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

## SECOND DRAFT DETERMINATION

Published: 28 October 2021

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

**National Electricity Rules – Rule 8.9**

**Date of Notice: 28 October 2021[1]**

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

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

## Invitation to make Submissions

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

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 18 November 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.

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[1] This document was first published on 28 October 2021 and republished with minor edits on 1 November 2021.

## EXECUTIVE SUMMARY

The publication of this Second Draft Report and Determination (**Second Draft Determination**) commences a third round of consultation conducted by AEMO to amend the market ancillary services specification (**MASS**) under the National Electricity Rules (**NER**).

AEMO is required by clause 3.11.2(b) to make and *publish* 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 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**). A Draft Determination and Report (**Draft Determination**, or **first Draft Determination**) was published on 14 June 2021 and AEMO received a further 44 submissions in response to the Draft Determination.

The MASS consultation had two broad objectives:

- The first was a general improvement objective, to resolve a number of ambiguities and make the MASS consistent with the rule requirements for mandatory primary frequency response.
- The second objective was to determine whether any changes to the measurement arrangements in the MASS were appropriate to facilitate increased participation of DER in the contingency FCAS markets.

The changes made to restructure and redraft the MASS, published with the Draft Determination, were well supported. There was no suggestion that AEMO should return to the earlier format. The substantive changes proposed were largely regarded as appropriate, although there was a variety of minor suggestions, which are addressed in the draft MASS published with this Second Draft Determination. AEMO considers the general issues to be largely settled and does not expect to receive further submissions on this aspect of the consultation.

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

AEMO decided that further analysis was required before making a final determination, with an additional round of consultation. AEMO publishes this Second Draft Determination to discuss the submissions and its response to the issues raised by Consulted Persons.

At this stage, based on the additional evidence submitted by Consulted Persons and further analysis from the University of Melbourne, AEMO proposes to vary its draft determination to:

- Require a minimum measurement time resolution for Fast FCAS providers of:
  - 200 ms for aggregated facilities with no inertial response (5% error applies if number of sites is less than 200); and
  - 50 ms for all other facilities.
- Leave the measurement location 'at or close to' the connection point.

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AEMO considers this change from the first Draft Determination is in the long-term interests of consumers and, hence, promotes the national electricity objective **(NEO**).

A combination of proposed changes to the FCAS verification methodology and the University of Melbourne (UoM) analysis of error associated with measurement time resolution has enabled the above change in resolution to 200 ms. The difference between the errors associated with data captured at 100 ms and 200 ms was less than 1%, and the UoM analysis also confirmed that the verification error decreases as the number of sites within an aggregated facility increases. AEMO will therefore allow a measurement time resolution of 200 ms but only for aggregated ancillary service facilities and with a discount of 5% applied to reflect the verification error when the number of sites within an aggregate is less than 200. A measurement time resolution of 1 second (s) was determined to be unsuitable due to the inability to detect detrimental under-damped oscillatory behaviour.

AEMO also considered whether to revise the measurement time resolution for all Fast FCAS providers. However, as the inertial component cannot be calculated with sufficient accuracy using data captured at 100 ms or 200 ms intervals, AEMO proposes to leave the measurement time resolution unchanged for FCAS providers with inertial response.

No change is proposed to the measurement locations as AEMO must ensure the proper orchestration of DER behind the meter (**BTM**), and the measurement location cannot depend on the number of controllable BTM assets at registration. AEMO must be able to verify the delivery of FCAS even if additional controllable BTM assets or smart devices, such as hot water diverters, are retrofitted.

The transitional arrangements for VPP Demonstrations participants proposed in the first Draft Determination included a discount error of 20% if data was captured between 200 ms and 1 s intervals. Based on the study completed by UoM and the analysis shared in formal submissions, the discount error has been revised to 5%.

The first Draft Determination set a transitional period until 30 June 2023 for participants in the VPP Demonstrations to either comply with the measurement arrangements in the MASS for trial facilities, or exit the FCAS markets. This is based on the following considerations:

- The total Fast FCAS capacity of Trial Participants is 31 megawatts (MW) across four regions, so allowing a transitional period is considered reasonable given their minimal impact on power system security.
- Trial Participants will need to make equipment and control system changes to be able to comply with the MASS measurement requirements if they wish to remain in the Fast FCAS markets. AEMO considers that the proposed transitional period until 30 June 2023 allows them 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 of Fast FCAS.

Unexpected behaviour of DER inverters continues to be a concern, and AEMO will work with distribution network service providers (**DNSPs**), original equipment manufacturers (**OEMs**), and aggregators outside of the MASS consultation to resolve several substantive issues. AEMO is also considering revisions to the benchmarking FCAS test requirements to detect any unexpected behaviour from a DER inverter.

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# 1. STAKEHOLDER CONSULTATION PROCESS

As required by clause 3.11.2(d) of the National Electricity Rules (**NER** or **Rules**), AEMO is consulting on the Market Ancillary Service Specification (**MASS**) in accordance with the Rules consultation procedures.[2]

AEMO's timeline for this consultation is outlined below.

| 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 August 2021 |
| Second Draft Report & Notice of third stage consultation published | 28 October 2021 |
| Submissions due on Second Draft Report | 18 November 2021 |
| Final Report published | 22 December 2021 |

The publication of this Second Draft Determination marks the start of the third stage of the consultation.

Note that there is a glossary of terms used in this Final 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 market ancillary service (**FCAS**)[3]. 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

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

[3] The term 'FCAS' has been used interchangeably in this document to refer to market ancillary services and frequency control ancillary services.

(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.

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;

In its role as the power system operator, AEMO's primary concern is the maintenance of power system security. In the context of the NEO, this incorporates the dispatch of electricity and other services in the most cost-effective manner so as to minimise costs to consumers.

## 2.2. Context for this consultation

The primary driver for this consultation was to determine whether and how to amend the MASS to facilitate the ongoing participation of DER in the FCAS markets. AEMO commenced a trial of the capability of virtual power plants (**VPP**s) 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:

- 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 range of general improvements and issues for consultation, spanning a variety of matters including improved guidance on Regulation FCAS requirements, service co-ordination, and refinement of service definitions. This opening of the MASS also 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.

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## 2.4. Second stage consultation

AEMO issued a Notice of Second Stage Consultation on 14 June 2021 along with a draft determination and report (**Draft Determination**) and a mark-up of the proposed changes to the MASS.

AEMO received 44 submissions in response to the Draft Determination.

Copies of all written submissions (excluding any confidential information) have been published on AEMO's website.[4]

One submission was entirely confidential. AEMO has not taken that submission into account in reaching any determination.

# 3. SUMMARY OF MATERIAL ISSUES

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

| No. | Issue | Raised by |
|---|---|---|
| 1. | Measurement Time Resolution for FCAS provided by DER. | Australian Energy Council (**AEC**), AGL, Clean Energy Council (**CEC**), CitiPower, Powercor and United Energy (**CPUE**), Dreambox Co., Energy Consumers Australia (**ECA**), Empower Energy, Energy Networks Australia (**ENA**), EnergyAustralia (**EA**), Energy Locals, Enphase Energy, Evergen, Hydro Tasmania, Intellihub, Members Energy, New Energy Ventures, Origin Energy, Public Interest Advocacy Centre (**PIAC**), Powerledger, Quinbrook Infrastructure Partners (**Quinbrook**), Redback Technologies (**Redback**), Reposit Power (**Reposit**), Rheem Australia & Combined Energy Technologies (**Rheem & CET**), SA Power Networks (**SAPN**), Government of South Australia Department of Energy and Mining (**DEMSA**), Shell Energy, Simply Energy, Social Energy, Solar Analytics, SolarEdge, sonnen, SwitchDin, Tesla Motors Australia (**Tesla**), Viotas |
| 2. | Location of Measurement Point for FCAS provided by DER. | AEC, AGL, Cape Byron Power (**CBP**), CEC, Discover Energy, Dreambox, Empower Energy, Energy Locals, Enphase Energy, Evergen, Hydro Tasmania, Intellihub, New Energy Ventures, Origin Energy, Powerledger, Quinbrook, Redback, Reposit, Rheem & CET, Shell Energy, Simply Energy, Social Energy, SolarEdge, sonnen, Tesla |
| 3. | Trial Participant Transitional Issues. | AEC, Australian Energy Regulator (**AER**), Empower Energy, Energy Locals, Evergen, Hydro Tasmania, Members Energy, Origin Energy, Quinbrook, Reposit, SAPN, Shell Energy, Simply Energy, sonnen, SwitchDin, Tesla |
| 4. | Consultative Forum on the provision of FCAS by DER. | AEC, AGL, Ausgrid, CEC, CS Energy, DEMSA, Victorian Government Department of Environment, Land, Water and Planning (**DELWP–V**), Discover Energy, EA, ECA, Empower Energy, Enphase Energy, PIAC, Shell Energy, Solar Analytics, SolarEdge, Tesla |
| 5. | Application of the NEO to the provision of FCAS by DER. | Australian Conservation Foundation (ACF), AEC, AGL, CEC, CPUE, CS Energy, DEMSA, DEWLP–V, ECA, Empower Energy, ENA, Energy Locals, Evergen, Members Energy, PIAC, Reposit, Rheem & CET, SAPN, Shell Energy, Simply Energy, SolarEdge, sonnen, SwitchDin, Tesla |

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

| No. | Issue | Raised by |
|---|---|---|
| 6 | Importance of VPP Demonstrations | AGL, Enphase Energy, Evergen, New Energy Ventures, Simply Energy, SolarEdge, Tesla |
| 7. | Relevance of Other Market Experience | CEC, Simply Energy, SolarEdge, Tesla |
| 8. | MASS Readability and Usability. | AER, CS Energy, Delta Electricity, EA, Hydro Tasmania, Reposit, SwitchDin |
| 9. | Clarification of References to the FOS. | AER |
| 10. | Requirements for Non-Frequency Responsive Facilities | Enel X, Hydro Tasmania |
| 11. | Co-ordination between different FCAS and PFR | AGL, EA, Enel X, Energy Locals, Hydro Tasmania, Quinbrook, Reposit, Shell Energy, Viotas |
| 12. | Requirements for Regulation FCAS | AGL, Delta Electricity, Hydro Tasmania, Shell Energy, Tesla |
| 13. | Clarification of Requirements for Delayed FCAS | Hydro Tasmania |
| 14, | Issues Associated with Pending Rule Changes and Matter for Separate Consultation | Enel X, Hydro Tasmania, Shell Energy |

All issues raised by Consulted Persons in submissions and forums, together with AEMO's responses, is contained in Appendix B.

# 4. DISCUSSION OF MATERIAL ISSUES – DER

The Draft Determination indicated that AEMO would leave the measurement arrangements unchanged from the current MASS. This was based on the information available on the adequacy of 100 milliseconds (ms) or 200 ms to verify the delivery of Fast FCAS and to identify oscillatory behaviour. The power system security concerns highlighted in the Draft Determination must be resolved, but AEMO understands that a number of those concerns have to be addressed outside of the MASS framework with distribution network service providers (**DNSPs**), original equipment manufacturers (**OEMs**), and DER aggregators.

Sections 4.1 to 4.7 address the key issues raised by Consulted Persons on key issues around the provision of FCAS by DER. Other issues are addressed in Appendix B, which also lists all issues with cross-references to where they are addressed in this Second Draft Determination.

As outlined in the following sections, there was a broad range of views from Consulted Persons on the need to amend the MASS to accommodate the provision of FCAS by DER. This range of views on central issues was a contributing factor to AEMO deciding that further analysis was required before making a final determination, with an additional round of consultation.

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

### 4.1.1. Issue summary and submissions

For the reasons set out in the first Draft Determination, AEMO determined to leave the measurement resolution for Fast FCAS at 50 ms or less. Several Consulted Persons challenged this position, in particular noting independent analysis from the University of Melbourne (**UoM**) indicating the degree of error a longer sampling rate would yield.

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

AEC:

> The AEC generally accepts as part of an interim approach:
>
> - The decisions not to change the measurement time resolution and measurement location point.

AGL:

> AGL acknowledges the system security risks identified by AEMO that will need to be effectively managed to support the continued integration of DER at scale. Nevertheless, we are concerned that the Draft Determination appears to conflate distribution network constraints and system security risks with the metrology requirements associated with market settlement.
>
> While we commend AEMO in commissioning independent analysis through the UoM to understand the nature of these risks and identify options to manage them, it is not clear that requiring more onerous metrology requirements than were required in the VPP Demonstrations will mitigate the system security risks AEMO is seeking to address. At the same time, these requirements risk impacting the maturity of the market for DER services by limiting the ability of a range of technology providers to participate in VPP services. As a result, the proposed specifications present an unnecessary barrier to entry for DER participation in Fast FCAS markets.
>
> …
>
> We note that the UoM analysis concluded that the 100 and 200ms measurement options are sufficient to meet AEMO's system security concerns. We understand that these options are much more cost-effective for a broader cross-section of inverter OEMs.
>
> …
>
> … we would recommend AEMO defer this component of the MASS and commission further test analysis to confirm whether 100 or 200ms measurement granularity is satisfactory for the purposes of AEMO's market settlement systems.

CEC:

> **2. Power system security concerns**
>
> We are very disappointed that power system security concerns were introduced late in this review process as a barrier to amendment of the MASS – particularly as the concerns raised seem to mostly be separate to concerns legitimate to the MASS and DER FCAS participation.
>
> CEC has been working closely with AEMO to address the power system security concerns cited in the Draft Determination. If power system security concerns can be used to veto any other initiative between AEMO and the renewable energy industry, then it seems pointless to work with AEMO on anything other than power system security concerns. …
>
> **2.1 Unexpected disconnection of inverters**
>
> …
>
> The CEC and its members are very aware of AEMO's concerns regarding DER inverter behaviour during local distribution network faults and power system disturbances. CEC and its members worked closely with AEMO to support the introduction of its short duration under voltage disturbance ride through (VDRT) test procedure, which has been mandatory in SA and on the Western Power network since 28 September 2020 and 1 July 2021 respectively and which will be mandatory in Victoria from 1 September 2021. This test procedure will be superseded when AS/NZS 4777.2:2020 commences from 18 December 2021. We estimate that bringing forward the date for compliance with the VDRT test procedure in advance of AS/NZS 4777.2:2020 cost inverter OEMs in the order of tens of millions of dollars in total for product changes and retesting of products.
>
> CEC has encouraged members to provide AEMO with inverters compliant with AS/NZS 4777.2:2020 to enable testing of their behaviour in response to power system disturbances. We understand that several manufacturers (OEMs) have already arranged to provide AEMO with 2020-compliant inverters or have plans to do so. There are already four OEMs whose inverters are listed on the CEC Approved Products List

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

as compliant with AS/NZS 4777.2:2020. We do not foresee any obstacles to AEMO commissioning independent testing of these inverters over the course of this year.

CEC would support the proposal to require compliance with AS/NZS 4777.2:2020 for all systems upon registration for FCAS. This would address the risk of unexpected behaviour by inverters installed prior to 2021.

Recommendation 1: AEMO and CEC members should continue cooperation on testing the behaviour of inverters compliant with AS/NZS 4777.2:2020 and consider formalising the program with a Memorandum of Understanding.

Recommendation 2: AEMO should require compliance with AS/NZS 4777.2:2020 for all systems upon registration for FCAS.

### 2.2 The control hierarchy for inverters

The Draft Determination expressed concern regarding 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).

The prioritisation table 2.6 in AS/NZS 4777.2:2020 (included below) does not stipulate prioritisation level of FCAS response but it does specify priority for sustained active power response to frequency disturbances (prioritisation level 4) ahead of power quality response modes like volt-var (prioritisation level 5). Frequency support does sit below generation control functions like export limits (prioritisation level 3), that will probably become dynamic/flexible in the future.

**Table 2.6 — Specification for prioritization of inverter functions**

| Prioritization level | Description |
|---|---|
| 1 | All disturbance withstand limits described in Section 4 while abnormal conditions prevail and until the duration exceeds the time limits of the passive anti-islanding settings in Clause 4.4. |
| 2 | All requirements to operate the automatic disconnection device. |
| 3 | Generation control function of Section 6. |
| 4 | Sustained operation for frequency disturbances of Clause 4.5.3. |
| 5 | Inverter demand response mode of Clause 3.2 and power quality modes of Clauses 3.3.2 and 3.3.3 (see Note 1). |
| 6 | Power rate limit of Clause 3.3.4. |
| NOTE 1 The prioritization requirements for the power quality modes is defined in Clause 3.3. | |
| NOTE 2 The performance of the inverter when responding to demand response commands is defined in Clause 3.2.1. | |

Thus, when frequency falls below the continuous operation range, inverters are required to increase their output if it was previously curtailed by volt-var and/or volt-watt response modes as illustrated, below.

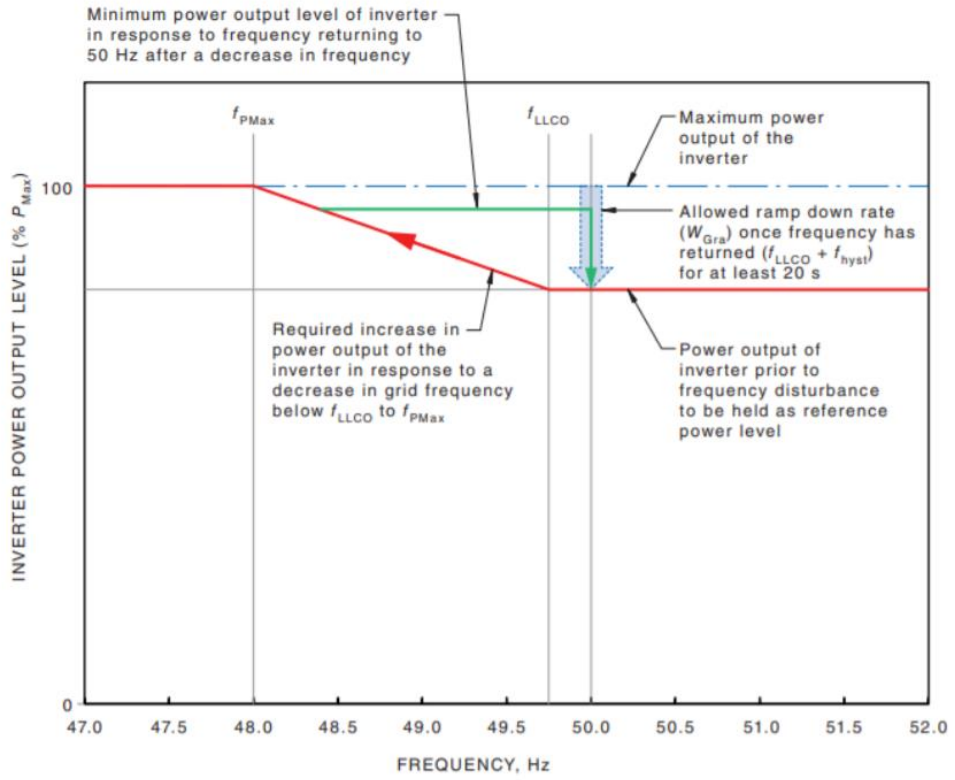


**Figure 4.1 — Example frequency response for a decrease in frequency for an inverter that has a reduced output**

The test procedure described in clause J.3.4, raises the voltage into the volt-watt region and then reduces frequency down below 48Hz to confirm this behaviour. This is a mandatory response. Delivering an FCAS response in advance of this would not necessarily conflict with AS/NZS 4777.2:2020.

The CEC is keen to understand AEMO's view as to which clauses in the revised standard could have an adverse effect on FCAS delivery.

We understand that these concerns were readily addressed in the SA VPP trials without any need to rewrite inverter standards.

Recommendation 3: AEMO and CEC members should work together to understand in more detail which aspects of AS/NZS 4777.2:2020, if any, could have an adverse effect on FCAS delivery, and how best to balance different priorities.

...

### 3. Time resolution for measurement of FCAS delivered by DER

The MASS requires measurements of power flow and local frequency be made at intervals of 50ms or less for the purpose of verifying FCAS delivery and AEMO has concluded that it is not appropriate to change the measurement resolution for Fast FCAS.

We understand the concerns that have led to AEMO's decision not to increase the measurement resolution to 1s. Nevertheless, we do not support the decision to leave the measurement resolution at 50ms. A resolution of 100ms has been demonstrated to be sufficient and would reduce costs to customer who are part of a VPP. This would benefit all consumers in the long term.

AEMO has confirmed that the maximum error introduced at 100ms measurement intervals is only 2.3%.

AS/NZS 4777.2:2020 commences 18 December 2021. It specifies measurement times of 100ms for voltage and frequency and 200ms for power. Alignment of the FCAS measurement requirements with AS/NZS 4777.2:2020 would reduce implementation costs and would benefit the long-term interests of consumers. AEMO had observes (sic) that data functionality is specific to each inverter make and model, but this does not change the expectation that better alignment of technical standards and market rules would reduce implementation costs.

**3.1 Power system security and measurement interval**

It is unclear how the concerns about the response of inverters to power system disturbances would be addressed by requiring VPPs to measure at 50ms intervals. This appears to be conflating two separate issues. AEMO has acknowledged that reduced granularity sampling will still identify inverter disconnection. We acknowledge that reducing the granularity of sampling would affect the accuracy of the verification of FCAS delivery, but the maximum error for 100ms measurement intervals would be only 2.3% and there are options to address that level of error. The Draft Determination states, "AEMO is committed to working with industry to address the DER inverter behaviour concerns but cannot raise the 50ms sampling rate requirement until this work is complete". However, AEMO has failed to adequately explain why the sampling rate cannot be changed or how leaving the sampling rate unchanged will help to address power system security concerns.

The Draft Determination states, "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". However, the Draft Determination provides no evidence for AEMO's expectation of imminent cost reductions in high-speed metering.

**3.2 Inverter capability**

OEMs are in the process of redesigning their inverters to comply with AS/NZS 4777.2:2020. The standard requires measurement intervals of 100ms for voltage and frequency and 200ms for power. This is the sampling rate requirement. We are not aware of any inverters that capture and store data at 50ms or 100ms intervals. Most capture and store data at 1s intervals.

...

**3.5 Data Capture Resolution Capabilities**

AEMO has requested clear information on the data capture resolution capabilities of OEM equipment to measure grid flow (at or close to the connection point), currently or with simple upgrades to current capabilities (e.g., firmware upgrades) and noting that this data capture capability is distinct from the sampling rates specified in AS4777.2.2020.

