accommodate the provision of FCAS by innovative new providers such as VPPS… … The South Australia government supports the deployment and improved integration of DER as part of the transformation of the energy system as it pursues its ambition to achieve 100% net renewable energy generation by 2030… … For those VPPs registered in the VPPP Demonstrations Program and currently providing FCAS under the interim specification, it is important that there be continuity beyond the Program's end date of 30 June 2021. The Division therefore supports incorporating the interim specification in the MASS (option 2) to the extent that AEMO is satisfied of the robustness of that specification, including delivery verification, such that the ancillary services market can operate effectively as VPP resources continue to grow…. … The Division does not support option 1, which would result in significant disruption to those current VPP FCAS providers and create (or reinstate) barriers to VPPs participating in FCAS due to cost prohibitive metering requirements. **Empower Energy** It is noted that the general sentiment underpinning the proposal is directionally correct and consistent with AEMO's mission and position as a leading ISO, particularly with respect to integration of DERs in markets necessary to improve and maintain grid stability. The need for change is real and AEMO's proactivity in these matters is correct, leading and laudable. There are however issues. The MASS 'Option' proposed within the Issues Paper ('Option 2') is based on experiences from AEMO's VPP Trial, which directly represents a limited portion of DER stakeholder interests and presents a solution with potential to create significant distortion in the fair, competitive procurement of relevant ancillary services, supporting retailing constructs and of DER assets able to supply and participate in the relevant services. This submission is not a complete review of all matters associated with the DER MASS process. It does attempt to highlight some salient issues with a view to illustrating that some modification with respect to the execution of these initiatives would serve to better realise their intent. **The rationale for the timing is difficult to understand** When asked, the specific response from AEMO as to 'why now' concerns the end of the VPP Trial. This is a highly unusual rationale for a change to market design, one not reflected in	these submissions and AEMO's rationale is detailed under section 4.1 and 4.2. AEMO largely agrees with Delta's comments, especially those directed at the need for confidence in the measurement technique, control response speed and accuracy of FCAS. Issues not addressed in sections 4.1 and 4.2 include concerns over end use customer churn (raised by CPUE and Simply Energy). This is not a matter for the MASS and appropriate AEMO staff will be provided the submission to consider how best the issue can be addressed.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Frequency Workplan Overview - which does not cite a need to redraft the MASS with respect to DER aims as an outcome of any workstream. Participants to the VPP trial represent only a subset of customers - a recent subset at that - of customers with DER assets participating in frequency response markets under the current MASS, which themselves are a subset of customers with DER assets in the NEM that are otherwise equipped with infrastructure capable of frequency response market participation compliant with the current MASS. In most instances these assets predate the VPP trial. AEMO's response on timing rationale concerns the revenue interests of a specific group of customers involved in a trial. Whilst it was understood that experiences from the trial would be used to shape future MASS, it was never made clear that the specific experiences tested within the VPP Trial design would form the sole basis of a new MASS. As per the AEMC's NEO, Market design is generally undertaken with a broader interest view. **It's difficult to see how this is fair for all** Rather than use the experiences of the VPP Trial to redesign the MASS in a manner using lessons from the VPP trial to increase DER access inclusive of assets and approaches predating the trial and newer means, the only two options presented are the trial conditions tested and the current MASS. The notion of these two sole Options being elucidated in detail communicates with some difficulty. The proposed changes broadly concern a modification of fast contingency response markets, within which a reduction of metering requirements at the connection point, the adoption of fleet MASS-compliant check metering and device ingestion testing per configuration type. The reduction in metering sample frequency for Fast FCAS from 20Hz to 1Hz effectively disincentives fast, useful frequency response by reducing the mechanisms by which response speed and volume are characterised. It may be possible to characterise these via indirect means in some cases (discussed later) however: • This change has a negative value effect on customers and companies already having bought or developed devices with comply with the existing MASS - some of which are registered for contingency FCAS under the existing MASS and outside of the VPP trial, • The options presented have not considered other options which may provide better outcomes for all. This may contravene the aforementioned energy objectives very directly - "Regulatory frameworks and market design should provide a clear, understandable set of rules without favouring one technology or business model over another". The MASS Option presented, in favouring the technical configuration of participants in the VPP Trial and their related stakeholders and business interests, may adversely impunge those compliant under the current MASS. **So are there other potential options?** Other options exist. AEMO proposed a 10Hz variant of the current MASS as part of trial conditions, though no VPP Trial participant chose to demonstrate this standard. It did not require injection testing or check metering.	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		It should be stressed at this point that the VPP Trial did not necessarily evaluate a statistically significant portion of all BESS DERs known to market, or beyond that of all DER types of all classes. Whilst the trial had many customers, it did not have significant technology or vendor diversity. A 10Hz approach without injection testing or check metering would usefully lower access requirements. A number of solutions exist in the market capable of 10Hz response on Modbus over RS485 communications, a common means of implementing metering infrastructure in many DERs (in particular in solar and battery inverters). All 20Hz infrastructure can compete in a 10Hz market with some additional measurement error (though considerably less than for a 1Hz solution). A 10Hz standard for primary frequency response measurement is also the solution being developed and trialled for electric vehicle supply infrastructure (EVSEs) in standards governing EVSE-to-EV communications (ISO 15118-20) and in relevant standards between EVSEs and charge point operators (OCPP). This is an important example, as: • The ultimate market for EVs is larger than the market for stationary BESS in Australia, • It is unlikely, in lieu of a significant automotive manufacturing industry, that vehicle manufacturers will adopt an indigenous standard of lesser performance, and • This current 10Hz direction is already in practical deployments overseas. Whether the ultimate solution is 10Hz or otherwise, it should be clear that alternate Options are available, are known and are tested. They should be evaluated on merits consistent with energy market objectives. Concerns over later-horizon DER asset classes outside of those best represented in the VPP Trial are relevant - the NEO, in particular, promotes "efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to (1) price, quality, safety, reliability, and security of supply of electricity; and (2) the reliability, safety and security of the national electricity system." **Energy Locals** On the whole, Energy Locals supports the direction AEMO is taking with a few specific callouts … … … there are some aspects of the proposed option which we believe should be modified: 1. **One HSM per 5MW.** This is an expansion of the current requirement that there must be one HSM per jurisdiction. We question the value of this additional cost burden given one HSM per 5MW will not provide any data on the performance of individual systems (most likely ~1k per 5MW in the case of small-scale VPPs). We believe that at most AEMO should require one HSM per technology type per jurisdiction. 2. **All controllable units within the same VPP operate with the same type of FCAS controller.**	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		We expect that as time goes on, more VPPs will be established by organisations that offer customers a choice of technology types. In this scenario we expect that more than one controller may be utilised in order to optimise the DER. 3. **HSM must capture the power flow measurements from the controllable devices, generating units behind the connection point, grid flow, and local frequency.** As the actual frequency performance will be measured at the device terminal, we don't understand the value HSM data capturing these other data points. 4. **1MW limit per connection point.** We believe this proposed limit will reduce the opportunity to deploy DER on commercial sites including residential apartment buildings as it will make it difficult to operate assets that are greater than 1MW as an aggregated fleet. Without this aggregation, the cost base for these >1MW assets will increase and this may make the deployment of otherwise good projects uneconomic. **ENA** ENA supports a framework that allows for greater participation of DER in FCAS. Changes should be supported by a growing body of evidence from past and current trials and research. **EQ** EQ suggests that any option that relaxes the measurement requirements for aggregated demand response will remove barriers. **Evergen** Evergen supports Option 2: embed measurement requirements tested in the VPP Demonstrations into the MASS. … Limiting market access for small-scale DER will deprive AEMO of: - interaction with customers who are moving towards more interactive "prosumer" roles in the electricity market; - participants and competition in the FCAS contingency markets; - the opportunity to develop networks of small DER at scale; - experience in DER operations for AEMO staff; and, - the opportunity to showcase Australia's progressive approach to decarbonisation and enablement of mass adoption of batteries, to support the mass adoption of rooftop PV in which we lead the world. Evergen would be able to meet Option 1 requirements at little cost if our hardware partners offered Option 1 monitoring requirements as part of their battery and inverter capabilities, and if they could deliver measurement from the connection point rather than the device. However, feedback from our hardware partners - who include some of the world's leading battery and inverter manufacturers and DER suppliers as well as a prominent utility meter supplier - is that they cannot meet Option 1 requirements at this stage. As technology evolves this may eventually be possible, but does not seem likely in the near future.	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		For this reason, **we support Option 2**, whereby AEMO would formalise the lessons and approach derived from the VPP demonstration program, and offer practical and viable measurement and participation requirements for VPPs comprising small-scale DER in contingency FCAS markets. **Hydro Tasmania** The initiative of including the DER (VPP) technical specification in the MASS is supported by Hydro Tasmania. We believe this is a critical step for DER to be recognised as a part of the NEM as well as be harmonized with other generation technologies at a technical level. Hydro Tasmania has the following observations about the specific options: **Option 1** Option 1 is not supported as the metering requirements applied on utility scale generators are not suitable for application at a domestic and/or commercial level due to their high cost. **Option 2** Option 2 provided useful experience for the VPP trial program and could be used as a benchmark to understand if other more cost-effective alternatives are available e.g., option 3. Hydro Tasmania would like to point out that the additional requirement stated in S2.3.2 point 3 'For every 5 MW of aggregated ancillary service capacity per region, a HSM is needed', doesn't appear in line with the original consideration of the VPP trail program, that only one HSM is needed per region for the purpose of system frequency checking in islanding. Hydro Tasmania noticed that in the recent consultation response AEMO provided a high-level explanation, Hydro would suggest AEMO share more technical details of this requirement. **Option 3** Hydro Tasmania would like to acknowledge the suggestion from other participants in the consultation meeting, particularly the proposal to consider using the invertor logger as one of the acceptable sources for VPP FCAS contingency response evaluation. It is recommended that AEMO explore the technical feasibility of using 100ms as an alternative for the fast contingency FCAS evaluation and facilitate VPP technical standards forming and overall cost saving in long term. We have observed that certain battery/solar manufacturers are already able to or very close to reach 100ms/per sample data resolution with only a marginal incremental cost above existing invertors. Hydro Tasmania would encourage AEMO to consult widely with these manufactures to understand how this technology is expected to develop. … Hydro Tasmamia is aware of the time frame of the existing VPP trail program and understands the intention of AEMO to establish certain technical requirements in the MASS and better guide the growth of VPP. Given the complexity of this, Hydro Tasmania recommends AEMO: 1) seek an interim technical specification with a few options (including IBR) co-existing in the MASS; then 2) focus on the technical consultation and seek more comprehensive proposals for longterm ongoing measurement, optimisation and settlement.	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Intellihub There are material issues with both options proposed in the consultation paper. Retaining the current MASS means cost and duplication making small-scale DER VPPs financially unviable. The proposed DER MASS is a complex and onerous arrangement, likely with negative impacts on market efficiency. There is a simple solution that eliminates these issues: use the revenue meter. We have proposed an alternative to the two options put forward in the consultation paper, encouraging, but not mandating, the use of the revenue meter for FCAS measurements. We believe this proposal is consistent with the NEO and will be effective in remove existing barriers for the participation of smallscale DER in FCAS markets. In summary, we propose: • Creating a set of measurement requirements which apply to small-scale DER sites, baselined from 3.6(a) of the current MASS, with only a minor relaxation in requirements; • Delaying the finalisation of these measurement requirements by a matter of months to allow the capabilities of upcoming revenue meters to be fully understood; • Encouraging FACS measurements to be taken at the NMI level rather than the device level, and • Consider how the long-term accuracy of measurements will be assured. … Intellihub recognises the barriers that the current (v6.0) MASS creates for the participation of VPPs comprised of small scale DER in the MASS fast raise and fast lower service. Chiefly these barriers pertain to the requirements for HSM facilities at each participating fast raise and lower site. The currently available means for meeting this requirement are impractical and cost prohibitive in the context of small DER sites. In the MASS consultation paper, AEMO has proposed two options: 1. Leave the current measurement requirements unchanged (“do nothing”) 2. Embed the measurement requirements which were tested in the VPP demonstrations: a. Permit measurement resolution of less than or equal to 1s (with conditions), relaxed from 50ms, and b. Permit the measurements to be captured at the controllable device (with conditions), rather than at the NMI. Intellihub proposes an alternative option for consideration, which encourages the use of revenue meters for measurement per the MASS requirements, thereby reducing cost and duplication. This option will more closely align with the NEO than the two options proposed in the consultation paper. … **Issues with the Proposals** The current MASS effectively requires an additional HSM to be installed at each participating site. The cost of this HSM solution typically exceeds any revenue expected to be produced over the lifetime of a small-scale DER installation, rendering it unviable to participate in the FCAS	In response to Intellihub’s comments: AEMO does not prevent a revenue grade meter from being used for FCAS purposes if it meets the measurement requirements of the MASS.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		markets. This specification was originally written with large generators in mind and is unsuitable in the context of VPPs consisting of small DER. Amendments are required to consider this use case and ensure viability of these types of VPPs. The DER MASS proposed in the consultation paper relies on specific models of DER in the VPP to have consistent and well understood behaviour in response to a contingency event, such that direct measurement can be avoided. While this approach has merit in principle, there are drawbacks, including: • The necessary limitation on the ability of VPP providers to mix different DER types, makes and models. This introduces an artificial market limitation and will hinder the efficient propagation of VPPs and therefore the value provided to the NEM. • The requirement for costly frequency injection testing for each type, make and model of DER to characterise the behaviour under contingency conditions. There is a further complexity here when managing different variants of the same device, such as differing hardware and/or firmware revisions – some of which will be deployed while the device is in service. Such updates may change the response of the device under contingency conditions, possibly inadvertently. Will each firmware update of each variant need to undergo frequency injection testing? Will each VPP operator be required to maintain a record of every DER and what characteristic response it had at any point in time? • The proposal fails to entirely eliminate the need for HSM, imposing additional cost and asset management burden on VPP operators. • The 1s measurements interval is unlikely to be fast enough to support an efficient ancillary services market. **Our Alternative Proposal** We have put forward an alternative proposal, described below, with the goal of reducing cost and duplication by using the capabilities of revenue advanced digital meters. Our proposal takes the measurement requirements in the current MASS as a starting point and permits a small relaxation in some of the characteristics described in 3.6 (a) when the site is considered a small-scale DER site. We have not attempted to define a small-scale DER site however, we believe that a reduction from the 1MW limit proposed in the consultation paper may have merit, to limit any impact of the relaxed measurement requirements. We consider this a pragmatic approach, setting the measurement specification to get the best possible performance from the revenue meter, without triggering significant cost for participants. We believe that this proposal is preferable to the two proposals described in the consultation paper, as our proposal better balances the practicality and cost of complying with the need for efficient operation of the ancillary services markets and is ultimately better aligned with the NEO. … [AEMO should not implement either option]. We have proposed an alternative option which we believe is preferable to both options proposed in section 2.3. **Karit** Of the options presented, Karit preference is Option 2: To embed the measurement requirements that were tested in the VPP Demonstrations in the ongoing MASS.	In response to Karit's comments: Refer to Section 4.2.2

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Karit would however prefer a scenario where the revenue meter is upgraded to enable measurement and verification data to be obtained from the meter via an open access mechanism which would significantly lower the cost of deploying infrastructure to support the Ancillary Services Market. **Landis + Gyr** Landis + Gyr supports Option 1 with a measurement period of 100ms. The next generation of meters being released into the market will be able to support this requirement, possibly even 50ms as metering platforms mature. At the same time DER appliances will continue to evolve and their response to events will continue to improve. The measurement device must therefore, as a minimum be closer aligned to existing market requirements. **Members Energy** We recommend implementing a hybrid of options 1 and 2, as follows: • Implement option 2 for a defined period of time, between 1 and 2 years. • Implement option 1 after the option 2 period expires. This will allow time for the industry to develop cost effective technologies to provide the increased accuracy required to ensure future growth of VPPs to fulfill a greater role in the power system. Why? We consider that option 2 in the short term will catalyse market competition and consumer uptake of VPP offerings. This time will allow technological development to reduce more accurate metering costs, while also allowing VPPs time to expand and play a larger role in power system security to the point where more accurate metering is required. **Mondo** Mondo supports the proposed amendment to the MASS to enable DER to more easily participate in FCAS Markets. AEMO's VPP Demonstration Program has demonstrated that aggregated DER can provide valuable ancillary services to the NEM. Unlocking DER to provide ancillary services should provide multiple benefits to energy users in coming years, including • reduced costs of FCAS due to greater competition/supply; • additional revenue streams to DER owners; • improved efficiency of DER installation and deployment due to rewards for providing services that benefit the broader market. ... Mondo supports Option 2, to embed the measurement requirements that were tested in the VPP Demonstrations in the MASS, on the basis that this expands the supply of Contingency FCAS and creates important incentives for DER participation in the NEM. We believe this will facilitate VPP models and greater NEM transparency. The VPP Demonstration trial conducted frequency injection testing for every different type of battery system. We would support a continuation of the intention of this approach, however we note that for larger systems of say 50kW-500kW there may be a degree of custom design and a range of technology combinations across a VPP. We would support the development of a frequency injection testing regime that achieved testing outcomes with the minimal number of	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		tests. Such a regime may infer the results of different inverter battery combinations without testing every combination, where the controller and control type remain common. While option 2 provides a good starting point, we note that FCAS were initially developed based, at least partially, on the capabilities of large-scale generation providing FCAS. Future versions of the MASS would be enhanced by also considering the capabilities of VPPs, and the inverter-based energy systems that underpin them. **Origin Energy** Increasing the participation of DER in ancillary service markets will enable the efficient use of all available technology to maintain system security. Origin supports the revisions to the MASS under option 2 as a first step in achieving this goal. Monitoring rules that allow for aggregated participation by small systems will lower the barriers to entry for some technologies and business models. **PAP** The current specification regarding measurement may not be adequate when considering network security @1s. PAP would support option two (under the MASS DER consultation process) at either 100ms or 50ms, to provide the system operator with required transparency around FCAS contingency events. **Reposit Power** Reposit asserts that AEMO should require all Fast Contingency FCAS market participants to implement Option 1 metering. Option 1 metering is cost-effective and accessible to all participants (**Section 2**[78]). Fast FCAS relies on a low-error delivery or withdrawal of energy from the grid to arrest a frequency deviation. Uncertainty caused by increased error in energy delivered or withdrawn will result in diminished system security. Option 2 metering introduces between 16%-22% (**Section 3.4**) additional error into Fast FCAS when compared to Option 1. This will result in a material reduction in system security and should be avoided (**Section 3**). ... **3.1 Option 2 formulation** Option 2 modulates only two parts of the MASS v6 measurement requirements. NMIs <1MW of capacity* can choose between the following metering requirements[79].	

[78] Reproduced in item 4 of Appendix B.
[79] MASS Consultation Paper - January 2021 - Section 2.3.2

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE

	MASS v6	Option 2	AEMO rationale for Option 2 relaxation
Time resolution of power flow and local frequency measurement	50ms	<1000ms	AEMO states it has been able to identify under-delivery of FCAS using 1Hz data[80]
Frequency injection test required for every controller + inverter + battery combination	Required (see Feb 2021 Reposit registration)	Required	(Not provided) Reposit posits that AEMO is characterising DER "type" and is assuming homogeneity of response across type.
50Hz meter at full MASS precision and accuracy requirements	Required on all Connection Points	Required at one device for every 5MW of capacity* per region	(Not provided) Reposit posits that AEMO is characterising DER "type" and is assuming homogeneity of response across type.
Power measurement location for the verification of FCAS delivery	Connection Point	Inverter or Controllable device	(Not provided) Reposit posits that AEMO is satisfied to disregard the error introduced into FCAS response by site loads.

*AEMO does not specify how this capacity is to be measured or specified.

AEMO has not provided a complete engineering argument for these relaxations of MASS v6 requirements. These relaxations were formulated during the design of the VPP Demonstrations project as part of hypothesis building. The VPP Demonstrations project must have rationale and supporting data to show that these relaxations have no material effect on the effectiveness or efficiency of FCAS delivery. Other than AEMO's assertion that under-delivery could be

[80] MASS Consultation Paper - January 2021 - Section 2.2.1

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		identified, these rationales and data have not been presented in the Knowledge Sharing Reports, nor in this MASS Consultation Paper. AEMO states that the VPP Demonstrations have informed the new or amended arrangements[81]. It is appropriate that AEMO present formal engineering arguments and raw supporting data that support the relaxations provided in Option 2. Without this data stakeholders are forced to propose AEMO's arguments for these relaxations. This is not conservative. AEMO are presenting a material change to the operation of Fast FCAS informed by AEMO's VPP Demonstrations project, and it is AEMO's responsibility to justify these changes with engineering rigour and supporting data. … **3.3 Engineering analysis of Option 2** AEMO's statements in the VPP Demonstrations design documentation, Knowledge Sharing Reports, and this MASS consultation paper can be parsed to synthesise AEMO's engineering argument for Option 2 metering. This argument is as follows:	

Premise 1	MASS v6 accuracy and precision is required for the measurement and verification of Fast FCAS
Premise 2	At least 50ms time resolution is required to measure the energy delivery response of each "type" of DER resource
Premise 3	AEMO assumes every unit of a DER resource type has the same energy delivery/withdrawal response to a frequency deviation
Premise 4	AEMO assumes every unit of a DER resource type has a frequency response identical to the "type" test result, over its entire life.
Inference 1	Every unit of a DER resource type delivers energy in exactly the same way every time it delivers energy, over its entire life.
Premise 5	Under-delivery of energy delivered into/withdrawn from a fast contingency event can be detected using 1Hz data
Conclusion	Therefore 1Hz metering is sufficient to measure energy delivered into/withdrawn from a contingency event, from every unit of a DER resource type, for any point into the future.

Reposit has examined this argument as follows.

3.3.1 MASS v6 accuracy and precision

3.3.1.1 AEMO premise 1:

MASS v6 accuracy and precision is required for the measurement and verification of Fast FCAS.

[81] MASS Consultation Paper - January 2021 - Section 1.1

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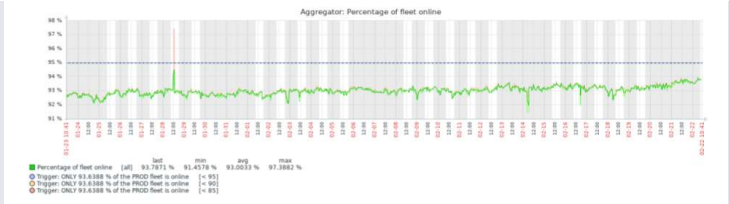
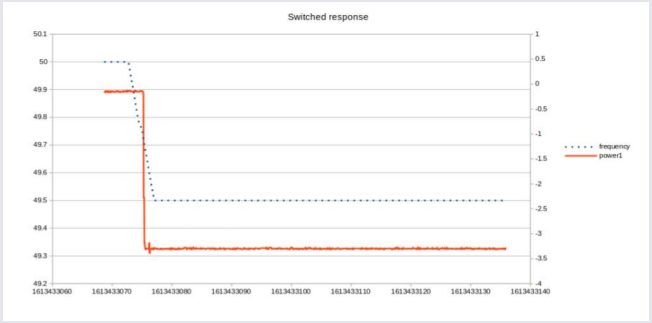
		3.3.1.2 Inferred from: AEMO does not modulate the accuracy and precision requirements for any metering in Option 2. High-speed and 1Hz metering all must meet MASS accuracy and precision requirements. The only modulation is in time resolution for device-level meters. **3.3.1.3 Reposit's position:** Reposit believes that the accuracy and precision requirements of MASS v6 are appropriate for a long-lived DER asset. The requirements are perhaps too restrictive for a 5-15kW DER unit in a 6-s response market. But the cost of delivering this functionality is low and it is likely that it will be required for future energy services in the NEM. **3.3.2 HSM required to measure energy delivery** **3.3.2.1 AEMO premise 2:** At least 50ms time resolution is required to measure the energy delivery response of each "type" of DER resource. **3.3.2.2 Inferred from:** AEMO requires a frequency injection test on every different type of controllable device that responds to an excursion. This must be measured at a time resolution of 50ms or less[82]. **3.3.2.3 Reposit's position:** AEMO agrees that 20Hz metering is sufficiently high-resolution to determine energy delivered/withdrawn with acceptable error. It is likely that this rate has been selected by past power engineering staff at AEMO in response to the error associated with measuring a continuous quantity (energy under the curve) with a discrete measurement device (a digital electricity meter/SCADA RTU). This error is described in detail in section 3.3.6.3.1 of this document. **3.3.3 Homogeneity in energy delivery over DER "type"** **3.3.3.1 AEMO premise 3:** AEMO assumes every unit of a DER resource type has the same energy delivery/withdrawal response to a frequency deviation - that is, a homogenous energy delivery/withdrawal response. **3.3.3.2 Inferred from:** AEMO will allow DER to meet the measurement requirements by capturing power flow and local frequency with a resolution $\leq$ 1s. That is, AEMO does not require high-speed energy delivery data from each unit of DER. The only information AEMO has about energy delivery from the DER unit comes from the "type" frequency injection test. The "type" frequency injection test was used on the VPP Demonstrations to characterise the response of a every different type of battery system in a VPP[83]. AEMO describes a battery system as being a unique combination of inverter model, battery model and control system.	

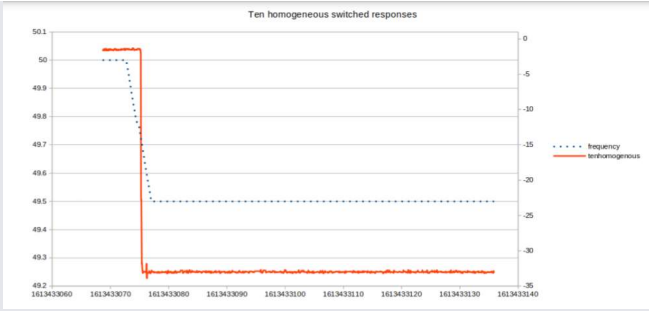
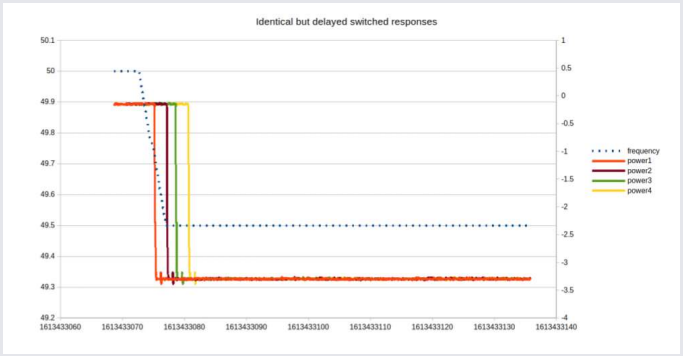
[82] MASS Consultation Paper - January 2021 - Section 2.3.2
[83] MASS Consultation Paper - January 2021 - Section 2.3.2

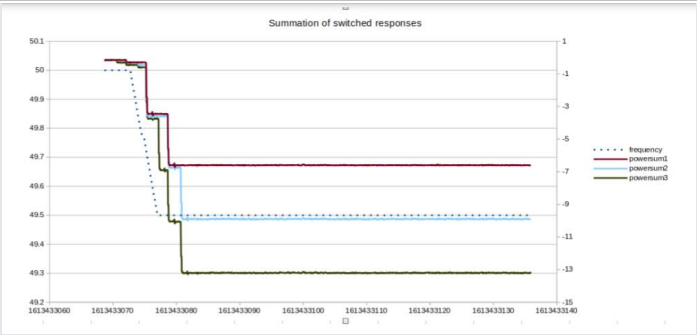
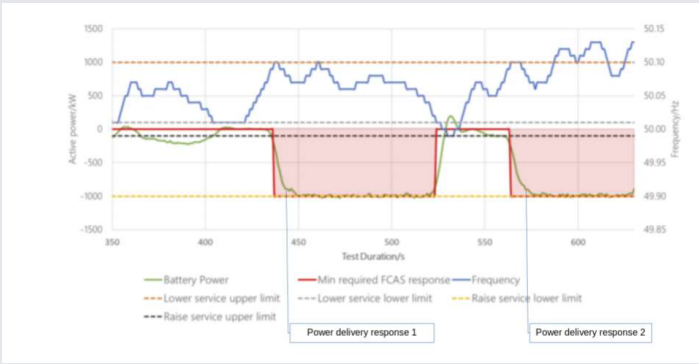
NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		3.3.3.3 Reposit's position: AEMO's premise is that a particular type of battery system in a VPP will respond identically to the same frequency deviation. Reposit asserts that AEMO's premise is incorrect. Reposit asserts that there is no validity in assuming that the energy delivery/withdrawal response of a DER unit of a particular "type" will be the same as that of the type tested unit for that "type", for any given frequency deviation. Reposit cannot find any evidence for this premise as an outcome of the VPP Demonstrations. Instead AEMO has shown that the response of battery systems in its VPP Demonstrations were not homogenous. In Knowledge Sharing Report #1, AEMO reported on the cause of an under-delivery of FCAS capacity as being related to a difference in configuration settings on different units of the same type[84]. "Energy Locals and Tesla realised that fewer systems than expected had the appropriate frequency support settings enabled. This led to fewer individual units responding as part of the VPP to deliver a reduced fast lower FCAS aggregate response; this equated to 83% of the expected response, or 828 kilowatts (kW) rather than 1 MW bid. The correct frequency settings were configured and activated upon enrolling additional systems into the SA VPP. These settings were later modified for some systems when a test was manually scheduled for the purpose of gathering data for the VPP-wide test, as described in the VPP Demonstration FCAS Specification. A benefit of VPPs is that once identified, this issue was fixed immediately by remotely reconfiguring the non-compliant systems. Since this event, Tesla informs AEMO that it has introduced daily checks on all systems to ensure they are responding according to the expected configuration requirements. It is expected that this approach will mitigate the risk of any future under-delivery. Energy Locals and Tesla The vendor committed to "daily checks on all systems" to "ensure they are responding according to the expected configuration requirements". This is a very simple and clear demonstration that "type" homogeneity is fragile at best, and non-existent at worst. This type of configuration difference between the unit used for the type test and the actual units in the VPP resulted in a low-energy FCAS response. In this case, it was able to be rectified remotely as it was a software inconsistency, but this will not be true of a hardware inconsistency. In fact, AEMO has demonstrated that even where it is a software configuration problem there can be up to 8% of units experiencing communication problems[85]. **Data quality insights** • Evidence indicates that VPPs experience communications drop-outs that result in around 5-8% of required data from their fleet missing at any given time. These communications problems may be chronic or intermittent. In either case, they present an opportunity for configuration, firmware and other software to be different on the same "type" of battery system. Data on these communications problems has not been made available by AEMO, however this metric is consistent with Reposit's experience of residential Internet connectivity.	

[84] VPP Demonstrations Knowledge Sharing Report #1 - Section 2.1.1
[85] VPP Demonstrations Knowledge Sharing Report #2 - Executive Summary

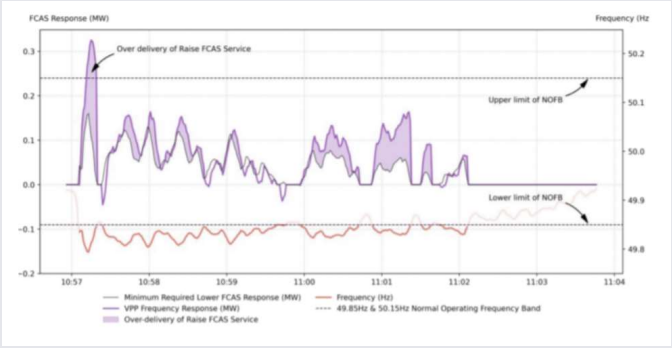
NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		 Reposit aggregate fleet connectivity over time – household internet connections Compounding the argument against homogeneity, AEMO published the responses of a switching controller-based VPPs in Knowledge Sharing Report #3[86]. It is notable that neither of these switching controller-based VPPs demonstrated the hallmarks of a homogenous, switched response. AEMO provides switching controller-based VPPs with Raise and Lower frequency deviation trigger settings[87]. A homogeneously responding, switched controller-based VPP should show a very sharp response to reaching a frequency deviation. This is because a switching controller's response is binary. It is either delivering/withdrawing power, or it is not. As a result, something like the following response is expected from a single switching controller:  This is a 20Hz data capture from an actual inverter under continuous Reposit control. Reposit is a switching controller. There is a clear step change in power at 49.75Hz. In this case the inverter went from idle power to delivering almost 3.5kW in under 1s. This is close to ideal control for a switching controller battery response and is characterised by two sharp discontinuities (or "elbows") in the power curve. Frequency is system global on FCAS timescales so a homogenous response from ten of these inverters of the same "type" would show the same curve, but with a 10x greater magnitude of response.	

[86] VPP Demonstrations Knowledge Sharing Report #3 - Figure 1
[87] MASS Consultation Paper - January 2021 - Section 2.3.2

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		 The aggregated response is the result of a linear time-series convolution of the responses from each of the providing storage systems. Convolution is a basic operation in digital signal processing and is the correct mathematical treatment for combining a collection of time series signals such as energy metering data. Note the clear step changes (the elbows) in the power graph. It is very clear that the aggregate response retains the discontinuous nature of switched control. A non-homogeneous response will lose this characteristic discontinuity and instead become continuous. This is because the difference in the responses creates error which smooths the discontinuity. It is notable that this smoothing is clearly evident in the switching controller responses published in AEMO's Knowledge Sharing Report #3. Below is the same response but replicated four times, with each replica given a small time delay.  Below are three linear time series convolutions of this data. Powersum1 adds power1 to power2. Powersum2 adds power3 to powersum1, and powersum3 adds power4 to powersum2	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		 It is clear that the discontinuity (elbows) that are characteristic of a homogenous switched response are being smoothed as more power curves are added. This is the non-homogeneity of the responses working together. The only difference in the power responses is a non-uniform delay in response initiation. The discontinuity will be smoothed further where other differences are apparent in the power responses, and as more non-homogenous power responses are added to the convolution. Any smoothing of a discontinuity means that the FCAS response of the units in the aggregated response are not homogenous. The graph below[88] shows a non-linear, but somewhat stepped response. It is not indicative of a homogenous response on power delivery. This is clear from the "curvy" shape of the power delivery initiation. A linear time-series convolution of homogeneous switched controlled systems does not display the discontinuity smoothing evident here.  Further to this, the initiations of power delivery response 1 and 2 in the above graph are different. The energy absorption of this switched controller VPP was materially different where	

[88] VPP Demonstrations Knowledge Sharing Report #3 - Section 2.1.1

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		nothing was changed except for a small passage of time and a previous small charging event. It is impossible for AEMO to claim that this VPP responds homogeneously when its power response is materially less after only a small increase in charge state. It should be noted that the energy absorbed by this VPP during ramping was substantially less in the second response than in the first. This is visible at 1Hz resolution and Reposit suggests that the 20Hz data would show an even greater discrepancy. This is even more evident in the second switched controller VPP response provided[89].  There is no evidence of the characteristic discontinuity of a homogeneous, switched controller response. AEMO state that this VPP implements some sort of hybrid response[90]: > The frequency deviation trigger setting of each battery system can be dynamically adjusted so the aggregated response from the VPP is proportional to the frequency excursion, even though each system essentially makes a step change in active power. This in itself suggests that each battery in the VPP does not deliver a homogenous response. The only way the response from the VPP can be proportional to frequency, with each battery making a switched response, is if different batteries are doing different things. This is by definition not a homogeneous response across the VPP and makes the "type" test of this DER type completely irrelevant. If Option 2 were to be made available by AEMO, this VPP could not adopt it. In short, the Knowledge Sharing Reports contain enough information to demonstrate that every unit of a DER resource type does not have the same energy delivery/withdrawal response to a frequency deviation. AEMO's own data demonstrates AEMO's premise 3 as being invalid. This result agrees with Reposit's 8 years of experience in controlling energy storage systems from multiple vendors. Reposit has large amounts of data that demonstrates that DER units composed of the same inverter, battery and control system combination do not natively behave	

[89] VPP Demonstrations Knowledge Sharing Report #3 - Section 2.1.2
[90] VPP Demonstrations Knowledge Sharing Report #3 - Section 2.1.2

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		homogeneously. This is a result of many differences, which can and do occur in the same model of equipment, including: 1. Inverter and battery firmware version 2. Inverter hardware revisions 3. Battery cell chemistry 4. Battery cell manufacturer 5. Battery form factor (e.g 18650, 2170, prismatic) 6. Battery string configuration 7. Controller hardware revision (CPU, RAM, storage) 8. Controller/inverter/BMS configuration settings These differences in a single "type" of DER cause significant deviations in energy delivery/withdrawal. Overcoming them requires closed, local and high-frequency control. Oftentimes, particular DER units will need to have their power contribution heavily discounted to account for the effects of differences within a "type". Further to this AS4777 prescribes that individual units modulate their power delivery to meet local conditions. And DER operating envelopes currently being explored by AEMO's Project EDGE, ARENA's Evolve, and several DNSPs will do the same. Homogeneity of response within a "type" cannot exist under the technical constraints imposed by these alone. Managing this lack of homogeneity is a key value add of a DER aggregator. It consumes large amounts of research and development resources, and is essential to the deterministic delivery of energy. It is in AEMO's interests to incentivise homogeneity of response as it is a strong indicator of a high-energy FCAS response. A VPP aggregator can do many things to improve the homogeneity of response if they have the incentive to do so. Option 2 assumes homogeneity of response and so removes this incentive. Reposit has learned over time that a conservative and reliable delivery/withdrawal of energy can only be achieved where each DER unit is managed, offered and controlled as an individual unit. That is, any assumption of homogeneity introduces unbounded error/uncertainty into energy delivery/withdrawal. This has not been acceptable to Reposit's DNSP customers in the past, and we expect it is not acceptable to AEMO. It has only been through the visibility afforded by in-field, high-frequency metering that these issues have been detected, characterised and resolved. **3.3.4 Homogeneity in frequency response over DER "type"** **3.3.4.1 AEMO premise 4:** AEMO assumes every unit of a DER resource type has a frequency response identical to the "type" test result, over its entire life. **3.3.4.2 Inferred from:** AEMO requires a single 50ms or better meter for every 5MW of capacity in a region. This is to confirm whether the response from the controllable system was initiated at the right time and	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		in the case of switching controllers, whether the local frequency went below or above the assigned Raise and Lower frequency deviation settings[91]. That is, AEMO does not require high-speed frequency response data from each unit of DER. This means the only reliable information AEMO has about frequency response comes from the "type" frequency injection test. **3.3.4.3 Reposit's position:** AEMO requires "5MW meters" as part of the requirements for the adoption of Option 2. AEMO does not make it clear what the intent of this meter is, only stating that the 5MW meter is used to determine response initiation characteristics for one DER unit in every one thousand DER units (in a residential DER context). Reposit presumes that AEMO is assuming that the response initiation characteristics of the 20Hz-metered unit are identical to those of the 1Hz-metered units in the 5MW aggregation. That assumption requires that the frequency response of the entire unit (controller, inverter and battery) is identical on the 20Hz-metered site and the 1Hz-metered sites. This is because it is the response characteristics of all three (not just the controller) that determines when a response-related energy transfer reaches the metering point. It should be noted that AEMO is assuming here that all DER responds homogeneously, not just of a DER type. This is because a 5MW aggregation may (and most likely will) have different "types" of DER in it, all proportional or switched controlled, but only have a single "5MW meter". In this case, it is impossible for the "5MW meter" to be measuring the response initiation characteristics of all of the types of DER in the 5MW aggregation. Data that validates the assumption that all DER has homogenous response initiation characteristics has not been presented by the VPP Demonstrations project. Nor has data been presented that shows that even a single "type" of DER has homogenous response initiation characteristics. Reposit asserts that this assumption is invalid for many of the same reasons described in section 3.3.3. Response homogeneity in a VPP fleet, even for systems composed of the same controller, inverter and battery, does not exist. There are too many variables that must be taken into account, and hence individual response initiations and deliveries are heterogeneous and must be measured. This has been shown by the VPP Demonstrations project and it is well known to Reposit. Reposit suggests that fleets of a single "type" of DER with more than 10MW of capacity will come to demonstrate this point. It is extremely unlikely that the response characteristics of the DER units at the "5MW meter" sites will display perfectly homogeneous response initiation and energy delivery for all future frequency deviations. This likelihood will fall as more capacity, and hence more "5MW meters" are added. At this point, AEMO will be presented with data that proves that units of a DER "type" do not respond homogeneously. Reposit suggests that the homogeneity assumption underlying Option 2 will be shown to be invalid and that Option 2 will no longer be able to be supported by AEMO. This will not be in the interests of Option 2 VPP providers.	

[91] MASS Consultation Paper - January 2021 - Section 2.3.2

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		For this reason Reposit suggests that a requirement of Option 2 should be the right for non-market, third-party metering of any "5MW meter" site, by any interested party at their own expense. This will: 1. Provide AEMO with multiple, non-VPP aligned metering streams of single events at a single site 2. Ensure that "5MW meter" sites are able to be verified as being representative of the unmetered sites 3. Provide an additional incentive to the owner of the "5MW meter" site to host additional metering equipment As with section 3.3.3, homogeneity in any part of the VPP aggregation cannot be assumed. It is the role of the VPP aggregator to deliver high-quality responses to AEMO when responding to contingency events. There is investment that must be made by VPP aggregators to deliver the kind of homogeneity that results in high-energy Fast FCAS responses. To assume this homogeneity removes incentive from a VPP-provider to work towards high-quality responses, ultimately damaging system security. **3.3.5 Homogeneity over time for each DER "type"** **3.3.5.1 AEMO inference 1:** Every unit of a DER resource type delivers energy in exactly the same way every time it delivers energy, over its entire life. **3.3.5.2 Inferred from:** AEMO does not specify the gathering of any post-frequency injection test high-speed data for energy delivery or frequency response - for the entire life of the DER asset. **3.3.5.3 Reposit's position:** AEMO infers the statement from Premises 3 and 4. Option 2 requires this inference because there is at best a 0.1% likelihood under Option 2 that any high-speed data will ever be gathered from a particular DER unit. This means that only the point-in-time "type" test data can be relied upon to determine energy delivery accurately. Reposit does not see any data to support AEMO's assumption that any kind of response homogeneity exists for DER units. This includes response homogeneity over time. Reposit's experience is that there is no consistent response, identical to that of any "type" tested unit, for every frequency deviation until unit decommissioning. There are simply too many variables that affect response. The variables listed in section 3.3.3 are essentially characteristics of equipment models and their evolutions. The following incomplete list of variables are much more point-in-time and have an at least equal effect on the energy delivery/withdrawal that a storage system will make into a contingency event: 1. Battery temperature 2. Battery state of charge 3. Inverter temperature 4. Inverter AC terminal/connection point voltage	

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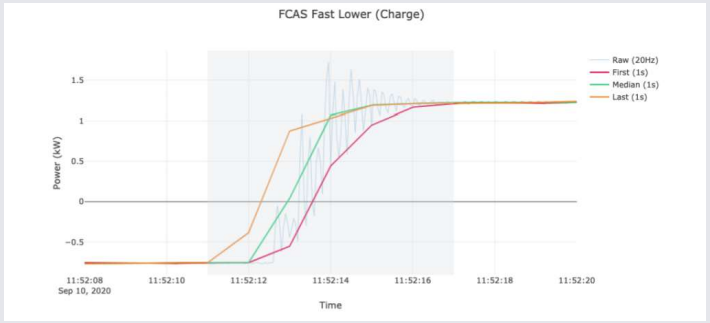
		5. Controller background processing load 6. Controller temperature Homogeneity of response between a "type" tested unit and any other unit of the same "type" cannot be assumed. It cannot be assumed between units of the same type, and it cannot be assumed to be consistent over any time period. The assumption of homogeneity is not correct. It is the role of the VPP aggregator to deliver high-quality responses to AEMO when responding to contingency events. There is investment that must be made by VPP aggregators to deliver the kind of homogeneity that results in high-energy Fast FCAS responses. To assume this homogeneity removes incentive from a VPP-provider to work towards high-quality responses, ultimately damaging system security. **3.3.6 Under-delivery of energy can be detected with 1Hz metering** **3.3.6.1 AEMO premise 5:** Under-delivery of energy delivered into/withdrawn from a fast contingency event can be detected using 1Hz metering data **3.3.6.2 Inferred from:** AEMO states that an under-delivery could be identified whenever the calculated minimum required FCAS response was more than the actual amount of FCAS delivered[92]. **3.3.6.3 Reposit's position:** Reposit does not understand how AEMO is sure it has been able to detect under-delivery of FCAS using 1Hz data. It is statistically very unlikely that AEMO has correctly measured the energy delivery/withdrawal made into a contingency event by a VPP, by using 1Hz data. The following is a measurement of an actual Fast raise response from a "VPP-enabled" storage system.  This response shows the sub-second power oscillations so frequently displayed by electricity storage systems examined by Reposit. These oscillations are not able to be detected with 1Hz metering, but are clear at 20Hz. Each of these oscillations results in less energy being delivered to the Fast raise response.	

[92] MASS Consultation Paper - January 2021 - Section 2.2.1

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		Note that the 1-s metering, done in three different ways makes this response look like a valid and reliable Fast FCAS response. The 20Hz metering however shows this response to be unstable, low-energy and dangerously oscillatory. *(Reposit has chosen to not include this hardware in its supported products list. However it is an attractive integration target under Option 2 metering as it sells well and there are many thousand of these storage inverters deployed in the NEM today.)* It is clear that low time-resolution data contains less information about a continuous property like energy, than high time-resolution data. An assumption must be made where data is missing. That is, AEMO does not know what energy was delivered during the period between measurements. To compute a quantity it must make some assumption as to what happened between measurements. This assumption carries with it highly material consequences. With this assumption comes a quantity of "assumed energy". Assumed energy is the quantity of energy that was not measured, but is assumed to be contributing to the arrest of a frequency deviation. A fall in frequency will not be arrested where assumed energy delivered is materially greater than actual energy delivered. Likewise, a rise in frequency will not be arrested where assumed energy withdrawn is greater than actual energy withdrawn. The assumption that is made when computing assumed energy, has a real and material effect on system security at precisely the moment when system security is at greatest threat. There are three workable (non-polynomial) options for the assumption, that can be used to compute assumed energy. They are the: 1. Left Riemann sum 2. Right Riemann sum 3. Trapezoidal sum Each method assumes that power (energy/time) is some value during the time period between actual measurements. If t_n is the measurement at time n, then t_{n-1} is the previous measurement. The left Riemann sum assumes that the power at t_n is equal to t_{n-1}. The right Riemann sum assumes that the power at t_{n-1} is equal to the power at t_n. The trapezoidal sum attempts to implement a more moderate right Riemann sum by somewhat splitting the difference. The following three graphs show the same 20Hz measurement of the Fast raise response discussed above.	

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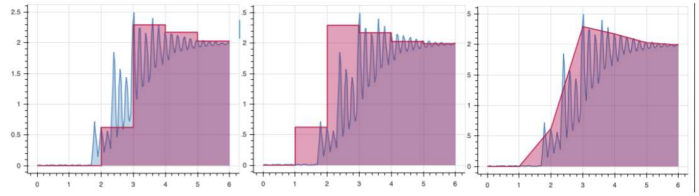

Different summations of energy delivered - 1. Left Riemann. 2. Right Riemann. 3. Trapezoidal

The S-shaped nature of a Fast FCAS response, and the proclivity for poorly-controlled residential electricity storage systems to deliver oscillatory power means that all three methodologies overestimate the amount of energy delivered.

Methodology	Computation (Wh)	Error
Left Riemann	71.16	-3.97%
Right Riemann	91.08	-33.08%
Trapezoidal	81.12	-18.53%
Actual	68.44	0.00%

In particular the right Riemann sum heavily overestimates energy delivered. The use of the right Riemann or trapezoidal summation methods is highly likely to result in AEMO receiving low-energy Fast FCAS responses from Option 2 meters.

However, given the discontinuous nature of electricity metering, the trapezoidal rule is the best choice for calculating the energy sum. The error for the trapezoidal rule is characterised by the following inequality[93]:

$$|R(f, I_n)| \leq \frac{1}{2}\nu(h)\bigvee_a^b(f).$$

This says that the error that you get from the trapezoidal sum is linearly related to step size for bounded functions. Or in metering terms, error in energy delivery increases linearly with increased step size. Option 2 metering has 20x the step size of Option 1 metering and so has 20x the energy sum error.

Option 2 does not modulate the 2% energy metering error requirement of MASS v6, and so energy sum error is 20x greater in Option 2 when compared to Option 1. Just to reinforce this point, the only way for energy sum error to remain constant between Option 1 and Option 2 would be to specify a 0.1% energy metering error, and then increase time-resolution error by 20x. Option 2 does not do this.

[93] https://journals.tubitak.gov.tr/math/issues/mat-00-24-2/mat-24-2-3-9911-3.pdf - Inequality 1.4

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		3.3.6.3.1 Energy sum error bounds calculation The error in the energy sum can be precisely calculated using the following inequality[94]: $$E_n^T(f) \leq \frac{|I|}{2n} \inf_r \|f_r\|_{BV,I},$$ • $|I|$ is 6 for Fast FCAS because the response is required over 6s • n is the number of measurement that are taken during the 6s response - 6 at 1Hz, 120 at 20Hz • inf becomes 1-(-1) because we are interested in percentage error r $\|\|f\ r\ \|\|BV, I'$ and so can operate on unit quantities, and so is 2 For Option 1 metering our maximum error is (6 / 240 * 2 = 0.05). We will have maximum error after all the measurements are done, which is after 6s. In percentage terms this is 0.05/6 = 0.83% error. For Option 2 metering our maximum error is (6 / 12 * 2 = 1). We will have maximum error after all the measurements are done, which is after 6s. In percentage terms this is 1/6 = 16.67% error. You can see that the first inequality holds. Option 2 metering has 16.67/0.83 = 20 times more energy summation error than Option 1 metering. For Option 2 metering, the energy sum error is 0.83%, which is below the 2% meter energy measurement error allowed by the MASS. This means that the leading error term for the total energy computation is the meter energy measurement. For Option 1 metering, the energy sum error is 16.67%. This dwarfs the 2% meter energy measurement error allowed by the MASS and now becomes the leading error term for the computation. This is an increase in summation error of 15.84%. This means that the increase in energy sum error with the adoption of Option 2 metering is workably 16%. This number is material to the certainty of delivery of a Fast FCAS response. AEMO has not described the computation that was applied during the VPP Demonstrations project. Reposit requests that the AEMO describe the computation methodology that was used in the VPP Demonstration project, and detail the computation method that will be used in Option 2 during the treatment of 1s data. **3.3.6.3.2 Sub-second time alignment effects** Compounding this problem is the time alignment of 1s response initiation to actual clock-tick (physical system) trigger time. Sub-second errors in alignment result in vastly different computations of FCAS response as shown below.	

[94] https://www.emis.de/journals/JIPAM/images/031_02_JIPAM/031_02.pdf - Inequality 1.10

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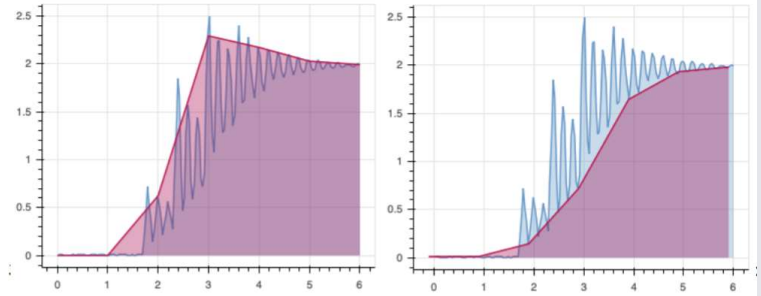

Time offset from initiation (seconds)	Energy (Wh)	Error
-0.5	46.98	-31.36%
-0.45	63.84	-6.72%
-0.4	70.86	3.54%
-0.35	58.38	-14.70%
-0.3	50.88	-25.66%
-0.25	68.46	0.03%
-0.2	74.94	9.50%
-0.15	61.02	-10.84%
-0.1	54.48	-20.40%
-0.05	69.66	1.78%
0	81.12	18.53%
0.05	67.92	-0.76%
0.1	59.64	-12.86%
0.15	72.36	5.73%
0.2	79.8	16.60%
0.25	68.16	-0.41%
0.3	63.96	-6.55%
0.35	78.72	15.02%
0.4	90.12	31.68%
0.45	83.7	22.30%
0.5	66.6	-2.69%

The nature of the error results from different time offsets suggest that very small errors in time alignment will have very large impacts on assumed energy.

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		The VPP Demonstrations project has not described the time alignment methodology that was used to generate the trial's results. Reposit requests that the AEMO describe in detail the time alignment mechanism that was used in the VPP Demonstrations project, and detail the time alignment method that will be used in Option 2 during the treatment of 1s data. Given the problems with 1s metering, Reposit suggests that AEMO should explain in mathematical terms the full Option 2 process for the conversion of multiple, 1s power flow and local frequency data captures into an FCAS response calculation. This process should characterise the assumed energy component of the FCAS response under various response profiles, and the error bounds associated with Option 2 response. **3.3.7 1 Hz metering is sufficient** **3.3.7.1 AEMO conclusion:** Therefore 1Hz metering is sufficient to measure energy delivered into/withdrawn from a contingency event, from every unit of a DER resource type, for any point into the future. **3.3.7.2 Inferred from:** AEMO's presentation of Option 2 as a valid metering option for Fast FCAS. **3.3.7.3 Reposit's position:** Option 2 is not a valid measurement solution for Fast FCAS. None of AEMO's assumptions of DER "type" homogeneity have been validated by AEMO. They have been shown to be false by the VPP Demonstrations project and they are known to be false by Reposit. Without the assumption of homogeneity in place, DER "type" testing is redundant in the consideration of FCAS response. Reposit asserts AEMO cannot assume to know anything about the performance of a particular DER unit of a particular "type" by looking at the performance of a "type" tested DER unit. Reposit does not agree that AEMO can detect under-delivery from 1Hz data. Reposit has shown that any workable summation method for 1Hz data will deliver substantial error. AEMO has not characterised the error of computed energy delivered/withdrawn using trial data, nor via mathematical proof. Reposit has shown that it is mathematically impossible to accurately calculate energy delivery/withdrawal using 1s data. Reposit suspects this is why Fast FCAS response has always been measured using 20Hz data. This means that the only way to understand the performance of a particular DER unit in energy delivery/withdrawal, for a particular frequency deviation, is to measure its response at high-speed. As a corollary, the only way to understand a particular VPP's response to a particular frequency deviation is to perform a linear, time-series convolution on the HSM data across each of its contributing units. To do anything else is to introduce vast amounts of uncharacterised error into the computation of energy delivered to/withdrawn from the grid as a result of a frequency deviation. To introduce this kind of error into this energy quantity is a mistake, and will increasingly damage system security with higher DER penetration into FCAS markets. Hence, Reposit asserts that only Option 1 is workable. **3.4 Option 2 will damage system security**	

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		Reposit asserts that use of Option 2 for verification of FCAS response will result in reduced system security if no additional FCAS is procured. This is because Option 2 diminishes the energy available to a contingency event in at least two ways: 1. Energy summation error - 16% 2. Device-level metering (energy absorbed) error - 6% Reposit estimates that an Option 2 Fast FCAS VPP will deliver with confidence 0.78MWh for every 1MWh delivered with confidence by an Option 1 VPP. A contingency event requires energy to be delivered to or be withdrawn from the grid to arrest a frequency deviation. AEMO determines the FCAS MW required to cater for the size of the contingency in a region. It then asks Participants to offer a magnitude of power modulation that can be sustained for a fixed period of time. Should the contingency arise then Participants are required to deliver energy in the form of a time-sustained power modulation. That is, Participants offer in power but deliver with energy. It is the quantity of actual energy reaching the grid that is important, not the quantity that is reported to AEMO. Ideally these quantities are the same. **3.4.1 Overestimation of energy delivered/withdrawn** Error in energy delivered into or withdrawn from a frequency deviation will affect the efficacy of an FCAS response. An overestimation of expected response from a VPP provider's offer will damage the ability of the Fast FCAS to arrest a frequency deviation. As discussed throughout section 3 of this document, Option 2 introduces significant error into the delivery of Fast FCAS. This comes from an incorrect assumption of homogeneity across DER "type" and is compounded by the assumptions that must be made if 1Hz data is to be used for measurement. Using this analysis Reposit estimates that Option 2 will decrease the certainty of energy delivered from a VPP to a Fast contingency event by 16%. That is AEMO would need at least 16% more Option 2 Fast FCAS MW than Option 1 Fast FCAS MW to arrest the same frequency deviation. Or in other words, Option 2 FCAS is likely to be no greater than 84% effective when compared to traditional FCAS. Additionally, Option 2 removes the majority of the incentive for VPP providers to deliver a well-controlled, homogeneous response. This is because it assumes a well-controlled homogeneous response as part of its verification processes. As a result VPP providers will make little to no effort to deliver high-energy FCAS responses but instead will focus on putting as much capacity into the market as possible. This is akin to the effect that solar feed-in-tariffs have had on the wholesale energy market. That is, well-controlled, reliably metered generation will be replaced by poorly controlled, poorly metered generation creating a double effect in the decrease of system security during frequency contingency events. Even a VPP provider that is committed to enhancing system security is foiled by Option 2. A VPP provider (and AEMO) cannot detect energy under-delivery/withdrawal with 1Hz metering (see 3.3.6.3) and so has no chance of being able to rectify it. Likewise, Option 2 blinds AEMO to the actual response being delivered to a contingency event when a material proportion of a region's Fast FCAS capability is being provided by DER fitted with Option 2 metering. Reposit asserts that should AEMO proceed with Option 2 but does not discount Option 2 FCAS, then system security will be diminished. Reposit suggests that this discount needs to be 16% (section 3.3.6.3.1) . FCAS providing DER accounts for 30MW of Fast FCAS response today -	

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		22MW of using Option 2 metering. This is a small percentage and a 16% error in this quantity is immaterial. However AEMO's own RIS has predicted up to 2.5 GW of aggregated, behind-the-meter storage within 5 years[95], most of it eligible for Option 2. This would be more than sufficient to saturate the FCAS markets with Option 2 DER. In this circumstance AEMO would be forced to address this error or be faced with a continuous and material risk to system security. **Rheem & CET** • Support Option 1 (2.3.1) to "Leave current measurement requirements unchanged" • Believe that there is no significant cost impediment to installing power metering capable of measuring power flow and local frequency at intervals of 50ms or less at every site (NMI) • … • Believe that Net metering does not obviate the need for smart consumer DER devices, (e.g. water heaters) with their own communications, to ensure that consumer amenity and safety is not put at risk • Believe that regulatory changes are required to ensure that all embedded DER control specifications allow efficient orchestration and participation of mixed DER in grid services … The market is in its early stages of utilising DER as a network asset. As we have outlined above, there are multiple DER types beyond embedded storage batteries that can participate, in many cases more cost effectively as grid assets, in the FCAS market. Many of these DER assets will exist on the same site. Our field experience suggests that this situation will only continue to grow exponentially. We support Option 1 – "Leave current measurement requirements unchanged" for the following reasons: • AEMO will remember that we consulted with your organisation some years ago during our product design and validation phase, to ensure that our interpretation of the FCAS metering specification was correctly implemented in our power metering solutions. Subsequently, over the past years we have invested significant resources in HEMs orchestration of behind the meter mixed DER and associated powering metering solutions. We have validated our metering solutions (across thousands of our mixed DER sites) in the NEM and WEM over the past years. Our power metering solutions meet the requirement to measure power flow and local frequency at intervals of 50ms or less at every site NMI • Our FCAS compliant power metering solutions have a manufactured cost of sub $200 (AUD) and as a result we do not see that there are impediments to maintaining the current specifications to measure power flow and local frequency at intervals of 50ms or less at every site NMI - i.e. at the site connection point. We contend that the costs and issues in NOT doing NMI connection point metering are far greater – see further below • We are aware that other Australian companies (as detailed and recorded by AEMO by multiple participants in the recent AEMO MASS Consultation Webinar) have similar cost-	