It is extremely difficult and unnecessary to measure and transmit the FCAS data in real time. The CET meter can store one hour of FCAS measurements. An external device is required to extract and store the FCAS data at the end of each FCAS event. The cost of the external device will be development time and cost, rather than equipment cost. The development task could involve firmware changes in the meter and coordination between the meter and the inverter so that the inverter can store the data. This could be complicated, especially if there is insufficient storage within the meter and changes to meters are required.

Typically, the way this works today for almost everyone with a storage inverter or AC coupled battery is as follows:

1. There is a metering device that is responsible for metering. It is separate from the inverter, and usually connected via RS485 serial protocol and installed next to the smart meter. That device must be capable of sampling faster than 50ms or it cannot do its job (e.g. calculate power factor, accurate power measurements, frequency readings, etc.)
2. The inverter polls that device regularly to enable it to figure out whether it needs to export limit, ramp up the battery, etc. What 'regularly' means varies a lot. It is likely to be slightly subsecond, but highly unlikely to be every 50ms.
3. There is a microprocessor on the monitoring device and some flash storage, but usually not much.

Currently there are no requirements for DER vendors to meter to 50ms levels of accuracy. There is a sampling response requirement of 100ms for voltage and frequency and 200ms for power thresholds in AS/NZS 4777.2:2020 but no requirements for data capture or recording.

Most OEMs will be able to achieve data capture and recording at the 100ms rate, with additional storage to enable uploading of data when an FCAS event has occurred.

Dreambox Co.

It is clear from the analyses performed by AEMO and other groups that sampling power and frequency at a rate of 1 Hz introduces unacceptable amounts of error when verifying Fast FCAS responses. It is also worth noting that AEMO has expressed interest in the ability to assess DER behaviour more generally during other events of interest (grid voltage fluctuations, etc.), and sample rates of 1 Hz will greatly diminish this ability.

With the above in mind, we are supportive of the move to increase the required sample rates of power and frequency from those in place during the VPP Demonstrations. However, we believe, as noted by AEMO in

the consultation document, that sample rates of 10 Hz, as opposed to the 20 Hz sample rates proposed in the draft MASS, represent a good compromise between accuracy and technical difficulty. In our experience, 10 Hz sample rates are close to the boundary of what can reliably be achieved with simple and inexpensive microcontroller-based measurement techniques. While the maximum error when using 10 Hz sample rates (and the trapezoidal integration method) was calculated by AEMO to be 2.3% in the consultation document, the average error, based on Figure 2 of the document, appears to be less than 1%. Given this low average error, we do not see the value of investing additional time and money into the development of measurement devices capable of 20 Hz sample rates.

ECA:

… we support the Draft Determination to maintain the current measurement time resolution for Fast Contingency FCAS which we consider will help to avoid any reduction in the efficacy of an FCAS response and the associated increase in costs for consumers. While we are sympathetic to the view that loosening this standard would allow greater rates of participation in the short-term we are not persuaded that this benefit outweighs the potential costs.

Empower Energy:

Empower Energy broadly supports the Draft Determination to maintain current MASS measurement requirements pertaining to Fast FCAS delivery. This support is offered as a function of options promulgated through the MASS review process rather than what our view might be following a holistic review of all possibilities associated with DER integration into the NEM. In particular:

- AEMO has determined not to accept options outside the metering status quo principally on grounds of system security. Empower Energy supports AEMO's contention that system security is a real and present concern, the importance of which is duly guided by the intent of the NEO.
- At the present time it has not been adequately demonstrated that a reduction in metering performance requirements – given the inherent possibility that quality of response within relevant frequency response services may degrade – would not adversely impact system security.

…

Systems complying with the MASS are designed for a clear performance paradigm that has existed with good stability for some time; market directions have, for various reasons, similarly made clear that these performance requirements are not broadly and reasonably able to be made inherent to DERs by OEMs without dedicated, market-specific investments in technology development. FCAS participation is a subset of the Australian market for DERs offering little certainty about uptake rates, market value and no secondary markets – these and other factors contribute to DER OEMs being unlikely to invest in solutions able to meet the MASS. These notions are duly reflected in the current market state: solutions for MASS compliance exist from a few specialist vendors, and DER vendors seeking FCAS participation have instead chosen to advocate for change to the MASS.

There are limits. The current MASS review has established that 1Hz metering is not sufficient for adequately-accurate characterisation of frequency response. The advent of AS/NZS 4777.2:2020 – implementing a 10Hz standard (albeit at lesser total accuracy than the MASS, were the MASS reduced to 10Hz sampling rate) allows a more rigorous minimum condition for participation – at negligible marginal cost – that is worthy of evaluation in future MASS reviews. As mentioned in our original submission, these developments are consistent with development and market directions for frequency response market participation from significant classes of DER in overseas markets, which will ultimately impact the availability and prevalence of such solutions in the Australian market.

Energy Locals & Quinbrook:

AEMO has concluded:

> "… that it is not appropriate to change the measurement resolution for Fast FCAS.
>
> While changing the measurement time resolution requirement to 1s may increase competition in the short term, any issues this could create for the Fast FCAS markets would not promote the NEO.
>
> While measurement resolution of 100/200ms along with 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."[6]

**System security concerns**

We don't believe AEMO's stated concerns about metering resolution relating to system security are supported by the evidence presented to date. AEMO does not use high speed metering (HSM) data as part of real-time operation and monitoring. The Draft MASS requires that Ancillary Service Facilities transmit real-time data via SCADA "every 4s to AEMO via SCADA and with no greater than 8s latency"[7]. As such, measuring FCAS on a 50ms, 100ms or 1s basis does not impact the real-time data sent to AEMO on a 4s basis and therefore cannot impact AEMO's ability to monitor and manage system security in real-time.

HSM data at FCAS is used for ex post analysis, especially around major events. A move to 100ms or 1s basis may limit the ability to analyse ex post outcomes on a sub-second basis to some degree. We note that where major incident reports do focus on high-speed data (50ms or less) the focus is typically system frequency and interconnector flows which would still be fully available to AEMO as would HSM data from transmission and distribution operators. AEMO does not explicitly highlight this as a risk and we would be interested to understand AEMO's view on how a different metering basis may impact its ability to conduct ex post event analysis now and in future with greater levels of DER penetration.

AEMO does raise several risks in the Draft Determination relating to "DER inverter behaviour" such as: unexpected disconnection due to a local network fault; behaviour during local distribution network and global power system disturbances posing a risk of under-delivery of FCAS due to inverter requirements; largescale, rapid active power injection or withdrawal … exceeding [operational] limits. These issues are analysed in a supporting report (DER Behaviour Report).[8] It does not appear that the analysis of any of these issues or the proposed solutions depend on 50ms metering of FCAS. The DER Behaviour Report uses HSM data (which appears to be 5ms or 10ms resolution) as part of its analysis, however this data is from distribution feeders, not specific DER assets, and in any case is higher resolution than the proposed MASS. There is no mention in the DER Behaviour Report of FCAS metering speed requirements in the MASS.

AEMO does raise another risk in the Draft Determination:

> "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."[9]

AMEO recommends a potential action to "maintain the 50ms measurement resolution requirement in the MASS in order to identify phenomena such as oscillatory responses".[10] This issue is not covered in any of the referenced reports and we are interested to understand the basis of AEMO's concerns and to have access to the supporting analysis informing their position as has been provided with the other issues. We suggest that even if this issue were to manifest:

- The issue could be analysed in the field in the same manner as the issues covered by the DER Behaviour Report – namely using distribution feeder level HSM data. It seems unlikely that AEMO would need individual device data to analyse a sub-second oscillatory issue at the distribution system level.
- Individual devices could be analysed on the bench using HSM.
- Specific, not all, devices could be analysis in the field using HSM.

Finally, AEMO states that it is "critical that the Fast FCAS response from proportional or switching FCAS controllers can be verified over the first 6s of a frequency disturbance"[11]. We agree. However, as noted above, AEMO only monitors the system on a 4s basis in real-time, so this is not a real-time operational requirement. We also note that even 1s metering resolution would allow AEMO to confirm ex post that a given FCAS resource was responding across the 6s after a frequency disturbance as opposed to ramping to full response at the very end of the 6-s response period.

We do not believe AEMO has made the case that system security requires all individual FCAS resources to record HSM at all times when this data is only used on an ex post basis in highly limited circumstances.

…

[6] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014, p19-20.
[7] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014, p22.
[8] AEMO, Behaviour of distributed resources during power system disturbances, May 2021.
[9] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014, p18.
[10] Ibid.
[11] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014, p14.

**Settlement accuracy**

AEMO's final concern relates to measurement error for the purpose of determining procurement quantities and in settlement. We believe this issue is overblown and can largely be managed by altering the MASS to a compromise metering resolution and adopting the trapezoidal rule for calculating quantities.

AEMO states "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 HSM will reduce this as a barrier to entry". We believe 100/200ms metering resolution is a reasonable compromise, and that given the results of the VPP Demonstrations there is ample evidence that this will work in practice. We also believe that moving to 100/200ms will ensure barriers to entry are reduced. In our experience there are many cost-effective metering solutions even at 100ms but this reduces significantly at 50ms for small scale devices and usually involves secondary costs beyond the unit cost of the meter (e.g. expensive annual subscriptions for meter reading platforms).

Recommendation

Our preferred position is that the MASS is updated to require measurement on less than or equal to 200ms and that the trapezoidal measurement rule is adopted. 200ms with the trapezoidal rule strikes the right trade-off between the short-term benefits highlighted by AEMO, the wider benefits under the NEO identified in this submission and manages metering accuracy.

Enphase Energy:

2.2 DC Coupled Vs. AC Coupled Storage Systems

The Draft Determination has assessments and determinations (Section 4.1, 4.2 etc) that are largely based on DC coupled systems (including Hybrid[12]). There is also analysis of older generation (AS/NZS4777.2:2015) inverters with limited AGF[13] presented that have limited relevance given the rapid development cycle of the DER industry.

Whilst DC coupled storage systems were common during the initial deployment of ESS[14] last decade, the current ESS market in Australia has swung rapidly to AC coupled ESS. Almost 90% of the domestic DER storage, installed so far in 2021, is AC coupled. By not providing equal consideration for AC coupled ESS, the Draft Determination would effectively kill 90% of the available DER for VPP's.

There are several reasons for the shift from DC coupled systems, not the least of which is the challenge to safely combine a battery and inverter from different OEMs. This involves extensive testing for DC coupled systems whereas AC coupled systems provide an already tested combination from a single vendor.

DC coupled systems have a lower overall efficiency as performance is compromised using the same inverter for both PV and Battery storage. An AC coupled solution has an inverter optimised for storage or PV only, resulting in greater power output availability across the entire operational envelop.

Field experience has, in addition, long shown that relying on a single Inverter for the entire system lowers reliability by introducing a single point of failure.

…

**3.0 Meter Measurement Resolution**

The Draft Determination states:

> "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".

During the consultation process, a metering measurement resolution of 1s (Option 2) was used however this was found to be inadequate. The Draft Determination proposes intervals of <50ms as Option 1 for metering however does not provide further commentary on how this resolution was arrived at.

[12] A Hybrid inverter is one that is designed to provide DC to AC conversion from more than one energy source using a single inverter with common electronics to perform both functions, e.g., converting PV Solar (~600 VDC) and Battery (48 - 400 VDC) to 230 VAC

[13] AGF = Advanced Grid Functions. AS/NZS4777.2:2015 mandated limited AGF. In 2018 IEEE & IEC standards introduced more prescriptive grid stability and measurement requirements. Australia currently has a mix of inverters built to 2018 standards and AS/NZS4777.2:2015 and largely accounts for the wide performance variations found during industry grid stability testing of inverters.

[14] ESS = Energy Storage Systems (IEC definition)

Enphase proposes that a 100ms would be a more viable interval rate. The UoM report[15] clearly demonstrates that a meter resolution of 100ms is a more than adequate measurement resolution vs. the 50ms interval proposed in the MASS. A 100ms interval has close alignment with AS/NZS4777.2:2020 measurement and calculation accuracy requirements that in most cases will negate the need for additional expensive metering equipment or R&D for product modification.

**Table 2.5 — Specification for measurement and calculation accuracy**

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

**Source: AS/NZS4777.2:2020 Grid connection of energy systems via inverters Part 2: Inverter requirements**

Evergen:

**Specific additional recommendations**

1. Amend the FCAS verification to use the trapezoidal rule for estimating delivered FCAS, instead of Riemann sums.
2. Amend the method for estimating to to use the midpoint method described in Section 3 to avoid bias towards overestimating FCAS delivery.
3. Persist with AEMO's original suggestion of adopting 'Option 2' requirements for Fast FCAS verification measurement resolution of 1-s for DER-based VPPs, since this resolution presents no barrier to effective verification.
4. Revise and automate the verification process, using contemporary data handling methodologies more suited to this task than spreadsheet-based assessment that has a bias against DER fleet-based FCAS provision.

...

6. AEMO should omit consideration of alleged oscillatory responses from their determination due to the implausibility of effects manifesting at the fleet level, and lack of evidence the issue is widespread.
7. AEMO should devote resources to re-commissioning the APIs established for the VPP Demonstration, update API documentation, provide an adequate API staging/test platform, conduct regular analysis (including automated analysis) of this data and share findings with industry on a half-yearly basis.
8. AEMO should consult on mandating compliance with AS/NZS 4777.2:2020 for all systems upon registration for FCAS.

…

**3 Measurement error**

The Draft Determination found that there was a large measurement error associated with sampling at 1s versus sampling at 50ms, contributing to their decision to retain the 50ms sampling requirement for all DER-based FCAS VPPs. AEMO's findings were supported by analysis contained in Reposit's initial submission to the MASS review, with additional research commissioned by AEMO from UoM (Mancarella, Zhang & Wang, 2021).

AEMO characterises this error as a "measurement error", a term Evergen regards as somewhat misleading. VPPs to date have consisted of hundreds of devices, and as such there are an excess of measurements at hand for verifying delivery. Any error is more appropriately characterised as a shortcoming of the existing verification approach, rather than a sampling rate deficiency or measurement error.

[15] The UoM report has demonstrated that 100ms metering measurement resolution provides a suitable solution, when combined with an update to the trapezoid method in the FCAS Verification Tool, the results of this proved a near zero error risk for verification purposes. A meter measurement resolution of 100ms is also appropriate for identifying oscillatory behaviour. A meter measurement resolution of 100ms will also align to the new AS4777.2:2020 requirements for Inverter accuracy when this standard is adopted on 18 December 2021.

Evergen has identified two key shortcomings in AEMO's verification approach, in addition to the shortcoming of using Riemann sums instead of the trapezoid method[16]):

1. AEMO's current approach for locally estimating frequency disturbance start time introduces bias; and
2. omitting most of the mandated measurement data from the verification methodology causes avoidable verification error.

The next sections cover these points in detail, and we suggest amendments to the verification approach.

The following analyses use a simulated DER response - a sigmoid function, similar to the response profile depicted in the Mancarella et al. study.

### 3.1 Estimating frequency disturbance time (FDT)

AEMO defines the FDT as the time when the frequency leaves the NOFB. We will refer to this as t0-actual. Each DER is required to monitor grid frequency locally, and each responds in accordance to its local measurements, so t0 needs to be estimated locally for each DER.

#### 3.1.1 AEMO's existing verification approach to estimating t0-actual

AEMO's approach to estimating FDT (we will refer to an estimate as t0-estimate) is to use the timestamp of the first sample where frequency falls outside of the NOFB as t0-estimate. This means that t0-estimate will always be some time after t0-actual.

This approach is named the 'relative window approach' by Mancarella et al., (2021). With this approach, the error in t0-estimate will not be uniformly distributed around zero across the devices comprising a DUID, it will include a bias, and a subsequent bias in estimation of FCAS delivered energy.

As shown in the UoM study, the relative window approach results in FCAS energy delivery being biased towards overestimation.

Inverters sense frequency much more often than once per second, even if storing and transmitting recorded data for verification is only achieved at 1-s intervals. So batteries have time to begin ramping up their response prior to the commencement of the FCAS-assessable period, which starts at t0-estimate.

This systemic bias towards over-estimation of FCAS delivery is larger for coarser sampling rates. For 1-s sampling for verification, the error in t0-estimate could be as much as 1s after the battery commences its response (or close to 0s if a sample occurs a very short duration after t0-actual).

This range of errors is depicted in Fig. 1 below. A sampled FCAS response might occur anywhere between the two depicted edge cases - always resulting in an over-estimate of FCAS delivered energy (the area under the curve over the assessable 6-s period).

[16] Evergen will not comment further on the choice of integration method for calculating energy, since this was well-covered in the Draft Determination and first round consultation. Evergen fully supports adopting the trapezoid method as the standard form of integration for calculating delivered FCAS energy for verification.

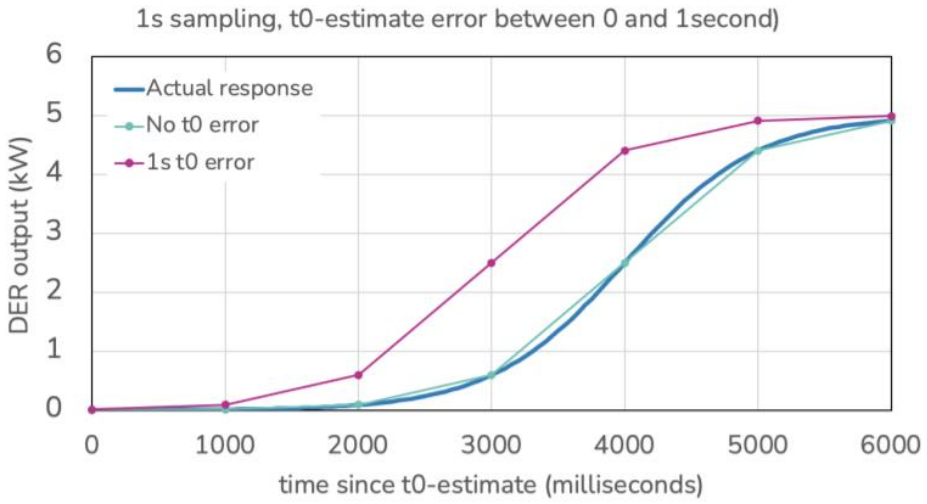


*Fig. 1. Range of sampled FCAS responses resulting from possible t0-estimate errors using AEMO's current "relative window" approach. Errors skew towards t0-estimate being later than t0-actual, and an overestimate of FCAS delivery.*

### 3.1.2 Two superior alternatives

Mancarella et al. included an examination of how FCAS delivery error is distributed if the error in t0-estimate could be eliminated, such that t0-estimate = t0-actual (see Fig. 20 and Fig. 21 from Mancarella et al. 2021).

They referred to the ideal case as the 'universal window' approach. It can be seen in Fig. 21 from their report that the error in FCAS for the universal window approach has a mean very close to zero in most cases, with a reasonably even distribution of errors either side of zero.

This is to be expected: with no bias from erroneous t0 estimation and using the trapezoidal approach to estimating delivered energy, the error associated with calculating energy by sampling power is neutral, not skewed towards overestimation.

The universal window approach provides a useful benchmark, but cannot be implemented practically, since it relies on perfect time-keeping for each device.

Evergen proposes two simple, no-regrets alternatives to the 'relative window' approach. Either approach would remove the systemic bias towards over-estimation that is inherent in AEMO's present approach, and both would also halve the size of the maximum possible error in t0-estimate, with a commensurate halving of the error in FCAS delivery verification compared to the relative window approach.

Method 1 - midpoint

Use the midpoint between the time of the last sample where frequency is inside the NOFB, and the time of the first sample when the frequency is outside of the NOFB, as t0-estimate. Calculating FCAS energy will therefore involve taking half of the first trapezoid, followed by a number of full trapezoids, followed by a final half trapezoid to reach 6s of energy. See Fig. 2. A sampled FCAS response would occur anywhere between the two edge cases, with a mean t0-estimate error of approximately zero (i.e., the actual response is in the middle of this range).

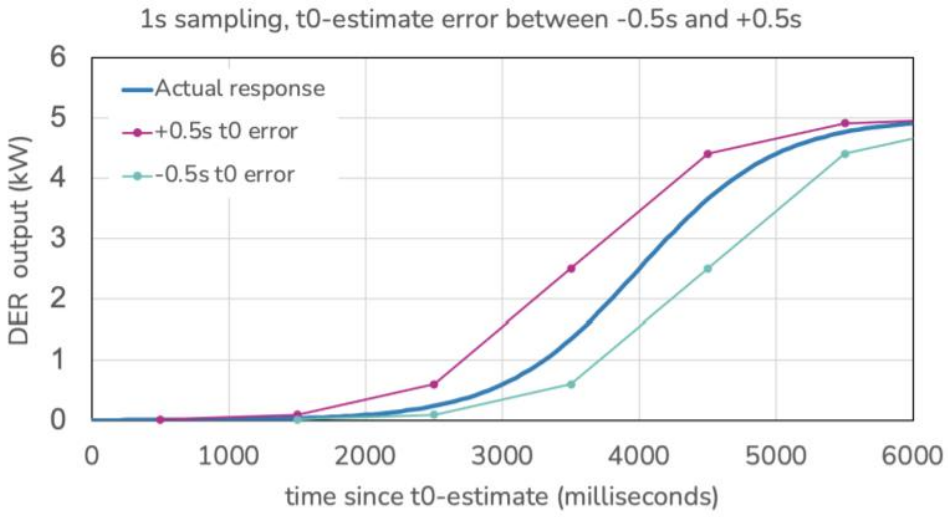


*Fig 2. Range of possible sampled FCAS responses across possible t0-estimate errors using alternative Method 1. Errors range from an overestimate to an underestimate, with a mean error of approx. zero. Note that 1s samples are offset compared to AEMO's approach by 0.5s. E.g., at 500ms, 1500ms etc, instead of 0ms, 1000ms etc. The FCAS delivery calculation involves taking half of the trapezoid between the -0.5s sample and the 0.5s sample.*

Method 2 - average

Calculate FCAS energy twice: once using the timestamp on the first sample where the frequency is outside the NOFB as t0-estimate, and once using the start time as the timestamp on the last sample where frequency is inside the NOFB as t0-estimate. Calculate delivered FCAS energy as the average of the two.

Both of these alternative approaches ensure that instead of a maximum error as big as a single sample interval (i.e. 1s for the sample rate adopted for the VPP Demonstrations), the maximum error in t0-estimate will now not exceed 0.5 sample intervals (0.5s for a 1-s sample rate).

For AEMO to implement either of these methods into their verification approach is a 'no regrets' change. The logic for the change is simple and straightforwardly an improvement on the existing approach.

By eliminating systemic bias, a change to t0 estimation in this way also means that 1-s sampling at each DER will be more than sufficient for VPPs comprising numerous DER to meet AEMO's tacit verification accuracy benchmark, provided AEMO improves their verification approach, as follows.

### 3.2 Sample rate, accuracy and number of devices

The benchmark for accuracy that AEMO is willing to accept is communicated in MASS v6.0. Namely, data from a single-plant DUID, sampled at 50ms, with a measurement accuracy for each sample of ±2%, is deemed to hold sufficient information to meet AEMO's requirements for accuracy of verification.

Evergen has conducted analysis that shows that there is sufficient information in the many individual measurements taken across a DER-based VPPs consisting of n devices, each sampled every 1s over 6s, to match or exceed the accuracy AEMO would accept from a single device sampled at 50ms intervals (120 measurements over 6s). This applies for a wide range of values of n, certainly for any of the VPPs participating in the VPP Demonstrations.

We provide an analysis of the number of DER required to exceed AEMOs tacit information content standard in the section below. Table 1 provides a guide to the number of measurements obtained for various sample intervals and fleet sizes, for comparison.

*Table 1. Number of measurements recorded per six seconds for various VPP configurations and sampling rates. The MW figures in parentheses assume 5kW size for individual devices, and is indicative of a fleet of residential-scale batteries. 120 samples over 6 seconds for a single plant, each measurement subject to up to 2% error, is acceptable to AEMO for verification purposes.*

| Sampling interval | 1 device | 100 devices | 250 devices (1.25 MW) | 1000 devices (5MW) | 10,000 devices (50MW) |
|---|---|---|---|---|---|
| 50ms | 120 | 12,000 | 30,000 | 120,000 | 1,200,000 |
| 100ms | 60 | 6,000 | 15,000 | 60,000 | 600,000 |
| 200ms | 30 | 3,000 | 7,500 | 30,000 | 300,000 |
| 1000ms | 6 | 600 | 1,500 | 6,000 | 60,000 |

### 3.2.1 AEMO's existing verification approach

AEMO requires VPP operators participating in the VPP Demonstrations to collect 1-s telemetry from every individual DER.

However, for verification, AEMO only makes use of a single time series, created by aggregating all the individual DER time series. For the VPP owner to perform this aggregation, individual DER time series are time-aligned using the t0-estimate for each DER, so that the power measurement in each time-aligned 1-s interval can be summed. The aggregate time series, which will consist of only 6 data points over a 6-s window, is what AEMO uses for verification (of course in addition to the balance of 54s, for the full fast market sustained response).

This is despite requiring that thousands of data points be recorded across a VPP comprising hundreds or thousands of DER.

### 3.2.2 Alternative approach

FCAS delivered energy could be calculated on a per-device basis, and the FCAS energies summed. If the bias towards over-estimation were eliminated as discussed in Section 3.1, then summing these energies would result in a reduction in error.

This is because, as was shown in the previous section and in Mancarella et al's analysis of the universal window method, the mean error across all devices approaches zero if the error is unbiased, and summed errors distributed evenly around zero tend to cancel one another with a big enough fleet.

Using an artificially-generated response curve based on a sigmoid (as in Fig .1, and similar to the FCAS response curve considered by Mancarella et al.), and assuming that any individual measurement is subject to a measurement error within ± 2%, we show that, for a single device, sampled every 50ms over 6s, the error in calculated FCAS energy using the trapezoid method has a 95% confidence interval of ±1.4% error (see Appendix A[17] for a detailed calculations). This is the benchmark accuracy implicitly accepted by AEMO for good verification.

We assume an onerous ±25% error in calculating the delivered FCAS energy for a single DER, arising just from using 1-s sampling instead of 50ms sampling. This error is much larger that what Mancarella et al. found when using the trapezoid method and universal window method for calculating FCAS energy, it is among the worst cases considered in the Mancarella et al. study.

Even with this assumed large error per individual DER, we determine that for an aggregation using the proposed alternative verification approach and the proposed midpoint method for estimating FDT, only 213 such DER would result in the same 95% confidence interval error range of ±1.4%. If the error per device arising from sampling at 1s were only 10%, then aggregating across **only 35 DER** with 1-s sampling achieves similar accuracy to sampling a single device at 50ms intervals over 6s. Again, sampling a single device at 50ms intervals sets the benchmark for what AEMO regards as sufficient information for acceptable verification.

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

Further results are included in Table 2, for a range of device-level estimation errors versus fleet-level estimation errors.

*Table 2: The minimum fleet size and 1-second measurement interval to achieve the fleet-level error indicated for each column. E.g., only 17 DER, each with a 10% error, would result in a 2% fleet-level error when aggregated.*

| Assumed sampling error per device | 2% error (fleet) | 1.4% error (fleet) | 1% error (fleet) |
|---|---|---|---|
| 10% error | 17 | 35 | 67 |
| 25% error | 105 | 213 | 417 |
| 50% error | 417 | 851 | 1667 |

### 3.2.3 Recommendations regarding verification approach

A simple desktop analysis (see Appendix A) readily shows that if AEMO were to fully utilise all of the data that they require VPP operators to collect as part of the VPP Demonstrations, they would have sufficient information to conduct highly accurate verification, provided AEMO updates and improves its verification approach.

Evergen recommends that AEMO take this opportunity to modernise the current outdated approach to FCAS verification. Parts of industry have already suggested to AEMO that their spreadsheet-based verification tool is opaque, and not fully specified in the MASS itself. That its use by AEMO for verification is manual and labour-intensive would lead to a high risk of introduced errors during data handling, not to mention being a time sink and pain point for AEMO staff.

Its use creates conditions which clearly and unfairly bias AEMO towards favouring single-plant DUID rather than VPPs composed of many DER. AEMO understandably lacks the resources to use such a cumbersome tool to validate the FCAS response of individual DER, hence requiring DER-based VPPs to aggregate first, throwing away device level data and magnifying verification error.

VPPs represent a new approach to delivering grid services, and industry is devoting millions of dollars to exploring and understanding the possibilities of using VPPs to deliver FCAS and near real-time operational data feeds across thousands of devices to AEMO. We believe AEMO should consider devoting internal resources commensurate with what industry is providing to modernise their alarmingly outdated tools. It is concerning that a major NEM-wide compliance process would be governed by manual copying of data received by email into a spreadsheet.

## 3.3 Oscillatory response

In the Draft Determination, AEMO indicated that an additional power system security risk associated with 1s data is that the occurrence of inverter sub-second oscillatory behaviour would only be apparent to AEMO with a shorter sampling interval of 50ms. It appears that this risk was raised in Reposit's initial response to the MASS review, where they provided one example of an inverter delivering an oscillatory response. Reposit indicated that although the frequency injection tests required for Option 2 compliance prior to registration could identify and exclude devices showing oscillatory response behaviour, this behaviour may theoretically only eventuate subsequent to this test. There is no current evidence on the likelihood of this behaviour, or how it may vary by technology or age of equipment.

Mancarella et al. (2021) included analysis of a DUID response with superimposed oscillatory response. Evergen notes that inclusion of this oscillation did not always result in an increased verification error in their study. Mancarella et al. did find an increased verification error resulting from the oscillatory response when using the trapezoidal rule and universal window method.

### 3.3.1 DER oscillations would not manifest at the fleet level

AEMO indicates concern about oscillatory behaviour in individual DER inverters, and yet AEMO's existing verification approach does not consider data from individual inverters, it only considers the fleet aggregation. As a result, AEMO would never see oscillatory behaviour among individual inverters during verification, even with mandatory 50ms measurement intervals. Requiring VPPs to sample at 50ms therefore imposes a cost on industry without materially improving verification of the FCAS response of VPPs regarding this specific issue.

In a fleet aggregation, oscillatory behaviour in individual DER inverters would at best appear as almost imperceptible noise in the aggregated fleet time series for battery power. A sub-1Hz oscillation of ±5kW in an aggregated fleet power of 1000kW (or even higher) is of no consequence.

For AEMO to observe significant oscillatory behaviour at the fleet level:

- Many inverters would need to deteriorate and begin exhibiting oscillatory behaviour, and
- The oscillations for each inverter would need to be both in phase and at the same frequency of oscillation after time alignment to the same FDT, to ensure the superimposed oscillations reinforce rather than destructively interfere with each other.

The idea that these conditions would occur is not plausible. Not only is there no evidence that this behaviour is widespread, but even should it be, oscillations at the DER level would not deliver a concerning oscillation at the assessable fleet/DUID level.

Oscillatory behaviour would notionally be more of an issue for individual large BESS with a single inverter to deliver the behaviour than it ever will be for a VPP comprising many DER. But single-plant DUIDs are not eligible for Option 2 coarser sampling regardless.

AEMO sought advice from the UoM on the impact of an oscillatory response at the fleet level (an oscillation with a huge magnitude of 30%, or 1.5MW for the 5MW fleet considered!). Mancarella et al. state that they included this case as a 'stress test' of the different integration methods (trapezoidal, Riemann sums etc). However, they also suggest that this response pattern "…might be seen in less diverse aggregates of inverter-based providers", (Mancarella et al., 2021, p.10 footnote).

This is misleading, because 'less diverse' is an understatement. It is implausible that a VPP would consist of a majority of devices that each failed in the same way such that the fleet aggregate would see such a significant oscillation. The faulty inverters would need to be identical in their failure, and in their response and oscillations at each time point. This is not 'less diverse', it is 'perfectly uniform'.

Figs. 3 and 4 show an example of how, even for an extreme edge case of a VPP consisting of 250x5kW DERs, where every DER suffers the same oscillatory response, would not result in a significant impact to the aggregated fleet response if all the oscillatory noise waves for each DER were not perfectly in phase. In the unlikely event that all DER had the same issue in the first place, it is not plausible they would all be in phase.

As can be seen in Fig.4, individual oscillatory responses destructively interfere with one another to dampen the possible oscillation at the fleet level when not perfectly aligned.

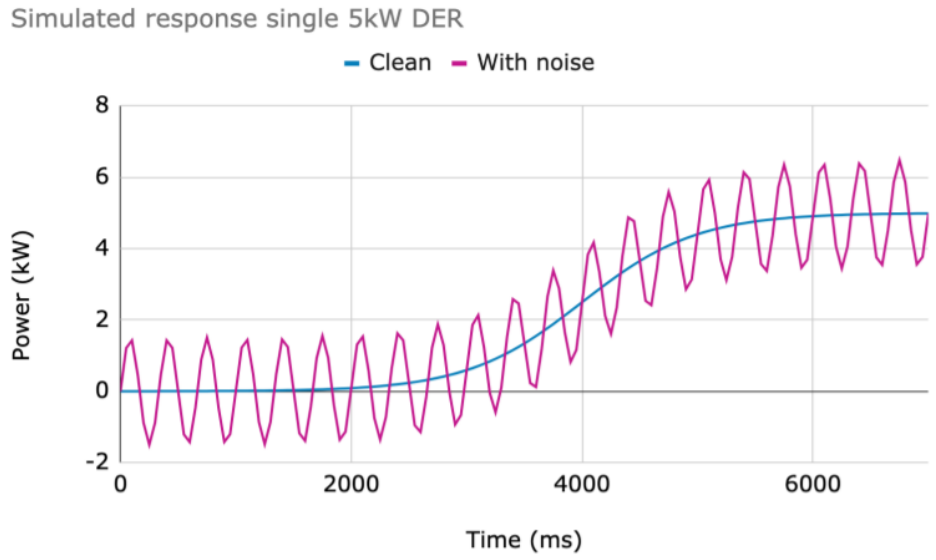


*Fig. 3. Simulated raise response of a single 5kW DER, with and without oscillatory noise. The noise is a superimposed sine wave with 3Hz frequency and amplitude of 30% of 5kW.*

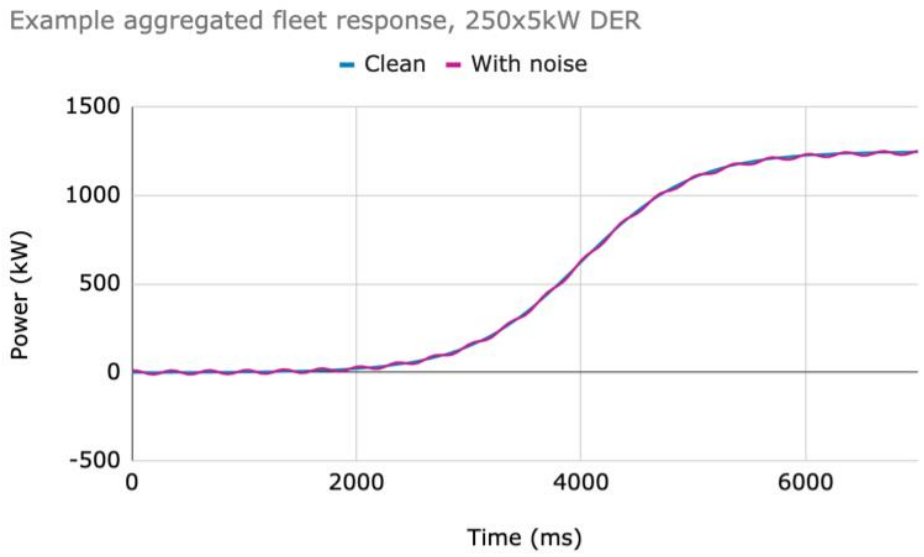


*Fig. 4. Aggregated power of 250x5kW DER, with and without noise. For the 'with noise' condition, the oscillatory noise added to each DER is offset by a time randomly chosen from the range 0 to 333 milliseconds. We did this since it is implausible that oscillatory noise in each DER would be perfectly in time sync. The result provides an example that even for the extreme edge case of every single DER in the fleet suffering from the same oscillation problem to the same amplitude and with the same period of oscillation, the aggregation of oscillations is subdued since they do not combine into a large oscillation over many DER when not perfectly time aligned.*

In summary, it can be concluded that alleged oscillatory behaviour that has been suggested may occur among some small inverters in a VPP consisting of many DER is of negligible consequence to either the aggregated fleet FCAS response, the verification of this response by AEMO (whether using 50ms or 1s granularity data), or overall power system security.

…

**5. DER behaviour (and potential impact on network stability)**

AEMO raises some concerns about the impact on power system security posed by DER. Evergen notes that these risks do not change whether Option 1 or Option 2 measurement requirements for DER-based VPPs are adopted. These concerns include:

A. Research conducted for AEMO suggests that legacy solar inverters are not compliant with recent standards and are prone to disconnecting from the grid under conditions of voltage and/or frequency disturbance. If this were to occur with FCAS-enabled battery-based DER, it would cause non-compliance and jeopardise system security;

B. AEMO shares concerns of DNSPs that multiple DER acting in unison to deliver FCAS might exceed secure distribution network operation limits;

C. DNSPs apply connection requirements to DER which may include limits on export (whether static export limits or dynamic operating envelopes) and Volt-VAr response. AEMO is concerned that complying with these requirements may conflict with FCAS deliverability and wishes to clarify the hierarchy of control commands; and

D. Measurement error resulting from sampling at 1s may fail to identify oscillatory patterns that allegedly may occur in some battery FCAS response profiles, which could impact system security. (This issue has been addressed previously in Evergen's response, we demonstrate that it is a non-issue and will not cover it further in this section).

**5.1 Behaviour of PV inverters vs battery inverters**

In May 2021, AEMO published a compendium of analysis conducted over the last 3 years in conjunction with UNSW, examining the behaviour of PV inverters over the course of various grid disturbances. Available at: https://aemo.com.au/-/media/files/initiatives/der/2021/capstone-report.pdf

The report found evidence of extensive disconnection of legacy PV inverters during voltage disturbances. The report also found low levels of disconnection during frequency disturbances where frequency

remained above 49.5Hz, and a greater degree of disconnection for larger frequency disturbances below 49.0Hz.

The report focuses solely on PV inverters, many of which would be many years old, given that grid-connected residential solar across Australia has been ramping up over the past 20+ years.

The report specifically excluded study of battery inverters.

Compared to rooftop PV, residential batteries and their inverters will be newer, and therefore more likely compliant with recent standards. For example, the Tesla Powerwall 2 was released in 2016. The two types of battery-inverter system comprising the two VPPs operated on behalf of Members Energy by Evergen have each only been available in Australia for less than two years, and are already compliant with the voltage ride through requirements specified in AS4777.2:2020.

**There are categorical differences between the battery inverters that comprise the VPPs participating in AEMOs demonstration program and the PV inverters considered in AEMO's study.**

Therefore, it is questionable whether the findings of this report bear great relevance to concerns over whether FCAS fleets will ride through grid disturbances in sufficient numbers to deliver on their FCAS enablements.

A far more relevant source of information on how battery inverters in VPPs respond during system disturbances is the VPP demonstration program itself. AEMO has previously indicated across three knowledge sharing reports and its initial MASS review documentation that **the VPP Demonstrations has shown that VPPs can deliver compliant FCAS bids**. Further, the VPP Demonstrations afforded AEMO an enhanced view of local telemetry such as local voltage readings which could facilitate further research.

As indicated in the Draft Determination, AEMO has identified that AS4777.2:2020 compliance could further improve certainty over inverter disturbance ride-through performance, and Evergen supports pursuing this, towards requiring all DER be AS4777.2:2020 compliant to be registered as ancillary service loads.

### 5.2 VPP-based FCAS exceeding network operating limits?

The risk posed by battery-based FCAS VPPs to distribution networks is dwarfed by the risk posed by the millions of rooftop PV systems already installed around the NEM. These PV systems all generate power in unison on a sunny day in a given area of the network and across the NEM.

That rooftop PV is magnitudes more significant than battery-based VPPs delivering FCAS is not just the current circumstance, but will be an enduring condition. It is almost never the case that a residential battery would be installed without a rooftop PV system, and there is no plausible scenario under which this would change.

For this reason it is ineffectual to use the MASS to render support or benefit to DNSPs in managing network constraints.

There are industry processes that are completely independent of and unrelated to the MASS that are already underway to grapple with the impact of large volumes of rooftop PV on distribution networks. These include the widespread imposition of export limits and solar curtailment measures (switching off of rooftop PV systems) by DNSPs, and investigation of dynamic operating envelopes as a more flexible alternative to export limits. Evergen does not see how battery based VPPs would be able to circumvent these measures without the explicit permission of incumbent DNSPs.

AEMO seems focused on trying to establish an industry-wide 'control hierarchy' before it will countenance modifying the MASS in line with Option 2 requirements. By control hierarchy, AEMO refers to the potential conflicts between FCAS response and controls such as export limits. We will respond to this in the next section.

### 5.3 The 'control hierarchy'

AEMO wishes to determine a control hierarchy to establish which battery commands will take precedence when both DNSPs and VPP operators bidding for FCAS request potentially conflicting battery actions.

In Evergen's view, DNSP controls should take precedence over market-based actions such as delivering FCAS, and should be assumed by VPP operators to take precedence. It is incumbent on the VPP operator to be aware of the potential for conflicting controls, and manage their fleet and moderate their FCAS bidding strategy accordingly. Managing risk is a responsibility of the VPP operator, not something that AEMO and DNSPs need to excessively regulate at the individual DER level.

That DNSPs have Volt-VAr requirements and export limits is a known consideration. These are not limits that any VPP operator would simply assume can be ignored or not complied with. Rather, they are limits to bid around.

Voltage issues that may necessitate a VAr response are localised often down to individual feeders, while FCAS fleets are region-wide. As seemed to be the case when considering measurement error for FCAS verification, AEMO is identifying an apparent issue at the individual inverter level, then improperly over-simplifying in magnifying that issue up to a fleet-wide issue. Potential conflicts for a portion of individual DER across a fleet can be mitigated with an appropriately conservative bidding strategy, and AEMO can enforce good bidding behaviour using existing compliance measures.

Since it should be clear that DNSP connection requirements take precedence over market-based activities, and competing controls at individual DER can be mitigated by the VPP operator and already enforced by both DNSPs and AEMO compliance measures, Evergen sees no reason to delay moving to Option 2 MASS requirements for DER-based VPPs based on system security concerns.

**5.4 Export limits and dynamic operating envelopes**

VPPs already behave conservatively, and export limits are simply another input to bidding logic. For example, if devices in a VPP are export limited to 5kW, then this could and should be readily incorporated into bidding logic. The end result may be that a VPP does not bid 1MW of FCAS until it has 1.5MW available. VPPs already manage uncertainty in battery state due to the challenges with forecasting load and solar output, and must conservatively assume that some portion of their fleet will not be available when making bids. DNSP requirements such as Volt-VAr response requirements are no different. AEMO and DNSPs can simply set the connection and compliance requirements and allow VPP operators to freely satisfy these constraints as they see fit.

The same applies for the advent of dynamic operating envelopes. VPP operators would incorporate knowledge of DOEs into their bidding and rebidding strategies.

**5.5 Managing risk and learning by doing**

VPP operators must already deal with the uncertainty of battery state, household load and solar output when day-ahead bidding and subsequent rebidding in FCAS markets. This uncertainty is accommodated with an appropriately conservative bidding strategy to ensure compliance. Incorporating unavailability of some DER due to Volt-VAr behaviours can be readily incorporated into bidding strategy risk management.

VPP operators routinely have grid voltage and power factor measurements as part of their operational telemetry, and can also determine export limits from operational telemetry if it is not already apparent in DNSP published requirements for grid connection. VPP operators are well-positioned to recognise the possibility that a portion of their fleet will be hampered in delivering an FCAS response - whether it is from lack of battery storage/headroom, insufficient solar output to charge the battery, communications issue, or localised competing DNSP controls, and conservatively bid around these issues.

Over the VPP Demonstrations Members Energy and Evergen began by adopting a very conservative approach to bidding to ensure compliance, and were in fact advised by AEMO to consider being less conservative in order to participate and learn.

The only way to properly undertake this learning is through participation. The cessation of the VPP Demonstrations and adoption of this Draft Determination will prevent this learning from continuing in a well-monitored and orderly fashion.