[95] AEMO RIS FAQ - https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-faq.pdf - page 3

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		effective power metering technologies available that comply with the current requirement to measure power flow and local frequency at intervals of 50ms or less at every site NMI • Further, AEMO would be aware from the recent MASS Consultation Webinar of a development being undertaken by a current Tier 1 metering supplier who intends to add the capability required for FCAS power flow and local frequency measurement at intervals of 50ms or less to connection point metering. (i.e. per site NMI). They have stated that this additional cost is minimal. **Shell Energy** Shell Energy supports AEMO's proposed option 2 to continue the exemption for systems ≤1MW to only require response measurement at 1s or lower. We believe that this approach will allow for a diversity in supply of fast (<6s) FCAS in a way that will minimise any distortion to the market. We consider that the Consultation Paper adequately demonstrates that the response provided by VPP services was delivered as requested. … Shell Energy also agrees with AEMO that pursuing Option 2, to embed the measurement requirements that were tested in the VPP Demonstrations in the ongoing MASS, will meet the NEO. Given the small size of most of these providers, we consider that there is at this stage very limited scope for market distortions to occur. Further, the Issues Paper highlights that the delivery of fast FCAS can be reliably verified using the Option 2 measuring requirements. As such, these considerations along with the benefits of increased competition in the fast FCAS market means that the benefits are highly likely to outweigh any risks. We question the need for a HSM configuration for every 5MW of response. It is unclear what AEMO's rationale is for this. While the Paper notes that AEMO will have discretion to allow exceptions to this, we would prefer to see a clear justification as to why this is necessary. Further, Shell Energy would prefer to see a clear guideline for where exceptions may be granted. … We accept AEMO's proposal to maintain the measurement requirements for Fast Contingency FCAS services that formed part of the VPP demonstrations. We consider this will help to diversify supply of these services and improve market competition, leading to better outcomes for consumers. Nonetheless, we believe greater detail is required on some aspects of AEMO's proposal for DER participation in these markets. **ShineHub** Option 2 is a far superior option for VPP operation. From our experience, residential battery inverter tends to have >2s raising time (10% to 90% Pmax), partially because of AS4777 requirement, and partially because of technical limitation. Even if the meter is able collect 50ms interval data, the inverter's response speed is limited. Secondly, inverters are distributed in a big geographical area where frequency over the battery fleet will be quite different, based on each site. Additionally, a 1s interval is similar to implementing an "inertia" into the fleet, which may be actually helpful as it will filter out some local frequency disturbances during the frequency event. Finally, 50ms interval data will become an unnecessary burden for communication network too as it requires 20x larger spaces to store and process all the data, in what is already a large data set. This limitation will not be noticed much at the current scale of	

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		VPP, but as we move into 100's of megawatts, this will require significant investment by VPP providers to handle all that data, and respond to the insights the data provides quickly. In traditional MASS setups it would not be an issue as 100MW can be supported by 1 site. However, 100MW requires 20000 sites when it comes to a residential VPP, and data transfer – or more specifically, the lag created by having thousands of sites pulling data and pushing commands in unison – is one of the biggest software development challenges of operating VPPs at scale. Would be keen to have further discussion and check the necessity of have 1 fast meter for every 5MW VPP capacity per region. First it could be hard to define 1 region. If it's one state, frequency can vary a lot from site to site. I'm doubtful about the accuracy of using the fast meter as a baseline to evaluate the frequency detection across a range of sites. Secondly it conflicts with the "Same Type of FCAS controller" requirement as the FCAS controller normally is the inverter, which is the measurement equipment. It then requires a new model of inverter to be tested and certified by AEMO. Finally, it's not practical for commercial solar + battery sites either. It'll effectively incentivize the FCAS providers to split the fleet into small groups that are less than 5MW each. It brings no benefit to grid safety and stability at all but purely increases the admin workload for AEMO and the service providers **Simply Energy** Simply Energy supports AEMO's proposal to embed the measurement requirements tested in the VPP demonstrations in the ongoing MASS. VPPs have potentially significant benefits for both consumers and retailers and Simply Energy supports reforms that improve the participation of VPPs in FCAS markets. … Simply Energy does not support AEMO's proposed Option 1, as the current measurement requirements in the MASS provide a barrier to the further development of VPPs. In particular, the metering obligations typically require proponents to provide high speed data samples less than or equal to 50ms for fast FCAS response (in the 6-s FCAS market), whilst slow and delayed services require measurements of 4 s or less to verify services. These are uneconomical if applied to each energy storage system in the VPP. For the VPPx project, Simply Energy reached an agreement with the AEMO VPP Demonstrations Program to have one HSM per type of energy storage system complimented by the fleet aggregation data at 1s resolution.[96] As previously noted, there would be significant benefits to consumers from the continued development of VPPs. However, without amendments to the MASS (and the continuation of the interim arrangements to recognise bi-directional flow from ancillary service loads to deliver FCAS[97]) it is unlikely that retailers and aggregators will find it economical to invest in VPPs. In addition, participants that are part of AEMO's VPP demonstrations will not realise the benefit of their investment in the trial. Simply Energy considers that the continued development of VPPs is in line with the NEO as VPPs can provide lower energy prices for consumers, additional value for consumers from their BESSs, and increased reliability and security of the electricity grid.	

[96] Simply Energy 2020, Simply Energy VPPx – Stage 2 Knowledge Sharing Report, June, p.25
[97] AEMO 2019, Interim arrangements for FCAS provision from DER – policy on classification of loads as ancillary service loads, December

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		The MASS should include requirements similar to those tested in the VPP Demonstrations Simply Energy supports the intention of Option 2 to amend the MASS to include the set of measurement requirements that were developed to allow VPPs to trial the capability for DER to deliver contingency FCAS. These measurement requirements have been critical in allowing the demonstration of the potential market-wide benefits of VPPs. Simply Energy agrees with AEMO's proposal to update the MASS to allow DER to meet the measurement requirements by capturing power flow and local frequency with a resolution of ≤1s across all NMIs (rather than ≤50ms). Fast FCAS response requires a full or proportional response from the provider within 6s of a frequency event. Given this, Simply Energy considers that maintaining a requirement to capture data with a resolution of ≤50ms at one or many sites would create barriers to market entry for little benefit. Simply Energy considers that aggregated one second metering from the fleet should be sufficient for response verification. It has become commonplace for battery inverter manufacturers to include one second telemetry as standard and Simply Energy notes that installing any specialised equipment at sites within a residential VPP comes with the additional risk and cost of the customer churning away and the retailer having to retrieve and reinstall the equipment. **AEMO should clarify other potential requirements in the MASS** *Requirements when the capacity of a VPP changes* The current framework requires that participants must supply a list of participating NMI's to AEMO each time the MW capacity of the VPP changes. This requirement becomes problematic when individual customers churn away from the retailer and the lost capacity can only be replaced when the retailer requests a change to its registered ancillary service capacity (for example, from 1 to 2MW). Instead of needing to update the entire registration, Simply Energy suggests that registrations be enabled in smaller increments or retailers be allowed to replace a churned NMI with one that has the same equipment and/or capacity installed at site. Simply Energy also proposes that frequency injection testing should not be required when there is an increase in the FCAS capacity of the VPP where the type and size of the new assets is identical to those already installed and providing services. There does not appear to be any benefits of requiring frequency injection testing in situations where the assets are identical and have previously been proven to work. In fact, this additional testing would impose costs on customers and disrupt the normal operation of their BESSs. *Droop limit* Simply Energy is concerned about AEMO's consideration of increasing the maximum allowable frequency response rate for proportional controllers. Simply Energy supports a droop limit with an effective limit of 0.7%, which is the limit currently used within the VPPx project and permitted under AEMO's interim arrangements.[98] Simply Energy does not consider that the VPP Demonstrations have identified any practical reason to increase the droop limit and is concerned that the current and future value propositions of VPPs to customers may be adversely impacted if the droop limit was to be increased. Simply Energy estimates that increasing the droop limit by 1%t could reduce the customer benefits derived from FCAS	

[98] AEMO 2019, Interim arrangements for FCAS provision from DER – policy on classification of loads as ancillary service loads, December

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		participation by as much as 60%. A reduction in potential benefits would in turn stall customers' uptake of DER to provide services within the NEM. *API requirements* The VPP demonstrations required several application programming interfaces (API) to be built and for participants to integrate with them. While not discussed in the issues paper, Simply Energy asks AEMO to provide some clarification about which, if any, of the API requirements will remain in place going forward. While the upfront costs of building the APIs has already been incurred, Simply Energy has ongoing costs of maintaining and updating these requirements. Simply Energy proposes that AEMO not include the API requirements in the ongoing MASS unless it can demonstrate the value and necessity of the specific requirements. **Social Energy** In general, Social Energy is supportive of the principle of amending the MASS based on the learnings from the VPP Demonstrations. Of the proposed options, we strongly favour Option 2 over Option 1. However, we also observe several failings of Option 2 to adequately address key issues relating to the current MASS rules. These are briefly outlined below and expanded in our response to the consultation questions: a) The VPP trial and *the paper* propose the use of HSM of power flow and frequency at 1 site per 5MW of aggregated ancillary service capacity per region. The paper appears to have altered the requirements over the VPP Trial so that the "highspeed meter installed… must capture the *power flow measurements from the controllable devices, generating units behind the* connection point, *grid flow* and local frequency."(emphasis added). By contrast the VPP Demonstrations FCAS Specification1 required only "One HSM (sampling of frequency on a time base ≤50ms) is required per region". The additional power flow metering proposed under Option 2 in the paper does not appear to reflect any specific learnings reported from the VPP Demonstrations but places a prohibitive technical and cost burden on both providers and customers. We strongly urge AEMO to review this condition to ensure it does not undermine success of the trial. b) The proposal for Option 2 states that *"the options to verify FCAS delivery using power flow measurements from the inverter or device level…, would be limited to Fast Contingency FCAS from ASLs rated at less than or equal to 1MW."*. This statement is not perfectly clear but seems to suggest that the proposed amendment relating to the FCAS measurement location would not apply to the Slow and Delayed Contingency services. Whilst the proposed change to the measurement resolution is only relevant to the Fast service, it is essential that the FCAS measurement locations in the VPP Demonstration be adopted for all FCAS Contingency services. This is because the impact of the baseline calculation (as described in the paper and the FCAS verification tool user guide) is even more severe in the case of longer duration services if the FCAS response is measured using the net flow from, or to, the grid. If the amendments to the MASS are applied exclusively to Fast Contingency FCAS, it will preclude DERs from participating in slower services, which would significantly weaken the economic case for participating in the Fast service, and be inconsistent with the objectives of both the VPP Trial, and the NEO. …	

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		Option two because the current verification rules which use the grid flow are not suited to residential DER co-located with uncontrolled loads. A residential battery inverter sits in a location with uncontrolled load and generation as a rule rather than an exception. Uncontrolled assets should have no influence on the provision of a frequency service as, regardless of the presence of a DER asset, they would continue to supply/consume whatever power they like whenever they like. Only assets actively providing an FCAS should be considered to be delivering that service. We acknowledge that it is possible for a loadfollowing device to act to negate an FCAS response from a battery. In this case monitoring of the connection point and local generation is required to verify the response but because these devices typically operate at slow (relative to Contingency FCAS) timescales, the monitoring time resolution does not need to be great. We note that option two as defined in the paper represents a deviation from the VPP trial metering setup as outlined in section 2.2.1 of the DER FCAS Specification. That paragraph in its entirety reads: *"One HSM (sampling of* frequency *on a time base less than or equal to 50 milliseconds) is required per region. The purpose of this meter to determine the expected fast FCAS response using the assigned droop setting of the variable/proportional controllers or the* frequency *deviation setting of the switching controllers."* The option two proposal states: *"For every 5 megawatts (MW) of aggregated* ancillary service *capacity per region, a high-speed meter capturing measurements of* ***power flow*** *and* frequency *with a resolution of less than or equal to 50ms on a common time scale must be installed. "* (emphasis added) Option two includes 50ms metering of power flows in addition to frequency at one site per region. It is not clear why this additional power monitoring requirement has been added or what additional information it is supposed to convey. All assets forming a VPP will be type tested in their response at 50ms before being accepted so there is no doubt that they can meet the requirements. By adding a single site that needs additional monitoring AEMO ends up with the worst of both worlds in terms of the benefits a VPP can bring over a standard large asset. VPPs are fault tolerant to local losses of supply and connectivity as well as other electrical faults in plant equipment. Requiring a single site to have 50ms metering of power means each VPP now has a single point of failure and the operators incur the cost of development, procurement, support & operation of 50ms class hardware which we understand it is the point of option two to avoid. … Option two should be extended to include the Slow and Delay services in its scope as this is how the VPP Demonstration rules were originally defined. Section 1.5 of the VPP Demonstrations FCAS Specification states: *"To determine if the VPP Demonstrations have been successful, AEMO will verify the performance of the VPP based on the aggregated response of the* ancillary service *loads to deliver contingency FCAS during a* frequency *disturbance."* Note this does not differentiate between fast, slow or delay contingency services. The final paragraph of option 2 on page 13 of *the paper* states:	

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		"AEMO therefore proposes that, if included in the MASS, the options to verify FCAS delivery using power flow measurements from the inverter or device level, and the less stringent data resolution requirement of less than or equal to 1 second, would be limited to Fast Contingency FCAS from ASLs rated at less than or equal to 1 MW." The requirement to verify response at the grid connection point limits the amount of inverter power that can be allocated to providing FCAS because a portion of it must always be reserved to maintaining a contracted baseline power (effectively negating the uncontrolled loads/generation in the house). For the Slow and Delay services this effect is magnified because the response times of the services (and hence the time the baseline is maintained) are long compared to Fast Contingency. Implementing Option 2 as currently defined will significantly reduce the business case for homeowners opting into FCAS compared to the VPP demonstration rules. The MASS should also be very explicit regarding the metering locations and the accuracy, resolution and sampling rate of each meter required. If using the model that involves 1 reference site per 5MW, the MASS should be explicit to specify if this is 5MW of identical hardware (e.g. all units must be Brand A, Model B1 and 8kWh) or if the 5MW can be any combination of hardware (e.g. a combination of 250 batteries of varying age, model, manufacturer and capacity, each with varying response times). If the former, reaching any kind of scale will be difficult and the VPP market will be far less competitive as VPP Operators choose to focus on only one or two battery types. If the latter, there exists a very real risk that aggregators will set up specific systems for the reference data which bear little or no resemblance to the remainder of the 5MW fleet. For this reason, a 50ms, multi-meter reference site is a bad idea. Much better results would be provided with 100ms-1s metering at every site and this would seem to be the only feasible method of providing a true reflection of the performance of a fleet. AEMO should also openly assess the need for any specific sampling rate for data. Why is 50ms, or 100ms necessary, and what benefit does this provide to the process over another arbitrarily selected sample rate, such as 500ms or even 1s? Rather than accepting the existing technical constraints, a sampling rate should be selected which meets the needs of the program with as little technical and developmental burden as possible, including reducing data storage. **Solar Analytics** Solar Analytics supports Option 2 as written. AEMO has demonstrated that this option is sufficient to verify FCAS. Option 2 will reduce the barrier for entry for DER providing FCAS, therefore adding greater competition and keeping costs down. <u>High-speed monitor</u> We would also be supportive of an amended version of option 2, excluding the requirement for one high-speed monitor per 5MW. As an alternative to 50ms intervals of power on one device, the accumulated energy, at 1-s intervals, measured on all devices, would be a more accurate representation of the FCAS delivery, since it captures everything that happens in between the 1s intervals. This could easily be compared to AEMO frequency data in order to analyse response in the case of under-delivery.	

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		Providing options on this point allows each participant to find the lowest cost solution for their technology, rather than favouring any particular type. We understand that there may be an argument for requiring one high-speed monitor for each technology type (each combination of battery/inverter/other hardware). We believe this would result in a prohibitive barrier to entry to smaller third-party providers aggregating systems with a range of technology types. This would embed an advantage to large OEMs providing single-technology DUIDs. We believe that diversity in technology reduces the system reliability risk associated with systematic technology failure and that the rules that encourage diversity should be favoured. Further, we believe that the benefit of excessive investigation of multiple different technologies within a small DUID would outweigh the benefits and that frequency injection tests are a sufficient source of detailed verification. Should a compromise be sought on this point, we would support a requirement for one high-speed monitor on each individual technology type that contributes more than 5 MW capacity on its own within a DUID. **sonnen** … we support AEMO in adapting the MASS to incorporate the changes verified in the VPP demonstration program, specifically those related to resolution and the location of measurements (*Section 2.3.2 – Option 2: Embed measurement requirements tested in the VPP Demonstrations*). … As a supplementary point, we do not see the rationale for requiring each participant to have one fast meter for every 5 MW in a region. **SwitchDin** SwitchDin's enabling technology is technically capable of providing a solution that would be able to meet the requirements of either Option 1 or Option 2. Specific feedback on the measurement resolution for fast contingency services and measurement location is provided below. Feedback on the thresholds at which to apply alternative measurement requirements is provided under Question 8[99]. **Tesla** Tesla strongly supports Option 2 put forward in the MASS Consultation Paper. This option is a reflection of the critical role that VPPs and aggregated DER can play in providing critical system services. We believe that this should be taken as a long-term reflection of how DER can be integrated into the existing market structure and provide high quality market services – and should set the future basis for market design principles based on optimal system use… In saying this, there are several elements … that we feel are not warranted and could be amended slightly to improve the experience for technology providers and customers. Specifically, Tesla questions the need for the following: DER • 1 high-speed meter per every 5MW of aggregated VPPs; and	

[99] Refers to the Issues Paper.

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		• A 1MW threshold for individual assets. ... ... Tesla strongly supports a review of the MASS to better utilise DER and VPPs in the FCAS markets. From a first principles perspective, Tesla believes that any asset that is capable of providing a particular service should not be artificially prevented from doing so on the basis of how market rules, regulations or specifications have been written or interpreted over the years. The energy market is in a period of rapid reform, and industry players are trying to both remove legacy barriers and create new fit-for-purpose market settings. The MASS review is a first step to removing legacy barriers, but will also influence the future market framework for aggregation as it will encourage more and more DER to participate under VPP arrangements. This position is also supported by the ESB. The ESB Directions Paper makes the following points in respect of Demand Side Participation: *"Market arrangements, along with those for metering and connection, do not support consumer preferences to access the products and services that could be offered (and which consumers may want from the providers they choose)"* The DER changes proposed in Option 2 in the MASS Consultation Paper represent an immediate low-risk/ high reward opportunity to address this issue on a permanent basis. Further, the MASS Consultation Paper recommendations made by AEMO under Option 2 are well supported by the AEMO VPP Demonstrations Trial. The VPP Demonstration Trial has been running since July 2019 which provides almost two years of in-market data verifying the technical capability of VPPs in providing FCAS and confirming the appropriateness of the settings being proposed by AEMO under this MASS consultation. Currently the AEMO VPP Trial has seven different market participants using five different technology types across a mix of proportional and switched controllers. More than 20MW of capacity is registered and participating in all six contingency markets. For context, half of the market participants currently registered with AEMO as a Market Ancillary Services Provider (MASP) registered as part of the VPP trial. This demonstrates just how influential the VPP Demonstration Trial was in bringing new FCAS providers into the market. The approach taken by AEMO in enabling open access for any technology type and market participants to participate in the trial has provided an incredibly robust basis for supporting the market changes proposed and should be considered as the gold standard approach for trial-based, technology-led market reform. The trial has been backed by three detailed knowledge sharing reports and AEMO ran a comprehensive survey process to bring customer views into the program – this provides critical insights for the future market integration of DER. The VPP performance in delivering high quality FCAS over the duration of the trial supports the changes proposed in Option 2. Figure 1 below highlights how the Tesla/ Energy Locals SAVPP responded during the South Australia Islanding event on 31 January 2020. As AEMO noted in their report *To help suppress the high* frequency*, the VPP very quickly increased its power drawn to beyond the enabled minimum response. Of particular note is the speed of the response: from zero to approximately 1.9 MW output in under 10 seconds, with a peak rate of change in this period of over 1.1 MW/s.*	

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		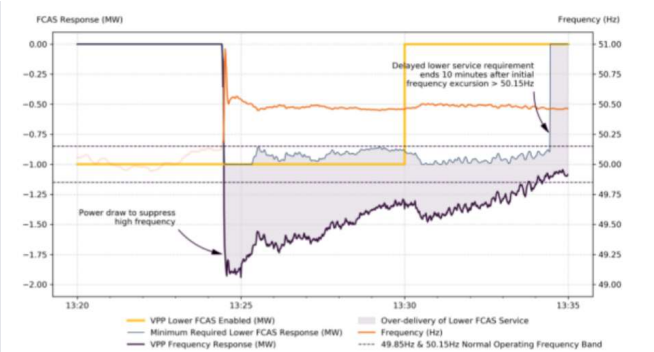 Figure 1: SAVPP response to SA Islanding Event - AEMO Knowledge Sharing Report 2 Tesla understands that the future potential of market integration options for aggregated DER is enormous and creating these early opportunities and quick wins is important in setting the right framework for the future. … 1MW threshold – per Tesla has a few concerns with this approach. • It introduces an unjustified, arbitrary, additional threshold for BESS assets above and beyond the 5MW threshold that currently exists (utility scale batteries over 5MW need to be registered as a scheduled generator/ scheduled load). • 1MW batteries can still register as a non-scheduled asset and classify that asset as an ancillary services generating unit, which would still be able to provide FCAS in a way that is invisible to AEMO. • This approach will, however, make it very difficult to operate assets >1MW as an aggregated fleet. Operating assets individually results in operational inefficiencies and additional costs, and may lock assets of this size out of the FCAS market even though they are technically capable of delivering high quality FCAS. Tesla believes that 5MW should remain as the only threshold with individual assets <5MW allowed to aggregate using the proposed DER settings. Suggest at a minimum, that the measurement location is still allowed at the device terminal. Larger systems will have more scope to afford HSM, but if we're measuring at a site level, will need to avoid a situation where we inadvertently lock out a huge subset of systems from providing FCAS. **UNSW** We do not have a specific preference on potential implementations from AEMO to the ongoing measurement requirements for DER. There are product solutions that are currently available in the market and that are technically capable of providing the required 50ms data capture for all	

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		systems, even those rated at a few kWs. However, a balance between appropriate data resolution to confirm provision of service and the amount of data stored does provide the best possible approach. **VIOTAS** See the extract in section 4.1.1	
2.	Various	**Which option is more consistent with the NEO?** **CPUE** Key benefits of proposed amendment include: • increased competition in the contingency FCAS market—more assets will be made available to participate in the FCAS market which will stimulate competition • more efficient and reliable market operation—AEMO will have access to a larger pool of assets to ensure the most efficient and reliable system operation • market investment and innovation—small-scale DER will have easier access to additional value streams through FCAS participation, without incurring significant costs. This has the potential to accelerate marketled investment in small-scale DER systems and promote innovation in the industry. **Delta Electricity** The NEO seeks to promote efficient investment. Investment that results in poor quality frequency control is not efficient. The NEM is focusing a lot of time and resources to improve frequency control suggesting market inefficiency already exists. To reduce the variability in the performance, common standards are recommended to be applied and expected for the specification. Allowing too much flexibility increases the likelihood of less coordination and defeats the objectives of frequency control. **Empower Energy** **A number of factors here make it difficult to entrain many vendors** It's finally important to again stress that potential stakeholders interested in increasing access to DER are considerably large in number, though vary significantly in resource capacity. For all but a select few, matters such as technical development, product development, market assessment and the like are not trivial undertakings and must be weighed internally against competing corporate priorities. It is imperative that the broad design of AEMO's efforts are shaped for transparency, certainty and lowest access barriers where possible. Appreciably, the DER space is fast-changing and this challenge alone is neither trivial. A rework of the MASS ahead of an AEMC determination that will again reshape the MASS - and have potential, significant impact on the access and value associated with DER FCAS participation - does not create the necessary confidence in the market for many vendors to dedicate resources creating a diversity of competitive outcomes for Australian consumers. As the VPP Trial has (indirectly) demonstrated, where confidence in these matters is low, as are the willing number of market participants.	A summary of the conclusions reached in the submissions on which option is more consistent with the NEO can be summarised as follows: **Option 1** — Landis + Gyr, Reposit Power, Rheem & CET, UNSW, VIOTAS **Option 2** — CPUE, EQ, Evergen, Karit, Mondo, Shell Energy, ShineHub, Simply Energy, Social Energy, Solar Analytics, SwitchDin, Tesla **Not expressed** — Delta Electricity, Empower Energy **Neither** — Intellihub, Hydro Tasmania, Members Energy See section 4.1.2 and 4.2.2 for a discussion on the issues associated with AEMO's assessment of Option 2 against the NEO.

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		Similarly, when understood, aforementioned difficulties around market access further impair the ability of technology vendors to invest in developing solutions - with the same end result on competitive outcomes for Australian consumers. Again, market objectives require that we do better. **EQ** It is EQ's view that lowering barriers to entry, and in turn bringing on lower cost FCAS capability, aligns to the NEO. Consequently, supporting the proposed VPP alternative and consideration of how this could be further extended to allow DNSP or aggregator use of audio frequency load control capability in the market, including the ability to attain revenue for this service, is recommended. **Evergen** Evergen relies on AEMO's expert advice regarding the suitability of Option 2 VPP monitoring requirements, given that AEMO has recently tested and continues to test the performance of VPPs with similar requirements as part of the VPP Demonstration project. To date, AEMO has facilitated significant learning and knowledge sharing through these demonstrations. On quality, safety reliability and security, AEMO advises that participating VPPs have been able to deliver compliant FCAS capability with measurable benefits. Based on this advice, Evergen believes that Option 2 is more consistent with the NEO. As well as satisfying the NEOs intent in terms of the above factors, Option 2 presents a lower barrier to entry for DER providers and an increase in the number and nature of FCAS providers. This increase will lead to more competition and resulting beneficial efficiency and price impacts. Option 2 also solves for greater system security by enabling more distributed FCAS resources. **Hydro Tasmania** Given that only two options have been proposed and discussed, a judgement of which one is more consistent with the NEO may be premature. **Intellihub** Neither are consistent with the NEO. We have proposed an alternative option which we believe is consistent with the NEO. Our alternate proposal eliminates the need for inefficient duplication of measurement equipment [the *price* consideration of the NEO] without compromising the reliability and security of the national electricity system, nor introducing distortions in the ancillary services market. **Karit** Option 2 is most consistent with the NEO as it allows entry into the Ancillary Services Market at a lower cost per site, however an option based on the standard meter would be even more consistent with the intent of the NEO. **Landis + Gyr** Landis + Gyr supports Option 1 with consideration given to a measuring interval of 100ms as this provides electricity consumers a cost-effective solution. Factors supporting this are: • The NEM currently has in place and established electricity metering system. Having the measurement in another device would replicate costs. The cost structure not only	

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		includes the measuring device but also the communications, data processing and business support and data validation processes. • The electricity meter is an established device that is calibration complies to various standards. Including the data points required for settlement of MASS events is viewed as the lost cost approach. • The measurement must occur at the Point of Connection as the market is looking for an aggregate response. Having the measurement at any other location may have perverse effects including market manipulation that may affect the reliability and security of the national electricity system. **Members Energy** We consider the above hybrid approach is most consistent with the NEO. **Mondo** Option 2 is more consistent with the NEO. We note that the context for this MASS Review, and the option to enable greater participation of DER (Option 2) in the provision of FCAS, is the work carried out by AEMO through the VPP Demonstration Program. Our understanding is that this program was successful, with achievements including: • Demonstrating the delivery of FCAS from aggregated small behind-the-meter storage; • Providing an incentive for VPP operators to collect and share DER information with AEMO; and • Improving the commercial basis for establishing VPPs and coordinating DER service delivery through the central market. Given that the ability of DER to provide FCAS has been demonstrated, the proposed metering requirements provide an appropriate balance to maintain reliability, safety, and security of supply while lowering costs. Option 2 reduces the fixed costs of smaller DER participating in the NEM. This approach significantly expands the number of devices which can actively participate in the NEM and therefore the size of the market. Option 2 specifically supports the NEO by: • Increasing competition for the provision for FCAS, which should lower the cost of FCAS over time, and its' contribution to electricity prices; • Making participating DER more visible in the NEM; making the market easier to manage in the longer term; • Providing an incentive for greater adoption of controllable DER, which have greater potential to provide valuable energy services than passive DER; • Establishing a working commercial framework for VPPs which can be leveraged by other VPP related market innovations; and • Providing a mechanism for customers to earn more from their DER. **Reposit Power**	

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		More Fast FCAS will need to be procured at the expense of Consumers AEMO will not compromise system security for the benefit of some VPP providers. AEMO will be required to purchase additional Fast FCAS MW to increase the certainty of arresting a frequency deviation. This additional cost is inefficient and degrades the NEO. This additional FCAS will come at the additional cost to consumers of approximately $1M for every 20,000 Option 2 DER units (Section 4.2) **Option 2 is a wealth transfer from Consumers to Option 2 metered participants** Consumers will unnecessarily pay Option 2 metering providers at least $60/DER device/year if Option 2 is adopted. This wealth transfer does not occur under Option 1 metering (Section 4.2.4). ... **Option 2 damages investment efficiency across all AEMO markets** The adoption of Option 2 penalises early market entrants and hence discourages technology innovation in the NEM. Likewise it heralds a new source of regulatory uncertainty and will necessarily increase investment discounting. Both create new investment inefficiency and are contrary to the NEO (**Section 4.4**). ... Option 1 metering is cost-effective and accessible to all participants (**Section 2**). Option 1 metering results in a more efficient procurement of Fast FCAS. The additional error created by Option 2 metering must be accommodated with discounting. This is inefficient at a cost of $48/DER unit/year (**Section 4.2.3**). Option 1 metering is the only equitable option presented. Option 2 metering results in up to $60/DER unit/year being unnecessarily transferred from consumers to Option 2 metered participants. This wealth transfer does not occur with Option 1 metering (**Section 4.2.4**). Option 1 metering is more efficient when the long term interests of consumers are considered. Option 2 metering results in a long-term loss of at least $60,000/MW as a result of meter replacement due to the definition of future services (**Section 4.3**). ... Option 1 metering is more consistent with the NEO. Option 2 metering is inefficient (**Section 4.2.3**), does not consider the long term interests of consumers (**Section 4.3.2**), discourages efficient investment (Section 4.4) and diminishes system security (**Section 3.4**). ... **3 Option 2 Metering Analysis** ... **3.2 Purpose of Contingency FCAS** MASS v6 states that Contingency FCAS are enabled to ensure the power system can arrest and recover from material frequency deviations that might arise from larger supply-demand	

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		imbalances[100]. Contingency FCAS provides this role by providing a fast injection of energy, or fast reduction of energy, to manage supply and demand[101]. It is the total injection of energy into, or withdrawal (reduction) of energy from, a Connection Point that makes an FCAS response effective. Because energy = (power x time), this can be redefined as the sustained modulation of power in response to a frequency deviation, for the total time that the power modulation is sustained. This means that a strong FCAS response will guarantee a larger amount of energy delivered into/withdrawn from a contingency event, than a weak FCAS response. This can be calculated simply enough as (MW of FCAS offered x required duration of delivery). For a 5kW machine offering into the Fast FCAS market, the best possible delivery of FCAS will see (5 x 1/60) = 0.083 kWh delivered into/withdrawn from to the Connection Point. Any factor that causes less than this amount of energy to be delivered into/withdrawn from the contingency event lowers the quality of the FCAS response. A low-energy Fast FCAS response will make it more difficult for AEMO to arrest a material frequency deviation. A UFLSS or system black will occur where a sufficiently large proportion of the Fast FCAS capacity provides a low-energy response. Fast FCAS is the last line of defence against large frequency deviations causing unscheduled load shedding and so the quality of the Fast FCAS response is material to the achievement of the NEO. As a result AEMO has historically treated Fast FCAS with the utmost seriousness. **3.2.1 Low-energy FCAS responses** Low-energy responses are any that cause the Connection Point to receive less energy than the amount implicit in the power offer made by a Participant. Examples of response characteristics that reduce energy delivered are: 1. A slow response - that is, one that only delivers the full power offer at the very last moment (e.g. at 5.9 s for Fast FCAS), resulting in reduced energy delivered to the Connection Point 2. A non-linear response - that is, one that achieves the required power modulation but then does not sustain required power during the entire response period, resulting in reduced energy delivered to the Connection Point 3. An absorbed response - that is, one that is diminished by changes in load or generation behind the grid connection point, resulting in reduced energy delivered to the Connection Point. Low-energy FCAS responses are clearly undesirable. It is AEMO's role to discourage and detect low-energy FCAS responses so as to maintain system security during material frequency deviations. Likewise, it is inefficient for AEMO to purchase FCAS with a higher likelihood of a low-energy response, when FCAS with a lower likelihood of a low-energy response is available at a similar or same price.	