To move from excessive conservatism to comfortable and efficient compliance, the most important prerequisite for VPPs becoming skilled at managing these varied constraints and conditions is experience, and AEMO and DNSPs can better assist this if they have improved visibility at the local level of system characteristics such as voltage.

**Lack of visibility is bad for system security.**

…

**7.4 APIs for operational telemetry**

As part of the VPP Demonstrations, AEMO required Trial Participants to integrate with AEMO via API for provision of de-identified 5 minute telemetry at both the device and fleet aggregate level. This is similar to API-based telemetry requirements in place for government DER funding initiatives, such as the NextGen program in the ACT.

Although there is an upfront cost associated with establishing an API integration and teething issues, both of these can be mitigated to an extent with improved documentation and a functional testing platform. Both AEMO and industry would get better at this… with experience. Once up and running, API-based automated telemetry provision to AEMO represents a low running cost and an incredibly valuable data

stream, offering insight both on the site level (e.g., of grid voltage), and of BTM telemetry. These APIs represented a mature, 21st century approach to visibility, monitoring and data.

Under the VPP Demonstrations, AEMO was privy to this data at no charge to AEMO. It would normally be reasonable that such an extensive, near real time data set would fetch a significant price for access. Even DNSPs lack this level of fine-grained visibility over site-level voltage on their own networks.

Given this, it is a concern that AEMO elected to decommission these APIs. Doing so suggests that AEMO did not devote sufficient resources to taking advantage of these valuable data streams. If they did so, the insights and fine-grained visibility delivered would outweigh any internal expense in maintaining the APIs and performing data analysis, especially when some degree of data analysis could be automated.

AEMO will need to constantly build on a solid capability for data ingestion and analysis, routinely handling huge volumes of data, to inform decision making. That the world is moving towards a big data and data science mindset is not a new idea.

That AEMO performs FCAS verification by having FCAS Providers email files which AEMO then runs through a spreadsheet should be a source of concern to AEMO and incumbents more broadly, more befitting small business accounting processes than operation of the NEM.

Decommissioning the APIs implies that in practice AEMO is still hampered by an outdated mindset, and is shying away from developing even its own internal capabilities. To match its own rhetoric, AEMO must work to operate in the contemporary context of big data, real time data streams, automated data analysis and machine learning. It is an unambiguous backwards step for AEMO to decommission these APIs.

Evergen recommends that AEMO reinstates the VPP Demonstrations APIs and makes API integration a condition of entry for new Trial Participants against the interim arrangements. This will ultimately benefit AEMO and contribute to the ongoing learning that needs to occur for both AEMO and industry to progress against AEMO's publicly stated aims of facilitating active consumers in the electricity market, and prosumer-based DER provision of grid services.

Hydro Tasmania:

AEMO has indicated that the UoM study and their verification processes prove that less granular data leads to a theoretical error (%). However, AEMO have also confirmed that less granular does not lead to any system security risks, as well as recognising that more granulated data comes at a higher cost. Hydro Tasmania, therefore supports the extension of the VPP Demonstrations in order to ensure that system security is guaranteed at the lowest practical cost and market-usable outcomes are developed.

Hydro Tasmania suggests that AEMO further explore the feasibility of using 100ms or 200ms data to be the standard resolution in the MASS in accordance with AS4777.2. We have noted that 200ms data is already feasible in the battery data logger of certain OEMs. If demonstrated successfully and accepted in the MASS, this could stimulate large scale commercial applications and significantly drive down costs.

…

**The uncertainty of DER behaviours:**

Hydro Tasmania acknowledges the technical concern in this area and the uncertainties involved. We encourage AEMO to continue to consider the learnings from the VPP FCAS initiative as well as engage with battery OEMs as well as Trial Participants in order to further understand this matter. DER behaviours due to voltage issues or extreme system conditions not within control of the VPP operator/MASP should be studied further in order to minimise the risk of non-compliance. Associated events, such as the DER Low Voltage Fault Ride Through (LVFRT) experience in the system event on 25 May 2021, triggered by Callide generator trip in QLD, can have a significant impact on the commercial viability of VPPs moving forward if performance requirements are not well understood and/or implemented.

For the VPP long term development, Hydro Tasmania believes that the necessary technical standard will be essential to ensure the DER performance. This technical document can be developed as a standalone piece, but refer to the MASS. With it, the Trial Participants can assess the performance upfront and minimize the potential non-compliance risk, AEMO could also address the system security concern due to the uncertainty and ultimately improve the competitiveness of VPPs.

Intellihub:

New Intellihub smart meters, including at residential sites, will be capable of providing measurement facilities for Fast FCAS by the end of the year. Our target price for this service is $10 per site per year, with no capital outlay.

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 provides assurance of data quality.

Intellihub will be introducing the next generation of smart meter later this year which will be available as standard issue for both 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.

We have completed thorough testing of our next generation meter against the MASS requirements for Fast FCAS and can confirm that the solution exceeds the requirement of 0.01Hz accuracy at 50ms intervals.

We would be pleased to demonstrate this capability to AEMO or any interested party.

We agree with AEMO's assessment that amending the MASS to accommodate alternative measurement arrangements for FCAS provision from DER is not necessary.

We do however ask that AEMO consider requiring measurement devices are tested or certified for accuracy to a common specification. This will provide the industry confidence that all measurement devices claiming to meet or exceed the MASS measurement requirements deliver this performance in reality.

…

We agree with AEMO's assessment that amending the MASS to accommodate alternative measurement arrangements for FCAS provision from DER is not necessary.

We maintain that advanced digital meters, performing the dual role of the revenue meter for the NMI, make the most sense in providing 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.

- Key benefits of this approach:
- Eliminates duplication of measurement devices on-site
- Is scalable to site-level orchestration of multiple assets
- Provides assurance of data quality through regulated revenue grade metrology and guarantees the long-term accuracy of measurements
- Aligns with the power of choice framework in leveraging the smart meter to provide additional value

**Measurement Interval**

In the time since our initial submission to the MASS review consultation in March, we have thoroughly tested the capability of our upcoming metering solution against the requirements of the MASS for fast raise and fast lower services. We can confirm that our metering solution meets and exceeds the current measurement requirements for Fast FCAS.

The table on the following page details the results of this testing.

| Requirement | MASS – Fast FCAS | Intellihub FCAS Service |
|---|---|---|
| Frequency of Local Frequency Measurements | ≤50ms | 10ms |
| Frequency of Generation Amount and Load Amount measurement | ≤50ms | 10ms |
| Measurement Range of Power Flow Measurements | As appropriate to the Ancillary Service Facility, with a margin of error of ≤2%, and resolution of ≤0.2% | Range: metering installation as appropriate to the connection point<br>Margin of Error: ≤1%<br>Resolution: ≤0.01% |
| Settling Time | ≤50ms | ≤50ms |
| Local Frequency Measurement Range | At least the ranged specified in the OFTB.<br>Margin of Error: ≤0.01Hz<br>Resolution: ≤0.0025Hz | Range: 45.00Hz – 55.00Hz<br>Margin of Error: ≤0.005Hz<br>Resolution: 0.001Hz |
| Frequency Disturbance Time | <10s | <10s (longer is possible) |
| Recording Period for Power & Frequency Measurements | ≥5s before the Frequency Disturbance Time and ≥60s after it | Configurable.<br>≥5s before the Frequency Disturbance Time and ≥60s after it |
| Trigger for Recording Measurements | At least whenever Local Frequency changes ≥Trigger Range. | At least whenever Local Frequency changes ≥Trigger Range. |

This new meter will become available as standard issue for residential and small business sites later this year, at no additional cost. At this time, we will launch our FCAS measurements service, which permits a VPP operator to request a meter exchange (if required) and enable the provision of FCAS measurements at any site in the NEM. Our target price for this service is $10 per site per year, with no capital cost.

Members Energy:

Another significant advantage of the suggested approach is enhanced data provision from VPPs to AEMO and DNSPs. AEMO and VPPs have invested considerable effort and expense in the current API data transfer mechanisms from VPPs to AEMO. The current AEMO/ARENA EDGE project is further exploring how to leverage data to provide greater visibility, forecasting and network flexibility. As rooftop solar PV continues to increase its penetration, provision of data becomes even more essential to minimising wastage of energy due to inflexible network limits being imposed on solar export. Facilitating the ongoing role of VPPs to continue to encourage residential battery purchase, plus maintaining the existing VPP to AEMO API data transfer mechanism will both contribute to ongoing capacity of AEMO and DNSPs to manage distributed solar export in such a way as to minimise impact on AEMO's social license. We therefore suggest maintaining this API.

**Technical Observations**

Members Energy has liaised extensively with our partners and fellow VPP providers in relation to the main technical concerns raised by AEMO to justify its proposal to abandon the VPP Demonstrations settings and revert to the existing MASS settings, being 50ms metering at the point of connection.

Our colleagues, Evergen and Tesla, have submitted comprehensive technical arguments in favour of 1s metering, with several possible rationales indicating greater measurement accuracy for distributed fleets at 1s resolution than for a single connection at 50ms resolution. We support their findings and suggestions.

…

We suggest, given the clear evidence advanced by others, that requiring 1s resolution is preferable. Given the fleet sizes required for VPPs to be economically viable it seems clear that the fleet accuracy from 1s resolution per system will be superior to the existing 50ms resolution for single system FCAS Providers. Keeping metering cost to a minimum allows for increased VPP competition and reduced service provision cost to customers, in line with the NEO, and maximises AEMO's social licence and therefore better supports the energy transition.

New Energy Ventures:

We agree with AEMOs decision that 1s measurement resolution is not sufficient. (So much so, we are curious as to why 1s measurement was allowed during the VPP Demonstrations when desktop analysis will clearly demonstrate its deficiency).

That said, we question AEMOs decision not to proceed with a "compromise" of 100ms resolution metering. The UoM analysis demonstrates that 100ms measurement results in low error risk. 100ms metering would also provide good alignment with AS4777.

If AEMO combine 100ms metering with an update to the trapezoid method in the FCAS Verification Tool (also considered by UoM), then it provides a near zero error risk for verification purposes.

Origin Energy:

measurement time – we understand the risks raised by AEMO and why this should remain unchanged at 50ms (i.e. Option 1). Our expectation is that hardware providers will be able to provide reasonably priced devices in the coming years that can meet this standard. We do not believe it is worth discounting system security if suitable products are made available in a reasonable timeframe. However, we understand there may be a need for transitional arrangements or if such products do not eventuate in a timely or reasonably priced manner.

PIAC:

PIAC is concerned by AEMO's decision to retain the 50ms metering resolution and not amend the MASS to a slower metering resolution. PIAC understands this is due to concern that slower metering produces an unacceptably high error compared to faster metering, and may negatively affect system security. PIAC appreciates AEMO's concerns however considers its draft decision may unnecessarily restrict competition in the Fast FCAS market and slow the integration of DER, to the detriment of consumers. Before making a final determination on amending the MASS, PIAC recommends AEMO undertake work to determine a minimum metering resolution that ensures the integrity of the Fast FCAS service while also encouraging VPP participation in the Fast FCAS market and creating signals for investment in DER products and services. PIAC provides feedback on aspects of AEMO's draft determination below.

**Measurement accuracy**

PIAC does not consider AEMO has satisfactorily demonstrated why 50ms metering is needed for measurement accuracy and thus why it is needed at all. Independent research commissioned by AEMO found 200ms and 100ms metering could, with adjustment to the measurement and verification methods employed, satisfactorily address the inaccuracy identified with slower metering. As such, it appears AEMO has largely chosen the 50ms resolution to address system security concerns.

**System security**

PIAC considers AEMO has not made clear how retaining the 50ms metering requirement in the MASS will address the system security concerns identified. These concerns relate to the potential for VPP operation to be impacted by local network constraints or faults, and behaviour of inverters in response to system disturbances.

AEMO identifies unexpected oscillatory responses of inverters as a system security risk that could be addressed by 50ms metering. PIAC agrees systems that exhibit such behaviour are a risk, albeit not one that emerged during the VPP Demonstration. We consider Tesla's suggestion to filter these systems out during the testing stage and use existing or underdevelopment requirements to provide confidence on the performance of a particular asset type, are reasonable and deserve to be investigated further.

The remaining system security issues identified are not proposed to be addressed through metering resolution and it does not seem appropriate for them to be dealt with through the MASS.

Excluding VPPs without 50ms metering capability from the Fast FCAS market does not prevent them participating in other markets, or implementing faster metering to continue in the Fast FCAS market. As such, as long as these VPPs are participating in a market – whether it is fast or slow FCAS or something else – the system security issues associated with them will remain.

The issue of large-scale, coordinated battery injections or withdrawals threatening system security is not unique to VPPs participating in the FCAS market and will occur regardless of whether they are subject to the MASS. It is an issue DNSPs are likely best-placed to manage alongside, or using, methods such as DOEs and flexible export limits. SAPN has demonstrated these methods can mitigate this issue in its Advanced VPP Integration Trial.

System security issues are not directly relevant in considering whether VPPs can effectively participate in the FCAS market. This is evident in the fact system security was not a focus of the VPP Demonstrations. PIAC agrees system security concerns must be addressed, however we consider this should not be through the MASS, rather through a separate process, such as the ESB's maturity plan, or other dedicated working group or forum. Rejecting otherwise appropriate MASS amendments that would introduce more competition into the FCAS market and build on the learnings and infrastructure of the VPP Demonstrations to address seemingly irrelevant system security concerns is not in the consumer interest.

…

**The path to the future energy system**

AEMO's CEO, Daniel Westerman, recently outlined AEMO's goal to be able to handle 100% instantaneous renewable energy on the grid by 2025, an ambitious goal that will require the optimisation of all tools at AEMO's disposal.

Powerledger:

**Sampling Rate of Fast FCAS delivery**

As there are a wide range of technologies currently deployed on a broad scale in the residential space that do not support metering in a sub-second resolution, retaining the current specifications of <50ms sampling rate limits a significant share of current and potential providers of FCAS.

The cost of retrofitting a system is likely to create unmanageable burdens for many resulting in reduced competition and limited incentive for system investment and therefore impair the adoption of battery technology across the NEM and therefore full realisation of system benefits.

The argument of under-delivery of FCAS through slower sampling can be met by the obligation to provide an increased FCAS response as indicated in the transitional arrangements published by AEMO. This would be a compromise and potentially incentivise investment in additional controlling capability for many stakeholders whilst not limiting other assets capable of frequency response from participating.

Furthermore, the implementation of one high sampling meter per 5MW of VPP capacity should provide insights into the materiality of actual under-delivery of proportional controllers with a measurement rate of 1s.

Additionally, a switching response to frequency deviations would not be as affected by slower sampling rates and result in lower under-delivery as their response is constant and not overstated by slower sampling to the same extent as a proportional controller. The difference would only be material at the start of the contingency event if the meter does not detect the frequency deviation as quickly as a meter with higher resolution.

Redback:

Redback does not see any issue meeting this requirement and can do so with a minor update to existing hardware. The pass-on cost to consumers for this change will be $0. The meter that is used by Redback Technologies utilises an industry standard chipset and is included with all of our products. We also retail it separately for $200.

Redback is ambivalent about whether the measurement interval is 50ms, 100ms or some other interval. However, we would like to affirm that 50ms is achievable for DER, and at a very minimal cost imposition to the consumer.

Reposit:

Reposit supports AEMO's MASS review draft report as it relates to the DER component of the review. Specifically, Reposit supports AEMO's reasoning and decision to leave the measurement sampling rate and metering point for Fast FCAS unchanged.

…

Reposit reasserts that the measurement and verification processes in the MASS should be consistent for all FCAS Providers regardless of capacity, technology type, market participation status or other differentiating factors.

**1.1 Measurement sampling rate**

Reposit supports AEMO's decision to leave the measurement sampling rate unchanged. Reposit reasserts that a change in measurement sampling rate is unnecessary from a cost perspective and is actively damaging to Fast FCAS service integrity.

**1.1.1 MASS compliant metering is not cost prohibitive**

MASS compliant metering at 50ms is cost-effective for deployment on residential connection points, and is currently deployed at thousands of connection points in the NEM.

Reposit has deployed over 4000 residential installations fitted with FCAS-compliant metering. Reposit is currently operating this DER capacity in all six Contingency FCAS markets, under market conditions with no relaxations or concessions.

…

**1.1.2 Slower metering increases uncertainty of Fast FCAS delivery**

Repost demonstrated in its first submission to this MASS consultation that 1Hz metering would contribute at least 16% error. This results from the mathematics used to compute Fast FCAS response from 1Hz instantaneous power readings.

AEMO completed its own analysis to validate Reposit's position and achieved results consistent with Reposit's. AEMO then commissioned independent analysis conducted by the UoM which validated the quantitative findings of both Reposit and AEMO.

UoM and AEMO also showed real world Fast FCAS responses computed with 10Hz (100ms) sampling and making use of the Right Riemann method to return errors of up to 2.3%. During the first stage consultation Reposit provided the mathematical upper bound of 3.3%[18] error contribution for FCAS delivery computations using 10Hz sampling and the Right Riemann method.

Reposit notes that the use of the Right Riemann method is used by the FCASVT and AEMO has not suggested its replacement with a more accurate method.

The UoM analysis (and mathematical theory for errors, time integrals, and power systems) shows that the use of the Right Riemann only delivers sufficiently low-error results when used in conjunction with 20Hz metering. Error builds quickly as metering sampling rate is relaxed.

The UoM suggested that lower error could be achieved using a "Universal Window" to improve accuracy. Reposit asserts that this requires at least two technical assumptions that are not realistic:

1. Sub-second time synchronisation across all units participating in an FCAS response. This would most likely require GPS time synchronisation equipment to be installed at each DER site
2. Identical timestamp processing pipeline timing across all responding units, across all VPP providers.

It should be noted that Universal Windowing only decreases error when 1s sampling is used. A comparison of Figures 14 and 18[19] of the UoM report illustrates that a Universal Window does not contribute error reduction at 100ms or 200ms sampling rates.

...

**2 System security**

Reposit considers the integrity of Fast FCAS to be critical to the secure functioning of the NEM. As a result, Reposit supports AEMO's decision to maintain the integrity of these services by having DER metering requirements remain consistent with other providers of the Fast services.

Compromising the integrity of these services as a way to achieve the NEO is wrongheaded. 50ms, full accuracy, full precision metering costs are low with multiple Trial Participants indicating that they are in possession of this metering at sub $500 cost.

Reposit reasserts and agrees with AEMO that 50ms, high accuracy, connection point metering is essential for the wider security of the NEM. This is driven by the increasing likelihood that a large proportion of electricity services will be provided by DER in the future.

**2.1 Visibility of DER response**

Reposit supports AEMO's determination that 50ms/20Hz, connection point metering is essential to the management of the system where DER is providing security services. Reposit is prepared to work with AEMO to deliver high speed, connection point metering data to AEMO as required for measurement and verification of Fast FCAS responses and other system management tasks as necessary.

**2.1.1 High speed metering**

Reposit reasserts that 50ms metering, accompanied by the accuracy requirements in the MASS is the only way that Fast FCAS error can be deterministically maintained at its current reliability.

This is especially true as increasing proportions of Fast FCAS are provided by inverter-based technologies. These technologies are able to deliver relatively high-frequency power oscillations more easily than rotating machines. This is because the current sine waves are produced by power electronics. A 10Hz+ power oscillation is not difficult for these machines to provide.

DER is almost purely power electronics mediated and high-frequency power oscillations have been observed by Reposit on several occasions from AS4777-compliant equipment under evaluation. This can be as a result of many control pathologies as were discussed in Section 3 of Reposit's initial submission. Reposit suggests that these oscillations are more prevalent during power ramping operations, such as those required of a Fast FCAS response. These oscillations can be detrimental to power system security

[18] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/meetings/mass-consultation-reposit.pdf, Section 2.4.1

[19] Fast FCAS Sampling Verification in Support of MASS Consultation - June 2021 -p.12-13.

where they result in a reduction of FCAS response, especially if they are unable to be detected by AEMO due to slow metering.

Power system security analysis is generally concerned with power transfers over time. The measurement of energy delivered or absorbed by DER is fundamental to the secure operation of the NEM as an increasing proportion of these power transfers are created by DER. Inaccurate measurement of energy delivered from or absorbed by these devices puts future system security analysis on weak foundations.

Where Riemann methods are used for measuring energy, any decrease in metering speed corresponds to a proportional increase in measurement error. Reposit notes that the right Riemann method is used by AEMO in the FCASVT and there is no mention of changing this. The use of 50ms metering during a 6-s response window negates much of the error introduced by the Right Riemann method by creating relatively small time slices.

Reposit asserts that this is important as the Right Riemann is the simplest method available and is used by people almost all of the time. Future AEMO power system security analysts need to be protected from error. Only 50ms or better metering can keep total connection point measurement error below 2% when using the Right Riemann. This amount of error has proven to be acceptable to the designers and operators of Fast FCAS for 20 years.

...

### 2.2 FCAS clawback mechanism

The NER has provided AEMO with a powerful penalty mechanism against under-delivery of FCAS. This "clawback" mechanism delivers a substantial and increasing penalty cost that works to incentivise Trial Participants to guarantee FCAS delivery. The power system security concerns raised by AEMO in the Draft Determination are already addressed by VPPs that are sensitive to the clawback mechanism.

Reposit suggests that Trial Participants are not being subjected to the clawback mechanism and hence do not have the incentive to manage the well-understood power system security concerns raised by AEMO. As a result they are most likely ignoring these concerns and AEMO has detected the results of this.

Reposit has managed all of the power system security concerns that AEMO has raised since its VPP participation in FCAS in markets beginning in 2018 (pre-VPP Demonstrations). This is evident in our FCAS delivery performance even with a 10x increase in capacity. This is because of the very strong incentive provided to Reposit by the clawback mechanism.

Reposit suggests that the widespread application of the FCAS clawback mechanism to VPP operators will be sufficient to manage these and other power system security concerns. Reposit goes further and suggests that VPP operators will be aware of other power system security concerns and their urgency before AEMO is. Some of these will be systematic to DER, and some will be specific to the particular hardware and software operating the VPP. This is undoubtedly the case with non-DER FCAS providing plants.

Reposit asserts that 20Hz/50ms metering at the connection point will provide sufficiently accurate information for AEMO to execute low-error measurement and verification (M&V) processes. Low-error M&V allows for the clawback mechanism to be operated equitably and with high confidence. This will provide VPP operators with the incentive to manage power system security concerns as they arise.

#### 2.2.1 Description of operation

The clawback mechanism for VPPs is enabled by 2.3.5(i) of the NER, which reads:

> (i) A *Market Ancillary Service Provider* or *Market Customer* (as applicable) is not entitled to receive payment from *AEMO* for *market ancillary services* except where those *market ancillary services* are produced using an *ancillary service load* in accordance with Chapter 3 or pursuant to a *direction* or *clause 4.8.9 instruction*.

This is interpreted by AEMO Settlements and Prudentials to mean that payments that have been made to an FCAS provider during a period where an under-delivery would have occurred are invalid. In response AEMO Settlements and Prudentials "adjusts" the payment for the current settlement period. This adjustment subtracts the FCAS revenue earned during the under-delivery period from the current period, and continues to do so until the full amount (sometimes with interest) is repaid - or "clawed back".

AEMO Operations does not have a documented mechanism by which the beginning of the under-delivery period is determined. Reposit assumes that this under-delivery period is calculated to have begun immediately after the last successful delivery into an FCAS. Reposit suggests that a formal mechanism for the beginning of a clawback period is formulated and documented by AEMO in the MASS.

The clawback mechanism relies completely on low-error and reliable M&V processes. It is irrelevant as to why there was an under-delivery, only that there was an under-delivery. That is, if the FCAS provider does not respond to the contingency event as bid then they are subject to penalties. This could be for any

reason. If the power transfer does not occur across the connection point, then the clawback mechanism can be executed.

### 2.2.2 Magnitude of penalty

The introduction of PFR has seen Contingency FCAS deliveries become very rare. This creates long periods of time between FCAS deliveries. This has the effect of creating very substantial and constantly growing penalties for under-delivery for all FCAS providers - including VPP providers who are being exposed to full market conditions.

Under May 2021 - July 2021 market conditions, this penalty is in the order of $47k/MW for Reposit. This penalty cost is more than enough to incentivise Reposit to make substantial investments to manage the power system security concerns raised by AEMO in the Draft Determination.

### 2.2.3 Sources of risk for VPPs

AEMO has identified several power system security concerns with specific regard to DER. These can be summarised as under-delivery to a contingency event as a result of:

1. Inverter disconnection due to a voltage transient
2. Inverter control hierarchy interactions
3. Distribution network unreliability as a result of poor connection agreement formulation and/or network planning
4. Inverter power responses that result in insufficient power transfer

Reposit agrees that these are valid technical concerns. Reposit has been managing these concerns for more than five years of operation in the provision of electricity services other than FCAS. In particular, during the provision of security services to DNSPs and RERT. Reposit also has a record of successfully managing these concerns in FCAS as demonstrated by Reposit's delivery performance to date.

The table below describes in broad terms the power system security concerns raised by AEMO in the draft report, and Reposit's mitigations for them:

| Risk | Mitigation |
|---|---|
| Inverter disconnection | • Rigorous and long term performance characterisation using 50ms (and faster) metering data across all deployed VPP nodes<br>• Automated and dynamic capacity factor calculation and application across all VPP nodes |
| Inverter control hierarchy | • Rigorous and long term performance characterisation using 50ms (and faster) metering data across all deployed VPP nodes<br>• Automated and dynamic capacity factor calculation and application across all VPP nodes |
| DNSP unreliability | • Adherence to DNSP Connection Agreements<br>• Detection of DNSP instability with the use of 50ms (and faster) metering data<br>• Implementation of Evolve Dynamic Operating Envelopes |
| Inverter power response | • Rigorous and long term performance characterisation using 50ms (and faster) metering data across all deployed VPP nodes<br>• Automated and dynamic capacity factor calculation and application across all VPP nodes |

Reposit outlined additional sources of under-delivery from a VPP in sections 3.3.3.3 and 3.3.5.3 of its submission to the MASS Consultation paper. These are of much higher likelihood than the concerns raised by AEMO as they are systematic to VPP operations. As with the concerns above, Reposit has actively managed these concerns for more than five years.

Many of these risks cannot be understood by AEMO as they are systematic to a broad range of technology at all levels in an aggregator's technology stack. This means that AEMO must present firm incentives for aggregators to manage these risks without stifling competition and innovation.

The technology required to deliver reliable responses from aggregated DER is sophisticated and cannot be considered to be homogenous across VPP providers. Reposit considers the reliable power transfer from its VPPs to be a key competitive advantage and hence invests heavily into its operation and continued development.

It cannot be overstated how influential penalty conditions on unreliable power transfer have been on past and current engineering of this technology. Appropriate penalty conditions - such as the FCAS clawback - present a powerful and pre-existing tool for AEMO to manage power system security concerns. Reposit asserts that these mechanisms are the correct means by which AEMO should be managing power system security concerns.

#### 2.2.3.1 AS4777:2020 compliance

AEMO states that compliance with AS4777:2020 for registration of DER FCAS capacity is a potential action to alleviate the "local network fault" scenario. Reposit supports AS4777:2020 compliance for all installations made after December 2021, but does not support a requirement for all future registrations to be made totally of inverters compliant with AS4777:2020.

Reposit considers this potential action to be unnecessary. This is because Reposit is aware of thousands of inverters that do not meet AS4777:2020 and are known to be stable and reliable providers of FCAS. Excluding these inverters from FCAS provision is inefficient and thus does not promote the NEO.

Reposit reiterates that AEMO's power system security concerns are best addressed by the FCAS clawback mechanism provided that AEMO is able to accurately measure Fast FCAS responses. This requires that FCAS metering:

1. Complies with MASS v6 accuracy standards
2. Is 50ms or better
3. Is made at the connection point

This will allow AEMO to reliably detect under-delivery where it occurs and apply the clawback mechanism as appropriate. This will provide VPP operators with sufficient incentive to not register inverters unable to deliver a reliable FCAS response. This obviates AEMO's need to police inverters on a unit by unit, or model by model basis.

### 2.3 DNSP provision of reliable power transfer

Reposit acknowledges the primary importance of distribution network reliability in the provision of any electricity services from DER. Electricity services cannot be delivered by DER to the NEM in any meaningful way without a reliable distribution network.

Reposit considers the exploration of DNSP reliability performance well beyond the scope of this MASS Consultation. However, AEMO has referenced this key topic in its draft report and has followed it up with a DNSP forum[20] within the scope of the MASS consultation. Reposit assumes this topic to now be within scope and will briefly address it accordingly. Reposit has spent several years considering this issue and is enthusiastic to contribute to a conversation at this time.

#### 2.3.1 Network role under the National Electricity Rules

The role of a network provider in the NEM is to connect Participants to the market. This is made very clear early in Chapter 5[21]:

> **5.1A.2** Principles
>
> This Part B is based on the following principles relating to *connection* to the *national grid*:
>
> (a) all *Registered Participants* should have the opportunity to form a *connection* to a *network* and have access to the *network services* provided by the *networks* forming part of the *national grid*, except that if the *connection* is to a part of a *network* that is a *designated network asset* then that *connection* and access will be subject to the relevant *access policy* for that *designated network asset*;
>
> (b) the terms and conditions on which *connection* to a *network* and provision of *network service* is to be granted are to be set out in commercial agreements on reasonable terms entered into between a *Network Service Provider* and other *Registered Participants*;
>
> (c) the technical terms and conditions of *connection agreements* regarding standards of performance must be established at levels at or above the *minimum access standards* set out in schedules 5.1, 5.2, 5.3 and 5.3a, with the objective of ensuring that the *power system* operates securely and reliably and in accordance with the *system standards* set out in schedule 5.1a;

Key to this is a commercial agreement that describes the terms and conditions under which this connection is made. This is referred to in the NER as a Connection Agreement.

[20] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/second-stage/dnsp-forum-minutes.pdf

[21] National Electricity Rules - 5.1A.22

The NER says that the objective of connection agreements is to ensure that "the power system operates securely and reliably". This objective was written to be technology agnostic (as is the entire NER) and undoubtedly will be referred to by Reposit and others many times in the near future.

### 2.3.2 Connection Agreements

Network Connection Agreements are central to how the NER operates. They define the power transfer interface between a Participant and the wider system. As such they are fundamental to AEMO's understanding of the NEM at a given point in time. Simplistically[22] AEMO should assume that the instantaneous aggregate power transfer capability of all NEM Connection Agreements is possible at a given point in time. This is because the Connection Agreement is the NEM's model for electrical coupling. Because of this, Connection Agreements are fundamental to the management and operation of the NEM.

The key input into a Connection Agreement then is the NSP's assessment of the continuous power transfer capability available in a particular location. This is discoverable via a person's submission of a connection enquiry to a NSP.

The timings and content of a response to a connection enquiry are governed by the NER[23]. The purpose of this is to allow a Participant to know what amount of continuous power transfer is available. This amount gets written into the Connection Agreement. The NER is then very clear that NSP is then obligated to provide that continuous power transfer[24]:

> (e1) A *Network Service Provider* must, except in so far as its *market network services* and parts of its *network* which are used solely for the provision of *market network services* are concerned, arrange for:
>
> (1) management, maintenance and operation of its part of the *national grid* such that, in the *satisfactory operating state*, electricity may be transferred continuously at a *connection point* on or with its *network* up to the *agreed capability*;

NSPs cannot renege on their Connection Point agreements due to the introduction of new electricity services being provided over their network. Any failure of a network to provide continuous power transfer within the limits of a Connection Agreement is a failure of the NSP.

It is not the fault of DER, or an Aggregator, or a Consumer. All NSPs, DNSPs included, are obligated under the NER to meet the commitments they make in their Connection Agreements.

Reposit understands that some DNSPs in particular may be unfamiliar with their network being used to deliver electricity services. It is however inevitable under the NEO as the economics of DER make it the most efficient source of electricity services in the NEM.

To these ends Reposit has been collaborating with DNSPs for more than five years to characterise and operate electricity services provided by DER. Likewise Reposit has been active in the development of Connection Point management technology to ensure that DER provided electricity services are able to be securely implemented at broad scale in the NEM.

## 2.4 Implementation of Dynamic Operating Envelopes (DOEs)

For some years Reposit has advocated for the use of DOEs to regulate DNSP Connection Points. This was initially motivated by work done by Energex/Ergon to statically constrain a residential connection point[25].

Reposit considers it inefficient for a DNSP to provide static and somewhat arbitrary connection point ratings for DER. The promotion of a concept associated with dynamic limits was adopted as policy by Reposit at this time.

The concept is relatively simple. DOE DNSP Connection Agreements are formulated with an obligation being made by a DNSP to make the maximum import and/or export power transfer available when it is available, in return for the Participant (or their customer) to adhere to limits being imposed by the DNSP when maximum power transfer is not available.

### 2.4.1 DOE function in relation to FCAS delivery

A Reposit-controlled battery will not commit capacity that violates a connection point constraint to FCAS real time bidding. This is the current operating procedure. It is done so as to not commit Raise or Lower capacity to FCAS markets that cannot be supported by the network. These limits are provided by the Connection Agreement that mediate the DER to the system. As a result they are decided during the battery connection process and are unchanging over time.

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[22] Realistically the power transfer across a connection point is often modulated by regulatory processes including central dispatch, wholesale energy prices, AGC, network tariffs and others.

[23] National Electricity Rules - 5.3.2

[24] National Electricity Rules - 5.2.3(e1)(1)

[25] https://www.ergon.com.au/__data/assets/pdf_file/0005/211199/Thinking-about-solar-PV.pdf

Reposit devices that are subject to DOEs will likewise not commit capacity to FCAS real time bidding that violates a connection point constraint. Where a DOE is active, the network limits are communicated to the Reposit controller as they change. The same machinery used to optimise solar and battery behaviour, and calculate bids volumes using static limits is employed where DOEs are active.

This results in modulated connection point-level FCAS bid volumes such that an FCAS bid is not made where a related FCAS delivery would violate the Connection Agreement. FCAS under-delivery as a result of network limits will not occur provided that a DNSP is correctly calculating and communicating the capacity limits of their network. Likewise, AEMO the clawback mechanism will not be executed. Reposit's multi-year investment in DOEs was prompted in no small part by the FCAS clawback mechanism.

**2.4.2 Evolve project**

Reposit is a part of the Evolve[26] project. This project seeks to build the infrastructure required to facilitate distributed orchestration of DER. It has been active since 2019 and is near completion. The project describes itself as:

**Collecting**: Operational data from the electricity system.

**Analysing**: The data to understand network capacity for all parts of the network

**Publishing**: Details about the congestion within the network will be securely published to customer devices in areas where congestion is currently, or likely, to occur during the day.

**Orchestrating**: Customers, and their aggregators will be able to more intelligently determine how to operate their batteries, electric vehicles and smart loads in their houses, businesses and industry in real time, working autonomously and invisibly according to the customer's preferences for their energy usage patterns.

**2.4.3 Initial implementation**

Reposit operates Evolve DOEs on selected systems in Essential Energy's network. These systems receive operating envelopes from Essential Energy and modify their behaviour accordingly.

It is important to note that this implementation has been operational for several months and is continuous. The Reposit software operating these systems is considered to be Production grade.

Reposit looks forward to the application of Evolve DOEs to other Evolve partnering DNSPs (Ausgrid, Energex, Energy Queensland, Ergon Energy).

Rheem & CET:

We support the report's findings and the Draft Determination to retain the MASS as it currently stands. This support is based on the knowledge that the measurement of power flow and local frequency at intervals of 50ms or less at every site (NMI) can be achieved cost effectively, and from our experience that net metering (connection point metering per NMI) is necessary to support mixed DER sites.

…

We additionally support the UoM report's findings that it is prudent to avoid diluting the metering specification, as this may erode the potential value of FCAS provided by DER as it reaches scale.

SAPN:

Our primary concern is that the Draft Determination seems to conflate technical concerns around distribution network constraints and system security risks with the metrology requirements for market settlement and validation. The system security issues appear to be the primary driver for retaining the 50ms metrology requirement of the MASS for the Fast FCAS, but it is not clear how this helps to address the system security issues raised. AEMO has indicated that retaining the 50ms measurement requirement is not expected nor intended to exclude VPPs from participating in FCAS markets. It considers that some VPPs will move to implement the required 50ms metering and continue to participate in the Fast FCAS market, while others could continue to participate in the slower FCAS markets. That being the case, it would seem that the system security issues will remain, as in practice the same batteries will be responding in the same manner to the same local frequency droop curves regardless of the markets they are registered in. Some of the issues raised in the Draft Determination will also arise from the growth in non-VPP-participating batteries, and/or from the coordinated response of DER to price signals other than the FCAS market.

It seems, therefore, that we cannot rely on the MASS to address these issues of system or network security. These are issues of great importance and we will need to put robust technical solutions in place regardless of the outcome of the MASS review. For example, we consider that DOEs are the key to ensuring VPPs

[26] https://bsgip.com/research/evolve/

operate safely within distribution network constraints, and we have trialled this approach successfully with Tesla's SA-VPP during its participation in the FCAS market over the past two years.

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5. The Draft Determination proposes that it is not prudent to reduce the granularity of the 50ms measurement requirement for VPPs to the 1s metering tested in the VPP Demonstrations. We understand that the review has found that an alternative measurement resolution of 200ms or 100ms could be effective in mitigating the inaccuracy issue while also meeting the original aim of the AEMO VPP Demonstrations. We understand that respondents to the MASS review have indicated that this level of accuracy should be achievable by a broad range of VPP providers without incurring the additional cost of dedicated high-speed (50ms) metering at every site. On this basis, our understanding is that AEMO's decision has been primarily motivated by the system security risks identified on pages 17 and 18 of the Draft Determination.
6. It is not clear why retaining the 50ms metering requirement in the MASS will help address the system security concerns raised. These concerns have to do with the potential for VPP operation to be impacted by local network constraints or faults, and behaviour of inverters in response to system disturbances, neither of which relate to the measurement regime used for market settlement and validation of FCAS response.
7. AEMO has indicated that retaining the 50ms measurement requirement in the MASS is not expected nor intended to exclude VPPs from participating in markets. It considers that some VPPs will move to implement the required metering and continue to participate in the Fast FCAS market, while others could continue to participate in the slower FCAS markets. That being the case, it would seem that the system security issues will remain, as in practice the same batteries will be responding in the same manner to the same local frequency droop curves regardless of the markets they are registered in.
8. One of the system security risks identified is that large-scale, rapid and coordinated injection or withdrawal of energy from batteries may exceed local network limits. This issue will arise in any event due to the coordinated operation of batteries in response to technical requirements and other price signals (even batteries that aren't aggregated in VPPs), independent of the FCAS market and the MASS. This is an issue that DNSPs must be able to manage in any event. In our view this issue is addressed by the use of DOEs or flexible export limits. We have demonstrated how this approach can mitigate this risk for VPP operation in our Advanced VPP Grid Integration Trial.
9. It would seem, therefore, that the MASS should be concerned only with issues of market integrity and settlement accuracy. The technical issues of grid integration of DER are extremely important and must be addressed, but these will arise independent of the MASS and hence need to be dealt with through a separate process.
10. We also note that there are market penalties to ensure that service providers do not underdeliver on their contracted FCAS response. This will mean that service providers must engage with the DNSP and other parties regarding the integration of DER to ensure that their systems are managed within network constraints and perform as intended when dispatched, to achieve the required market outcomes.

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Simply Energy:

**The identified measurement errors at 1s resolutions can be mitigated through additional testing**

Simply Energy understands AEMO's concerns that measurement errors could lead to an over-delivery of Fast FCAS to the grid during frequency disturbances. However, when deciding on the appropriate mitigation for these risks, AEMO should have undertaken an assessment of the costs and benefits of different measurement time resolutions. Simply Energy is concerned that AEMO has taken an overly cautious approach to the risks of measurement errors, which will have detrimental impacts on the emerging VPP market.

AEMO's own assessment of the UoM analysis suggests that any measurement errors from a 1s resolution are not insurmountable. In particular, AEMO identified that changing its verification methodology to a 'universal window' approach 'is shown to reduce the average over-estimation bias to around 0% for 200ms data samples and a maximum of 3% for 1s data samples.'[27]

[27] AEMO 2021, Amendment of the Market Ancillary Service Specification – DER and General Consultation: Draft report and determination, June, p. 16.

Simply Energy considers that the overall error for VPPs, where aggregation can be used, would be significantly lower than demonstrated through the statistical analysis.

The UoM analysis suggests that the risks associated with 1s metering intervals could be mitigated through some additional testing and analysis of different verification methodologies. Simply Energy considers that there is a clear benefit in undertaking that additional testing before any decision is made on measurement time resolutions in the MASS.

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**Imposing a 50ms resolution requirement would not appear to address system security concerns**

It is not clear how AEMO would address the identified system security issues by restricting VPP participation in Fast FCAS markets (through the 50ms measurement requirement) while allowing continued VPP participation in slow and delayed FCAS markets. This approach fails to address that battery systems within VPPs will typically use the same local frequency droop curve settings regardless of the market that they are participating in. This means that any system security concerns that existed prior would continue to exist even if those batteries only participated in the slow and delayed FCAS markets.

Simply Energy considers that the choice of measurement resolution is largely separate to the system security concerns identified. AEMO has not sufficiently explained how the choice of measurement resolution used for dispatch and settlement would address unexpected disconnection due to a local network fault or the responses of DER inverters to system disturbances.

AEMO identified that there are risks associated with large-scale, rapid injection or withdrawal from batteries that exceed DNSP limits. This does not appear to be an issue that is confined to VPPs and could be fully addressed through changes in the measurement resolution. For example, batteries outside of VPPs may be coordinated in response to technical requirements and price signals. DNSPs will need to manage these risks regardless of any requirements imposed on VPPs through the MASS. For that reason, any technical issues related to DER integration should be dealt with separately to the MASS review.

As previously stated, AEMO should extend the end-date of the VPP Demonstrations program until 30 June 2023. This would enable AEMO to investigate the materiality of any risks that were not tested through the initial VPP Demonstrations.

Social Energy:

**1. Time resolution of measurements**

Under 1) AEMO has identified that lower time resolution (e.g. 1s) introduces an average error in the quantity of FCAS delivered using the current FCAS Verification Tool methodology of 15%, and a maximum error of 19.7%.

Whilst we agree with the conclusion that reducing the time resolutions can lead to an error in the quantity of FCAS delivered, this in itself does not necessarily preclude the use of lower time resolution measurements. The UoM, in its study commissioned by AEMO, proposes an alternative methodology to determining the FDT that reduces the error to 0% for up to 200ms data samples and a maximum of 3% for 1s data samples. However, it does caveat that time stamp synchronisation is a potential issue to be clarified and warrants further analysis. In any case, AEMO has shown through its transitional arrangement for Trial Participants that this can potentially be addressed by applying a discount to provider payments reflecting the associated error with the measurement resolution they have implemented.

We urge AEMO to conduct further analysis with the aim of applying fair and proportionate discounts to all providers who are able to provide Fast FCAS response so as to avoid excluding valuable capacity from the market whilst ensuring power system security. This mechanism will bring lower data rates inline with AEMOs stated NEO assessment principles: promoting competition by minimising barriers to entry and avoid unnecessary costs in provision of FCAS.

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**Power System Security Concerns**

Pages 17-18 of the Draft Determination outline several concerns related to DER assets and their impact of the security of the Power system.

**Unexpected disconnection due to network fault**

We agree that AEMOs mitigation action of requiring participating assets to comply with AS/NZS 4777 should address this concern. We also note that this is not a problem limited to DER and is in fact a strength of distributed assets – where a local network fault occurs, other remote assets can pick up the slack and the wider VPP will deliver the contracted power. Provided that sufficient operational monitoring is performed it is incumbent on the VPP provider to ensure that their fleet can always provide the

contracted service level, including when portions of the fleet are having issues. Typically, this is done by oversizing each unit to increase fault tolerance. Our years of experience of using residential assets to provide Frequency Response services in the UK has allowed us to develop robust operational modes and demonstrate strong resilience to localised disturbances at fleet level.