[100] MASS v6 - Section 2.1
[101] https://arena.gov.au/blog/what-is-frequency-control-ancillary-services/ - accessed 22/2/21 12

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		The key question that AEMO must answer when considering alternative Fast FCAS metering arrangements is: "are AEMO enabling, incentivising or accepting low-energy Fast FCAS responses with the alternative metering arrangements?". Reposit argues that Option 2 clearly enables, incentivises and validates low-energy FCAS responses to the detriment of system security and the NEO. ... **4 NEO Impact Analysis** It is Reposit's opinion that AEMO's proposal to amend the MASS to include alternative metering arrangements (Option 2) for some NMIs does not promote the achievement of the NEO. Reposit asserts that this proposal is detrimental to the achievement of the NEO as it runs counter to concepts explicitly referenced by the objective. It is also not clear that AEMO has described how the proposed alternative metering arrangements promote the NEO. **4.1 No NEO promoting argument** The National Electricity Law states that AEMO must have regard to the NEO when carrying out its statutory functions[102]. This means that AEMO is legislated to provide NEO-based justifications for decisions made. As quoted in section 2.4 of the consultation paper, the NEO's primary concern is efficiency. Specifically the NEO is concerned with efficient investment, operation and use of electricity services. NEO supporting arguments are ones that describe how a feature of the NEM improves productive, allocative or dynamic efficiency. These arguments discuss electricity services rather than assets. And they describe how the long term interests of consumers are promoted even if there are short term costs. AEMO states in section 2.4 of the issues paper that the key issues of non-compliance, gaming, unnecessary costs and competition will guide the assessment of Option 2's adherence to the NEO. The NEO does not directly consider any of these issues. Perhaps AEMO has some rationale for how the stated key issues relate to the NEO, but this has not been made clear to the market. Reposit also asserts that AEMO cannot claim to be guided by the NEO where decision making is focussed on alternative key concepts to those in the NEO. Reposit suggests that there must be a clear NEO-based justification of Option 2 if it is to be adopted. This is especially necessary when market participants such as Reposit believe that the proposal is detrimental to the NEO. Ultimately AEMO is legislated to execute its statutory functions with regard to the NEO. It is difficult to see how the proposal can be successfully implemented into the NEM when there is no NEO-promoting argument offered, and only NEO-diminishing arguments are offered by its detractors. **4.2 Does not promote more efficient decisions** When assessing a change to the NEM for promotion of the NEO, the key question that should be answered is "does this change promote more efficient decision making in the investment, operation and use of electricity services in the long term interests of consumers?"[103]. The NEO is not promoted where the answer to this question is no, and the change cannot be implemented in the NEM.	

[102] NEL - Part 5, Division 1, 49(3)
[103] AEMC - Applying the Energy Market Objectives - https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf - section 1.2

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		4.2.1 Some additional metering cost Reposit asserts that AEMO's proposed Option 2 does not improve decision making consistent with the NEO. Reposit argues that Option 2 actively degrades decision making with regard to FCAS. This is because the proposal introduces unnecessary uncertainty into FCAS Measurement and Verification (M&V), procurement and investment processes. Uncertainty results in discounting which is a source of productive inefficiency in the investment and use of FCAS. AEMO's states in the consultation paper that its key consideration of efficient operation and use of FCAS is based on the perceived additional cost of metering under Option 1 as compared to Option 2. Reposit agrees that there is no more than a $40-$120 (depending on phase count) additional cost per NMI for Option 1 metering over Option 2. This number is conservatively estimated. Reposit incurs a $25/phase metering cost in doing Option 1 metering in 2021. This is described in detail in Section 2.1 of this document. This cost is incurred as a result of more costly meter componentry and some additional meter installation cost. It represents at most a 0.8% increase[104] in the most popular battery system in the market[105]. It also represents an amortised annual cost of not more than $12/year for the life of a DER asset given that a 10-year warranty period as standard in the market. It should be noted that a connection point meter with at least 1Hz time resolution will be required on all NMIs under Option 2. This is the only way to satisfy the "not being negated on purpose" requirement stated in section 2.3.2 of the consultation paper. **4.2.2 Option 2 metering encourages error in energy delivery from DER** The vast decrease in metering time-resolution, and the accompanying assumptions that must be made to compute energy delivery create the conditions for VPP aggregators and hardware manufacturers to disinvest in sub-second control stability and response homogeneity. The result is vastly increased, and almost completely uncharacterised error on Fast FCAS energy delivery. This error is described in section 3.4 of this document. This error will need to be managed by AEMO's system management team proportional to the amount of Option 2 metered FCAS enabled in a period. In effect, Option 2 metering creates a second, high-error, identical-cost Fast FCAS product in the NEM. This product will need to be co-optimised with Option 1 metered FCAS such that error is acceptable. Inevitably the energy error associated with slow-metering (described in section 3.3.6.3) means that AEMO will need to discount energy delivered from Option 2 metering. **4.2.3 Option 2 metering will cause additional FCAS procurement** In return for at most a $12/NMI/year annual saving, the NEM will incur significant additional costs. AEMO will need to discount the FCAS provided by Option 2 DER and hence procure more FCAS in response to the energy measurement error of Option 2 metering. Fast FCAS was a $144M[106] market in 2020. Assuming FCAS bidstack homogeneity (which is extremely conservative), every 1% error in FCAS response energy delivered into Fast FCAS will result in AEMO spending an additional $1.44M on Fast FCAS annually. This assumes that there are no	In response to Reposit's comments: AEMO acknowledges the distortionary impact that a slower measurement resolution could have on the fast FCAS markets in terms of determining the need of the power system, the economic procurement and the payment for FCAS enabled.

[104] https://www.solarquotes.com.au/blog/another-powerwall-price-rise/ - February 2021
[105] Formbay - Solar Cutters Community Update - January 2021
[106] http://www.nemweb.com.au/REPORTS/CURRENT/Ancillary_Services_Payments/AS_PAYMENTS_SUMMARY_2020.CSV

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		additional costs associated with managing the possibility of over-delivery as a result of this error. Option 2 is more efficient than Option 1 only where 120,000 Option 2 DER units increase total FCAS response error by less than 1% ($1.44M/$12 = 120000 units). Option 2 becomes inefficient if 120,000 Option 2 DER units increases error by more than 1%. The reality is that 120,000 Option 2 DER units would contribute 360MW to the Fast FCAS bid stack assuming a very conservative unit size of 3kW. This is conservatively in the order of 25% of total NEM Fast FCAS MW. If a very conservative 16% energy delivery error as a result of Option 2 metering eventuates (section 3.4 puts this at 22%), the NEM would need to procure an additional 4% Fast FCAS. This comes at a cost of $5.8M to market participants, and inevitably consumers. That is, if Option 2 is adopted, the NEM will spend annually an additional $5.8M in Fast FCAS procurement to save at most $1.44M in metering costs for Option 2 DER. This relationship is linear and so for every $1.44M in metering costs saved by Option 2, the NEM will spend an additional $5.8M in Fast FCAS procurement. This is the same as the NEM spending an additional $48/year/Option 2 metered DER unit on FCAS to save $12/year/Option 2 metered DER in metering costs for some participants only. **4.2.4 Option 2 creates an inequitable wealth transfer** Option 2 metering will result in additional Fast FCAS to be procured by AEMO. Because the additional FCAS revenue will at least partially go to VPP aggregators, there is the potential for up to $60/year/Option 2 metered DER unit ($48 + $12) to be inequitably transferred from all energy consumers to only Option 2 metered Participants. It should be noted that there is already 22MW of Option 2 metered DER systems providing Fast FCAS in the NEM today. Using the same calculation, this represents an annual wealth transfer of $264,000/year ($60 x 4400) from all energy consumers to Option 2 (VPP Demonstrations) FCAS providers. The calculations above make it clear that Option 1 is not only more efficient, it is also the only equitable option. **4.3 Faster power modulation required in the near future** The AEMC is currently considering several new market ancillary services. These services are FFR, Inertia and System Strength. There is no doubt that DER will be able to provide FFR, and DER will demonstrate Inertia and System Strength capabilities in due course. It is important to note that correctly instrumented and controlled DER is often able to deliver additional system security services at zero marginal cost. Additional services are typically enabled in software, and software is zero marginal cost. When coupled with the AEMC's principle of least demanding assumptions[107] it is likely that these new services will be able to be delivered by DER. The nature of these services is such that their measurement and verification will require high-speed, high-resolution data for M&V. At least System Strength requires connection point	However rather than procuring additional FCAS to offset the error, which would increase the cost to consumers, AEMO would consider the following mitigating measures: • Applying a discount to the fast FCAS delivered as measured from slower measurement resolutions. • Limiting the fast FCAS enablement of providers with slower measurement resolutions.

[107] AEMC - Applying the Energy Market Objectives - https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf - section 1.2.3 - page 6

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		metering, and Reposit is unconvinced that device-level verification is consistent with the NER as it stands. **4.3.1 Option 2 metering is a false economy** A DER asset may not require new power conversion hardware should it want to participate in these new services, but it will require advanced metering equipment. As described in section 2.1 of this document[108] the additional hardware cost of this metering is at most $120/NMI for a competitive participant in 2021. The cost of labour to refit metering at a DER site is at least $200 and rising, as labour shortages lift prices as a result of solar PV uptake. This means that Option 2 metering conflicts with the NEO in two additional ways. Option 2 metering creates a productive inefficiency of at least $250/NMI or approximately $60,000/MW. This is easily calculated as (refit labour cost + redundant slow metering cost) x number of DER systems/MW. This inefficiency exists assuming that the AEMC will introduce new market ancillary services during the warranty period of a DER asset. It relates to the "long term interests of consumers" test contained within the NEO. The warranty period is typically how consumers measure the economic life of DER. The warranty period of a DER asset is typically 10 years. This defines the "long term interests" component of the NEO for this matter. Consumers consider the end of the warranty period as being the end of the economic value of a DER asset. They take their cue from the manufacturer in this regard. A consumer assumes they will need to replace the asset soon after the warranty period is over. It is hence when the capital or fixed components used in the provision of energy services can be changed[109]. That is, decisions made at the installation time of a DER asset have NEO-relevant efficiency consequences for 10 years. **4.3.2 Option 2 metering will be replaced with Option 1 metering in a competitive market** Option 2 metering also creates an allocative inefficiency of $hundreds of thousands/MW. Option 2 DER will not have advanced metering available without a refit and so will be unable to participate in these new services. Instead these new services will need to be provided by new capacity of the sort which typically costs $millions/MW. It is assumed that this new capacity will be co-optimised, and so it is not unreasonable for the order of magnitude of allocative inefficiency to be in the $hundreds of thousands/MW range. It is clear that Option 2 DER at a NMI will be refitted with advanced metering where competition is not stifled. It is clearly more efficient to equip existing electricity storage and conversion hardware with appropriate M&V to deliver new services, than it is to duplicate that storage and conversion hardware. This is clear when the productive inefficiency of $60,000/MW for a metering refit is compared to the allocative inefficiency of $hundreds of thousands/MW. A competitive market will pursue the least cost option, which is a replacement of Option 2 metering on DER that is able to participate in new market ancillary services. This consequence of Option 2 metering alone makes it grossly inefficient in regard to the NEO. **4.4 Option 2 metering damages investment efficiency**	

[108] Reference is to Reposit Power's submission.

[109] AEMC - Applying the Energy Market Objectives - https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf - section 1.2.3 - page 5

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		Investment signals are a key part of the governance framework of the NEM. Decentralised decision making on the right investments to make is facilitated by the publishing of price signals, service definitions and market reviews. Investors allocate capital on the certainty that these instruments provide. Some of this investment is in research and development to create new technology able to deliver existing electricity services at a lower cost. Other investment is in new physical machinery that implements research and development outcomes to provide existing electricity services at a lower cost. Both of these forms of investment are important to the dynamic efficiency of the NEM. Decisions that discourage these kinds of investments create dynamic inefficiency and so are detrimental to the NEO. Option 2 erodes both forms of investment. It is Reposit's opinion that it does this directly for FCAS, but also anywhere else where AEMO decision making is relevant to any investment that attempts to improve the efficiency of electricity services. **4.4.1 Option 2 discourages innovation** Innovation in electricity often takes time. This means that successful innovators in the space need to be able to predict well in advance what will happen to the markets that they operate in. Predictions are always discounted for uncertainty. More uncertain markets attract more discounting. At some point a market is too uncertain to predict, regardless of the value in the market and so no innovation occurs in that market. This type of market has low dynamic efficiency and does not work in the interests of consumers. It is the opposite of that encouraged by the NEO. Stable regulation and market operator adherence to that regulation make it easier for innovators to get their predictions right. This results in less discounting and more innovation. The NEM has seen strong innovation since 2014 because investors have judged its transformation to be relatively predictable. That is, the NEM is moving towards renewables and high-speed electronics, and away from fossil fuels and electromechanical control. Regulations that are consistent with more renewables and high-speed electronics are considered to be low-risk to the transition. The metering requirements for contingency FCAS have been the same since at least MASS v4 dating back to at least 2012. Innovators such as EnelX and Reposit invested in R&D on metering equipment that met those requirements as part of an effort to bring DER to FCAS. This metering is operating in the NEM today. Other innovators have also invested in MASS-compliant metering, but have yet to bring it to market for various reasons. AEMO's adoption of Option 2 will diminish the investment returns that these innovators have made in R&D. This will not go unnoticed in the NEM and innovators will be forced by their governance regimes to heavily discount NEM-centric R&D as a result. It is Reposit's opinion that the adoption of Option 2 by AEMO communicates the following to innovators: 5. Technical requirements of plant will change even if those changes are contrary to the NEO, the interests of existing (non-trial) participants and trends in technology 6. Early entry to a NEM market is disadvantageous. The market operator will remove short-term, technology-based competitive advantage in the interests of promoting competition	

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		7. Investments in regulatory change activities are more likely to deliver returns than R&D where your existing technology does not meet NEM requirements. The adoption of Option 2 creates a strong barrier to innovation and discourages the uptake of new technology. Both of these are characteristics of dynamically inefficient markets[110] and so Option 2 does not promote the achievement of the NEO. **4.4.2 Option 2 creates unnecessary investment uncertainty** Investment in physical assets is essential to the correct functioning of the NEM. This is especially true during the current transition to renewable energy. Investment must be made into new plant to deliver electricity services to consumers. The mechanisms that drive investment in the NEM are price signals, market information and regulatory certainty. Any action by a market body that diminishes the functioning of these mechanisms creates investment inefficiency in the NEM. This action is considered deleterious to the achievement of the NEO. Option 2 creates unnecessary regulatory uncertainty in much the same way as it discourages innovation. It signals to the market that long-standing technical requirements of electricity service delivering assets are subject to change contrary to general trends in the market and the NEO. This has likely not been taken into account by investors and so represents a new source of uncertainty, and hence discounting. This discounting contributes to investment inefficiency in the NEM and does not promote the achievement of the NEO. This mechanism affects investors in plant, not investors in R&D. There are circumstances in which they are the same party, but often this is not the case. Where DER is concerned, these investors are most often the Consumers referenced in the NEO. These investments are made by Reposit's customers to reduce the effective "price" of electricity services via the return of economic value through their DER participating in the use of electricity services. More uncertainty translates to a lower return on their DER investment for these Consumers. This can be argued as increasing the price of their electricity services. In this way Option 2 is doubly damaging to the NEO. Not only does it create investment inefficiency, but it also acts to effectively increase the price of electricity services for some Consumers. **4.5 Does not make the least demanding assumptions** Key to the long term interests of consumers are regulatory arrangements that are both flexible and resilient enough to respond and evolve whatever the future may bring. Flexible and resilient regulatory arrangements are those that rely on the least demanding assumptions[111]. Option 2 makes assumptions that Reposit does not consider to be the least demanding and so considers the adoption of Option 2 to degrade the MASS's flexibility and resilience. **4.5.1 Large amounts of DER in FCAS are likely** Option 2's introduction of large amounts of error into Fast FCAS response could be argued as acceptable where small amounts of DER were expected to participate in FCAS. Instead it is	

[110] AEMC - Applying the Energy Market Objectives - https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf - section 1.4 - page 12

[111] AEMC - Applying the Energy Market Objectives - https://www.aemc.gov.au/sites/default/files/2019-07/Applying%20the%20energy%20market%20objectives_4.pdf - section 1.2.3 - page 6

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		probable that the combined capacity of VPPs operating in the FCAS market will exceed the capacity of traditional large scale generating units currently in market at some point in the future. The ENA and CSIRO have predicted that the combined capacity of DER will exceed 40GWh by 2030[112]. It is therefore safe to assume the percentage of FCAS provision in Australia that comes from 'small-scale' generators will rapidly grow over time. Allowing vastly increased metering error for a generator type that will represent a rapidly increasing and future dominant proportion of the overall generation mix in the NEM, will have direct and negative implications with regard to the ongoing security of the grid. **4.5.2 Future generators may not be fixed in capacity or location** The penetration of Electric Vehicles (EV's) in Australia is steadily increasing. These assets when connected to the grid can contribute to the FCAS market. The nature of these assets however mean they are transient. They will not always be connected to the grid, or not always connect to the grid at the same point. In fact, they will likely change the location upon which they connect to the grid frequently. Given this, there may be fixed locations which act as single "generating units" with respect to the FCAS market, that will not have a fixed capacity, charge stations or car parks for example. It is possible that the transient nature of the capacity connected to these generating units means that they will have an FCAS biddable capacity that at times sits above 1MW of capacity and at others sits below 1MW of capacity. It is unclear with the introduction of this threshold how these locations will be treated, and what metering requirements will be applied. Further, the situation in which a single registered 'generating unit' (location) could both sit above and below this threshold depending upon the time of day or year further exemplifies the arbitrary nature of having a threshold at all. **4.5.3 VPP Demonstrations derived assumptions** The VPP demonstrations provides insights into the establishment and operations of VPPs in highly controlled 'sandboxed' environments with non-representative market and consumer samples. However, the insights presented in the Knowledge Sharing Reports fall short of providing a reliable evidence base to inform regulatory, compliance, or policy design outcomes. In particular, the VPP trial cannot be considered to provide least demanding assumptions due to trial design limitations, and the low replicability of results and evidence. **4.5.3.1 Trial design limitations** Reposit asserts that there are material limitations in the trial design that unavoidably bias the trial. This means that insights from these VPP demonstrations should not be generalised and used to inform decision making. This assertion is based on the review of NEM VPP Demonstrations Program Final Design[113] and the Knowledge Sharing Reports[114]. There seems to be no clear leading hypothesis for the VPP demonstration or articulation of trial assumptions expected key results, or controlled sampling techniques. Nor is there a clear 'business problem' articulated. At best, the trial objectives and research questions are open	

[112] https://www.energynetworks.com.au/resources/reports/electricity-network-transformationroadmap-final-report/
[113] https://aemo.com.au/-/media/files/electricity/der/2021/nem-vpp-demonstrations_final-design.pdf
[114] VPP Demonstrations Knowledge Sharing Report #3 - Table 1

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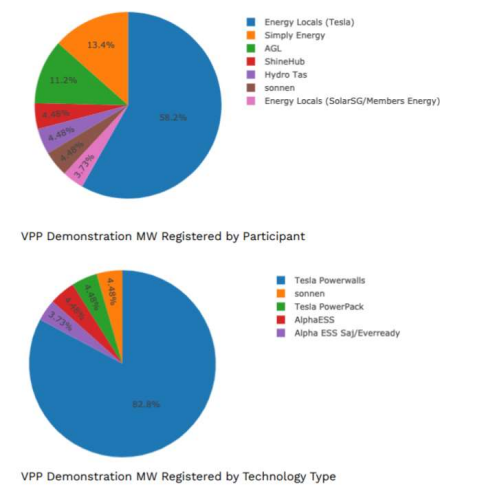
		ended and exploratory. Additionally, there is limited description of the options analysis having been undertaken to ascertain trial scope and intent around verifying and validating the key assumptions of the trial. Which Reposit infers are: 1. MASS-compliant metering is not commercially viable 2. DER response is homogenous across units of a "type" 3. Energy exported from a non-generator Connection Point cannot contribute to an FCAS response under the existing NER. Furthermore, the technologies used by the trial participants are not a representative sample of the real world deployments, nor are they representative of the market segmentation under real market conditions. It is evident that there is a clear bias towards certain vendors and technology solutions.  **4.5.3.2 Replicability of results and evidence** The VPP Demonstrations project has not made any raw trial data publically available. This includes 1Hz data from FCAS responses, 20Hz "type" testing data, and the methods and calculations used to validate FCAS responses. As a result it is impossible for a third-party to examine the conclusions of the trial in respect to the data used to come to the trial's conclusions. For example, based on the Knowledge Sharing Report #3[115], it appears that the ShineHub Alpha ESS response has NOFB set to very tight settings, in order to trigger a trip. Based on Reposit's operational experience in the market, this does not reflect actual frequency response in the	

[115] VPP Demonstrations Knowledge Sharing Report #3 - Figure 1

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		market. This treatment was not mentioned in the Knowledge Sharing Report, nor was any raw data made available for examination. Furthermore, the trial FCAS Verification Data template indicates a lower level of robustness in verification as compared to the MASS v6 FCASVT. No data on FCAS response verification has been provided at time resolutions other than 1Hz. Nor descriptions as to how the measurement of energy compares under different time resolutions, in particular in respect to error quantification. Reposit accepts that the VPP Demonstrations project is largely complete and that in-depth criticism of the project is not constructive. Reposit asserts however that the trial lacked rigour and that it cannot be used to inform future policy or engineering decision making in the NEM. Reposit will contribute meaningfully to a review of the trial where the opportunity arises. **Rheem & CET** … we believe that Option 1 is more consistent with the NEO. Further viewpoints in respect to consistency with the NEO can be found in our answers to AEMO's other MASS consultation questions. **Shell Energy** Shell Energy also agrees with AEMO that pursuing Option 2, to embed the measurement requirements that were tested in the VPP Demonstrations in the ongoing MASS, will meet the National Electricity Objective. Given the small size of most of these providers, we consider that there is at this stage very limited scope for market distortions to occur. Further, the Issues Paper highlights that the delivery of fast FCAS can be reliably verified using the Option 2 measuring requirements. As such, these considerations along with the benefits of increased competition in the fast FCAS market means that the benefits are highly likely to outweigh any risks. **ShineHub** Option 2, as stated in Q1. (See the extract in item 1 In Appendix B.) **Simply Energy** **VPPs can benefit consumers and help strengthen the resilience of the electricity grid** In its knowledge sharing reports, AEMO noted that consumers would likely benefit from the coordination of DER through VPPs in two ways:[116] · Consumers who own VPP assets would earn value from delivering grid services · All other electricity consumers would benefit from a more efficient power system. *Direct benefits to consumers that participate in the VPP* To participate in a VPP, consumers need to opt-in and agree to give the VPP operator a level of control over their BESS. In Simply Energy's experience, the key factor in influencing consumer participation in the VPP program has been the cost of residential BESSs, specifically the level of subsidy available to reduce the price of the system over its lifetime.[117]	

[116] AEMO 2020, AEMO Virtual Power Plant Demonstration – Knowledge Sharing Report #1, March, p.5
[117] Simply Energy 2020, Simply Energy VPPx - Lessons Learnt Report, October, p.4

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		During the VPPx project, Simply Energy trialled a number of product designs and subsidy structures and found improved uptake when consumers were able to access subsidies from both the South Australian Government (capped at $6,000) and from Simply Energy ($5,100 paid over several years). The most pronounced spike in demand immediately preceded a $2,000 reduction in the South Australian Government subsidy and an announcement that Simply Energy's VPP subsidies had limited offers remaining.[118] The VPPx project has enabled customers to increase their self-consumption of energy generation (through the combination of a solar panel system and battery storage) and embrace the development of renewable energy technologies. The integration of a distributed energy market platform in VPPx is intended to enable customers to access greater economic value from their energy storage assets.[119] Once VPPx reaches an appropriate size, customers could also access the benefit of their energy storage systems trading in the FCAS market. *Benefits to all consumers through VPPs helping to strengthen the resilience of the grid* During the VPPx project, Simply Energy demonstrated the performance of the VPP-enabled batteries in terms of their ability to provide reactive power, real power and frequency support for the grid.[120] However, due to the limited size and dispersed nature of the installed fleet, VPPx has not been able to access monetary value for network services to date.[121] Simply Energy entered the contingency FCAS market in October 2020 via AEMO's VPP demonstration trial program and is planning to increase the available fleet to 4MW's as the final round of storage systems are installed and integrated. While VPPs are still in their infancy, AEMO has found that the current VPP demonstrations have identified the value that VPPs can provide in relation to operational visibility and forecastability.[122] **Social Energy** Option 2 will promote the uptake of DER/VPP services as its technical requirements represent a lower barrier to entry comparted to the current MASS rules. Our experiences from operating in the UK market show that VPPs hold several advantages over traditional large static assets. Their distributed nature means they are more resilient to local losses of electrical supply, data connectivity, and other faults. Their higher granularity can increase the efficiency of auction processes that they participate in realising better value for money for TSOs. Procuring frequency balancing services from VPPs will improve all metrics outlined in the NEO. **Solar Analytics** The NEO refers to "price, quality, safety and reliability and security of supply of electricity" and "the reliability, safety and security of the national electricity system." In our view, option 2 will result in more participants providing contingency FCAS. The greater volume of FCAS available in the market will improve the reliability of the system responding to	

[118] Simply Energy 2020, Simply Energy VPPx - Lessons Learnt Report, October, p.4
[119] Simply Energy 2019, Simply Energy VPPx – ARENA Stage 1 Knowledge Sharing Report, February, p.7
[120] Simply Energy 2020, Simply Energy VPPx – Stage 2 Knowledge Sharing Report, June, p.5
[121] Simply Energy 2020, Simply Energy VPPx – Stage 2 Knowledge Sharing Report, June, p.5
[122] AEMO 2021, AEMO Virtual Power Plant Demonstrations – Knowledge Sharing Report #3, February, p.14

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		contingency events and the increased competition will reduce the cost of providing this reliability. **SwitchDin** Aligning FCAS measurement requirements for DER with the future mandatory requirements of inverters (AS/NZS 4777.2:2020) would result in the lowest cost implementation in future and therefore is more consistent with the NEO. **UNSW** Given the availability of devices that can capture and store disturbance data at 50ms intervals, the relatively small incremental cost for the inclusion of such devices and with the aim of future-proofing the system (as captured data can be used for other functions beyond FCAS delivery validation), we believe that Option 1 is more consistent with the NEO. **VIOTAS** VIOTAS believes, on balance, Option 1 (no change to the MASS measurement requirements) is the most consistent with the NEO. VIOTAS believes upholding the highest standards of metering and control for the provision of ancillary services. Particularly as the power system continues to require faster response and more sophisticated services such as FFR and inertia, which will result in the best long term outcome, both for the NEM power system (in terms of reliability, safety and supply security), and for end-consumers (in terms of maximising the utilisation of all available resources and the associated benefits in terms of competition, efficiency and prices).	
3.	Various	**Other principles AEMO should take into account** **Delta Electricity** A fundamental principle to seek is **coordination of the overall response**. Uncoordinated responses are not good control and contribute to inefficiency. Amongst other key aspects of the specification, permitting variability of the standard of instrumentation and control performance measurements reduces the objective of a coordinated frequency response. **DEMSA** Market frameworks, generally, should seek to be technology neutral as far as possible, allowing different technologies to compete. However, where a technology, particularly an emerging technology, is precluded or cannot practically comply with the existing rules of specifications due to inherent attributes or prohibitive costs, consideration should be given to adapting those frameworks to accommodate different technologies or models while meeting fundamental outcomes. There is precedent for this in the case of the advent of the semi-scheduled classification where the new variable renewable generators could not comply with dispatch requirements. **EQ** EQ agrees that the objective as stated appears appropriate. **Evergen** …	AEMO's view is that the NEO provides the fundamental basis for any decision to amend the status quo. In other words, changes to the MASS will be justified only if they promote the NEO better than the status quo. In response to Delta's comments: Delta Electricity's principle of "co-ordination of the overall response" should not be seen as an additional principle. AEMO considers this to be covered by its obligation to maintain power system security and reliability, which underpins all its operational decisions. In response to DEMSA's comments: DEMSA's reference to technological neutrality and comparison with the semi-scheduled generation classification is not a direct comparison. The NER was amended by the AEMC to effect the creation of a new category of classification for generation.