**Unexpected responses from inverters**

50ms power monitoring will have a higher likelihood of capturing sub-second noise in an inverters AC output compared to 1s samples. This is considered a risk by AEMO. In our extensive experience of testing residential battery systems, we know that output noise profiles are inherent properties of a particular inverter model and, systems as a rule, do not develop increased sub-second noise in the field post-install. If they do, then it will generally be accompanied by other faults/warnings which will otherwise prevent them from participating in FCAS until an engineer has visited the site. Given this, we believe that AEMOs current process of requiring lab-based verification of an asset responding to injected frequency profiles with power output sampled every 50ms is enough to provide a reliable "type test" of a model of inverter. With the confidence this provides, slower metering can be used operationally which reduces cost and complexity of installation.

In conclusion Social Energy consider that the proposed amendments to measurement location and time resolution set out in the original MASS Issue Paper satisfy AEMOs objectives of enabling greater participation of DER in FCAS markets whilst maintaining power system security and minimising costs to the consumer, and that other concerns expressed in the Draft Determination regarding these points are substantially unwarranted.

Solar Analytics:

Solar Analytics broadly supports the submission that the CEC will make on the Draft Determination. Therefore we will provide brief additional comments here.

**Feedback to Draft Determination**

Regarding the telemetry resolution, there were two reasons given for leaving requirements unchanged at <=50ms.

1. Systematic error in calculating delivery when using 1s resolution.
2. Uncertainty around the general response of DER to system disturbances.

Regarding the systematic error, we expect others will well cover the arguments for and against. We simply note that the draft determination concluded that the error would likely be overcome with reasonable changes to the verification tool. We therefore propose that these changes be pursued and consultation renewed with an updated verification tool.

However the Draft Determination argued that this is not worthwhile pursuing due to the uncertainty around general response of DER to system disturbances. We believe that these issues should be dealt with separately.

The issues surrounding DER response to disturbances have been known to a large extent since at least early 2019, with the publication of the incident report into the Aug 25, 2018 double-islanding event. It would have been preferable for these issues to have been considered in the VPP demonstrations project and in the stage one MASS consultation if they were considered material to FCAS delivery. As lead organisation on one of the projects which uncovered these issues, Solar Analytics could have provided valuable contribution to such a consultation. Instead we are left to consider a wholesale abandonment of reform without a proper investigation of the impacts of DER response. In particular, the impact of data resolution and measurement location with respect to uncertainty in DER response has not been outlined at all. Instead, it appears that AEMO is simply opting to not change the MASS in the hope that this will discourage further VPP participation in FCAS, buying time to resolve DER response issues.

We urge AEMO to present a proper analysis of the impact of data resolution and measurement location on FCAS verification with respect to the DER response uncertainty that has been highlighted. This should be the basis of further consultation.

We also suggest that part of the reason for undesirable DER response during system disturbances is the lack of strict compliance and/or incentive regimes. Discouraging DER participation in FCAS markets continues to limit incentives to resolve undesirable response.

It also penalises the entire industry for issues that can be resolved by individual OEMs.

We urge AEMO to base FCAS participation on appropriate registration testing and delivery verification such that the onus is on participants to ensure their technology responds as intended.

SolarEdge:

A primary concern raised in the MASS Draft Determination is whether VPP performance can be accurately verified by a 1s resolution. There are a number of ways that this can already be addressed without opting to maintain the MASS in its current form. The MASS verification techniques have no impact on system operation and provide no insights to AEMO operations of VPP operations.

…

**3. Measurement & Resolution**

**3.1 Time resolution for measurement of FCAS delivered by DER**

In the Draft Determination there was a view that unexpected responses from inverters might not be identified using low granularity measurement and cites the example of an oscillatory response going undetected if measurement is done at 1s intervals. However, this oscillatory response is separate to the metering and as such whether metered at 50ms, 1s or 5s the oscillation may still occur.

Furthermore, as AEMO has not divulged any data highlighting such an event it is assumed that such a situation is only a theoretical risk at this stage and as such impossible to understand the cause of or implement any prevention for.

SolarEdge has not experienced and is not aware of any actual examples of oscillatory behaviour as expressed as a concern in the Draft Determination.

Any oscillatory behaviour of a particular asset type should be detected during the frequency injection test that every system is required to undertake as part of the FCAS registration process. If AEMO is concerned that oscillatory behaviour is not being detected, it should review the laboratory test requirements for FCAS registration.

This concern if valid, could also be addressed with 100ms measurement intervals. The benefit of 100ms intervals over 50ms intervals would be sufficient to enable detection of oscillatory behaviour and other behaviours of concern to AEMO and the 100ms metering requirement aligns with AS/NZS 4777.2:2020.

The UoM analysis has demonstrated that 100ms resolution with large sample size provides greater accuracy than single-sample 50ms data. With an update to the MASS FCAS verification tool, it should be adopted to provide AEMO with absolute certainty of performance post the event. Again, 100ms resolution aligns with the AS4777.2:2020 metering requirement and is more fit for purpose for DER than the 50ms resolution in the MASS which was first introduced when the MASS was first drafted.

Ideally for Fast FCAS measurement a resolution of 100ms should be considered viable as an alternative to the 50ms resolution currently required and included in the Draft Determination and as such should update the MASS FCAS Verification Tool to use the trapezoid measurement resolution approach.

A 100ms rate creates a negligible risk for AEMO over the proposed 50ms level as it sits well below the 2% allowable power measurement margin of error for fast FCAS currently allowed within the MASS. Furthermore, with regards to oscillations, there is no evidence that 50ms resolution provides any additional value over 100ms or 1s. Statistical analysis shows that the overall sample size of the fleet has a more significant impact on accuracy than the measurement resolution. A fleet of >200 sites (necessary to meet the 1MW bidding requirement) with a 1s measurement rate, has a lesser error rate than a single site with a more granular measurement resolution. This is an error that warrants further consideration from AEMO.

We understand the concerns that have led to AEMO's decision not to increase the measurement resolution to 1s. Nevertheless, we do not support the decision to leave the measurement resolution at 50ms. A resolution of 100ms has been demonstrated to be sufficient and would significantly reduce VPP costs, which will benefit all consumers in the long term whether at the connection point or at the inverter terminals.

AEMO has confirmed that the maximum error introduced at 100ms measurement intervals is only 2.3%.

AS/NZS 4777.2:2020 commences 18 December 2021. It specifies measurement times of 100ms for voltage and frequency and 200ms for power. Alignment of the FCAS measurement requirements with AS/NZS 4777.2:2020 would reduce implementation costs and would benefit the long term interests of consumers. AEMO's observes that data functionality is specific to each inverter make and model, but this does not change the expectation that alignment of technical standards and market rules would reduce implementation costs.

With this in mind, SolarEdge remains in a position of recommending 1s sampling rates for Fast FCAS verification measurement as it presents no barrier to effective verification and remove entry costs for DER participation.

**3.2 Measurement of unexpected (oscillatory) responses using low granularity measurement**

Unexpected responses from inverters have also been expressed in the draft determination by AEMO, although such a risk might not be identified using low granularity measurement and cites the example of an oscillatory response going undetected if measurement is done at 1s intervals.

Again, we understand that the inverter in question was never approved for FCAS registration, and the behaviour only mentioned by Reposit

The risk of oscillatory behaviour is not an argument for retaining the MASS in its current form. It is an argument for reviewing the laboratory test requirements for FCAS registration.

### 3.3 Power system security and measurement interval

It is unclear how the concerns about the response of inverters to power system disturbances would be addressed by requiring VPPs to measure at 50ms intervals.

AEMO has acknowledged that reduced granularity sampling will still identify inverter disconnection. We acknowledge that reducing the granularity of sampling would affect the accuracy of the verification of FCAS delivery, but the maximum error for 100ms measurement intervals would be only 2.3% and there are options to address that level of error. The Draft Determination states, "AEMO is committed to working with industry to address the DER inverter behaviour concerns, but cannot raise the 50ms sampling rate requirement until this work is complete". However, AEMO has failed to adequately explain why the sampling rate cannot be changed or how leaving the sampling rate unchanged will help to address power system security concerns.

The Draft Determination states, "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". However, the Draft Determination provides no evidence for AEMO's understanding of current costs or expectation of imminent cost reductions in high-speed metering.

### 3.4 Inverter capability

SolarEdge, along with all other OEMs looking to offer compliant product into the market post 18 December 2021 are in the process of redesigning their inverters to comply with AS/NZS 4777.2:2020. The standard requires measurement intervals of 100ms for voltage and frequency and 200ms for power. This is the sampling rate requirement. For frequency response however SolarEdge inverters operate at around a 20ms rate which is well within the metering resolution. We are not aware of any inverters that capture and store data at 50ms or 100ms intervals. Most capture and store data at a minimum of 1s intervals.

...

### 3.6 Data capture resolution capabilities

AEMO also requested to industry clarity on the data capture resolution capabilities of OEM equipment to measure grid flow (at or close to the connection point), currently or with simple upgrades to current capabilities (e.g., firmware upgrades) and noting that this data capture capability is distinct from the sampling rates specified in AS/NZS 4777.2.2020.

It is extremely difficult, costly and wholly unnecessary to measure and transmit FCAS data in real time. Ultimately what will be prescribed will be an external device to extract and store the FCAS data at the end of each FCAS event. The cost of the external device will require development time and cost, rather than equipment cost. The development task could involve firmware changes in the meter and coordination between the meter and the inverter so that the inverter can store the data. This will most likely be complicated, especially if there is insufficient storage within the meter and changes to meters are required. Furthermore, such development work just for FCAS participation in Australia alone is unlikely to become a priority task for global inverter OEMs like SolarEdge.

For any SolarEdge systems there is already a metering device that is responsible for metering. It is separate from the inverter, and usually connected via RS485 serial protocol and installed next to the smart (utility billing grade / NMI) meter.

What is now being asked of this meter under the draft determination is that that the device must be capable of sampling faster than 50ms (50ms is the maximum time interval), which is, to measure and calculate power factor via accurate power measurements and frequency readings, etc. The inverter will then need to poll the meter regularly to enable it to figure out whether it needs to export limit, ramp up the battery, etc. "regularly" varies a lot. It is likely to be slightly sub-second, but highly unlikely to be every 50ms. To be able to carry out the task at this higher frequency will require firmware updates and possible additional processing and storage capacity on the inverters internal communication hardware. There will also need to be a microprocessor on the monitoring device and some flash storage to allow for buffering of data and a small amount of local storage to allow for latency, again such a requirement is not part of current metering. All of this comes at a cost and a decision to divert technical and R&D resources to develop a response.

Currently there are no requirements for DER vendors to meter to 50ms levels of accuracy. There is a sampling response requirement of 100ms for voltage and frequency and 200ms for power thresholds in AS/NZS 4777.2:2020 but no requirements for data capture or recording.

...

**4.1 Measurement of grid flow**

AEMO has requested confirmation of whether the grid flow is already captured when a hybrid system (battery plus PV) has been newly installed or where a battery system has been retrofitted, or would the grid flow only be measured if a site were participating in the FCAS markets?

A separate meter needs to be installed if an inverter requires export limitation or has a battery installed. The meter is not required to be revenue grade.

Grid flow is always measured. The issue is the frequency of capture.

**5. Power system security concerns**

Power system security concerns were introduced late in this review process as a barrier to amendment of the MASS particularly as the concerns raised seem to mostly be separate to concerns legitimate to the MASS and DER FCAS participation.

SolarEdge via close collaboration with the CEC has been working with AEMO to understand how to address the question of power system security concerns cited in the draft determination. If power system security concerns can be used to veto any other initiative between AEMO and the renewable energy industry, then it seems pointless to work with AEMO on anything other than power system security concerns. We therefore concur with the position of the CEC to commence this submission by responding to AEMO's power system security concerns and with a proposal for a process to address these concerns.

Additionally, if power system security concerns do exist and AEMO pursue the pathway to use such concerns (without fully testing and verifying the impact of new inverters complaint with the more rigorous response modes contained in AS/NZS 477.2:2020) then moving DER outside the scope of VPP and FCAS participation by creating costly and onerous requirements will create a self-fulfilling prophecy of lack of visibility and control. DER OEM's will simply view the technical requirements as simply not worth the effort in developing for such a small market on the global scale, additionally installers may see the installation requirements and obligations as too complex and system owners will simply not want to pay for all of this additional hardware and functionality in such a price sensitive market. Therefore, the inevitable outcome will be that more systems become installed outside of the scope of VPP's and AEMO visibility supporting system security risks in their own right.

Conversely if AEMO were to relax barriers and even go one step further to outwardly incentivize VPP and/or FCAS participation then the level of visibility and control, as well as accountability and governance offered under the structure would directly be able to address system security concerns as well as build a much better understanding of the causes, effects and requirements to prevent any such issues moving forward.

**5.1 Unexpected disconnection of inverters**

...

SolarEdge is already very aware of AEMO's concerns regarding DER inverter behaviour during local distribution network faults and power system disturbances. Through the work of VDRT and lately FDRT which has now moved into the UNSW Project Match we have worked closely with AEMO to support the introduction of its short duration under VDRT test procedure, which has been mandatory in SA and on the Western Power network since 28 September 2020 and 1 July 2021 respectively and which will be mandatory in Victoria from 1 September 2021.

The revised test procedure will now be superseded when AS/NZS 4777.2:2020 commences from 18 December 2021. We estimate that bringing forward the date for compliance with the VDRT test procedure in advance of AS/NZS 4777.2:2020 has generally cost inverter OEMs in the order of tens of millions of dollars in total for product changes and retesting of products.

We are already aware of three OEMs whose inverters are listed on the CEC Approved Products List as compliant with AS/NZS 4777.2:2020. AEMO can access inverters compliant with AS/NZS 4777.2:2020.

Furthermore, SolarEdge is very willing to offer products already tested and certified, ahead of CEC listing to enable testing of their behaviour in response to power system disturbances. We do not foresee any obstacles to AEMO commissioning independent testing of these inverters over the course of this year to fully test and understand if the risk of unexpected behaviour by inverters will be satisfactorily addressed by the new inverter requirements.

**5.2 The control hierarchy for inverters**

The Draft Determination expressed concern regarding 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 prioritized over active power (FCAS response).

The prioritization table 2.6 in AS/NZS 4777.2:2020 (included below) does not stipulate prioritization level for FCAS response but it does specify priority for sustained active power response to frequency disturbances (prioritization level 4) ahead of power quality response modes like volt-var (prioritization level 5). Frequency support does sit below generation control functions like export limits (prioritization level 3), that will probably become dynamic/flexible in the future.

**Table 2.6 — Specification for prioritization of inverter functions**

| Prioritization level | Description |
|---|---|
| 1 | All disturbance withstand limits described in Section 4 while abnormal conditions prevail and until the duration exceeds the time limits of the passive anti-islanding settings in Clause 4.4. |
| 2 | All requirements to operate the automatic disconnection device. |
| 3 | Generation control function of Section 6. |
| 4 | Sustained operation for frequency disturbances of Clause 4.5.3. |
| 5 | Inverter demand response mode of Clause 3.2 and power quality modes of Clauses 3.3.2 and 3.3.3 (see Note 1). |
| 6 | Power rate limit of Clause 3.3.4. |
| NOTE 1 The prioritization requirements for the power quality modes is defined in Clause 3.3. | |
| NOTE 2 The performance of the inverter when responding to demand response commands is defined in Clause 3.2.1. | |

Source: AS/NZS 4777.2:2020

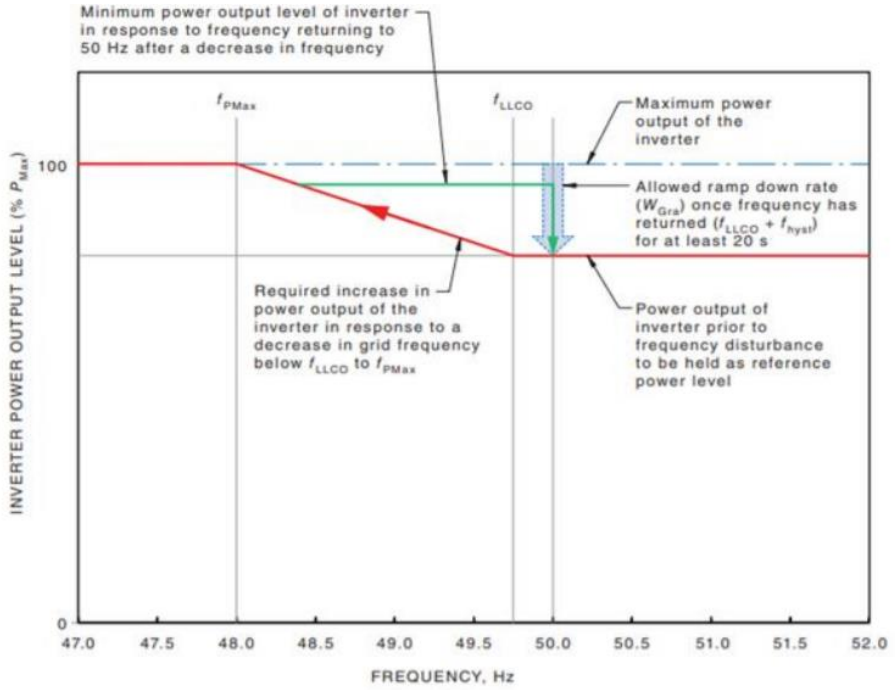



**Figure 4.1 — Example frequency response for a decrease in frequency for an inverter that has a reduced output**

So, when frequency falls below the continuous operation range, inverters are required to increase their output if it was previously curtailed by volt-var and/or volt-watt response modes as illustrated in figure 4.1. The test procedure described in clause J.3.4, raises the voltage into the volt-watt region and then reduces frequency down below 48Hz to confirm this behaviour. This is a mandatory response.

Delivering an FCAS response in advance of this would not necessarily conflict with AS/NZS 4777.2:2020.

SolarEdge understands that these concerns were readily addressed in the SA VPP trials without any need to rewrite inverter standards.

### 5.3 Risks of exceeding the limits of secure network operations

The Draft Determination expresses concern regarding "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" and describes this as one of the risks "associated with the behaviour of DER inverters".

This is not a risk associated with DER inverter behaviour.

This is a risk associated with management of distribution networks.

In the short term, it could be managed with a process of registration of FCAS Providers to ensure that no feeder is at risk of being overloaded.

### 5.4 Proposal for a process to address power system security concerns

SolarEdge, with its close relationship with the CEC recognizes that one of the key issues that AEMO is currently facing is the lack of reliable data from DER which can better help AEMO plan for the high DER scenarios.

This situation creates issues both for AEMO, and for SolarEdge as well as other industry stakeholders as this lack of consistent and accurate data with visibility into what is happening on the low voltage networks. This has resulted in rushed solutions and risk-averse policy and technical requirements being implemented over the last few years without valued industry consultation. The outcome is marginal results for AEMO at the expense of OEM's and system owners who ultimately bear the cost to comply.

The most telling example of this was the recent VDRT test requirements. These were released by AEMO and rushed through the SA Smarter Homes program in 2020 with limited consultation. This resulted in industry investing tens of millions in compliance costs. We have now been informed by AEMO that this test has been ineffective in solving for ride-through issues and has not created any noticeable system security outcomes. If AEMO had worked more closely with the industry, we could have worked through potential trials and offered data to help develop the same level of outcome with minimal expense and lack of negative industry impact.

During the VPP Demonstrations, AEMO developed an API to capture real-time fleet and asset level data from Trial Participants and DER that had previously been invisible to AEMO. This data was invaluable for fault detection and forecasting behaviour, however AEMO has opted not to maintain the API. This is a perplexing decision and raises concerns about the future alignment of AEMO processes with DNSPs who are primarily looking at API-based interfaces. If AEMO uses a different system for asset visibility, forecasting and dispatch, it is unclear how this is can be properly coordinated with the work being done by DNSPs and OEMs.

### 7. Recommendations

...

2. AEMO should review its laboratory test requirements for FCAS registration and whether they are sufficient to detect the oscillatory behaviour as reported by Reposit (only).
3. AEMO should maintain the 1s sampling rate for DER inclusion in fast FCAS markets, removing a key barrier to entry for DER participation. This can be effectively introduced following methods used internationally using smaller sample rates during test verification prior to registration and 1s sampling for operation.
4. AEMO should consider aligning as much as possible with the DER technical specifications of AS/NZS 4777.2:2020.

...

6. AEMO should accelerate the testing the behaviour of inverters compliant with AS/NZS 4777.2:2020 and consider formalizing the program with a Memorandum of Understanding.
7. AEMO should specify compliance with AS/NZS 4777.2:2020 for all systems upon registration for FCAS.

...

9. AEMO should work closely with OEMs to understand in more detail which aspects of AS/NZS 4777.2:2020, if any, could have an adverse effect on FCAS delivery, and how best to balance different priorities.
10. AEMO should work with DNSPs and other industry stakeholders on measures to mitigate the risk of exceeding the limits of secure distribution network operation limits during FCAS response.

sonnen:

Recognition of the capacity of BTM battery storage systems to deliver a predictable export FCAS raise response has made a significant contribution to advancing ancillary service provision from DER. However, the lack of meaningful advancement in accommodating DER into the proposed MASS is an egregious waste of tax-payers funds and the significant contributions made by the Trial Participants. The failure to drive further diversity, competition, and innovation in the provision of FCAS will ultimately be borne by consumers in the form of higher costs for the services needed to support a transition to a renewable future.

We are disappointed by the late introduction into the consultation of power system security concerns, and an apparent lack of critical review of some of the material provided to AEMO. sonnen would like to stress the importance of ensuring the MASS is focused on providing a framework to deliver technology agnostic and efficient market outcomes. The MASS is not an appropriate tool for addressing technology specific technical requirements such as those dealt with by network access arrangements or equipment standards. Neither should costly measurement requirements replace a rigorous equipment qualification process.

…

**Effects on power system/distribution network security**

sonnen is concerned that AEMO's conclusion appears to unjustifiably conflate the separate issues of power system security and market settlement accuracy. DER has an existing relationship with DNSPs through equipment standards and network access arrangements. There is no direct regulatory relationship between the MASS and these interfaces. AEMO has not established a reasonable basis for applying another layer of regulation that is only applicable to a subset of DER, nor has AEMO presented any quantified technical analysis supported by the DNSPs that the metering requirements of the MASS will address the system security concerns raised.

**Recommendation**

Focus MASS development on enhancing market participation and efficiency.