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		2. Almost all of Evergen's hardware partners are unable to achieve 50ms power and frequency sampling now or in the near future. … 4. All existing DER in Evergen's fleets and almost all residential DER in the country lack this hardware and would be immediately excluded from participating in VPPs offering FCAS. … 6. Limiting the delayed FCAS markets to switched control only will impact VPP value streams or drive VPPs to offer switched control across all markets to maximise participation. … In satisfying the principles in Section 2.4 [of the Issues Paper], AEMO should do so with consideration to the wider context for DER and the realities of participation. At present, the contribution of VPPs comprising small-scale DER is a tiny but promising proportion of the whole FCAS market. Similarly, the FCAS value stream is a potential opportunity for DER suppliers, but not their core offering. AEMO's approach to date allows a low-cost way for aggregators to explore the benefits of enrolling VPPs for FCAS, meeting compliance requirements, and learning-by-doing. Option 2 continues this progression, and given the small slice of the FCAS market presently occupied by small-scale DER VPPs, the short-term impacts to the electricity system - even under the highly unlikely event of widespread VPP non-compliance - are negligible. In contrast, the potential longer-term benefits of fostering new entrants to the FCAS contingency markets and increased competition is invaluable. **Hydro Tasmania** Hydro Tasmania supports the principles listed in the Section 2.4 though would suggest keeping the Technology Neutral principle on the list. **Intellihub** In addition to the principles described in section 2.4 [of the Issues Paper], AEMO should consider how the long-term accuracy of FCAS measurements at small DER sites will be assured. **Karit** An additional principal that should be considered is one that promotes the utilisation of existing infrastructure (revenue meters should be upgraded to support measurement and verification of FCAS) as the preferred toolset for measurement and verification. **Landis + Gyr** The NEO provides the market with clear guiding principles and sets the framework for policy and market rules to be implemented against. At this stage Landis + Gyr believes the NEO provides sufficient guidance to the market. **Members Energy** No **Mondo**	In response to Evergen's comments: Evergen's comments seem to be directed at the low penetration of the FCAS markets by DER providers and how they can't do much damage and provide much-needed competition. The reality, however, is far more complex. See section 4.1.2 and 4.1.3 for a fuller discussion. In response to HydroTas' comments: As with DEMSA, Hydro Tasmania wishes technological neutrality to be an additional principle for AEMO to consider. For the same reason as given in response to DEMSA, AEMO will not elevate technological neutrality to a separate principle if it does not promote the NEO. Intellihub & Karit's points generally go to the question of whether Option 2 promotes the NEO. AEMO agrees with Landis + Gyr.

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		The principles described in Section 2.4 are the appropriate ones for AEMOs assessment on the two options. **Reposit Power** **Consistent metering requirements for all Fast FCAS market participants** Reposit is opposed to any optionality in the measurement and verification of FCAS services. Reposit believes that the measurement and verification processes in the MASS should be consistent for all NMIs regardless of capacity, technology type, market participation status or other differentiating factors. This approach promotes the achievement of the NEO and is consistent with the market design principles currently described in the NER. **Option 2 metering will be replaced by Option 1 metering within 5 years** The availability of very fast new system services and DER's participation in them will drive the refitting of Option 2 metering in the NEM. This represents an inefficiency of $60,000/MW in refitting cost (**Section 4.3.2**[123]). … **DER responses from units of the same "type" are not the same** Many factors influence the speed, volume and stability of energy delivery from, or absorption to, a DER device. These factors are different for each particular device, and change in an unsynchronised way over time. This makes an assumption of response homogeneity invalid. As such responses cannot be "deemed" as a result of type testing (Sections **3.3.3.3**, **3.3.4.3**[124]). **Option 2 metering will damage system security** … Option 2 violates the Market Design Principles stated in the NER … clearly specify: • 3.1.4(a)(3) - avoidance of any special treatment in respect of different technologies used by Market Participants • 3.1.4(a)(5) - equal access to the market for existing and prospective Market Participants Metering optionality, particularly a technology-specific relaxation such as Option 2 is in clear violation of these principles (**Section 5.1**). … Option 1 metering promotes innovation, investment and technology development in NEM FCAS markets. The implementation of Option 2 metering irrevocably damages future investment across all current and future AEMO operated services (**Section 4.4**[125]). Option 1 FCAS response is measured and managed with provably low-error energy computations. Option 2 FCAS response is estimated using unvalidated and ungeneralisable	In response to Reposit Power's comments: The market design principles in clause 3.1.3 of the NER have been raised by Reposit Power and Tesla. The provisions state: **3.1.4 Market design principles** (a) This Chapter is intended to give effect to the following market design principles: … (3) avoidance of any special treatment in respect of different technologies used by *Market Participants*; … (5) equal access to the market for existing and prospective *Market Participants*; The opening sentence of this provision clearly indicates a **statement of intention** for Chapter 3 of the NER. The NER and instruments required by the NER have been drafted to achieve these, to the extent possible. We need to reiterate this, because of the inherently different responses of different types of equipment, for example switched vs variable controllers. To attempt a different interpretation would be to ignore the fact that the NER had to be amended to accommodate intermittent generation by creating the semi-scheduled generation classification.

[123] Reproduced in item 2 of Appendix B.
[124] Reproduced in item 1 of Appendix B.
[125] Reproduced in item 2 of Appendix B.

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		assumptions, uncharacterised error and uncontrolled future states (**Sections 3.3.6**[126] and **4.5**[127]). Option 1 metering is aligned with the market design principles described in the NER. Option 2 metering clearly violates these principles **(Section 5.1**). AEMO is legislated in the National Electricity Law to have regard to the NEO when carrying out its statutory functions (**Section 4.1**[128]). AEMO is also obligated to obey the NER and the market design principles held within (**Section 5.2**[129]). Reposit asserts that any other principles are either encapsulated in the NEL, NEO or NER already, or are irrelevant (**Section 4.1**). … **5 Market Design Impact Analysis** **5.1 Violation of NER Market Design Principles** Section 3.1.4(a) of version 156 of the NER provides the market design principles which govern the creation or modification of electricity markets. In particular, subsections (3) and (5) state the following principles when considering the introduction or alteration of electricity markets: • 3.1.4(a)(3) - avoidance of any special treatment in respect of different technologies used by Market Participants • 3.1.4(a)(5) - equal access to the market for existing and prospective Market Participants Option 2 clearly does not avoid any special treatment in respect of different technologies used by Market Participants. It is trivial to show that Option 2 is clearly intended to relax the requirements of DER, while maintaining a strict metering regime for other types of generation and loads. Likewise, the adoption of Option 2 provides lower-cost access to the Fast FCAS markets for new entrants. It is trivial to show that lower-cost access is not equal access, because there are existing participants in the Fast FCAS markets using technology of the same type as would benefit from Option 2. These market design principles make it unlikely that Option 2 could be adopted in the NEM without a rule change. Reposit suggests that these market design principles in particular are central to what makes the NEM a market and that any rule change is unlikely to be successful. Additionally, Reposit considers it unlikely that the NEL can be interpreted such that these principles are not applicable to AEMO decision making. **Rheem & CET** We believe that the guiding principles as detailed in Section 2.4 [of the Issues Paper] cannot be realised without further addressing a number of impediments to the successful growth of orchestrated mixed DER. The embedded DER issues we have identified (as highlighted in our	In response to Rheem & CET's comments: Rheem & CET raise several issues, none of which can be seen as principles outside of the NEO. In fact, most of these are considerations to be had in determining whether

[126] Reproduced in item 1 of Appendix B.
[127] Reproduced in item 2 of Appendix B.
[128] Reproduced in item 2 of Appendix B.
[129] Reproduced in item 8 of Appendix B.

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		response to Question 1[130]) are a real and present threat to the successful growth, operation, competitiveness and delivery of FCAS in mixed DER sites. To ensure an open, successful and competitive market for participation of mixed DER (at a site/NMI) in Contingency FCAS, it is our view that the following issues need to be addressed as part of the MASS Consultation: • Participation of one form of DER in FCAS must not be to the detriment of other DER resources / assets at a site seeking to participate in FCAS or other grid services • Open, local, standards-based control interfaces are required on all embedded DER to ensure their ability to be orchestrated with other site DER resources (e.g. smart water heaters, pool pumps, HVAC, batteries, EV charging, solar PV etc) for the provision of HEMs services inclusive of mixed DER FCAS • Local access to the monitoring and control of DER is necessary to ensure a consumer's DER assets can be migrated by the asset owner (consumer / site owner) to any other energy market service provider (aggregator, retailer etc) they may choose, without any loss of functionality, or continued reliance on the day to day involvement of the DER manufacturer • Having a DER device operating outside the orchestrated site control is to the financial detriment of the site/consumer AND decreases the reliability of the site orchestration in providing grid services such as FCAS • The principles of technology neutrality should be observed in the consideration and making of any changes to current NEM rules / specifications relating to DER participation in grid services such as Contingency FCAS. *In support of this position we note the following*: In the recent "Project EDGE" kick off meeting hosted by AEMO, the "Testing a DER Marketplace" introductory slide stated: • "Consumer interests (must be) met by identifying efficient DER integration pathways that align to the NEO". In the DER Wholesale Integration WIP Spreadsheet presented to the Forum by AEMO, it is stated that the DER solution must: • "Ensure all smart hardware can act on a local control signal from an EMS (i.e. local energy management system); • "Enable any aggregator to control any device, so that a new aggregator does not have to roll a truck to implement their proprietary control devices", and; • "Maximise retailer/aggregator competition for my business (and home) and incentivise them to use my controllable devices"; The above AEMO statements seem to be consistent with our response, and our identification of other important principles that must be addressed to ensure the successful participation of mixed DER in FCAS and other grid services. In that respect we believe we are correct in raising	Option 2, or any other options, promotes the NEO better than any other option. Retailer (or other service provider) transfer is outside of the scope of the MASS. AEMO will notify relevant AEMO staff of the issue.

[130] See item 1 in Appendix B.

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		(for resolution) the issues with embedded DER and that resolution of this issue as part of the MASS consultation is required if the intent of the NER are to be adhered to, i.e: • "Promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity", and; • "Promote competition – by minimising barriers to entry so that more FCAS providers can compete in the market". **ShineHub** Safety of Battery Technology should be carefully considered too. Unlike most MASS participants who normally has its own sites and secured by fences, Most VPP providers are using Lithium batteries that sit in residential homes. Plus, FCAS normally requires maximum power charge & discharge where it could incur faults or even fires if the battery material is unstable. Any safety risks to homeowners could be detrimental to the VPP FCAS program. Critically important is Server Location and Data Security: as the data of power usage are sensitive and data transmission to AEMO should be secured and reliable, it may need to consider requiring the participants' data server to be located in Australia and the data transmission should be limited within Australia. More specifically, the data flow from the inverter, to VPP provider, and to AEMO should all be done within Australia – without any data being sent overseas. **Solar Analytics** At the centre of the energy system are consumers. The AEMC guide to Applying the energy market objectives highlights that "Consumers should have options in the way they use energy" (section 1.4). This should include the option to increase participation in the energy system and be rewarded for it. Option 2 lowers the barrier to achieving this. Facilitating a greater contribution of DER to FCAS is also expected to increase the return on investment for distributed energy storage, encouraging greater deployment. This not only supports the choice of consumers to become more selfsufficient in their energy supply, but also increases the availability of flexible demand in the system, providing greater opportunity to meet the NEO through energy arbitrage, wholesale demand response, network support etc. **SwitchDin** SwitchDin recommends that technology neutrality is explicitly included as a principle to be considered by AEMO to guide its assessment. **VIOTAS** VIOTAS does not have any additional principles beyond those described in section 2.4 [of the Issues Paper] which recommends AEMO consider as part of its assessment. VIOTAS believes the first principle ("ensuring that the delivery of FCAS from DER can be reliably verified to identify non-compliances and minimise potential for gaming") is the most critical. This ensures a level playing field amongst providers and ensuring that, where participants are providing a service, being paid for it and relied upon by the system to provide it, they are able to appropriately demonstrate / verify that they have provided it, with a degree of accuracy appropriate to the service.	In response to Shinehub's comments: ShineHub raises the issue of safety of battery technology as an additional principle. The safety of the electricity system is a consideration that is part of the NEO and, to the extent that any battery is connected to the grid, it is part of the electricity system, and so is covered by the NEO. The issue of safety to homeowners is not one that AEMO has any direct involvement with and should be raised with technical and safety regulators, such as Energy Safe Victoria. In response to Solar Analytics' comments: In section 1.4 of the AEMC's Applying the Energy Market Objectives, the AEMC highlights a number of principles, but also indicates that the assessment of any proposal is a holistic exercise where several issues are weighed up before reaching a determination. In response to Viotas' comments: VIOTAS' submission is similar to Delta Electricity's. in that it seeks to ensure a level playing field for all FCAS providers. AEMO considers this to be covered by its obligation to maintain power system security and reliability, which underpins all of its operational decisions.

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4.	Various	**Difference in implementation costs between options** **AGL** It would take significant investment for VPP operators to meet the requirements of Option 1, measuring power flow and local frequency at intervals of ≤50ms at every site. The costs of implementing the necessary hardware and software to achieve measurement per Option 1, would likely outstrip any potential revenues that a VPP operator could earn through FCAS market participation. … We consider the implementation costs for capturing 50ms data at every site are prohibitively high at present, in part due to a lack of hardware vendors who can provide the necessary equipment. Until there are more hardware providers in the market, this will remain the case. Additionally, the IT systems required to manage and process the significant amount of incoming data add both to the costs and technical complexity. Should DER providers be required to capture 50ms data at each site, we would need to think about where that data is stored and how often it is accessed and assessed, given the burden this would present. **CPUE** **Lower resolution data is sufficient to provide FCAS participation of VPP assets without impacting system security** We consider the current MASS rules to install high-resolution metering are a cost barrier for small-scale DER systems to participate in the FCAS markets. Based on our research, the cost of metering significantly increases with the increased metering resolution. The current products available in the market will cost in excess of $3,000 plus installation and operational cost per NMI. In most applications existing inverters will capture 1s data without incurring additional metering costs. As the VPP trial has demonstrated that lower-resolution (≤1s) data is sufficient to prove FCAS participation of VPP assets without impacting system security, we consider lower resolution data is sufficient to reduce unnecessary costs to consumers. **CEC** See item 1 in Appendix B. **Delta Electricity** Inaccuracy can exist in source transformers and instruments that provide for the recording. Costs of aligning source transformers to common standards is probably prohibitively expensive but good quality high-speed instruments and recorders are not. AEMO should include specifications for the controller reactions, the controller's frequency input data and sampling rate separately from specifications of the recorded data. If the Unit controller is responding to a frequency value only sampled at 1s will it provide the necessary response required? If the controller is rapidly detecting and reacting to frequency fast enough, the recorded data can probably be taken at a slower sample rate but it is better that control and monitoring data are comparable. Accurate MW and MVAr transmitters with fast settling times recently purchased were difficult to locate from international suppliers but at around $2- 3k per instrument are reasonably	A consideration related to the variable of price in the NEO is the cost of implementation of each of the two options posited for FCAS delivered by DER. Several submissions were made on this issue, all of which commented on the cost of Option 1, which can be summarised as follows: **Submission** / **Option 1 Cost** / **Option 1 Cost – Standardised on a per NMI basis** **CEC** / $10,000-$15,000 per HSM / $10,000-$15,000 **CPUE** / $3,000 per *NMI* / $3,000 **Delta Electricity** / $2,000-$3,000 per transmitter $50,000-$100,000 per HSM / $52,000 - $103,000 Cost appears to be more relevant to *power stations* **Empower Energy** / $50 per phase / $150 for 3-phase **Evergen** / $1,000 per existing DER asset $800-$1,700 per *NMI* / $800-$1,700 **Hydro Tasmania** / >$10,000 per HSM / $10,000 **PAP** / Negligible for C&I High for Residential / **Reposit Power** / $120 per *NMI* / $120 **Rheem & CET** / <$200 per NMI / <$200

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		priced. High speed recorders that can maintain a 2-week continuous record of data sampled at 20ms are only $50- 100k. **DEMSA** The Division does not support option 1, which would result in significant disruption to those current VPP FCAS providers and create (or reinstate) barriers to VPPs participating in FCAS due to cost prohibitive metering requirements. **Empower Energy** A repeated theme throughout the recent DER MASS review discussion concerned the purported high cost of fast-response metering infrastructure. The claim that such metering infrastructure is sufficiently costly as to render it inaccessible in a DER context is false. Fast-response on-site metering of a usable quality is neither inaccessible nor impossible, and within a year will be mandated on all inverting DERs regardless: • Where metering infrastructure is external to the DER asset, the Bill of Materials cost of HSM infrastructure is typically under $50 per phase (in limited volumes; relevant solutions capable of supporting this functionality as a feature subset have existed in the Australian market since 2015, and at the start of the VPP trial retailed at some $600 - these compare favourably to technical gateway solutions prevalent in the VPP Trial). • Metering infrastructure inherent to any DER asset, management gateway or revenue meter is often able to be utilised for the same purpose with appropriate firmware development. This renders the cost of access to customers to zero - such a solution utilises latent value within existing infrastructure. • It should further be stressed that in the last five years a number of organisations have committed to building dedicated, low-cost devices that approach, and in some cases meet some or all the requirements of Section 3.6 of the current MASS. The participants of the VPP Trial are not a complete representation of these efforts. More critically - every small-scale inverting power device certified after December 2021 (which includes all inverters and AC-coupled BESS used in the VPP trial) will need to meet a 10Hz, 0.1Hz resolution measurement requirement at any rate (and an according power measurement at same frequency). These devices must comply with AS/NZS 4777; the new version of which - AS/NZ 4777.2:2020 - stipulates these very requirements very clearly, and is currently intended to be effective in the market from December 2021. The Standards process leading to his determination was both wide and consultative. The 10Hz implementation of these measurements is to be regulated to serve the correct management of inverter ride-through in times of impared grid power quality, and to be able to support droop-linear responses and the like to support frequency deviation events (much aligned with the MASS review's intent). Fast metering is not hard, and at 10Hz it's more accessible, it rewards best performance, it gives customers and companies invested in the previous MASS a fair glide path to comparable value generation and thanks to AS/NZS 4777… it's soon to be ubiquitous. That it wasn't evaluated in the VPP trial is not a good reason not to build a regulation around it. Furthermore - as a general paradigm - if 10Hz works, then there is no need for check metering and characterisation efforts. It's simple.	<table><tr><td>**Shine Hub**</td><td>Cost to upgrade systems is >$200,000 per annum</td><td></td></tr><tr><td>**Social Energy**</td><td>>$120,000 per MW</td><td>$600 (assuming that the residential BESS can charge/discharge 5kW)</td></tr><tr><td>**SwitchDin**</td><td>$400-$500 per *NMI*</td><td>$400-$500</td></tr><tr><td>**Tesla**</td><td>$10,000-$15,000 per HSM</td><td>$10,000-$15,000</td></tr></table> Furthermore, while submissions from AGL, EQ, Intellihub, Karit, Mondo, PAP (for residential customers only) and Solar Analytics commented that the cost of implementing Option 1 was prohibitive, they did not submit any figures to substantiate this. AEMO's determination not to amend the MASS to relax the metering requirements for DER has been informed by these submissions. The issue of customer churn (also mentioned in CPUE and Simply Energy's submissions in item 1 of this Appendix B) is not one for the MASS. AEMO will notify relevant AEMO staff of this submission.

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		But still, no one's tried something other than the current MASS or the VPP trial This is neither true. AEMO was party to at least one trial outside of the VPP Trial where a 10Hz approach using existing metering within DER assets was successfully demonstrated. It wasn't possible for the trial stakeholders to agree to commercial terms consistent with the requirements of the VPP Trial, so a private demonstration was held. AEMO was invited and attended, and agreed the work was positive. There's also quite a lot of development work by a number of DER vendors locally, in addition to a significant body of overseas work at 10Hz. It's also very simple to simulate the impact of 10Hz sampling from existing Australian 20Hz data, and to assess the effect on measurement error, value generation and the like. Multiple data avenues have existed to assess this approach in aggregate. There is at least one DUID registered to a VPP complying to the current MASS. With some delicacy, it is stressed that the implied commercial terms of the VPP Trial - particularly with respect to resource commitments and open knowledge sharing of a development effort - are not favourable for all vendors operating in this space. In some cases (consistent with my own experience) it was difficult to elicit technology partners to willingly partake. There are myriad reasons for this. Whilst the VPP Trial has certainly proven to be a valuable experience and knowledge source which should influence and serve as a point of reference, as much as any other local or international example of relevance - there is no cogent argument wherein the VPP Trial should be the sole exemplar of a rule change. … **Compliance testing really isn't workable** It should also be mentioned that physically installing MASS-compliant check metering at customer premises creates additional costs beyond the cost of equipment. Firstly there's the need to find a customer site to install the relevant equipment. In a general sense, the equipment involved is not trivial - these instruments are generally large. What happens if that customer then wishes to churn to another retailer, as it is their right to do? Are incentives to retain that customer fair - has AEMO given any consideration as to, in a competitive market for such offerings - how other customers may view 'missing out' on such incentives? Do any such incentives need to be disclosed as part of a market offering allowing customers to make informed choices as to how they use energy and the benefits any given offering may afford them? Are extra check meters to be installed to allow customers to churn at will as the law allows? Will there be grace periods for a VPP operating in lieu of them if their 'check meter homes' all churn away in a given instance? If a VPP is based around a single inverter design and a second is introduced, do customers with that asset need to be metered separately? The costs associated with managing these operational efforts are presently unaccounted for, as technical trial environments do not sufficiently explore them.	

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		Let alone that it's yet to be proven - and is quite difficult to understand in technical practice - how check metering a small number of technologically similar DER assets creates a statistically accurate understanding of the initial response characteristic critical to arresting the nadir of any grid frequency excursion, and thus limiting the impact of any contingency event and accordingly maximising grid stability e.g. where energy storage systems are concerned, does AEMO propose to assess individual system response at all SoC? Compliance testing is not a workable solution in a practical environment. **EQ** EQ believes provision of the 50ms metering on small DER and loads would be prohibitive. EQ does not currently have detailed experience in DER inverter metering capabilities. However, the expectation is that it will be far more likely that inverter metering could provide 1s metering without additional metering, while 50ms metering is expected to require additional dedicated equipment. It is currently impractical for Energex's and Ergon Energy Network's controlled load to provide either the 1s or 50ms metering at the load. Conversion to electronic kilowatt hour meters at the premise will not provide this level of metering in the immediate term. It is our view that a metering solution at a higher network level is required. If the customer's electronic metering (owned by the retailer / metering provider) provided the capability to shed the controllable circuit based on frequency parameters and had a disturbance recorder type function for 1s metering, there may be a market for the retailer to provide an aggregated fast raise service. **Evergen** Evergen supports Option 2, based on two key considerations: 1. The infeasible cost and logistics of upgrading vast numbers of existing systems to deliver Option 1 requirements. 2. The additional cost and complexity in purchasing solar & battery systems should specific hardware devices need to be added to meet Option 1 sample rate and measurement point requirements. **Existing systems** Inverter and battery vendors have existing cloud infrastructure, software and servers in place to monitor and control DER and store data as part of their standard non-VPP offering to consumers. DER firmware updates and cloud infrastructure modifications are frequently all that is needed to facilitate 1-s telemetry and automatic response to frequency excursions. This standard offering is not able to deliver 50ms telemetry measured at the connection point. To allow existing systems to participate under Option 1 would require one of the following two options: 1. New monitoring hardware installed on site 2. Access to data from an existing revenue meter already installed on site, where the meter provider can offer access to telemetry sufficient for FCAS reporting requirements. **Installation of monitoring hardware**: Sending a technician to a site to install new hardware would cost approximately $300 plus the cost of the hardware itself, much more for	

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		more remote locations. Total costs may exceed $1000 per DER. The consumer would wear this cost, on the promise of additional revenue from participation in FCAS markets. Evergen regards this as non-viable for the following reasons: - The uncertainty attached to quantifying FCAS revenue. - Lack of clarity for consumers about how FCAS works - it's difficult to convince customers to invest additional money if they don't fully understand what they are investing in and the conditions on achieving a return on investment. - Other uses of VPPs (e.g., for spot price arbitrage or network benefits) do not require installation of new hardware, so consumers can still benefit from VPP participation without the cost, complexity and questionable value attached to FCAS participation under the Option 1 specification. **Accessing data from an existing revenue meter**: On the assumption that revenue meter manufacturers or electricity retailers are willing and able to facilitate cost-effective and compliant Option 1 data access to an aggregator such as Evergen, using revenue meter data still presents logistical barriers. To enable an existing residential site to participate, Evergen or a client VPP partner would need to determine the make and model of meter installed at the customer's site. For many existing customers, this may require a site visit, or else an arrangement with the customer's retailer to report the meter make and model to Evergen, after the appropriate data sharing permissions have been secured. Evergen would also need to maintain two separate API integrations per site (one for battery control, and one for meter data collection) and integrate data across both sources to deliver a solution. Lastly, this solution would introduce commercial complexity, with FCAS participation for a customer requiring some level of involvement from the customer, Evergen, the meter provider, the retailer, the battery/inverter hardware partner, and the system supplier. Given the logistic barriers to this approach, it is likely that FCAS participation of customers with existing DER would be unviable. Evergen would guide such customers towards the other value streams that come with VPP participation but do not require 50ms resolution data from the connection point. **New installations** The offerings of DER manufacturers are not built to deliver Option 1 FCAS capability, because customers do not presently require this. Residential battery uptake is still in the early adopter phase, and FCAS participation does not yet impact custom decisions compared to the value a battery-based DER provides to customers for reducing grid imports and environmental impact. Unless the value to the customer is sufficiently visible and high, such that customers will opt to demand a DER that is Option 1 FCAS capable, then DER manufacturers will have no reason to deliver this capability. Evergen has spoken to several battery/inverter manufacturers and their advice has been that the cost and complexity of modifying their hardware to do this is prohibitive - DER sales are not currently driven by FCAS capability even under Option 2, let alone the Option 1. To the extent that customers are interested in VPP participation on potential benefits, Evergen and DER manufacturers can offer this without participating in contingency FCAS markets, and Evergen already works with clients interested in securing VPP services that are not related to FCAS. One manufacturer indicated that while their hardware is capable of monitoring at 50ms	