**…**

sonnen notes that no objective benchmarks or metrology framework have been provided linking the accuracy of measurement to the quality and effectiveness of FCAS scheduling and delivery. While AEMO states its conclusions are guided by the principles of the NEO it has not established how an 'efficient frontier' was established with regard to measurement accuracy in order "to promote efficient investment in, and efficient operation and use of, electricity services for the long-term interests of consumers of electricity".

The NEM energy market metrology framework balances measurement and settlement accuracy with the cost and complexity of metering installations. However, the MASS metrology framework has remained substantially unchanged from its introduction at a time when FCAS was primarily provided by large synchronous machines and the measurement provisions were aligned to the typical capabilities of high-speed fault or power system disturbance recorders installed on large synchronous machines to support asset management strategies. The suitability of these legacy arrangements in a power system that is rapidly diversifying is questionable.

sonnen expected that data gathered through the VPP Demonstrations would be used to inform a 'fit for purpose' FCAS metrology framework for a market undergoing a rapid transition, but this has not happened.

sonnen suggest that once a quantitative based relationship has been established between the accuracy of FCAS delivery measurement and the true power system and market consequence of degraded accuracy an appropriate discount can be applied to resources utilising lower sample rate metering.

If enablement quantities for the purpose of dispatch and settlement are discounted for objectively lower quality FCAS resources then competitive forces will resolve the efficient balance of measurement equipment costs and utilisation of DER capabilities.

…

**Recommendation**

Following the principles used in energy market metrology establish tiered measurement requirements that seek to balance the cost and complexity with the scale of the FCAS resource. Utilise the analysis performed by the UoM to establish discount factors linked to an efficient (typically 90%) confidence level of delivery for the sample rate of the measurement installation.

…

**Interpretation of MASS measurement requirements**

Key elements of the Fast Contingency FCAS MASS measurement requirements have a legacy relationship with common specifications of high-speed fault and disturbance recorders installed on large synchronous machines. These devices are an important tool for demonstrating compliance with Generator Performance Standards and making asset management decisions following a significant power system fault in or near a power station. The use of data for FCAS verification is a secondary purpose of disturbance recorder data.

Choices in the methods deployed to determine power system frequency at high update rates are strongly linked to the robustness of the solution when subject to high rates of change of frequency, power system noise, and transient disturbances. Highly robust solutions such as those found in grid protective relaying or disturbance recorders for large synchronous machines implement sophisticated algorithms and higher sample rates to derive accurate and consistent responses in the challenging conditions found under real operating conditions during major disturbances. These limitations and effects on accuracy are clearly understood and have been characterised by the power systems engineering community.

In sonnen's view the frequency measurement requirements in the MASS are not sufficiently complete to avoid different engineering interpretations. The settling time requirement of 99% of final value after a step change from zero is nonsensical in a frequency measurement context as this implies an ability to accurately track a rate of change of frequency (RoCoF) of approximately 1000Hz/s. In the absence of adherence to this dynamic response criteria the remaining frequency measurement resolution and accuracy requirements are specified in the MASS without reference to handling of dynamic influences such as high RoCoF or common noise sources present in a power system.

A cost sensitive engineering solution that is capable of accurately reporting frequency of a stationary noise free 50Hz signal is unlikely to provide similar accuracy in response to a power system disturbance with dynamically varying frequency under typical noise conditions experienced in a distribution network. The accuracy and achievable resolution of a low cost simple zero-crossing detector as suggested in a response to the first stage consultation degrades substantially under real world conditions1. Similarly, rudimentary filtering approaches add delays and level shifts that degrade accuracy under dynamic conditions.

Convergence in the cost estimates from market participants or interested parties is unlikely to occur unless AEMO documents the dynamic and noise rejection expectations associated with the accuracy requirements stated in the MASS. A provider of robust and predictable frequency measurement devices implemented proprietary algorithms for protective relaying, large synchronous machine or network performance monitoring, or measurements in a power engineering laboratory will provide a significantly higher cost estimate based on an expectation that good dynamic response and noise tolerance is required.

**Recommendation**

To drive consistency in frequency measurement installations provide additional specifications addressing accuracy requirements under typical system disturbance conditions.

SwitchDin:

**1. Measurement Requirement for Fast FCAS Verification to Address Power Quality Concerns**

The primary concern that we would like to raise with the Draft Determination is the ongoing requirement for the measurement of power flow and frequency at 50ms or less for every site within a VPP in order to participate in the fast Contingency FCAS markets.

AEMO's main reason for conducting this consultation was "with regards to measurement requirements for DERs to participate in the Contingency FCAS markets". The Draft Determination is a poor outcome for DER and will un-necessarily limit the ability of DER to deliver fast FCAS.

The proposed arrangements will:

- Significantly increase the cost and technical complexity for DER to be able to provide fast FCAS through a VPP, compared to the previous VPP trial arrangements
- At least in the short term, potentially lock out DER from the highest value FCAS markets, thereby making participation in FCAS un-economical.

SwitchDin understand that AEMO's overarching reason for continuing to require measurement at 50ms is due to the DER inverter behaviour concerns identified and that "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."

While we acknowledge the importance of maintaining power system security, the measurement of power and frequency as required for verification of delivery of FCAS is not necessarily associated with the inverter's control behaviour and changing the FCAS reporting rate will not in itself lead to a resolution of the inverter behaviour issues. The resolution of the DER inverter behaviour is independent of the issue of

FCAS measurement data reporting. We would recommend that AEMO treat these as separate rather than compounded issues.

We recommend that AEMO directly addresses power system security issues through more appropriate measures such as type testing at point of registration. Further detail is included in the following points.

**2. Options for Direct Management of Power Quality Issues**

Power quality issues and their management can be split into two separate categories: inverter specific behaviours and aggregator response issues.

The inverter specific behaviours that have been identified by AEMO are:

- 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.
- 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.

The issue of unexpected inverter disconnection is already addressed through AS/NZS 4777.2:2020, and unexpected inverter responses, such as oscillation, could be identified through type testing. We therefore suggest that these inverter specific power quality issues are addressed directly by AEMO by requiring type testing of inverters, including compliance with AS/NZS 4777.2:2020, at the point of registration. This would provide a minimal barrier to DER wanting to provide FCAS, so long as the registration requirements are clearly defined.

The aggregator response issues identified by AEMO are:

- 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).
- 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.

We agree that these issues do warrant concern as penetration increases and that the impact of locally concentrated aggregator responses on the distribution network needs to be carefully managed in general, and not just in relation to providing an FCAS response. Prioritising voltage management in the distribution network over an FCAS response is a risk that the VPP operator should be expected to manage when determining their FCAS bids. Likewise, while the risk of large-scale, rapid active power injection exceeding the limits of secure distribution network operation limits is primarily a DNSP issue, VPP operators should be expected to take dynamic operation envelopes into account as part of their operation.

We therefore suggest that VPP operators should be responsible for managing these distribution/ aggregator power quality issues and risks as part of their operation. Clear rules around the penalties that apply for under-delivery of FCAS would assist VPP operators in implementing an appropriate risk management strategy.

**3. Measurement Time Resolution for FCAS Verification and Monitoring Cost**

We agree that power system security is paramount and it is important for AEMO to have reliable measurements of the FCAS services provided by DER that enable AEMO to retrospectively verify system operations (up to 20 days later). It is important to note that these measurements are not used in any power system control actions by AEMO (or by the DER) and they only play a strategic role in determining system security. With this in mind it is not apparent that AEMO has taken into account the actual requirements of the contemporary power system in determining an appropriate FCAS measurement resolution requirement for DER. The 50ms requirement is an historical precedent that was instigated at a time when FCAS was provided by a few large generators and DER was not envisaged as a feature of the power system. Given the growth in DER it may be appropriate to consider the impact on measurement resolution requirements which may be different for DER compared to centralised generation due to the differences in system size, location and the effect of system diversity on aggregated DER.

We suggest that AEMO undertake the necessary technical analysis to determine the appropriate resolution required for FCAS measurements. This analysis should consider whether there are different requirements for DER and centralised generation and whether these different requirements could be accommodated in the business processes of AEMO so as to maximise whole-of-system benefits.

The other AEMO concern is that lower sampling rates may result in an overestimation of the volume of FCAS provided which will lead to financial settlement error. The modelling by the UoM has shown that for a measurement sampling rate of 200ms the overestimation of FCAS delivery is less than 3%. Whilst this may be considered a small decrease in the financial efficiency of the FCAS system, this loss needs to be considered in relation to the overall whole-of-system benefits arising from the participation of DER. The cost of providing 50ms measurements is prohibitively higher than the cost of 200ms measurements and we are concerned that this additional cost will exclude DER, especially smaller systems, from participating in FCAS.

Tesla:

**Power system security concerns will not be resolved by maintaining the MASS**

Tesla accepts the power system security concerns highlighted by AEMO, however these are largely separate to the MASS requirements and appear to be driven by broader AEMO concerns on the market participation of DER and/or related to the high penetrations of DER more generally. Importantly, these issues will not be resolved by maintaining the MASS in its current form, and Tesla is disappointed to see the MASS review process conflated with these broader DER concerns.

In fact, Tesla expects that these risks will be exacerbated by increasing market barriers for DER because removing market access also removes incentives for customers to invest in smarter, more active DER. This in turn results in less DER providing system security services, and it also results in less visibility of DER performance for AEMO. Tesla believes that these issues are critical for AEMO to address, but this needs to be done through a separate forum to the MASS review process.

…

**Power system security**:

Tesla does not believe that the power system security risks articulated by AEMO in the Draft Determination are relevant to the outcomes of the MASS Review– they need to be managed regardless of whether the MASS is updated or maintained in its current form.

Tesla proposes that these issues need to be addressed through strong industry collaboration – and through a bespoke forum specifically focused on DER Power System Security concerns. Alternatively, an existing forum, such as the ESB "Maturity Plan" or the DEIP could be used to address these concerns.

Alternatively, Tesla is supportive of the proposed "Consultative Forum" proposed by AEMO and would be happy to support this as a forum to addressing the broader system security concerns flagged.

Further, it seems as though the lack of DER visibility is central to all DER power system security concerns raised by AEMO. This can be managed through maintaining the API that was developed for the VPP Demonstrations and making this an ongoing requirement for all VPP FCAS Providers.

Complying with the ongoing data provisions and providing AEMO with real time fleet and asset visibility via API, should first be included in the MASS and then adopted into the rules through the 'Scheduled Lite' rule change and the implementation of the Visibility Model explored by the ESB.

…

In providing our response, Tesla has considered the business impact of complying with the requirements put forward in Draft Determination. While we note that these requirements are consistent with the MASS as it currently stands, Tesla has invested resourcing and development efforts over the last two years into the VPP Demonstrations based on the fact that the trial settings were designed to create a more fit for purpose environment for DER/VPPs to participate. No development work has been done on complying with the 50ms measurement resolution and given that there are no international drivers for 50ms compliance, this is not development work that Tesla will undertake.

…

**6.2 Measurement resolution**

**Statement of concerns**

Tesla understands that AEMO is concerned about the error introduced when 50ms and 1s samples are compared using the right Reimann sum method which is the approach currently used in the FCAS Verification Tool. Tesla specifically understands that AEMO has two key concerns in this respect:

1. The current error rates with 1s measurement resolution can lead to AEMO overpaying for FCAS delivered; and
2. 1s measurement resolution does not adequately capture potential oscillation risks that exist.

The primary issue that should be considered as relevant for the purpose of the Draft Determination is whether 50ms resolution is necessary for appropriate verification of Fast FCAS, or whether a less granular resolution is acceptable by AEMO. For the purposes of the VPP Demonstrations, 1s resolution was used with a single high-speed meter per jurisdiction. The Draft Determination has since considered the 1s resolution to create additional errors in respect of verification of performance.

The risk of inverter oscillations should be considered as a broader issue for AEMO, as it will also impact on the delivery of slow and delayed services. While verification should be the only topic considered within the scope of the MASS review, AEMO has also flagged broader DER power system security concerns as a driver for maintaining the 50ms measurement resolution. These issues exist for all DER and should not be resolved as part of the MASS review process. For completeness, however, Tesla has addressed these concerns as well as the specific performance verification concerns covered. The below section covers:

- Tesla's position on performance verification concerns raised by AEMO and justification for our recommendations.
- Analysis of technical concerns raised by AEMO – specifically oscillation risks used to justify 50ms measurement resolution.

**Fast FCAS performance verification**

Tesla summary position

The primary concern raised by AEMO in the Draft Determination is that the 1s measurement resolution does not provide suitable granularity for verification of performance and can lead to overpayment for fast FCAS delivered.

As highlighted in section 4, it is important that AEMO understands that these concerns on measurement resolution only relate to the verification of performance and not the technical delivery of performance. We understand that AEMO needs a means of checking compliance data that is provided and verifying the delivery of performance. But the two-step approach introduced during the VPP Demonstrations of frequency injection test plus fleet wide test should provide AEMO with full confidence of the technical capability of FCAS registered DER to provide the services they are registered to provide.

Tesla believes that based on what AEMO has presented, the concerns can be managed with the following approach:

1. For the provision of Fast FCAS, AEMO should require conditional logging of data at 100ms [or 200ms] resolution during an FCAS event. These aggregated VPP sites should be measured at 1s resolution for the rest of the year – with data provided to AEMO via the existing VPP API, or equivalent.
2. In parallel, update the FCAS verification tool to use the trapezoid rule instead of the right Riemann sum.
3. Finally, Tesla believes that the overall energy band risk associated a fleet of hundreds of smaller assets providing FCAS is much lower than a single asset due to the larger overall number of samples. Tesla has undertaken a detailed statistical analysis to support this position.

This solution brings the error risk to effectively zero, and thus minimizes AEMO's concerns about overpayment. Importantly, as noted by AEMO in the Draft Determination, 100ms is a technical solution that can more readily be provided by more DER, which increases competition in both the FCAS and customer retail markets and aligns with AEMO's obligations under the NEO (explored in more detail in section 3).

Justification for proposed verification approach

Tesla's justification for the recommendations put forward are based on several factors:

- Tesla's own analysis of the different measurement resolutions, as well as detailed statistical analysis on fleet error rates.
- The independent UoM analysis undertaken; and
- Alignment with AS4777.2:2020

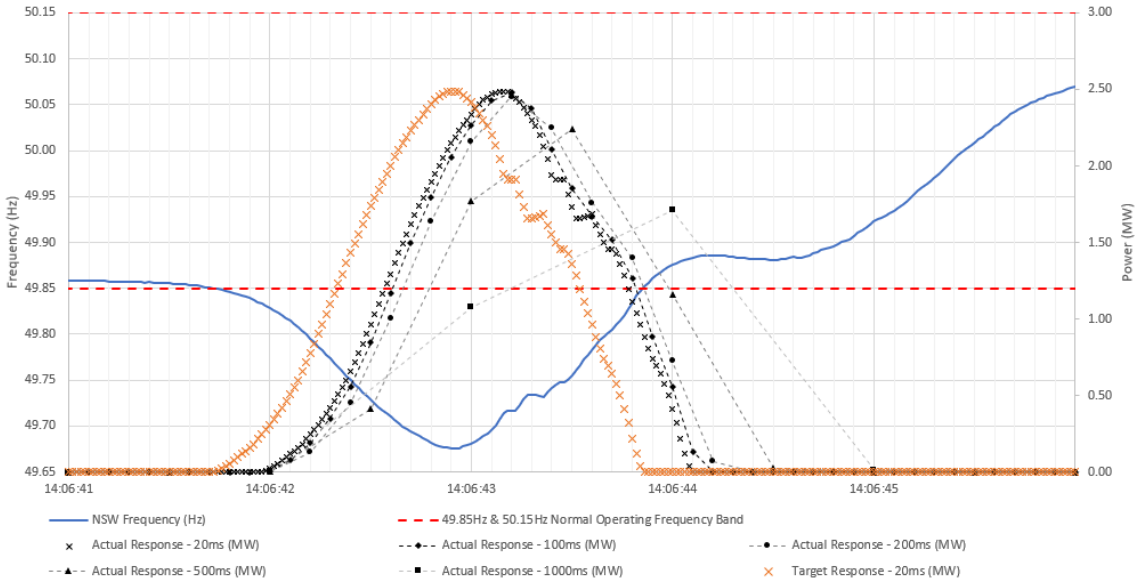
More detail on the justification for each of the recommendations made by Tesla as we discuss each of the recommendations made above in more detail.

**1. Allow 100ms resolution for Fast FCAS verification on a conditional logging basis**

To support this position, Tesla has undertaken a detailed statistical analysis of the application of different measurement resolutions across a fleet of Powerwall assets. This analysis was undertaken based on 20ms data provided by AEMO and looking at the verification of performance at different measurement

resolutions. Tesla has also undertaken Monte Carlo simulations across these measurement resolutions to further assess the error bands. This analysis modelled fleet response to the Callide C frequency event on May 25 across both NSW and Queensland – noting that the duration of the frequency deviations in these jurisdictions differed significantly.

This analysis is attached in full for AEMO in Attachment A. Tesla has also provided the full excel based model with all assumptions to AEMO for further consideration.




As shown in Figure 11, the verification of response when undertaken at all measurement resolutions will be slightly behind the target response due to a ~250ms response observed during frequency injection test. Tesla demonstrates that there is no noticeable difference when the 100ms resolution or 200ms resolution is compared with a 20ms measurement resolution.

These findings are further backed up by the detailed Monte Carlo simulations undertaken by Tesla to support this position. This simulation considers whether the verification error rates decrease as the fleet numbers increase. Figure 12 provides an overview of the findings of this analysis in respect of total energy provided in response to an FCAS event. This analysis has been undertaken using the right Riemann verification approach (with further discussion on this in the following section).

In considering the outcomes of the Monte Carlo analysis, Tesla has made the following assumptions:

Tesla considers the minimum fleet size that should be considered by AEMO as relevant to this statistical analysis as 200. This will be the minimum number of systems needed to support a 1MW bid on an aggregated basis given the 5kW nameplate capacity of a Powerwall.

Secondly, Tesla has considered a <2% error to be appropriate – in line with the current MASS requirements which allow "an error of less than or equal to 2% of the measurement range" (refer 3.6)(a)(v) of the MASS for allowable error rates for fast FCAS delivery). While this is currently applied on an individual asset basis, it makes sense for AEMO to apply the same error band to a VPP fleet operating as a single asset.

Based on the assumptions above, Tesla has drawn the following outcomes:

When considering a fleet of 200 systems, the energy error bands assessed in both NSW and Queensland is <0.5% for all measurement resolutions 100ms – 1s.This is well under the 2% allowable error band.

This error band continues to decrease as the total fleet size increases. For a fleet of 1000 systems the error band is <0.15% for all measurement resolutions in Queensland and NSW, for both the truncated and the rounded methods.

**Energy Error (%)**

**Queensland**

| Truncated | Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|
| | 1 | 1.01% | 1.02% | 1.01% | 0.99% | 1.03% | 1.13% |
| | 10 | 0.29% | 0.31% | 0.29% | 0.29% | 0.30% | 0.35% |
| | 25 | 0.18% | 0.19% | 0.20% | 0.19% | 0.19% | 0.21% |
| | 50 | 0.13% | 0.14% | 0.12% | 0.13% | 0.14% | 0.15% |
| | 200 | 0.07% | 0.06% | 0.07% | 0.07% | 0.07% | 0.08% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.05% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% |

| Rounded | Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|
| | 1 | 0.99% | 0.98% | 1.00% | 1.01% | 0.97% | 1.17% |
| | 10 | 0.31% | 0.29% | 0.27% | 0.29% | 0.30% | 0.34% |
| | 25 | 0.19% | 0.19% | 0.18% | 0.17% | 0.20% | 0.22% |
| | 50 | 0.12% | 0.13% | 0.13% | 0.13% | 0.13% | 0.14% |
| | 200 | 0.07% | 0.07% | 0.06% | 0.06% | 0.07% | 0.08% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.05% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% |

**New South Wales**

| Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| 1 | 1.04% | 0.98% | 0.98% | 1.03% | 2.11% | 5.04% |
| 10 | 0.29% | 0.29% | 0.30% | 0.29% | 0.62% | 1.43% |
| 25 | 0.18% | 0.18% | 0.18% | 0.19% | 0.39% | 0.88% |
| 50 | 0.13% | 0.13% | 0.13% | 0.14% | 0.28% | 0.66% |
| 200 | 0.06% | 0.07% | 0.07% | 0.07% | 0.14% | 0.31% |
| 500 | 0.04% | 0.05% | 0.04% | 0.04% | 0.09% | 0.20% |
| 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.07% | 0.14% |

| Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| 1 | 1.01% | 0.99% | 0.98% | 1.00% | 2.14% | 4.99% |
| 10 | 0.29% | 0.30% | 0.30% | 0.30% | 0.63% | 1.39% |
| 25 | 0.19% | 0.18% | 0.18% | 0.20% | 0.42% | 0.87% |
| 50 | 0.13% | 0.13% | 0.13% | 0.13% | 0.29% | 0.61% |
| 200 | 0.07% | 0.07% | 0.07% | 0.07% | 0.14% | 0.32% |
| 500 | 0.04% | 0.05% | 0.04% | 0.04% | 0.09% | 0.19% |
| 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.06% | 0.14% |

*Figure 7 - Monte Carlo simulation results for absolute value of energy error (500 simulations)*

Figure 12: Tesla analysis - energy error bands for different fleet sizes

Tesla believes that the error associated with total energy provided during an event is more important than the error associated with max power provided because the MASS v6 defines the amount of Fast Raise and Fast Lower services for dispatch purposes, in section 3.3 and 3.4 respectively, in terms of energy provided over the 60s following the FDT.

In addition, devices using open loop controls to provide FCAS like Tesla's Powerwall don't use frequency or power measurements to provide that response. Instead, these measurements are used for verification purposes only, and the lower aggregate power measured is due to the measurement method as opposed to the actual FCAS response. However Tesla has also done additional Monte Carlo simulations looking at the error rates associated with different measurement resolutions in respect of power – see Figure 13.