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		resolution, they would be faced with the additional cost of delivering monitoring at the connection point and modifying the data transport, cloud servers and storage capabilities to handle the much higher volumes of data. It is unlikely going forward that many DER manufacturers will modify their own offerings to deliver Option 1 FCAS compliance in the short term. For new installations, Option 1 compliance going forward would therefore require either the installation of dedicated Option 1 FCAS monitoring equipment at additional cost to consumers, or else for the DER installer to note the revenue meter make and model, and for an aggregator such as Evergen to develop cost-effective data access via the revenue meter manufacturer. In addition to the cost burden of consumers, implementing numerous devices is simply poor value for money. There are currently 2.6 million households in Australia with rooftop solar. Many of these will acquire batteries. Implementing additional costly devices represents a multi-million dollar investment across households for dubious benefit to either the energy market or DER owners. If we regard DER as a significant pillar in our future energy network, we should avoid unnecessary costs. ... Being hardware agnostic, Evergen itself is well-positioned to form VPPs and meet requirements whether Option 1 or Option 2. We are working with hardware vendors who can meet the 1-s telemetry requirement for fast FCAS under Option 2, but there are certainly still many companies who do not yet offer even 1-s telemetry. Developing 1-s telemetry capability was an investment for the companies that are now capable of this. The limiting factor for Evergen to deliver a VPP that is Option 1 compatible is the measurement and monitoring capabilities of existing installations, and of our hardware partners into the future. As discussed previously, information we have received from battery and inverter vendors, and advice from a utility meter vendor is that they cannot deliver Option 1 capability now or in the near future. Considering 3rd party, non-utility-meter providers of monitoring/control hardware that would be capable of Option 1, to our knowledge there is only one consumer device able to meet Option 1 requirements. We are aware that hardware and installation costs for these devices can be between $800 - $1,700. Of the 100,000+ residential PV-battery systems currently operating in Australia, only a small fraction include these devices, so the cost to pursue a hardware solution for enabling these existing systems is likely prohibitive and likely not possible without significant disruption to consumers, cost, and risk. Option 1 would prevent most existing DER from participating. Other providers of similar equipment may provide less expensive hardware, but likely lack 50ms measurement resolution. Using providers such as these would theoretically allow participation in the slow and delayed markets, but not the fast market, significantly reducing the benefit to VPPs and their constituent end-users from undertaking to provide contingency FCAS. **Hydro Tasmania** There is a material difference in terms of the implementation costs for data at a resolution of 50ms vs. 1s. As 1s data has been widely adopted by the battery manufacturers there is only a	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		marginal increase for batteries to participate in the VPP FCAS markets. In contrast, the initial cost of a 50ms high speed data logger installed per region is over $10k. To find a lower cost solution, we contacted a number of 3rd party meter manufacturers in Asia and were informed that 50ms isn't a standard resolution in many countries. Developing one for Australia would require development work and a minimum procurement volume, limiting the ability to lower the high cost. Hydro Tasmania believes it would be more practical and cost effective in the long term to simply use the invertor's internal data logger as the primary source for contingency FCAS evaluation, particularly as 100ms is already feasible. **Intellihub** **By the end of this year, every new Intellihub smart meter installed, including at residential sites, will be capable of providing measurement facilities for FCAS fast raise and lower services by default.** Advanced digital meters, or smart meters, are the most cost efficient, reliable, and fit-for-purpose solution to enable VPPs consisting of small-scale DER to participate in the contingency FCAS markets. Use of the revenue meter for FCAS measurements both avoids the need for a costly additional meter and avoids the need for complex arrangements to infer the behaviour of small-scale DER under a contingency event. Intellihub will be introducing the next generation of smart meter later this year to be used across all standard residential and small-business installations. One of the key benefits of this new smart meter is that it is capable of the high-speed measurements required for FCAS validation. While detailed test results are not yet available, we are confident that the new meter will either meet or come very close to meeting the measurement requirements under the current MASS. ... Given the significant cost advantages of using the residential revenue meter to provide FCAS measurement, we believe there is a strong case for setting the measurement requirements at the level which upcoming revenue meters can meet. We believe that the benefits in removing the barriers liming VPPs from participating in FCAS markets will outweighed by any minor trade-off in measurement capability. We propose delaying the finalisation of the DER MASS measurement requirements until the capabilities of upcoming revenue meters are better understood. We expect the lab testing activity will be completed in a matter of months. ... If the revenue meter is used to capture FCAS measurement data as per our proposal, there will be negligible implementation cost to the VPP. **Karit** Option 1 inflicts significant costs on the addition of new sites to a VPP that desires to participate in the ancillary service markets, when a large proportion of those sites are residential or small commercial. The contribution of value from each site does not justify the investment if option 1 is selected. Whilst option 2 is preferable because it enables more sites to participate, a solution that uses a shared infrastructure, such as a revenue meter, for	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		measurement and validation (as is the case with the wholesale market) would be even more cost effective. **Landis + Gyr** Landis + Gyr has taken the view that the verification and validation of a market response must be undertaken by the electricity meter at the Point of Connection. The electricity meter is a ubiquitous device that is designed and constructed as a cost-effective, precision certified measuring instrument. The communications and data processing infrastructure that has been implemented has proven to be to be secure and robust. The addition of MASS data collection and processing to this infrastructure whilst not free would be a small incremental cost when compared to a new alternate system. The market has seen a similar change with the introduction of 5-minute data to the whole market. The cost associated with this change was largely confined to the back-office data storage and processing. There was minimal additional cost to the measuring and data collection system. A similar outcome is expected with the capture of MASS data. **Members Energy** • We are still determining accurate metering costs with our partners, but contend that, given the suggested one to two year delay before mandating this level of accuracy, technology costs and communication requirements can be managed. **Mondo** Mondo considers that 50ms data resolution is cost prohibitive to customers and, if mandated, would be a barrier to DER participation in Contingency FCAS markets. In addition to the cost of the HSM, the requirement could limit participation because some makes of battery and solar systems do not have the ability to provide data at this resolution. Storage used to capture data would also be more expensive or would have much shorter useful life and require more frequent replacement. **PAP** PAP in Australia currently addresses the C&I sectors where the Renewable Energy generation generally starts at 100kW up to 5MW. Therefore, our submission comes from this background. In the C&I space, where the generation starts at 100kW, the cost to implement meters is negligible. These meters will obvious cost more, but as a percentage of the solution cost, it is manageable. Coming from a residential perspective, the relatively cost to comply can be quite high. However, by combining residential loads in a VPP and using eleXsys as part of the solution at an appropriate place on the feeder circuit, it is also manageable. See high level graphic below:	

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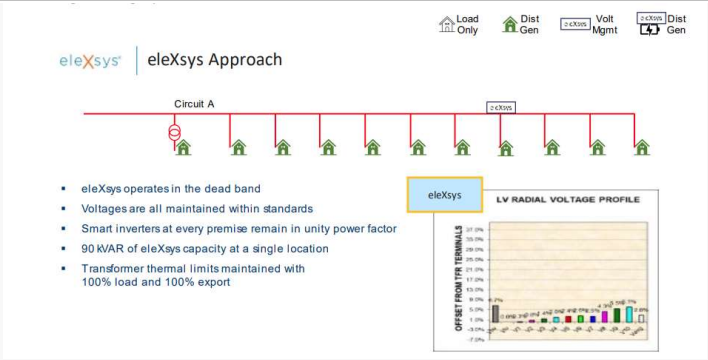

Reposit Power

MASS v6 compliant metering has a marginal cost of no more than $120/NMI

MASS compliant metering is cost-effective for all scales of generation and load (**Section 2**).

...

Option 1 metering results in a more efficient procurement of Fast FCAS. The additional error created by Option 2 metering must be accommodated with discounting. This is inefficient at a cost of $48/DER unit/year (**Section 4.2.3**).

Option 1 metering is the only equitable option presented. Option 2 metering results in up to $60/DER unit/year being unnecessarily transferred from consumers to Option 2 metered participants. This wealth transfer does not occur with Option 1 metering (**Section 4.2.4**).

Option 1 metering is more efficient when the long term interests of consumers are considered. Option 2 metering results in a long-term loss of at least $60,000/MW as a result of meter replacement due to the definition of future services (**Section 4.3**).

...

In 2016 Reposit was delivering fully MASS v6 compliant metering at $97/phase. This is not the marginal cost of MASS compliance, but the cost of the entire meter/phase. In 2021 Reposit delivers better than MASS v6 compliant metering at a marginal cost of $25/phase. That is, the marginal cost of MASS v6 compliant metering over 1s, low accuracy/precision metering is $25/phase. Reposit has demonstrated technology to bring this marginal cost down to $15/phase (**Section 2.1**).

It is extremely conservative to state that fully MASS v6 compliant metering can be delivered to any residential connection point in the NEM for a lifetime marginal cost of less than $120 (**Section 2**).

2 Metering Cost Analysis

MASS-compliant metering is cost-effective for deployment on residential connection points today. This has been the case for at least five years. It is the result of cost-reductions in electrical quantity measurement facilitated by low-cost, high-speed analogue to digital

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		converters (ADCs) and embedded computing. All of Reposit's installations have included MASS-compliant metering since 2016. Reposit operates the largest in-market FCAS participating VPP (not under trial or demonstration conditions). This is a result of investments made into research and development in 2013-2015 in the area of MASS-compliant metering. The Fast FCAS metering requirements of the MASS have not changed since at least 2012 and this has provided ample time for VPP aggregators to make the required investments. Reposit is able to meter up to 3 grid phases at the 20Hz metering requirement, as well as additional metering for subcircuits or legacy AC solar with lesser requirements, on a single RS485 bus. The fact that Reposit has been able to do this sustainably for over 5 years makes it very clear that such metering is technologically possible, commercially viable and cost effective. Given that MASS-compliant metering is already proven to be commercially viable, Reposit asserts that it is a key enabler of DER and the wider transition to renewables. Furthermore it would seem that the metering time-resolution change proposed in Option 2 would penalise the metering innovations of Reposit and others made up to this point. **2.1 Marginal cost of HSM is small** Reposit's first generation, MASS-compliant metering cost $97/phase. This metering was designed in 2015. Reposit has continued to invest in MASS-compliant metering and now has a cost of not more than $25/phase. This cost includes all metering ICs, supporting components, PCB, manufacturing, high-accuracy CTs and calibration. The cost-down design work was done by 1.5 FTE hardware/electronic engineers and 1 FTE firmware engineer. The total metering development costs at Reposit over the last 8 years are approximately $340,000, or $43,000/year. To a consumer, $25 per phase adds no more than $75 to a solar and battery system which typically costs between $5,640 - $19,440 or 1.3% - 0.39% as of February 2021[131]. There are no additional installation requirements given that both Option 1 and Option 2 require connection point metering, and MASS-compliant metering is virtually physically identical to non-MASS-compliant metering. Reposit cannot comment on the cost of competitor metering and so for additional conservatism has assumed that it is zero cost. This is clearly inaccurate, but it is the best possible case for the combined cost of the required Option 2 grid metering and the Option 2 device-level (device internal) FCAS metering. In the interests of conservatism, Reposit assumes that all NMIs attract a $120 lifetime additional cost for Option 1 (MASS-compliant) metering over Option 2 metering. This includes all hardware and data costs. This is an overestimation of between 4.8x and 1.6x depending on the proportion of three-phase residences in the NEM. **2.1.1 Fast frequency measurement costs are low and falling** Reposit continues to seek lower-cost MASS-compliant metering. Development efforts have identified the use of a "Zero Cross Detect" (ZCD) mechanism as being able to deliver MASS-compliant frequency measurement. This approach implements a circuit that simply emits a signal every time the sine wave of the reference signal crosses zero. In the case of grid metering	

[131] https://www.solarchoice.net.au/blog/battery-storage-price

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<tr><th>NO.</th><th>CONSULTED PERSON</th><th>ISSUE</th><th>AEMO RESPONSE</th></tr>
<tr><td></td><td></td><td>this refers to the AC sine wave. Many off-the-shelf, low cost metering integrated circuits (ICs) already contain such functionality and can emit the signal to a low cost PIC Microcontroller for further processing. These ICs and PICs are both readily available from IC manufacturers such as Microchip and Analog Devices.

Reposit experimented with designing and implementing a native Zero Cross Detect circuit. This simple circuit was designed with nothing but capacitors, resistors, op amps and an oscillator. The total component cost of this circuit was $2.31. The bill of materials for this circuit is below:

<table>
<tr><th>Name</th><th>Value</th><th>Quantity</th><th>Cost (AUD)</th></tr>
<tr><td>Capacitor</td><td>100nF</td><td>15</td><td>0.00312 at 10k</td></tr>
<tr><td>Capacitor</td><td>10nF</td><td>5</td><td>0.01039 at 4k</td></tr>
<tr><td>Capacitor</td><td>4.7uF</td><td>10</td><td>0.00971 at 4K</td></tr>
<tr><td>Resistors</td><td>1M</td><td>3</td><td>0.00331 at 10k</td></tr>
<tr><td>Resistors</td><td>47k</td><td>6</td><td>0.03682 at 5k</td></tr>
<tr><td>Oscilator</td><td>10MHz</td><td>1</td><td>1.60426 at 1k</td></tr>
<tr><td>MCU</td><td>16 Bit MCU</td><td>1</td><td>4 /unit</td></tr>
<tr><td>Isolator</td><td>ISO7730FDW</td><td>1</td><td>1.57248 at 2k</td></tr>
<tr><td>op amps</td><td>LM321LV</td><td>3</td><td>0.09260 at 3k</td></tr>
</table>
Reposit projects that further development of this approach would result in MASS-compliant metering at no more than $15/phase.

This circuit has been verified under lab conditions with a reference frequency of 50Hz and the output observed using an oscilloscope. The results of this test can be seen in the annotated oscilloscope output below.</td><td></td></tr>
</table>

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		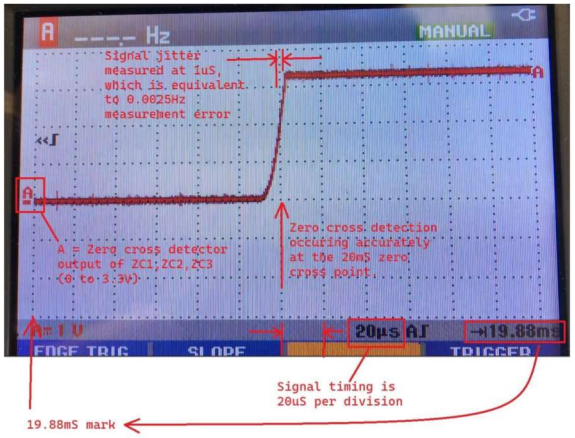	

Of note in this oscilloscope output is that this circuit delivers:

- Reliable zero cross detection at 20mS (the interval of zero crossings you would expect at 50 Hz - 1s / 50 Hz)
- Signal jitter at 1uS for 0.0025 Hz error - in line with the requirements of the MASS.

Similar circuits are well documented in electronics engineering literature, and are easily found via simple Google searches.

2.1.2 Fast energy measurement costs are low and falling

Whilst the MASS imposes tight requirements in terms of accuracy and precision of frequency measurements - "error of less than or equal to 0.01 Hz, and resolution of less than or equal to 0.0025 Hz"[132] - power requirements are notably less stringent and allow "error of less than or equal to 2% of the measurement range, and resolution of less than or equal to 0.2% of the measurement range". Power measurements that greatly exceed these requirements (even when coupled with low cost CTs) are available via a wide range of metering ICs including the low cost Microchip ATM90E36A[133] 3-phase SOC available for under $5[134].

Open source development kits or breakout boards can be found for a range of suitable ICs including the ATM90E36[135] , MCP39F511[136] and ADE7816[137] at costs of less than $65 for a full

[132] AEMO MASS v6 - item 3.6.vi, Available: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-co nsultations/2020/primary-freq-resp-norm-op-conditions/market-ancillary-services -specification---v60.pdf

[133] https://www.microchip.com/wwwproducts/en/atm90e36a

[134] https://www.digikey.com.au/products/en/integrated-circuits-ics/pmic-energy-meter ing/765?k=ATM90E36A

[135] https://www.tindie.com/products/whatnick/three-phase-energy-monitor-atm90e36 -featherwing/

[136] https://www.tindie.com/products/whatnick/mcp39f511-breakout/

[137] https://www.tindie.com/products/whatnick/ade7816-breakout/

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		development kit. It is worth noting that these development kits have not been developed for commercial deployment and that the economies of scale, cost engineering and design for manufacture would all contribute to dramatically lowering this cost. Low-cost, MASS-compliant power measurement is a trivial problem. Full MASS compliance for power and frequency can be delivered at not more than $15/phase in 2021. **2.2 HSM data costs are negligible** Reposit asserts that the data costs for HSM are negligible. Reposit does not dispute that the transfer and storage of 20Hz data 24/7 is costly. However there is no requirement under the MASS to stream 20Hz data 24/7. The data requirement is that the 6s prior and 60s after an FCAS fast event are captured and stored. As such it is entirely feasible to discard any high-speed data that does not meet this criteria and only transfer the high-speed data as required. All DER aggregators must have software to detect a contingency event in order to respond to it. This same process is easily leveraged to gather the required high-speed data for a contingency event, and discard all other data. By way of comparison, Reposit uses 5 s data as the standard operational data collection, transfer and storage interval. This equates to approximately 17,280 data points per device per day or 518,400 per month. 66s at 20Hz for three phases is 3,960 samples per FCAS fast event per device. Since the introduction of the Primary Frequency Response[138] Rule Change Reposit is observing approximately two Fast FCAS events per month or a total of 7,920 samples per month. This means that the overhead of 20Hz FCAS data adds 0.02% to our overall data transfer and storage. A naive (capture and transfer everything 24/7) approach to handling 1Hz data creates approximately 2,592,000 data points per month. This is over 300 times higher than the simple approach to high-speed data described above. Reposit suggests that it is not the frequency of the data that creates cost, but a lack of sophistication in data management. Strong data management is a key competitive advantage for a VPP aggregator. **Rheem & CET** Our FCAS compliant power metering solutions have a manufactured cost of sub $200 (AUD) and as a result we do not see that there are impediments to maintaining the current specifications to measure power flow and local frequency at intervals of 50ms or less at every site NMI - i.e. at the site connection point. We contend that the costs and issues in NOT doing NMI connection point metering are far greater – see further below … We believe that the technological challenges associated with multiple agents controlling various DER at a single site are currently too significant to be overcome in the short term. The most cost effective and robust contingency FCAS solution currently is orchestration of DER at a site with connection point metering. **Shell Energy** Option 1, which would see all such services require HSM (≤50ms) required for fast FCAS less than 1MW, would all but remove such VPP services from the market given the costs involved in installing such metering configurations. While the cost and installation of the meter alone	

[138] https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response

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		would amount to around $15,000, there are additional costs required to handle the additional data and communications. In all likelihood, the total cost would be more like $20,000-$30,000, which for installations of that size would be a barrier to entry. Should AEMO reconsider a faster measurement requirement, we note that a metering requirement of 200ms would be substantially cheaper than a 50ms metering installation. **ShineHub** Currently, our VPP is capturing data in 1s intervals. Keeping the data requirement at this level will be no issue and we can continue to offer our current VPP products to the market. However, moving to 50ms would require two main things: • Upgrade to our software infrastructure o Initial development cost (estimated at an additional $85,000) o Ongoing software maintenance (estimated at an additional $135,000 per year) o Additional data and server costs (estimated at an additional $27,000 per year) • Ability to collect that data on-site o We aren't product manufacturers so we don't know the exact cost here. However, it's fair to say that this will add significant development cost which will make the batteries more expensive to the end user – potentially outweighing the benefits of joining a VPP. **Social Energy** Consider a VPP of 1MW consisting of 250 battery inverter systems. Each site will require a replacement SCADA capable of 50ms data gathering. The equipment costs and man-hours will amount to hundreds of dollars each per-site. There is also additional administrative overhead in contacting customers to arrange the updates as well as training costs for the engineers for installing the new equipment. In total it is reasonable to assume costs of >$120k per MW. Whatever server-side infrastructure must be scaled up to handle 20 times the data throughput compared to 1s resolution data. Usually, this kind of cost scales linearly on public cloud providers and data storage represents a large proportion of cost for VPP operators. **Solar Analytics** Solar Analytics has an existing option to capture data at 1s resolution as outlined in option 2. Meeting a resolution of ≤50ms at low cost of deployment could not be achieved with our existing hardware and would need to be developed either in-house or by partnering with another provider. The costs are not currently known, but the uncertainty and the effort of such a development/integration would almost certainly cause Solar Analytics not to pursue FCAS markets in our offering. We anticipate that providing a solution for 1 system per 5MW will also be expensive, but manageable if it is only for 1 system per 5MW. **Sonnen** … remaining with the existing MASS for measurement will force us to withdraw from some, if not all of the contingency FCAS markets due to the cost related to upgrading existing installations and modifying existing battery models. **SwitchDin**	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		A current solution capable of 50mS measurement is likely to add around $400-500 to each site/measurement point in hardware alone compared to 1s measurement, increasing to over $600 when installation is taken into account. We expect that these costs would decrease significantly due to economy of scale if this level of resolution was required at every measurement point for FCAS participation. **Tesla** Our preliminary estimates of the cost of HSM is: ~$10-15k. This can be broken down as follows: - $5,000 - $10,000 cost of utility grade meter (depending on type) - $2500 cost of installation - $2500 cost of additional works (non-standard installation requiring space for the metering in a new subboard, as well as independent network connection and setup) **VIOTAS** VIOTAS proprietary VIO Link metering and control technology has, as standard, the capability to measure both frequency and active power with a 20ms resolution (which is in excess of the minimum resolution required in the MASS for the provision of Fast Contingency services, however VIOTAS anticipate long term this requirement may change). This system is designed and developed completely in-house to enable the provision of high speed ancillary services and the validation of the resulting response, and has high speed communications capability back to VIOTAS central systems. VIOTAS is developing a new system which will enable increased viability of providing ancillary services with progressively smaller controllable loads. This product will retain the ability for high resolution data capture and communications. Therefore, VIOTAS believes the cost differential between 50ms and 1s data resolution does not constitute a sufficiently high barrier to the participation of small sites.	
5.	Various	**Each Option's impact on competition in Contingency FCAS markets** **AGL** … Option 2 is likely to result in more competition in contingency FCAS markets, as it would enable ongoing VPP participation once the AEMO Demonstrations conclude. Option 1 could be construed as presenting a barrier to entry, given the very low number of vendors supplying suitable hardware, and the prohibitively high costs of meeting this level of measurement requirement. **CPUE** We are supportive of amending the measurement requirements in line with the learnings from AEMO's VPP demonstration. The proposed amendments will make it economical for a larger number of small-scale DER systems to participate in the FCAS market. This will increase AEMO's FCAS pool and consequently, promote competition in delivering the required FCAS in the NEM. **Delta Electricity** Competition will be more effective when there is greater clarity of purpose in the design specification, consistency in data metrology, effectiveness in performance monitoring of like-	A large proportion of Consulted Persons concluded that Option 2 would lead to greater competition in the Contingency FCAS markets, as summarised in Table 2: **Table 2 Which Option would lead to greater competition in Contingency FCAS markets?**

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		for-like information improving the confidence of the Operator that more/less supply of specific services improves frequency control objectives **Empower Energy** The only incentive to change fast FCAS market access in this time of frequency response regulation change - prior to a holistic approach to frequency regulation being finalised - may be to provide a certain customer and technology segment with access to markets that are intrinsically more financially lucrative. If so: • This is not an opportunity afforded to any other asset class through any other process. • This may create market opportunities for the customers so affected, but creates value challenges for all participants already competing under the current MASS (whether DER or not), • This decreases primary contingency frequency response market performance by failing to incentivise better performance. The above points would seem to contravene the AEMC's market objectives. … **Does the approach in the VPP Trial make it easier to bring DER FCAS access to market?** Not for everyone, unfortunately. It is understandable that technology vendors may 'hear' 1Hz and assume that in being less than 10Hz or 20Hz, that this trial makes their products easier to design, that this should reduce costs and increase access to FCAS markets, both of which and make their products easier to sell. But check metering and injection testing costs are not trivial, and generally are not carried by technology manufacturers. Nor are technology vendors consistently involved in retail energy customer acquisition efforts. Imagine an energy retailer trying to pull together a VPP offering. It'd be great if all VPPs were procured as per the SA government's trial - a large, firm order from a single government vendor, a monolithic technology offering with a well-resourced and highly proactive technology vendor, and a single retailer procured as part of the above. There's an enviable certainty around this approach that's very useful in planning retail business activities. However favourable or ideal this scenario, whilst there are many VPPs active in Australia none have been procured similarly. In many cases customers are acquired one by one as per typical retail energy customer acquisition campaigns. In many cases, retailers are gentailers already have MASS-compliant check metering infrastructure including client and server asset relationships, whole-of-system management processes and the like. These installations are expensive - up to $20k per measurement node. In many cases, retailers seeking a maximum addressable market of customers will initially wish to acquire customers with any DER assets having latent value in FCAS markets. These combinations are infinite in number, particularly when considering hybrid inverters with DC-	**Option 1**: Reposit Power, Rheem & CET **Option 2**: AGL, CPUE, EQ, Evergen, Karit, Members Energy, Mondo, ShineHub, Social Energy, Solar Analytics **Both**: Hydro Tasmania **Other**: Delta Electricity, Empower Energy, Intellihub, Landis + Gyr, SwitchDin, VIOTAS A large proportion of Consulted Persons appear to have equated the idea of 'competition' with greater participation in the Contingency FCAS markets and concluded that Option 2 would lead to greater competition. In its submission, Delta Electricity stated: > Competition will be more effective when there is greater clarity of purpose in the design specification, consistency in data metrology, effectiveness in performance monitoring of like-for-like information improving the confidence of the Operator that more/less supply of specific services improves frequency control objectives AEMO agrees with this statement by Delta Electricity. Competition is not just a matter of creating an environment where many providers can enter the FCAS market to bring market prices down. Competition will only be effective if AEMO purchases services that are equivalent to each other in quality and capable of measurement in a way that does not distort

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		coupled batteries or behind-the-meter aggregated response (e.g. from resistive element water heaters, BESS, etc). Does each combination need to be injection tested? This doesn't scale. An easier solution for a given retailer would then be to work with select customers with specific technology combinations and to support those. Again, this also contravenes market objectives - quite clearly. We need good, robust competition with respect to new DER assets to raise consumer awareness, promote good practices in supply and lower costs. We need to procure as much frequency regulation services as possible for grid stability and resilience. With respect to DER and despite good intent, the current Option proposal has the potential to limit this much. This neither scales to the future. The current rewrite of AS/NZS 4777 is written in part to address the potential of grid-connected, which is massive and positive for our grid. In a developed market over 95% - and closer to 99% - of EVSEs [electricity vehicle supply equipment] will be AC, with ISO 15118-20 supporting frequency response from AC connections. The frequency response characteristic of a given EV, particularly an AC-connected EV concerns: • Static and dynamic energy storage system characteristics, • Battery management system characteristics, • On-board charger characteristics, and • EVSE characteristics. In short, there are three key components in the car affecting response, in addition to the characteristics of the asset the car is plugged into. Per the Option presented, does each combination need to be injection tested in order to characterise the response and permit access to fast contingency FCAS markets? That's clearly not workable. Not least as it'd significantly hamper the potential of a very lucrative, cost-effective means of stabilising the grid. And in doing so, both with reference to limiting access to a strategic, low-cost alternative and again in preferring certain technologies over others, it again contravenes market objectives. **EQ** EQ suggests the proposed VPP option is more likely to generate additional participants and consequently more competition in the Contingency FCAS markets compared to not adopting the VPP proposal. **Evergen** Option 2 will result in more competition in the contingency FCAS markets because it will most readily allow VPPs comprising small-scale DER to participate. Option 1 represents a significant barrier to entry, and means that the majority of existing DER would be ineligible to participate without upgrades. … What Option 2 will do is facilitate new entrants to the FCAS market. In the longer term, this can only have a positive impact on the markets by driving competition and lower prices. **Hydro Tasmania**	AEMO's understanding of how much FCAS is required at all times and how much delivered FCAS, regardless of source, has actually met AEMO's requirement. See also the discussion on integrity of fast FCAS under section 4.1.2.

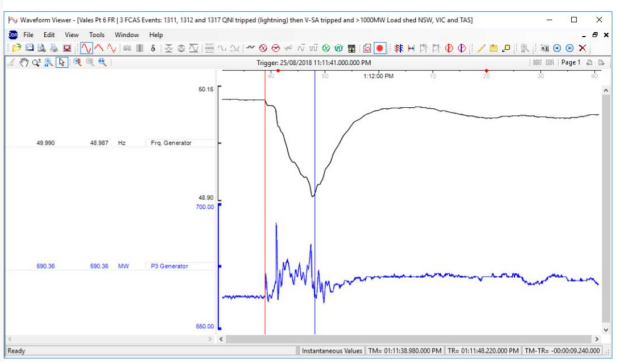
NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Hydro Tasmania believes that both options, in so far as they drive wider adoption of VPP, will facilitate greater competition in the contingency FCAS markets. The objective of the proposed VPP FCAS measurement approach should be independent from the market competition. **Intellihub** Both options presented create barriers to competition. If the current MASS is retained, the cost and impracticality of installing secondary HSM will stifle competition, as the addressable market will be too small to support significant competition. If the VPP demonstration measurement requirements are adopted, significant barriers for VPPs wishing to use a mix of technologies and vendors will be introduced, again artificially restraining the market size and competition. There are strong indications that the 'bring your own battery' VPP model will be attractive for both the VPP operator and energy consumers. Current VPP fleets which consist of 100% a single model of device are common in the demonstration phase, however any long term framework will need to support VPPs having a diverse mix of makes / models of equipment. Under the proposed option 2, where each individual DER variant is required to be tested and characterised, building a 'bring your own battery' style VPP would be prohibitively expensive and therefore competition will be supressed. Market distortion may also occur, with single vendor VPPs becoming dominant, and those DER owners not having a system from a specific vendor find themselves locked out and missing out on value. We believe that our proposed alternate option will result in healthy competition in the contingency FCAS markets. **Karit** Karit believes that option 1 will reduce the amount of potential competition by imposing a high cost of entry as opposed to option 2 which is less onerous on solutions that operate with storage assets in residential and small commercial sites. However as previously stated, an option such as the one discussed on the consultation call that utilises an upgraded revenue meter, would provide a more cost effective entry for a broader range of participants. **Landis + Gyr** To create a competitive FCAS market, a large deployment of devices is required to be installed behind "the meter". Landis + Gyr believes that responding to an FCAS event should be separated from settlement of the event. This will allow a large number of devices that detect and act upon an FCAS event to participate as they are not burdened with measurements and communication requirements associated with a metering system. The other aspect is the measurement interval. Whilst Landis + Gyr believes 50ms is achievable, landing on 100ms for instance would allow for a range of devices to operate within the same metering framework. … **Measurement Location** The market is looking for a response over a network area and as such the measurement must take place at the point of connection. If this not done and settlement is done at the appliance	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		then there may be perverse outcomes when one appliance behind the point of connection responds in a positive manner to the event whilst another appliance responds in a negative manner which negates the response or could even be worse. **Members Energy** We consider option 1 will result in less competition in the FCAS market, as the initial cost hurdle will drastically reduce the likelihood of new entrants to the market at the worst possible time. This is why our hybrid recommendation seeks to achieve the best of both worlds, with a lower cost requirement in the short term to encourage market participation while VPPs are still maturing. This to be followed in the medium term with a higher technology cost requirement, by which time the market will be more mature and the need for the increased technology cost can be absorbed by market participants as the size of VPPs grows. **Mondo** Option 2 will provide more competition in the provision of Contingency FCAS. We anticipate that FCAS capacity provided by VPPs will grow to become more significant over time. **Reposit Power** Option 2 will result in more Participants in Fast FCAS markets but less competition. Option 2's assumption of homogenous response across a DER "type" removes the key objects of competition between VPP providers in FCAS. They are: 1. Stable and reliable control of distributed energy storage sufficient to deliver a fast, sustained and linear response 2. Time synchronised response across large numbers of DER units 3. Efficient forecasting of energy available to a service a contingency event given DER unit current and future state 4. Efficient forecasting of energy available to a service a contingency event given uncontrolled loads at the connection point All of the competitive objects above are made irrelevant by Option 2. Option 2 removes this competition to the detriment of system security and the efficiency of Fast FCAS. DER unit response is not homogeneous within a type (**Sections 3.3.3.3 and 3.3.4.3**). Homogeneous response is the ideal, it is far from a given. Stronger competitors will be able to provide a more homogeneous response than weaker competitors. FCAS measurement and verification processes reward fast, sustained and stable responses from VPPs with the ability to submit higher bidding volumes. Because Option 2 assumes a homogeneous response, and introduces device-level metering, all VPP providers will simply offer the sum of their nameplates into Fast FCAS. This will be regardless of whether the whole summed nameplate capacity will act to support a fast contingency event when one arises. Option 2 providers are also advantaged during customer acquisition as a result of a lower initial cost of metering. Likewise they are advantaged through the avoidance of having to manage and process per NMI 20Hz data to inform AEMO measurement and verification, as well as system security improvement processes. Additionally they do not need to find cost-reductions on advanced metering as they are largely exempted from it. Option 2 also heavily advantages VPP providers that are connected with a vertically integrated controller+battery+inverter manufacturer. This is because the Option 2 requirements to type	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		test and install "5MW meters" are much more onerous for a commercial entity that has many "types" of DER. This penalises the aggregation of different "types" of DER within a single commercial entity. This will act as a strong barrier against customers switching from a VPP provider which is discrete from the manufacturer of their DER hardware. Option 1 has none of these competitive issues and has no substantial barriers to entry (**Section 2**) or customer switching. **Rheem & CET** We believe that 2.3.1 [of the Issues Paper] Option 1 with connection point metering will result in far more competition in the DER FCAS market for the reasons that we have detailed in our responses to previous questions above. The one major caveat to this position is that installations of "closed loop" DER assets cannot continue to be allowed. DER assets that do not allow local, on site, standards based control access effectively excludes their participation in mixed DER sites under orchestration of a local HEMS site gateway (e.g. IEEE2030.5 complaint). If installation of such products continues, asset owners will be limited in their ability to participate in the future energy market, and the reliability of a grid response such as Contingency FCAS will be put further at risk. **ShineHub** Option 1 will significantly lower competition in the market because: • Few manufacturers will be able to deliver 50ms data response from the product side. Those that will, will be charging a premium for their products which prevents customers from adopting them in the first place. • With 50ms data requirement, VPP operators will be required to invest more heavily in data management and software infrastructure which will essentially require heavy investment to get underway. This would limit the VPP operators to the large wellfunded companies, and prevent the smaller, more start-up style companies from participating and innovating. **Social Energy** Option two will reduce barriers to entry for VPP participation in the Contingency FCAS markets which will increase competition for providing those services. **Solar Analytics** Option 2 will result in more competition, as outlined in response to Q1&2.[139] **SwitchDin** Requiring VPPs to be registered as either a proportional service or a switched service will limit some devices to only one VPP type. This means that achieving scale (multiple MW) within a single region will become more difficult. As an example, Tesla's API currently only includes provision for proportional response for FCAS. Other devices, including controllable loads, may only be able to implement a switching response. This may lead to increased competition for switched services but a lack of competition in the proportional market. **VIOTAS**	

[139] See the extract in section 4.2.1.

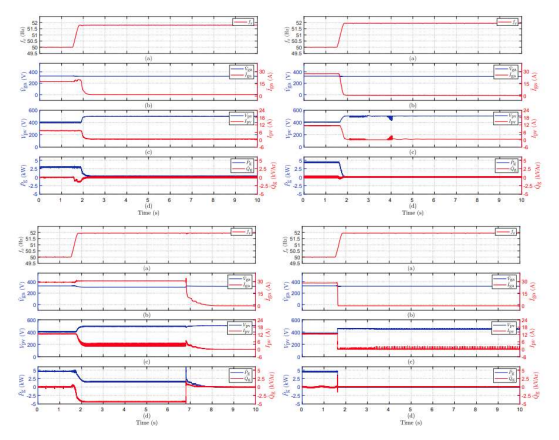
<table>
<tr><th>NO.</th><th>CONSULTED PERSON</th><th>ISSUE</th><th>AEMO RESPONSE</th></tr>
<tr><td></td><td></td><td>Any benefit associated with implementing Option 2 in terms of enabling additional participants to participate in providing FCAS (and the associated potential increases in competition), needs to be carefully balanced against any potential system reliability implications of reducing the stringency of the technical requirements associated with providing the services, in particular the Fast Contingency FCAS. In addition, creating multiple measurement / verification standards for different participants providing the same service risks creating a market distortion.</td><td></td></tr>
<tr><td>6.</td><td>Various</td><td>Technical risks associated with Option 2.
AGL
In the absence of high-speed data (measured at 20ms or 50ms), it can be difficult to identify when a technical issue is occurring in a particular site's frequency response provision. We also acknowledge that as more sites join VPPs, this concern grows.
We consider that with the current levels of DER in the market, this issue can be effectively managed in two ways.
Firstly, the MASS could require participants to undertake periodic testing. Participants in the VPP Demonstrations were required to conduct and pass step tests before being allowed to provide contingency FCAS. AEMO could mandate that relevant tests be conducted at biennial intervals or when significant changes are made to a system, such as firmware upgrades.
Secondly, the 1MW threshold AEMO proposes to apply, described on page 13 of the Issues Paper, provides an appropriate safeguard for the growing segment of C&I connections joining VPPs. If concern regarding this threshold increases in future, AEMO can revisit the MASS and potentially revise the threshold down if necessary.
CPUE
As the VPP trial has demonstrated that lower-resolution (= 1s) data is sufficient to prove FCAS participation of VPP assets without impacting system security, we consider lower resolution data is sufficient to reduce unnecessary costs to consumers.
Delta Electricity
Electrical response during large contingency events happens in cycle-time and 1s scans will miss important activity particularly where it is monitoring delivery from new technologies capable of acting much faster than 1s. Reducing the scan times is going in the opposite direction to what is required, presently, and certainly in the future as and when system inertia reduces.
Lack of coordination and separation of performance between participants with faster recordings and, of more relevance to frequency control objectives, faster controllers, from those with controllers relying on 1s sampled information whose units may be varying in uncertain ways between each sample point, unknown to the participant's controller and to AEMO, could affect the overall steadiness and response of frequency and, due the nature of the accepted low resolution data, not be identifiable as the cause of unsteadiness in both transient and steady state conditions.
…
The permission for participants to use 1s data will limit the capability of AEMO or any other organisation to analyse large contingency events that contain great variability.</td><td>The main risks of adopting Option 2 identified in submissions are as follows:
<table><tr><th>Risk</th><th>Submission</th></tr><tr><td>Need HSM to identify risks.</td><td>AGL, Delta Electricity</td></tr><tr><td>Quality assurance of measurement data.</td><td>Intellihub, Karit,
Rheem & CET, VIOTAS</td></tr><tr><td>Time to develop and implement data collection and processing systems.</td><td>Landis + Gyr</td></tr><tr><td>Diminish power system security</td><td>PAP, Reposit Power,
VIOTAS</td></tr><tr><td>No homogeneity of response by DER inverters.</td><td>Reposit Power, UNSW</td></tr><tr><td>One HSM per every aggregated capacity of 5 MW creates a single point of failure</td><td>Solar Analytics,
Social Energy</td></tr></table>
Both Members Energy and Mondo commented that the size of DER capable of providing FCAS today is too small a risk to be concerned about, but its growth should be monitored, whereas Reposit Power cites ARENA & CSIRO's</td></tr>
</table>

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		The chart below is 70 s of frequency and power traces during 25 August 2018 separation of NSW and Victoria systems from Queensland and South Australia. This data was captured in NSW at a 20ms sampling rate.  Observations: • The red and blue cursors are 9.24s apart • The frequency decline is non-linear but in 1s sampling, this detail would be lost • The MW variations and rises and falls are regular and as large as 100MW in 0.3s. Such variations may not be captured by 1s data sampling particularly when examining fast responding frequency services • Controllers that only assess the frequency every second are also probably less responsive to all variations in frequency (but actually for computerised controllers this might be common and perhaps is preferred to smooth the overall response) **Evergen** At the current scale of DER participation in the FCAS market, the potential negative impact of lower resolution frequency support on the network is extremely small. There will be a tipping point, at some time in the future, where reliance on DER is higher and the impact of possible DER inadequacies is greater. There is an expectation that the market will change in tandem with the rise of renewables and DER. The current single operator paradigm is likely to shift into decentralised energy systems (and possibly markets) and DNSPs are likely to take on increasing operational responsibility for managing DER, the so-called DSO (Distribution System Operator) role. There is a risk that some FCAS providers will be unable to supply suitable frequency control at reasonable prices in this DSO-driven future. This risk can be mitigated by the introduction of new ancillary services as the network evolves, providing investment certainty to hardware manufacturers and customers. The definition of new ancillary services designed to support a DSO-managed decentralised network is not currently within the remit of AEMO but relies on	projections that this growth will reach critical levels within the next 5 years. On the other hand, VIOTAS was concerned about the impact of locking in decreased functionality for DER. AEMO considers that the technical risks may be less impactful on the power system now due to the current capacity of DER capable of providing FCAS, however, more DER are *connecting* to the power system, and AEMO must set the requirements to minimise any risks in light of this increase. As the participation of DER in the FCAS markets increases and the power system becomes reliant on the Fast FCAS response from DER to arrest a fall or rise in power system frequency following a *contingency event*, it is critical for AEMO to be able to reliably verify the response from DER and equally important that there are no unexpected responses from DER inverters when they are participating in the FCAS markets. For more details, see also section 4.1.2.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		the work of the ESB defining the post-2025 market and the AEMC managing current and future rule change requests. We believe that successful qualification and participation in the AEMO VPP trial using relatively small and relatively inexpensive household batteries demonstrates that fleets of DER can meet the technical requirements and standards required to be a reliable component of the energy system. As rule changes such as 5MS and others are adopted, we believe this will become more valuable for AEMO and the energy system as a whole. **Hydro Tasmania** As mentioned above, Option 2 provides a good benchmark for exploring the other options, but AEMO should not be limited by this option. Hydro Tasmania believes that as VPP is still a nascent in the FCAS markets, with limited global references, its initial measurement requirements need to be reasonably conservative and avoid over committing participants to specific, high-cost solutions. **Intellihub** **Measurement Quality Assurance** The proposed DER MASS does not consider quality assurance of the measurement data, in other words, how the accuracy of the measurement data is guaranteed over the lifetime of the DER installation. We believe that this issue warrants consideration. Currently Metering Providers, including Intellihub, have asset management plans and calibration sampling processes for their fleet of meters in place as required by chapter 7 of the NER. These plans are carefully designed, reviewed, and approved by AEMO to ensure the long-term accuracy of the data that underpins the NEM settlements process. The accuracy of meter fleets are monitored over their lifetime and replacements are automatically triggered if accuracy falls outside allowable limits. A considerable advantage of using revenue meters to capture measurement data for FCAS validation is that the long-term accuracy of these measurements are assured. This assurance comes for 'free' through these existing asset management plans. An additional benefit of the measurements being provided by the accredited Metering Provider, with no financial interest in how the VPP responded to a contingency event, is that an additional layer of probity and integrity is added to the ancillary services market. We recommend that AEMO consider how the long-term accuracy of FCAS measurement data will be assured. ... Assurance of measurement data quality. Assurance that the behaviour of all DER in a VPP matches the behaviour as during the frequency injection test. **Karit** The most significant material risk is the reliance on hardware devices, such as solar inverters, to act as points of measurement and validation. When the operating paradigm of the inverter was designed, the designers did not see this as a prime responsibility of the inverter. If AEMO maintains a list of acceptable inverters that are capable of delivering measurements at an acceptable level, then the test process could be simplified to validate the ability of the VPP to deliver the desired response outcomes. A register of MAS measurement and verification	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		capability of each inverter brand would also give each participant utilising that technology a baseline against which to deliver. **Landis + Gyr** **Implementation Time Frame** Whilst technical possible within the existing metering system infrastructure, time is required to develop and implement the required functionality in the metering devices together with the back-office data capture and processing systems. Clear and precise specifications are required which are considerate of the overall outcome that is sought. **Members Energy** Nothing beyond what is already being addressed in the VPP demonstration. We consider those risks are very manageable in the short to medium term, during which VPPs will not be large enough to increase this risk. **Mondo** VPPs will respond differently to large scale generation, however differences are unlikely to result in material risks over the short term. Mondo supports ongoing monitoring of VPP performance with periodic risk assessments as VPP capacity grows. We note that while VPPs do represent new risks that differ from the traditional large-scale generation, the changes are not only 'one way', the decentralised nature of VPPs brings with it advantages and technology that can provide mitigations to these risks. It will be important to monitor the change in risk as capacity of VPP systems grows. We also note that the techniques required for managing risk across a range of small systems will be different to those for single large assets, and statistical approaches may be more appropriate. **PAP** See item 1 in Appendix B. **Reposit Power** Option 2 metering will increasingly diminish the security of the NEM (Section 3.4). Materiality will increase to critical levels as more Option 2 DER is introduced into Fast FCAS markets. AEMO (Section 3.4.1), ENA and CSIRO (Section 4.5.1) reports suggest that this will occur within 5 years. **Rheem & CET** As outlined in our previous responses, we believe that the adoption of Option 2 (in conjunction with device level metering) would present a threat to the growth of, and effective orchestration of, mixed DER sites, and hence the effective provision of FCAS on sites with more than one form of active DER. We believe the risks and commercial implications of adopting Option 2 measurement requirements (interval and location) to be significant, adding cost to the consumer, technical complication and FCAS delivery risk. It will create a major impediment to the ubiquitous growth of mixed DER sites (whereas current 50ms interval metering will enhance mixed DER service delivery verification) and the participation of those sites in grid services such as FCAS.	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		We have shown there is no significant cost impediment to maintaining the current MASS for monitoring Power and Frequency at the site NMI. Further, we have detailed why it is an imperative that NET connection point metering be a requirement of MASS DER site participation in FCAS and why local, open standards based interfaces for control of all DER assets are required for the successful orchestration of sites with mixed DER assets. **ShineHub** We do not see any risk with Option 2. **Social Energy** By adding a single site that needs 50ms monitoring of power AEMO ends up with the worst of both worlds in terms of the benefits a VPP can bring over a standard large asset. VPPs are fault tolerant to local losses of supply and connectivity as well as other electrical faults in plant equipment. Requiring a single site to have 50ms metering of power means each VPP now has a single point of failure and the operators incur the cost of development, procurement, support & operation of 50ms class hardware which it is the point of option two to avoid. Simply not including the power flows in this requirement allows an operator to reduce this risk by seeking out more reliable sites to position their frequency meter which may not otherwise be participating in the VPP. There is no reason for the frequency measurement to be co-located with an inverter and residential broadband can be a limiting factor for single assets in a domestic VPP. It then becomes simpler and cheaper to add additional sites which increases fault tolerance further. **Solar Analytics** There is a risk of failure of any element of the 1 system per 5MW with high-speed monitoring. Failure of the inverter, battery, communications or monitor could impact how representative the system is. A mitigation of requiring high-speed monitoring on all systems (as per option 1) would be prohibitively expensive. Since the high-speed monitor is required only in the case of determining causes of under-delivery, a reasonable mitigation against failure of this system would be to require renewed frequency injection testing and/or fleet-wide response test in order to identify systematic errors. An alternative mitigation is to rely on 1s sample of accumulated energy rather than power, with the former containing much more information (as discussed in Q2 response). Alternatively, it may be sufficient to rely on appropriate penalties/payment claw-back to incentivise providers to identify and fix any issues. **UNSW** In order to mitigate technical risks under Option 2, AEMO should consider not only the number of VPP trials conducted, but also the number and different models of inverters that will be part of the future fleet of inverters participating in VPPs. This should include both the inverter model as well as the specific firmware and inverter settings that the inverter was tested under and confirming that the same firmware and parameters are used in the actual installation after commissioning.	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Based on our inverter bench-testing (See details in Section 2[140]), we have observed a broad range of responses from inverters to frequency and voltage variations. The following figures show a sample of four inverter responses to a frequency increase with a RoCoF of 10 Hz/s. In each case, the top figure shows the grid frequency[141], while the bottom figure shows the power[142].  If Option 2 is selected, it is critical to establish a detailed and comprehensive set of tests that the participating inverters will be validated against. We have found that a single test or a single frequency injection might not be fully representative of the inverter response and additional tests (e.g. Freqeuncy steps, RoCoF events, slow and fast frequency modulation tests, combined voltage and frequency tests) would help provide a more accurate picture of an inverter response. We would also recommend that, although the data for DERMASS is sampled at 50ms, the inverter response is captured at significantly higher resolution during inverter testing. **VIOTAS** As set out in our response to question 4[143], key risks associated with implementing the Option 2 measurement requirements include: ▪ 'Locking in' significant deployments of service capability with lower specification metering and control technology that is not best suited to providing increased response speeds for future services or to delivery assessment using scalars to remunerate providers based on actual response speeds;	

[140] Section 2 of the submission is titled: About UNSW's ARENA funded "Addressing Barriers to Efficient Renewable Integration" Project.
[141] The frequency is common for all tests.
[142] Instantaneous calculation of power is used in all our measurements and results.
[143] See extract in item 4 of Appendix B.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		▪ Actual service volumes delivered and measured by lower resolution data systems in accordance with relaxed verification requirements, may fall short of that which the system has paid a particular participant to provide; ▪ Intentional or unintentional response from other assets behind the same NMI may fully / partially negate the response measured at the controlled device. Additional details on these risks and their effective mitigation are included in the response to question 4.	
7.	Various	**Potential for Market Distortion caused by different Sampling Rates** **Delta Electricity** It won't impact on the market itself unless AEMO finds reasons with the lower resolution information to reduce services when, if better information was collected, the opposite may be obvious as being required. However, the market purpose to control frequency may be reduced in reliability if overall frequency control continues to be considered by the operator as being inadequate and frequency quality, continued to be considered a threat to system security. If power system security due to frequency quality remains a concern, particularly in events that can occur rapidly and interrupt interconnectors and disconnect customers, greater detail in the information is required, not less, to ensure the operator can adequately identify all causation. **Empower Energy** See item 1 in Appendix B. **Evergen** Given the current scope of VPP participation, any market distortion is negligible. FCAS providers who satisfy existing MASS requirements have the significant advantage of incumbency and will retain a large market share of the FCAS market for a long time to come. VPPs require sites with battery installations and customers willing to participate. Even under Option 2, it will be some time yet before VPPs can deliver FCAS in large enough volume for the possibility of market distortion to be credible. **EQ** EQ does not believe that this option will create market distortion or negatively impact the FCAS markets. Given that compliance is determined over 6s, EQ is unsure of the validity of needing 50ms data for any participant. **Intellihub** We believe a 1s sampling rate may be too slow to validate the response of each DER installation and may distort the FCAS market. **Karit** Without specific data to review both options operating in a parallel against the same installation, we are not able to make a comment. However as long as the system can adequately identify the occurrence of an event and that the registered device/s delivered an appropriate	Refer to information on error introduced with lower measurement time resolution under Section 4.1.2.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		and timely response, then the least cost option should be pursued to promote greater competition and participation in the service. **Landis + Gyr** Consideration needs to be taken on both the measurement period and the size of the DER device. Australia is leading the world in the deployment of small scale (household) solar energy systems and they are now a significant contributor to the energy market. Having a lower requirement for this market segment may indeed create market distortion or create risk in the FCAS market. **Members Energy** We contend the AEMO demonstration has shown that option 2 at the inverter is adequate for fast contingency markets for the present and near future. Our hybrid suggestion allows time for increased metering precision to be developed for future, larger VPPs, including with additional revenue stacks for demand response, etc, with the metering point remaining at the inverter. Our hybrid suggestion will not impact the existing FCAS markets detrimentally and will facilitate increased competition by allowing newer aggregator style market entrants to engage. We believe this will enhance the FCAS market, rather than 'distorting' it. **Mondo** We are not aware of any market distortions created by option 2, however ongoing monitoring should assess if option 2 is being 'gamed'. A particular area for monitoring should be assessing whether participants are opting for multiple Option 2 installations instead of establishing larger installations. **Reposit Power** The 1Hz sampling rate and the device level metering create unacceptable error bounds of 16-22% in Fast FCAS response (Section 3.4). AEMO will not diminish system security and will procure upwards of 4% additional Fast FCAS for every 120,000 Option 2 DER units enabled for Fast FCAS. This will result in an unnecessary wealth transfer from consumers of at least $9600/MW/year to Fast FCAS providers (Section 4.2.3). Additionally, consumers will subsidise only Option 2 metered DER VPPs at the rate of $12/year/Option 2 DER unit in the form of reduced metering costs. This results in a total wealth transfer of at least $60/year/Option 2 metered DER unit (Section 4.2.4). **Rheem & CET** As outlined elsewhere in this response (e.g. in our response to Q5[144]), we believe that the MASS should support NET metering and site wide orchestration of all DER seeking to participate in grid services for each DER FCAS implementation (per connection point NMI). The use of the current 50ms metering for Fast Contingency FCAS ensures enhanced verification and thus options for participation of mixed DER sites. From a consumer perspective, Rheem and CET are aware that any large scale adoption and control of DER assets will be based on both consumer reward for participation, and consumer assurance that their amenity will not be adversely impacted. Regardless of whether control and metering is conducted at either the site or device level, consumers will require smart DER	

[144] See extract in item 5 in Appendix B.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		assets that not only respond to control signals, but that are capable of opting in or out of events based on status knowledge (e.g. charge state, current kW, temperature etc). This will particularly be the case for active DER such as smart water heating and embedded battery storage. The development and deployment of smart assets such as these will become more and more prevalent, and a prerequisite is to ensure reliability of prediction and control as a grid asset. It is therefore an imperative that market rules support local two-way interaction with smart DER appliances, and that they not encumber ubiquitous appliances such as water heating with additional physical control requirements such as AS4755.3 DRED interfaces. Whilst such DRED interfaces have a place in the control of generation sources such as solar and battery inverters for the protection of grid assets, the high capital cost of an inverter system (relative to the cost of a basic water heater) adds only a minor cost for those that can afford Solar and Battery inverter systems. Water heating is an essential service and not an optional choice for consumers. The cost impediment on water heaters of 4755.3 is not justified for the reasons given above, particularly when a smart option such as AS4755.2 enables other monetisation pathways for the asset owner and achieves a better outcome. In the longer term, Rheem believes that DER assets such as water heaters may use technological advances to respond automatically to network changes (such as voltage) and adapt their behaviour accordingly. DER assets working individually, but in unison, may in the longer term displace the need for site orchestration. Unfortunately, this solution is some way off. As a result of the above, we believe that consumer participation, and the growth of a successful competitive market for mixed, orchestrated DER at consumer sites, will be negatively impacted in the short term if FCAS delivery was to be measured at the device level. **Shell Energy** Shell Energy supports AEMO's proposed option 2 to continue the exemption for systems 1 MW or less to only require response measurements at 1 second or lower. We believe that this approach will allow for a diversity in supply of fast (< 6 second) FCAS in a way that will minimise any distortion to the market. **ShineHub** No inverter level sampling (aka Option 2) would be the best option because it helps to tell how much power inverter and battery output. It would also be the simplest plugin method on the current load forecasting modules that AEMO has. **Social Energy** Option two will reduce barriers to entry for VPP participation in the Contingency FCAS markets which will increase competition for providing those services. An increase in competition will reduce market distortion. **Solar Analytics** No [potential for market distortion]. **UNSW** As commented above, data for tests under Option 2 should be captured at significantly higher resolution.	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		VIOTAS Care must be taken to ensure that creating different measurement requirements for different providers of the same service does not create a market distortion. For example, reducing data resolution measurement requirements for sites with up to 1 MW per NMI may create an incentive for such sites to preferentially select a service provider with lower specification equipment, if this results in a cost saving. Creating a disincentive for such relatively large sites to deploy state of the art metering and control technology is unlikely to be desirable, and would present a significant market distortion. Accordingly, analysis is required to ensure that any such threshold below which a site can avail of reduced measurement standards does not create an incentive for sites whose participation in ancillary services would have been commercially viable with state of the art systems to instead be locked in to less sophisticated technology. There is an additional risk of distortion if a discrepancy in ability to utilise an alternative measurement location is created between different service providers. For example, a provider with a 1 MW controllable load which is verified at the connection point is likely to have to build in a certain conservativeness in its bidding behaviour to ensure that, irrespective of any other unrelated load changes that may occur at the site (behind the same NMI) it is still able to deliver the committed service volume. This will not be the case for a provider whose performance is verified at the controlled device, and this risks creating a market distortion between providers. Any such distortion must be minimised to ensure that the benefits in terms of reduced entry barriers for smaller sites and associated increases in competition, justify any potential negative impacts of the distortions inevitably caused by creating multiple measurement standards for different providers of the same service. VIOTAS recommends that fairness and equity of treatment between providers are paramount, alongside other considerations such as reducing barriers to entry for smaller service providers.	
8.	Various	**Whether Option 2 measurement requirements should be limited to small-scale DER (for example under 1 MW or 5 MW per NMI)** **Risks and benefits of expanding the Option 2 requirements to other FCAS providers** **AGL** AGL supports limiting the Option 2 measurement requirements to small-scale DER, under 1MW at the connection point. As stated in response to question 6[145], we consider this MW limit provides an appropriate safeguard against technical risks to the system and can be revisited in future as DER penetration increases. Conversely, applying a higher threshold, such as 5MW, diminishes risk mitigation. **CPUE** **Consideration needs to be given to the MASS measurement requirements for varying generation thresholds** The changes to the measurement requirements of the MASS in relation to generation thresholds should be based on the value add that high-resolution metering provides to the NEM. Larger generators participating in the market have a bigger impact on system security and reliability during mal operation. Hence, they will have a greater need to have high-	Submissions on this issue were quite mixed. A summary is presented in Table 3. **Table 3 Whether Measurement Requirements should be Scaled** **1MW**: AGL, Karit, Mondo, Solar Analytics **5MW**: EQ, ShineHub, SwitchDin **Up to AEMO**: CPUE, Evergen, Intergen **No limit**: Hydro Tasmania, Landis + Gyr, Reposit Power, Social Energy **Other**: VIOTAS

[145] See extract in item 6 of Appendix B.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		resolution metering for fault investigations and system safety. We believe that AEMO is best placed to determine the size of the systems to which this proposed amendment should apply. **Delta Electricity** Delta Electricity does not recommend the adoption of Option 2 even for smallscale DER which should be encouraged to aggregate capability and install appropriate recording for the whole aggregation to improve efficient outcomes that do not overburden low cost suppliers but also do not undermine frequency control objectives. All Fast FCAS providers should be asked to invest in both accurate instrumentation with fast settling times for use in both the controller AND a suitable fast capturing recorder, assuming the controller and the recorder do not use the same data feed which is possibly the case in some existing systems.	As AEMO's proposal is not to change the measurement requirements of the MASS, there is no need to include any scaling requirements for small-scale DER.

Risks	Benefits
Unfair standards if lesser quality standards are not equally permitted to be installed by all participants.	Cheaper system development costs
Greater inaccuracy and subsequently lower coordination in control	More options in development
Expansion of lesser quality of controlling and monitoring and retarded control delivery impacting on overall coordination requiring overuse of mandated control systems or emergency response systems	

Energy Locals

Please refer to comments made in the response to Question 1[146].

EQ

We propose a 5MW limit be imposed to align with other limit breaks determining requirements, such as the scheduling requirement which is currently 5MW.

EQ expects an increase in small DER under 5MW and wishes to enable participation to support the NEO. However, in order to minimise operational issues and risks to power quality, it is suggested that the DNSP is informed if DER is participating in MASS as part of an aggregated response, similarly to a wholesale demand response participant.

Evergen

The economics of large scale assets differs from aggregated fleets: larger assets are required to register with AEMO as Market Generators (and Market Customer for import-related services), and have access to lucrative Regulation FCAS markets. Individual large assets avoid the need for complex fleet orchestration systems and associated customer operations, and the relative cost of registration and compliance are lower per unit of power. Given the complexity of managing fleets, and the competition energy markets will have with local self-consumption

[146] See extract in item 1 in Appendix B.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		priorities, it's reasonable that advantages are conferred to residential (or commercial) behind-the-meter assets that are not shared with larger scale assets. The demarcation lines have been drawn at 5MW as maximum size for an individual device in a VPP, with the suggestion that devices > 1MW could not use Option 2 varied measurement requirements. Evergen is happy to defer to AEMO on the technical need for high-speed monitoring for devices in this range. However, we note that devices at this scale for C&I or community battery purposes are still in the early-adopter stage of market penetration, and are more sensitive to cost impacts from the additional measurement requirements than very large batteries. 1-5MW batteries in VPP fleets will not have access to regulation FCAS participation, and don't have the same economies of scale as 100+MW batteries. **Hydro Tasmania** If 100ms can be adopted as a global standard there will be no difference in terms of the measurement requirements between utility scale generators and VPP. If 50ms is retained, the MASS shouldn't be limited to DER under 1MW. Hydro Tasmania has a mix of customers above and below the 1MW threshold, including some that will transition across that threshold over time. If 50ms is retained, the existing metering requirements should remain at a State level, rather than a meter per 5MW as the cost to install will be prohibitive for existing use cases and markets. AEMO should also articulate what technical concern needs to be managed by tightening the measurement requirements further and the cost benefit analysis that supports that. **Intellihub** We believe changes in the measurement requirements should be limited to small-scale DER, however we don't have a view on the definition of small-scale DER. The limit should be balanced to maximise the efficiency of the market: low enough to ensure that the negative impact on the market of any relaxed requirements in the DER MASS is limited, but high enough to reduce the barrier to entry for the majority of VPPs consisting of small-DER. **Karit** Two issues need to be considered here; (1) the makeup of the participant (many small sites, a few larger sites or one very large site); and (2) the ease of participants to accumulate significant numbers of small sites willing to allow participation in the FCAS market. Setting a high threshold such as 5MW, invokess a handbrake on competition as it discentivises small organisations from recruiting significant numbers of participants to enable them to register as an FCAS provider. A threshold for option 2 should be based on the participation of a single site, and in that instance 1 MW might be more appropriate. **Landis + Gyr** Please refer to comments made in the response to Question 7[147].	

[147] See extract in item 7 in Appendix B.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Mondo Mondo supports the 1 MW threshold. **Reposit Power** Option 2 metering requires the assumption that a FCAS providing unit responds identically to units of the same "type" for each frequency deviation and for all time. This assumption is known by Reposit to be incorrect and has been shown to be so by the limited information provided by the VPP Demonstrations project. (**Sections 3.3.3.3, 3.3.4.3**) Increasing MW of Option 2 metered plant increasingly damages system security and NEM efficiency (**Section 3.4**). Allowing larger units to be Option 2 metered simply reduces the amount of time that AEMO has to address this new threat to system security. Additionally, Option 2 metering limits towards becoming Option 1 metering (disregarding the device-level metering) as the number of units of a "type" approaches 1. This means that it is irrelevant unless there is a large number of identical units deployed as would be the case if a single vendor were to become dominant in the market. This would indicate a market failure and would be addressed by market bodies and participants via the NEM's regulatory mechanisms. … **5.2 Generator capacity and electrical materiality** Option 2 seeks to create different "classes" of MW. Those that are delivered from centralised (>1MW) units, and those that are created from aggregated (<1MW) units. This is not compatible with the design of the market. The MASS review discussion paper states the following in its argument for relaxed metering requirements for individual generators below a 1MW generation threshold: > "Larger facilities have more capability to impact the power system, and an ASL with a capacity of more than 1 MW at the NMI will have a significantly larger change in active power per hertz than residential battery systems. For these larger connections, HSM of power must be captured to verify compliance with the MASS." This statement uses the capacity of individual generating units, and the materiality of that capacity to the grid, to compare a single residential generating unit to a large scale generating unit in arguing the case for relaxation of metering requirements. What this argument fails to take into account, however, is that as part of a VPP, these individual residential units do not act individually. They will act in an orchestrated way with many other small scale generators to deliver their combined capacity to the grid at the same time. Electrically speaking, the materiality of outcome with respect to the electricity grid from generation delivered in this way is no different to the materiality of generation delivered from large-scale generation, as now the scale of generation between the two is comparable. With respect to verification of delivery, AEMO's own FCAS Verification Tool also considers a VPP in aggregate only, requiring aggregated data to verify the delivery of service to market. This renders the application of relaxed metering requirements for small scale generators void, as their aggregated capacity, delivery and impact on the grid is not small-scale. **Rheem & CET**	

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		As outlined in our responses to earlier questions, we do not believe that Option 2 should be adopted at this time. **Shell Energy** Shell Energy considers there is a case to increase the threshold for eligibility for these arrangements from 1 MW to 1.5 MW, given that this is level at which some DNSPs, including Ausnet Services, place more stringent requirements on small embedded generators. **ShineHub** For most of the new house and land development sites, it's around 400 homes. If they are doing an embedded network, each home with 5kW inverter + battery, it would still all fall under one NMI and the total size would be higher than 1mW. Using a 5mW capacity will be better if AEMO wants to accommodate embedded networks to provide FCAS going forward. **Social Energy** The timescales of Contingency FCAS delivery are long relative to the 50ms data rates currently required in the MASS. It is hard to imagine what additional information is conveyed by this higher data rate from generators of any size for these services. If the pre-qualification tests can satisfy AEMO that plant can provide its response in a suitable fashion then that ought to be sufficient. **Solar Analytics** Higher data resolution is always better if it can be achieved at a reasonable price by a reasonable number of participants. The cost of monitoring with respect to capacity of FCAS should be considered. For a single 1MW device, the cost of monitoring is much lower than it is for 200 x 5kW devices. Therefore, we believe a 1MW threshold is appropriate, but we are not opposed to increasing the threshold if AEMO is satisfied in its ability to verify FCAS delivery. **SwitchDin** We consider that 5MW would be a more appropriate threshold for application of the revised measurements rather than 1MW. This is particularly in view of large C&I customers that may wish to operate their own VPP, integrating a range of different DER assets across multiple sites, which may have a significant range of capacity from tens of kW to the low MW range. A 5MW threshold would be consistent with other capacity-based limits already in place within the NER, such as generators with a nameplate rating of less than 5MW being exempt from generator registration and having significantly less complex requirements for grid impact modelling. **Tesla** Please refer to comments made in the response to Question 1[148]. **UNSW**: We believe that a more cautions approach is preferable, as the increase of DG in the grid together with changes in the generation fleet across the NEM will result in reduced inertia, higher RoCoF events and generally expectations to provide frequency ancillary functions at a more consistent rate in a more challenging environment.	

[148] See extract in item 1 in Appendix B

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Another point for consideration should be the provision of inertia from other forms of distributed generation participating in VPP operation, such as solar PV systems. There are current technical solutions to allow PV inverters to provide such functionality (see [1[149]] for example). Such approaches may affect future registration and operation of VPPs with multiple sources of FCAS. **VIOTAS** VIOTAS agrees with AEMO's proposal that, if adopted, any measurement requirement relaxations should only be permitted for ancillary service loads below a certain threshold. This will ensure an optimal balance between reducing barriers to participation by aggregations of smaller sites, while also ensuring that the current high resolution measurement standards are retained for larger sites which have a greater impact on the power system. VIOTAS recommends two distinct thresholds if AEMO decides to adopt Option 2: - **A 200 kW threshold** for reduced measurement resolution (1s). In other markets VIOTAS already provides fast response ancillary services using controllable loads smaller than 500 kW per site and as set out in our response to Question 4[150] VIOTAS is in the process of developing technologies that enable it to do so using progressively smaller loads without sacrificing high resolution data measurement and verification capability. Therefore, VIOTAS recommends that, if Option 2 is adopted, AEMO reduces the threshold to 200 kW per NMI below which providers can avail of reduced data resolution measurement requirements. This will reduce the barrier to entry for very small sites (e.g. aggregations of residential properties) while still requiring that larger sites require more sophisticated technology to participate. This will avoid 'locking in' less sophisticated monitoring and control technologies, and will drive future system benefits as the services procured evolve. - **A 5 MW threshold** for relaxed measurement location requirements. VIOTAS believes that, if implemented, the merit in enabling FCAS provision to be verified at the controlled device is also be worth extending to larger sites up to 5MW per NMI. If this option is adopted it will be important to implement robust processes (such as periodic spot checks to validate delivery data measured at the controlled device vs. that measured at the connection point) to ensure no perverse incentive is created for gaming to deliberately negate the response with other on-site loads behind the same NMI. VIOTAS understands these thresholds (200kW and 5MW) are commonly used by networks for embedded generation to classify a system as either 'small' or 'large'. Similarly, these thresholds are mirrored in Australian Standards, for example AS4777 and AS5139. VIOTAS believe consistent classifications across the industry (albeit informal) make for an efficient, equitable and technology agnostic electricity system.	
9.	Various	MASS Readability and Usability – See section 5.1.1.	See sections 5.1.2 and 5.1.3.
10.	Various	Clarification of References to the Frequency Operating Standard – See section 5.2.1.	See section 5.2.2 and 5.2.3.

[149] H. D. Tafti, G. Konstantinou, C. D. Townsend, G. G. Farivar, A. Sangwongwanich, Y. Yang, J. Pou and F. Blaabjerg, "Extended Functionalities of Photovoltaic Systems With Flexible Power Point Tracking: Recent Advances," in IEEE Trans. Power Electron., vol. 35, no. 9, pp. 9342-9356, Sept. 2020.

[150] See extract item 4 in Appendix B.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
11.	Various	Requiring Non-Frequency Responsive Facilities to deliver FCAS only when Enabled up to 150% of Enablement Amount – See section 5.3.1	See section 5.3.2 and 5.3.3.
12.	Various	Co-ordination between FCAS and PFR – See section 5.4.1.	See section 5.4.2 and 5.4.3.
13.	Delta Electricity, Infigen & Tesla	Relationship between MASS and other Instruments/Institutions – see section 5.5.2	See section 5.5.3 and 5.5.3.
14.	Various	Requirements for Regulation FCAS – See section 5.6.1.	See section 5.6.2 and 5.6.3.
15.	Various	Clarification of Requirements for Delayed FCAS – See section 5.7.1.	See section 5.7.2 and 5.7.3.
16.	Various	Issues Associated with Pending Rule Changes and Matters for Separate Consultation – See section 5.8.1.	See section 5.8.2 and 5.8.3.
17.	Infigen & Tesla.	Need for a more holistic review of the MASS – see section 6.2.1.	See section 6.2.2 and 6.2.3.
18.	Ausgrid, CPUE, ENA & EQ.	Leveraging Network Assets – see section 6.3.1.	See section 6.3.2 and 6.3.3.
19.	Tesla	As an immediate step, Tesla supports AEMO implementing regional based minimum quantities for contingency FCAS procurement, as previously explored in the Frequency frameworks review.	AEMO is progressing work on potential regional FCAS procurement outside this consultation and expects to present findings and recommendations in an appropriate forum in the coming months.
20.	Delta Electricity	IMPROVE THE CONNECTIVITY BETWEEN DISPATCH SYSTEMS AND THE MASS AEMO could improve connectivity between existing practical FCAS systems and the way that the AEMO dispatch system and individual units communicate and transfer energy dispatch targets from NEMDE to the Unit via the AEMO AGC processing and the Unit control process. In the best development of the next version of a revised MASS, an understanding of all these mechanisms and, more particularly, the impact of inadequate total system response on the performance of each individual unit, should be included in the MASS and considered for in the objectives of the specification. … CONSIDER CHANGING THE REGULATION DISPATCH PROCESS The existing regulation dispatch process carries with it inherent delays due to the AEMO delivery upon the energy dispatch target. This delivery separates regulation FCAS adjustments from PFR. Ironically, the present MASS design, as applied in many controllers, means that PFR delivery is more similar to that of 6s FCAS delivery than it is to regulation control. Regulation signals delivered on the energy dispatch target become subject to necessary and less transient plant limitations as energy targets relevant to market energy changes are shaped, smoothed	AEMO acknowledges that the MASS is focused on the expected behaviour of FCAS providers separate from the behaviour of the power system itself, and that in reality, system performance can feed back into facility performance. In all FCAS assessments, AEMO's engineering judgement is a critical part of assessing whether FCAS providers have met their obligations, rather than just the results of the FCAS Verification Tool. AEMO is interested in tangible examples as to how the MASS could potentially be improved to consider system behaviour. Separation of the regulation and energy signals in AGC is a possibility. AEMO would be interested in discussing the possibility of a limited trial with an interested party.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		and delayed in response to cater for continuous operation design safety limits which are not necessarily relevant to match for transient frequency response. Regulation FCAS dispatch if separated from energy dispatch signals and sent into a unit's frequency control loop instead of its MW dispatch control loop could, in combination with the local unit's stored energy for FCAS control, be able to respond immediately to the regulation requirement and respond better during times when ramping of energy dispatch is also occurring something which, in the existing regulation FCAS dispatch design, performance is less successful.	
21.	Delta Electricity	**Distinguish further between Controller and Recorder Specifications – Both are Important and may be Different Systems on Some Installations** AEMO are also advised to define, clarify and distinguish further between control input specifications and recorded data specification. Obviously, if the instrument that is providing the data for performance monitoring is suitable in quality and the unit complies with dispatch expectations, the performance is acceptable but, when it is not, the reasons may relate to different specifications, not included for in the MASS, having been applied to the instruments and data used by the controller and, if systems have not been constructed with suitable quality of data in the controller they will also be less likely to coordinate well with other controllers and objectives for system-wide precision and control. Each machine's electrical response depends on and compliments the system's electrical response. As the system performance deteriorates, the response time of each unit will likely lengthen particularly if less machines are providing accurately measurable performance. Droop reactions necessarily limit a Unit's response to the relevant and fair proportion of energy required by that Unit to assist in the correction of the system frequency deviation. The level of stored energy and the output position of a Unit prior to a required response will also affect the resultant response of the unit. Knowledge of this variability in response and a performance based on the overall recovery time for the system might be worth considering in the assessment process. In addition to the extensive description of the performance calculations of previous versions (many now removed to the supporting guide on the FCAS Reg Tool which Delta Electricity thinks should be returned to the MASS or a MASS attachment to ensure it remains more relevant in guiding those that may wish to construct their own assessment tool), the revised MASS ought to equally describe the design and control block expectations of the controllers, the specifications for the data feeds that controllers depend on and, in this way, describe the uniformity necessary in relevant aspects of the frequency control design AEMO consider required to facilitate good frequency control.	The potential difference between frequency controller and FCAS measurement/recorder specifications is noted. AEMO will engage with industry in a suitable forum to discuss the case for setting out these requirements separately and how to achieve the appropriate level of guidance. AEMO also notes that how facilities should deal with consecutive frequency events is unspecified in the MASS, and that this is a potential area where better guidance should be considered in future MASS Reviews.
22.	ENA	There are potential inconsistencies between the Energy Security Board's (**ESB**) P2025 market design and the direction of discussion in recent AEMO workshops. We support a review to ensure that measurement and verification of services as appropriate for industry participants to deliver an efficient and reliable power system. … There is a significant amount of change occurring in the current regulatory environment. It is therefore critical that there is alignment between key developments such as the ESBs P2025 market design. WE note that some of the ESBs stated principles are to provide a technology	Refer to Sections 4.1, 4.2, 5.8 and 6.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		neutral market design that shifts obligations away from an asset-based approach to a trader and services model. Firstly, it was clear that from the discussion of the workshops there is a perception from Original Equipment Manufacturers (**OEMs**) that the proposed changes to the MASS heavily favour one incumbent to the detriment of others. In the spirit of being technology neutral and encouraging competition we are supportive of lower barriers to entry and encourage AEMO to consider ways to address this perceived one-party endorsement by more deeply engaging with those OEMs who currently feel deeply disenfranchised. Secondly, the MASS seems to suggest moving obligations away from the connection point to inverters (Assets) This seems contradictory to the ESB's stated goals which indicate policy development in the other direction. We suggest that AEMO review their proposal to deliver greater alignment with the ESB.	
23.	Shell Energy	For clarity, Shell Energy recommends that AEMO (and the MASS) should use the term "continually frequency responsive" to refer to proportional controllers. Switched controllers are also frequency responsive but this occurs at a known (trigger) frequency. The proposed approach to refer to switched controller as non-frequency responsive as set out in the Paper implies that switched controllers do not respond to frequency, despite the fact they do respond, just in a different manner to proportional response. As such, "switched frequency responsive" would be a better way to describe the response provided by switched controllers. … As the Paper discusses the need for, in AEMO's view a significant proportion of facilities being frequency responsive, we consider that this is where the need for improved terminology becomes apparent. As we have argued, both proportional and switched controllers do respond to frequency, but AEMO's classification of the former as frequency-responsive and the latter as non-frequency response muddies the issue. We have interpreted AEMO's arguments in section 3.7 of the [Issues] Paper as suggesting that continuous frequency response – that provided by proportional controllers – are required to adequately maintain control of frequency. Shell Energy disagrees with this assertion. In our view, AEMO's under procurement of services has been the primary factor in deteriorating frequency control in the NEM. In our view the number of facilities actually providing a response is less important than the level of actual response being provided within the required time duration.	'Continually frequency responsive' may be a better term to use. AEMO will consider using this in the future.
24.	Shell Energy	AEMO proposes that a set of constraint equations is needed to ensure an appropriate level of FCAS on the mainland, in line with the constraint equations that already exist for the Tasmanian region. AEMO provides scant detail on what this may look like. Given the little amount of detail provided, we recommend AEMO provide additional details regarding what AEMO is actually proposing. Certain constraint equations could restrict the level of enablement of switched frequency responsive facilities in the very fast, fast and slow contingency FCAS to a known value as opposed to requiring a minimum requirement from continuous frequency responsive facilities. The two approaches could produce vastly different results.	See section 5.3.
25.	Shell Energy	We also consider that more detail is required on AEMO's indication that it will reassess the maximum allowable frequency response rate (droop). We believe that more details are required in this area and must include consideration of the replacement of mandatory PFR with a	Further work on allowable frequency response rates will be undertaken outside of this MASS consultation.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		market-based PFR in line with the AEMC's current considerations through the Primary Frequency Response rule change.	
26.	Shell Energy	While we support AEMO's consideration of area-based limitations on FCAS procurement, greater details regarding any proposal must be supplied in the Draft Report. We agree that it should be implemented as a maximum as opposed to a minimum requirement in any region and that pricing must remained based on the marginal cost of supply on a global basis. Price differentiation between regions should only apply where a region specific (local) FCAS procurement requirement is imposed.	Further work on area-based requirements for FCAS is being conducted outside of this MASS consultation, and AEMO hopes to share progress with industry in a suitable forum soon.
27.	Shell Energy	The original requirement in the MASS to prioritise Contingency FCAS over Regulation FCAS when power system frequency is outside the NOFB was based on prioritising frequency control for system security. This recognised that line loading is managed by the NEMDE on an N-1 basis and the geographical spread of multiple contingency FCAS providers would generally limit the change in flow on any individual transmission element. This was always an intended outcome which AEMO managed for via the inclusion of additional safety margins in all constraint equations with line flows then corrected by the NEMDE at the next DI. We also note that any form of mandated or market based regulated PFR as opposed to secondary (AGC) PFR would also respond to prioritise frequency control over compliance with a dispatch instruction or AGC signal. Mandatory or Market regulation PFR based on a tight deadband setting will automatically prioritise frequency control over AGC response. It cannot do otherwise unless AEMO wants the generator to defeat the deadband setting if the generator is in an active constraint equation for the direction of response that would make the network congestion worse. Pragmatically, AEMO's proposal is unworkable and shows one of the main weaknesses created by mandatory PFR where a unit will respond based on its available, headroom, foot room or stored energy based on the observed local frequency deviation. Units with little or no headroom, foot room or stored energy may not respond at all or by a small amount whereas units with larger levels of headroom, foot room or stored energy will respond by a large amount, leading to less control of flows over network elements. The NEMDE, by procuring known FCAS reserves from generators has greater control over generator response levels and if calculated correctly network flows. From a compliance perspective it would create an unmanageable outcome for generators to have to disable an automated response under certain conditions such as being impacted by a binding network constraint. Going forward in calculating FCAS enablement, the NEMDE shouldn't enable FCAS on a unit in the direction that would make the network congestion worse. Shell Energy strongly argues that market participants should not be responsible for managing this, if it is actually required for secure operation of network flows, it should be a feature embedded in the NEMDE. The development of a market for the provision of primary regulation response reserves should assist AEMO to procure PFR from units that will improve as opposes to worsen network congestion when utilised.	Refer to section 5.4. Actions on regional allocation of FCAS is another piece of work that can help with managing unscheduled transmission flows. See section 5.8.
28.	Origin Energy	**Minimum Droop Setting** … more work is needed to lower barriers to entry for DER participation in frequency control markets. Currently battery systems that provide FCAS must have a droop minimum setting of 1.7%. 1 This requirement may be unnecessarily onerous and impedes the ability of smaller systems to participate in the market.	Further work on allowable frequency response rates will be undertaken outside of this MASS Review.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		Participants in the VPP trial were able to register with a minimum of 0.7% droop with no observed issues. In considering the learnings from this trial, AEMO should investigate the feasibility of lower droop requirement for smaller battery systems providing ancillary services. Origin considers that lower droop obligations could be applied to both aggregated VPP battery systems, and small stand-alone battery systems (e.g. 1-2MW capacity). Applying these VPP droop settings to individual units would allow C&I customers to better participate in FCAS markets.	
29.	PAP	Frequency Responsiveness of FCAS: PAP assumes that based on the outcomes from the various VPP trials, particularly on the aggregated response of the ancillary service loads to deliver contingency FCAS during a frequency disturbance being relatively ineffective, this is the driver behind a change in the proposed specification. … As the PAP eleXsys technology stack addresses the issue regarding frequency at the point of connection to the grid, any potential issues from a power system point of view are addressed. Therefore, our product **already complies** with AEMO objectives. Whilst initial measurement is essential to ensure participants and paid for response the larger issues that need to be solved for aggregated VPP within a DNSP are: 1. Voltage management, in particular voltage rise due to generation in the lower voltage levels on the network, 2. Voltage fluctuations from intermittent generation, 3. Network reliability, 4. Voltage balance between phases, 5. Harmonic mitigation, 6. Fault identification and location. As outlined by AEMO in various VPP FCAS trials, a major concern / problem was that small generation sources connected to a Distribution Network, were unable to sustain the energy level for a long period of time, as the voltage caused instability issues. For this reason, we believe it is essential that a secondary measurement period be included to ensure that a secondary frequency event is not caused by small scale generation backing off or being curtailed in some form. See link below: https://arena.gov.au/assets/2017/02/virtual-power-plants-in-south-australia-stage-2-publicreport.pdf	Refer to power system security concerns under section 4.1.2
30.	Reposit Power:	**6.3 Trial formulation** AEMO has substantially reworked the "Trials of New Technologies" section in its proposed new form of the MASS…. This is considered by Reposit to be generally correct for a trial of new technology. In particular the period and quantity limited nature of a trial under this formulation is important. Reposit suggests however that the period and quantity limits should be explicitly quantified and stated in the MASS.	AEMO does not consider the suggested changes to be appropriate. The reason for the changes is to permit AEMO to set restrictions on any trials in an ad hoc manner otherwise it would be necessary for AEMO to commence a consultation if a trial required different conditions to those

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		An AEMO trial should not be interpreted by Participants to be a backdoor into AEMO markets. This interpretation would reduce investment certainty and discourage innovation, as Participants may inefficiently invest in the attainment and promotion of a trial of their non-compliant technology instead of in compliant technology. This is detrimental to the achievement of the NEO and may impact the trust other Participants feel towards the market operator. Technology trials can be important, but only where there are no other efficient ways to gather the required information. Reposit asserts that AEMO should define the precise conditions under which a trial will be granted. Reposit suggests that the VPP Demonstrations has been useful in providing the NEM with lessons learned in this area, and that Participants are interested to work with AEMO to define these conditions. AEMO has removed any and all specific restrictions on a trial in section 11 of the new proposed form of the MASS. For the reasons discussed above Reposit asserts that this is detrimental to the NEO, AEMO's position as the market operator, and Participants of new and existing market ancillary services.	specified in the MASS and this is not an efficient way to carry out this work. AEMO agrees with Reposit Power that a trial is not a back door into any of the markets AEMO administers, however, there is a need for flexibility in specifying the scope and conditions for participation in any trial. Any trial that has the potential to result in changes to a market that is in the longer term interests of consumers is consistent with the NEO and AEMO does not wish to stifle efforts to learn from innovations by putting up artificial barriers to the commencement of trials.
31.	Enel X	While not in scope of this review, AEMO has not provided any evidence, either in the issues paper or the RIS, to justify its conclusion that limits on the quantity of switched reserve will be required. AEMO must conduct a proper assessment of the potential system security risks before commencing a review of the constraint formulation guidelines for this purpose. … **Managing frequency responsiveness of FCAS reserve in aggregate** AEMO has not provided any evidence, either in this paper or the RIS, to justify its conclusion that limits on the quantity of switched reserve will be required. Imposing such restrictions without properly understanding the materiality of the problem (and indeed whether it is a problem) would inefficiently prevent some types of suppliers from providing FCAS and so increase the cost of AEMO's FCAS procurement. As noted above, NZ analysed the impacts of over-provision of switched load and found that 25% of the total system load in the North Island, and 16% of the total system load in the South Island would need to be providing the interruptible load service for it to present a system security concern. AEMO must conduct a proper assessment of the potential system security risks, like NZ did, before exploring solutions or commencing a review of the constraint formulation guidelines for this purpose. AEMO should also seek to model the impact of a limit on switched controllers on FCAS costs. A major contributor to FCAS cost reductions over the past few years has been switched control following the introduction of Ancillary services unbundling rule. It is not a matter of the cost or complexity of the controller: proportional control is simply not possible for most of these loads. Cutting out low cost switched providers and pushing up costs for no clear system security benefit runs counter to the NEO. Further, AEMO can already set the trigger frequencies for switched providers. It can also increase the granularity of the setpoints it gives switched loads. This means that it can create a pseudo-proportional response by staggering trigger frequencies across more granular setpoints.	Refer to section 5.3.

NO.	CONSULTED PERSON	ISSUE	AEMO RESPONSE
		We also seek further information on the limit on the quantity of switched reserve in the Tasmanian FCAS markets, as there does not appear to be any publicly available information on what the constraints are or the NEO argument for introducing them.	
32.	Shell Energy	Shell Energy proposed the following amendments and questions to the proposed, redrafted MASS [AEMO: amendments marked in red]. *Definitions* Shell Energy recommends the inclusion of a definition for Enablement amount defined as: The amount of procured frequency control ancillary service reserves procured by AEMO for the current DI that represents the limit for which a frequency control ancillary services facility may be dispatched or required to respond. The definitions of R*aise Control Limit, Raise Rate Limit, Regulating Lower Response* and *Regulating Raise Response* should then all include "subject to the *Enablement amount*". Switching Controller. Add "It can also provide an increase or decrease in generation output or load consumption not just a digital on/off control outcome" Variable Controller: Replace "Corresponding" with "proportional". *Section 2* 2.1 Open Access: Add "on a technology neutral basis" at end. 2.4 Inertia: This should be subject to deletion if very fast contingency services (sub one-second) are included in the MASS. Inertia response should be included as a component of FCAS response. 2.5 Delivery of FCAS by Ancillary Service Facilities. Add "subject to dispatch instructions issued in the Energy Market" at end. Section 3 "AEMO procures FCAS reserves to manage System Frequency during normal operating conditions and following contingency events. FCAS usually takes the form of an increase or decrease in active power output or consumption by an Ancillary Service Facility to address the impact of supply/demand imbalances on System Frequency from the theoretical dispatch trajectory for the Ancillary Service Facility at any given point in time within the DI. Each type of FCAS is delivered to different specifications to address different needs." 3.2 Regulation FCAS: Regulation FCAS is the deviation away from the theoretical dispatch trajectory at any given point in time within the DI subject to the bid Energy ramp rate limitations of the provider. The maximum deviation from the theoretical dispatch trajectory is based on the enablement amount in any DI. Section 4 4.2.1 Replace "dealing" with "detailing" Section 5 5.2 Enablement: Add "FCAS providers are only required to provide FCAS response based on their Enablement Amount" Section 9	AEMO has considered each of these suggestions and implemented a subset. Not implemented. Implemented. Implemented. Implemented. Not implemented Any changes to reflect the creation of a market for FFR will be made at the appropriate time. Not implemented – already includes special term *enabled* which means an instruction from NEMDE. Implemented in part. Not implemented. The typo in section 4.2.1 has been corrected. Not implemented – already covered by sections on Verification and 6.2.2 for Contingency FCAS and 10.3 for Regulation. To be revisited at next opportunity.

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		Shell Energy asks whether there should be a Section 9.3, to replicate the wording of the existing sections 7.3 and 8.3. Sections 7 to 10 Shell Energy requests clarification on the definition of price band and whether this refers to Market Ancillary Services Offer price band. If so, it should explicitly state this. Alternatively, price band could be included as a defined term in the Glossary – Section 1.2 in the MASS and be defined as applicable only to a Market Ancillary Services Offer in accordance with NER Clause 3.8.7A Section 10 10.5 Verification: Where it refers to the sum of the enabled price bands, Shell Energy wishes to understand if this refers to the sum of both the raise and lower price bands, or the sum of the enable raise price bands, or the sum of the lower price bands. We have noted an error in paragraph (a). We believe it should read "…equal to the lesser of the sum of the enabled price bands of the relevant market ancillary services offer ~~and~~ or the corresponding…" Additionally, the procedure as described should stipulate that measurements are only to be made during a period where a contingency event does not occur. If a contingency event occurs, the test must be repeated. The procedure should also set out the conditions which would apply where a mandatory regulation PFR response in the opposite direction to that required under the regulation secondary (AGC) frequency response test occurs.	The MASS uses the term *price band* in italics, which means that it is using the term as it is defined in the NER. No change needed. Added clarification in footnote. There is no error in paragraph (a). The use of 'and' is grammatically correct. Implemented; paragraph (c) has been added to section 10.5 to address this.
33.	Mondo Tesla	**Time Critical** We also commend the proposed timeline for finalising the new MASS (21 May 2021). As the market develops to include more DER, the impacts of changes on customers will increasingly need to be considered. AEMO's proposed timeline for this updated MASS will achieve positive customer outcomes by providing a continuation of customer involvement in active VPPs and customer engagement for planned VPPs. We would also strongly encourage AEMO to maintain the timelines proposed with this review. This will allow a seamless transition for those VPP participants that are currently participating in the trial. As Tesla believes this is a low-risk/ high-reward review process, adopting these changes quickly will also enable AEMO and the rest of the industry to start building up more significant portfolios of aggregated DER, and progress the variety of other market reforms impacting on DER at the moment.	See section 6.1.2 and section 6.1.3.

APPENDIX C. ATTACHMENT 1 – DRAFT MASS

The draft MASS is published as a separate document on AEMO's website with this Draft Report

VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
3.0	17/6/2021	Amended by change to correct error to list of submissions commenting on Option 1 costs, in Appendix B, page 142.
2.0	15/6/2021	Amended by: • Substituting "Energy Locals" for "Empower Energy" to correct error in section 5.6.1 • Correcting typo double full stop in section 5.8.2 • Realigning columns in Table 1 in Appendix B so all text is clearly visible • Repairing table formatting throughout so header rows repeat on new pages • Recreating Table of Contents for new page numbering
1.0	14/6/2021	First release of Draft Report and Determination