**Power Error (%)**

**Queensland**

| Truncated | Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|
| | 1 | 1.00% | 0.99% | 1.00% | 1.06% | 1.04% | 1.04% |
| | 10 | 0.30% | 0.30% | 0.27% | 0.30% | 0.27% | 0.30% |
| | 25 | 0.18% | 0.18% | 0.19% | 0.18% | 0.18% | 0.19% |
| | 50 | 0.14% | 0.13% | 0.13% | 0.13% | 0.13% | 0.13% |
| | 200 | 0.07% | 0.06% | 0.06% | 0.06% | 0.06% | 0.06% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% |

| Rounded | Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|---|
| | 1 | 0.99% | 0.98% | 0.99% | 1.01% | 1.02% | 0.99% |
| | 10 | 0.30% | 0.30% | 0.28% | 0.29% | 0.30% | 0.31% |
| | 25 | 0.19% | 0.20% | 0.19% | 0.17% | 0.19% | 0.18% |
| | 50 | 0.13% | 0.13% | 0.13% | 0.13% | 0.13% | 0.14% |
| | 200 | 0.06% | 0.07% | 0.06% | 0.06% | 0.07% | 0.07% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% |

**New South Wales**

| Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| 1 | 0.96% | 1.01% | 0.99% | 1.51% | 5.89% | 16.83% |
| 10 | 0.29% | 0.30% | 0.34% | 1.23% | 9.30% | 30.22% |
| 25 | 0.18% | 0.19% | 0.24% | 1.25% | 9.21% | 30.62% |
| 50 | 0.13% | 0.13% | 0.19% | 1.26% | 9.33% | 30.64% |
| 200 | 0.07% | 0.07% | 0.16% | 1.26% | 9.35% | 30.82% |
| 500 | 0.04% | 0.04% | 0.16% | 1.25% | 9.35% | 30.96% |
| 1000 | 0.03% | 0.03% | 0.16% | 1.25% | 9.37% | 30.86% |

| Nb of sites | Sampling rate (ms) 20 | 50 | 100 | 200 | 500 | 1000 |
|---|---|---|---|---|---|---|
| 1 | 0.99% | 1.00% | 1.07% | 1.42% | 5.69% | 16.44% |
| 10 | 0.29% | 0.30% | 0.70% | 1.51% | 8.89% | 20.50% |
| 25 | 0.19% | 0.19% | 0.75% | 1.50% | 9.07% | 20.10% |
| 50 | 0.14% | 0.13% | 0.78% | 1.54% | 8.96% | 20.04% |
| 200 | 0.06% | 0.07% | 0.81% | 1.55% | 8.98% | 20.12% |
| 500 | 0.04% | 0.04% | 0.81% | 1.54% | 9.02% | 20.03% |
| 1000 | 0.03% | 0.03% | 0.81% | 1.54% | 8.98% | 20.03% |

*Figure 8 - Monte Carlo simulation results for absolute value of power error (500 simulations)*

Figure 13: Tesla analysis - power error bands for different fleet numbers

Applying the same assumptions as those outlined above, the following additional conclusions can be drawn from the assessment of power error bands:

For fleets of 200 systems or more, for both Queensland and NSW – a measurement resolution of 100ms or 200ms still falls well under the 2% allowable error band.

The shorter duration of the NSW event leads to higher power error for NSW at a lower granularity – 500ms or 1s. However, the 100ms and 200ms error bands at the power level also fall well under the acceptable 2% error band. The increase in error from one site to multiple sites is addressed in the application note.

If AEMO was to look purely at the error bands associated with total energy delivered over a fleet of >200 assets it is clear that the overall error rate is well within the acceptable bands for fleets providing verification data to AEMO at all resolutions – including 1s. Even if AEMO were to change the overall MASS methodology to also consider the power error bands, 100ms and 200ms fall well within the error bands acceptable and allowable by AEMO.

Conditional logging

Tesla also notes that logging of 100ms on a conditional basis only is critical to the scalability of VPPs. Under this approach, Tesla proposes to commence logging at 100ms as soon as frequency exits the NOFB and for 60s thereafter. Data will be logged on a 1s basis for all other times of the year.

This approach significantly reduces the data housing costs for an aggregated fleet. (for context a fleet of 3500 systems would log and store 1.1 trillion datapoints per year per signal if logging occurs at 100ms resolution on a permanent basis). Noting that most of this data does not provide value to AEMO for the purpose of verifying FCAS delivery, and that it does not improve performance at all, this approach will reduce the overall costs of entry for aggregated fleets of DER, whilst maintaining data integrity requirements. It is a critical step in enabling the scalability of VPPs.

Alignment with AS4777.2:2020

This point was also considered by AEMO in the Draft Determination. Several responses to the earlier MASS consultation noted that 100ms is aligned with the measurement requirements included in AS4777.2:2020. In response AEMO noted in the Draft Determination that:

> "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."

This may be true; however, it is also a fit-for-purpose DER standard that most inverter OEMs will be basing their development work on. Transitioning from 100ms input data, to logging at 100ms requires less work and cost than transitioning to a 50ms data resolution. The current 50ms requirement is a legacy requirement first developed for single utility scale; transmission connected assets. AEMO can now consider whether a better starting point for DER is to align with an existing DER inverter standard.

**2. Update to the FCAS Verification Tool**

In addition to Tesla's analysis, the independent analysis undertaken by the UoM presented to AEMO as part of the Draft Determination supports the potential adoption of 100ms and 200ms resolution. The final position put forward by the UoM noted a near zero error risk associated with 100ms and 200ms. Note that this analysis was based on the universal window method is used in this analysis and as such AEMO has determined that "more conclusive information [and] significant further work [required to use of the universal window]" would be needed.

Tesla believes that the same zero error risk outcome can be achieved through the adoption of the trapezoid verification approach while keeping the relative window. This would only be a minor adjustment to the FCAS verification tool and as such would not require the significant work that is flagged by AEMO.

As demonstrated in the figures below, adoption of the Trapezoid method, in combination with a 100ms resolution with a relative window provides a near zero error band. This near error risk finding is consistent with Tesla's analysis (demonstrated above) and reduces as the overall fleet size increases.

Tesla also notes that the MASS v6 allows "AEMO to update the algorithms and its form from time to time" (section 6.5) and the FCAS Verification Tool was updated to use the Trapezoidal rule to generate AEMO's average error calculation plot in in the draft report and determination (section 4.1.2), which demonstrated very low error (<2%) with 100ms measurements

| Reg 1 Provider 1 Lower, 0-6s response | | | | |
|---|---|---|---|---|
| MWs | 50ms | 100ms | 200ms | 1s |
| Left Riemann | -28.82 | -28.60 | -29.02 | -30.64 |
| Right Riemann | -29.25 | -29.46 | -30.74 | -39.29 |
| Trapezoid rule | -29.04 | -29.03 | -29.88 | -34.97 |
| Simpson's rule | -29.04 | -29.03 | -29.88 | -35.15 |
| Simpson's 3/8 rule | -29.04 | -29.03 | -29.88 | -35.06 |
| Boole's rule | -29.04 | -29.03 | -29.88 | -35.15 |

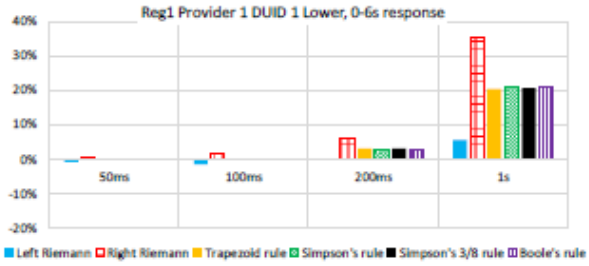



*Figure 12. Comparison of different integration methods for registration event provider 1 lower FCAS response, with relative window.*

| Event 7 Provider 1, 0-6s response | | | | |
|---|---|---|---|---|
| MWs | 50ms | 100ms | 200ms | 1s |
| Left Riemann | 11.89 | 11.80 | 11.60 | 11.56 |
| Right Riemann | 12.10 | 12.20 | 12.40 | 15.63 |
| Trapezoid rule | 12.00 | 12.00 | 12.00 | 13.60 |
| Simpson's rule | 11.99 | 12.00 | 12.00 | 13.57 |
| Simpson's 3/8 rule | 11.99 | 12.00 | 12.00 | 13.51 |
| Boole's rule | 11.99 | 12.00 | 12.00 | 13.58 |

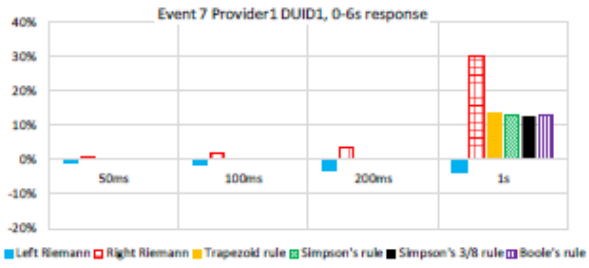



*Figure 13. Comparison of different integration methods for event 7 provider 1 raise FCAS response, with relative window.*

Figure 14: University of Melbourne analysis

| Event 7 Provider 1 oscillation profile, 0-6s response | | | | |
|---|---|---|---|---|
| MWs | 50ms | 100ms | 200ms | 1s |
| Left Riemann | 11.76 | 11.67 | 11.51 | 11.82 |
| Right Riemann | 11.96 | 12.08 | 12.31 | 14.86 |
| Trapezoid rule | 11.86 | 11.88 | 11.91 | 13.34 |
| Simpson's rule | 11.86 | 11.86 | 11.84 | 12.93 |
| Simpson's 3/8 rule | 11.86 | 11.86 | 11.83 | 13.71 |
| Boole's rule | 11.86 | 11.87 | 11.86 | 12.84 |

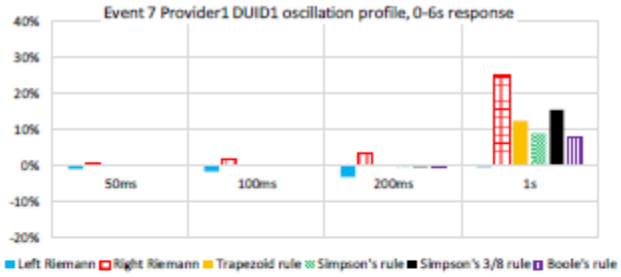



*Figure 14. Comparison of different integration methods for event 7 provider 1 raise FCAS response with superimposed alternate signal, with relative window.*

| Event 1 Provider 2 DUID 1, 0-6s response | | | | |
|---|---|---|---|---|
| MWs | 50ms | 100ms | 200ms | 1s |
| Left Riemann | 80.00 | 78.66 | 85.52 | 99.40 |
| Right Riemann | 80.58 | 81.57 | 91.72 | 130.59 |
| Trapezoid rule | 80.29 | 80.11 | 88.62 | 114.99 |
| Simpson's rule | 80.31 | 79.96 | 87.75 | 115.91 |
| Simpson's 3/8 rule | 80.30 | 80.14 | 88.09 | 113.70 |
| Boole's rule | 80.32 | 79.89 | 87.51 | 115.93 |

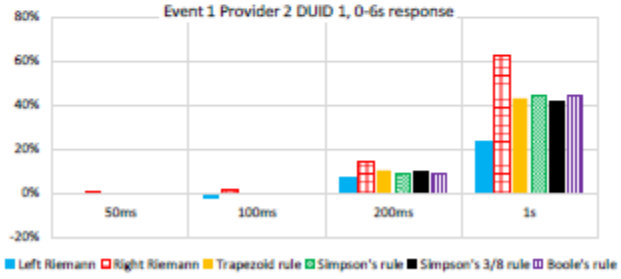



*Figure 15. Comparison of different integration methods for event 1 provider 2 raise FCAS response, with relative window.*

Figure 15: UoM analysis

Based on both Tesla's broad statistical analysis of the fleet level error risks, as well as the independent assessment from the UoM, Tesla believes that updating the verification tool to the trapezoid method is a low cost, low effort means of improving the error bands associated with verifying the quantum of Fast FCAS delivered. Furthermore, we understand that this change was already implemented by AEMO as part of the second stage consultation to allow AEMO to form its own view on measurement speed.

**Summary findings and recommendations**:

Based on the analysis above, Tesla has drawn the following conclusions:

- There is effectively zero risk for AEMO in immediately transitioning to 100ms or 200ms resolution as it provides the same resolution outcomes as 20ms.
- Updating the FCAS Verification Tool to the trapezoid method is low cost, low effort, and the mechanism to make this update already exists within the existing MASS framework.
- AEMO should also do further work to enable 1s resolution at a fleet level.

As such, our recommendations are as follows:

- AEMO to enable 100ms or 200ms resolution for Fast FCAS on a conditional logging basis.
- AEMO to update the FCAS Verification Tool to allow for trapezoid verification approach.
  - Note that given the combination of a 100ms or 200ms resolution with an update to the trapezoid approach provides a near zero error band, Tesla recommends that this approach is adopted for all Fast FCAS providers, not just VPPs.
- Based on the statistical analysis above, AEMO should also seriously consider providing the option of 1s measurement resolution for VPP fleets with more than 200 assets. This appears to be low risk and worthy of further consideration.

**Technical delivery of service**:

Oscillation risks

Tesla understands that AEMO has concerns around the oscillatory behaviour of inverters during power system disturbances. These concerns are outlined in the AEMO "Behaviour of distributed resources during power system disturbances" report[28]. These should be split into two broad categories. Expected inverter oscillations and unexpected inverter oscillations. The former can be broken down as:

- Concerns around inverter oscillations during voltage disturbances; and
- Concerns around inverter oscillations during frequency disturbances

Uncontrolled oscillations during a frequency event seem to be the particular concern of AEMO. In the Draft Determination AEMO notes one response to the earlier consultation which identified oscillation behaviour from a particular battery type (not currently being used within the respondees aggregation portfolio). This appears to be the primary basis for AEMO's concerns in respect of uncontrolled oscillations. Tesla agrees that this type of oscillatory behaviour is entirely unacceptable and devices that perform as such should not be enabled to provide FCAS regardless of the measurement resolution used for such a system type. In our >2 years of experience in providing FCAS, with more than 25MW of Powerwall capacity registered across three VPPs (equating to more than 5,000 systems) we have not observed a single instance of similar oscillatory behaviour. We also note that the fluctuations presented aren't oscillations but measurements of AC waveform at random voltage points.

Notwithstanding the above, it is quite clear that AEMO should be looking to prevent these systems from being registered for FCAS, rather than debating the granularity of measurement resolution necessary to observe this behaviour. This should be achieved through each registered piece of equipment through the Frequency Injection Test – Device (**FIT-D**).

The following requirements that are already in place, or under development, should provide AEMO with sufficient confidence on the performance of a particular asset type:

- FIT-D required for each different system type registered with AEMO for the purpose of providing FCAS.
- Mandating compliance with AS4777.2:2020 and the AEMO Low Voltage Disturbance Ride Through (LVDRT) specification – the disturbance ride-through requirements will manage performance.
  - Note that Tesla also supports retrospectively requiring all inverter based DER registered for FCAS currently to demonstrate compliance with AS4777.2:2020
- Developing an iterative approach for the FIT-D which allows the test to be updated from time to time to include new requirements developed by AEMO under the broader DER technical performance standard.

Tesla expects this will solve for unexpected oscillations and ensure that systems that demonstrate the behaviour highlighted in the Draft Determination are not registered for FCAS. This approach acknowledges that while there is no "generator performance standard" equivalent, there is an inverter

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

standard which has been developed to provide the same network protections at the distribution level. In addition, the fact that AS4777.2:2020 and DER is now explicitly referenced with the NER provides AEMO with the framework to continue to manage DER technical requirements and make iterative changes

In respect of controlled or expected oscillations, during a credible contingency event DER inverters enabled for FCAS will oscillate proportionally to the frequency with the aim of bringing the frequency back within the NOFB. If inverters swing from charging or discharging to the other it's because they are just reacting to the frequency changes instantaneously.

Tesla has also been working closely with the AEMO DER standards team to provide more visibility as to how inverters behave during emergency events. As noted in our response, it appears that a key issue AEMO is facing at the moment is lack of accessible data – and visibility of performance.

Tesla believes that AEMO should maintain the API that was stood up for VPPs to access real-time DER data at both an asset and fleet level. This will provide AEMO with far more useful information on oscillatory behaviour that the compliance data provided by DER providers following a contingency event. This will enable AEMO to analyse inverter performance in real-time during a myriad of different power system security events. This also means that an increase in VPP registered capacity benefits AEMO because there will be a direct correlation in VPP capacity and DER visibility.

FIT-D requirements

As noted in section 4, the AEMO VPP Demonstrations established a two-step means of verifying technical performance. Over the duration of the VPP Demonstrations, AEMO was overwhelmingly positive as to the technical capabilities of DER in providing FCAS. Based on the subsequent content released in the AEMO Draft Determination, there seems to be some conflation between the 50ms measurement resolution being linked to actual performance, versus being used to verify performance.

The Tesla Powerwall uses open loop controls to provide Contingency FCAS, whereby the grid-tied Powerwall inverter initiates a power response as soon as it detects a frequency deviation. The Powerwall power response therefore does not depend on frequency measurements from a meter. The measurement resolutions considered in the Draft Determination are in no way linked to the actual system performance, they simply provide AEMO with a means of verifying the delivery of the total service.

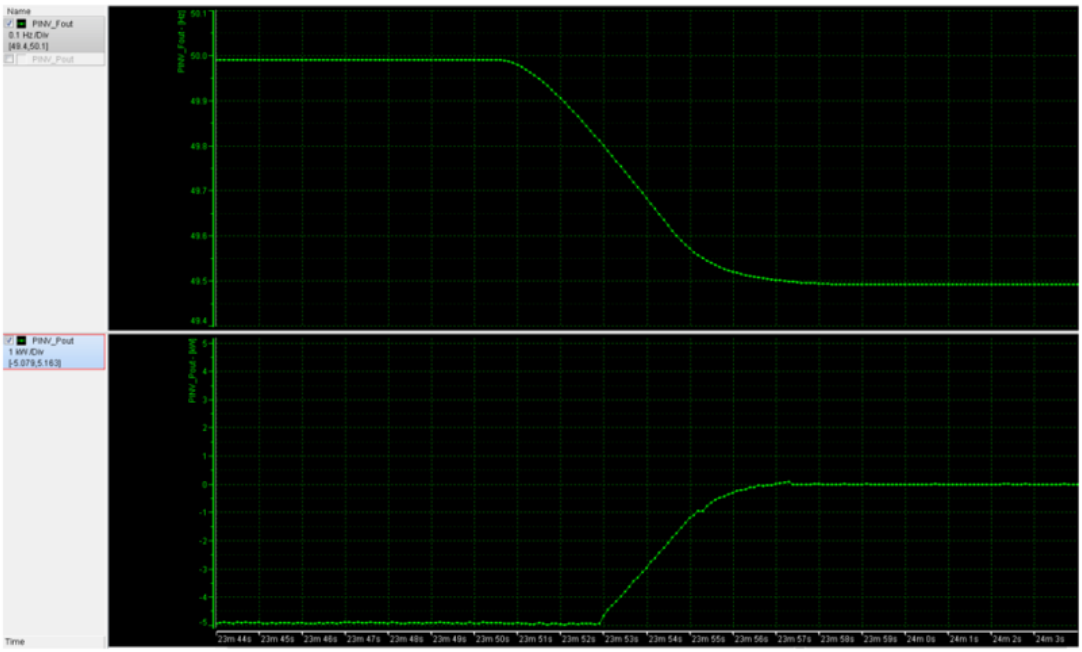


Figure 16 - Tesla Powerwall 2 Frequency Injection Test Results: 5kW Raise Response

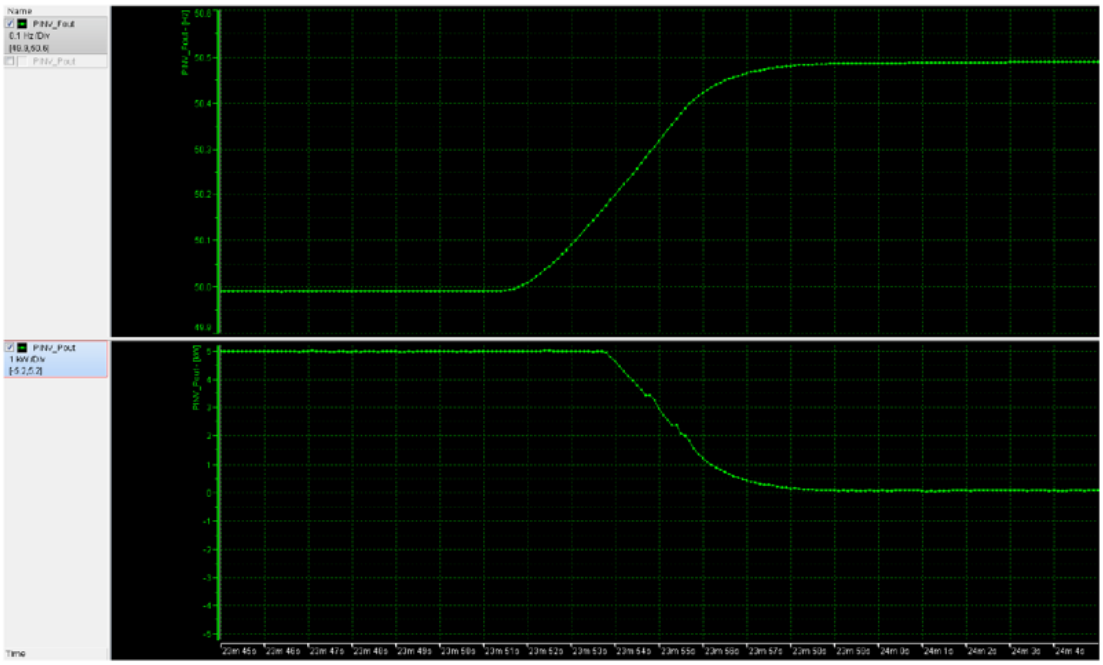


Figure 17 - Tesla Powerwall 2 Frequency Injection Test Results: 5kW Lower Response

The purpose of the FIT-D required upon registration of a new technology in any VPP is to demonstrate the technical capability of the technology to respond to frequency deviations using the settings provided by AEMO, such as the 0.7% droop. The power response from a 5kW Tesla Powerwall 2 ("Powerwall") to frequency deviations simulated in a laboratory is shown in Figures 18 and 19. These tests and the associated ≤50ms power and frequency measurements were validated by AEMO as part of the registration process of DUID VSSEL1V1.

In addition to this test, a Frequency Injection Test – DUID (FIT-DUID) is also required upon registration of a new DUID. This allows AEMO to confirm that the response demonstrated by a device during the FIT-D is delivered by a fleet of the same devices before that fleet can participate in the FCAS markets. The FIT-DUID test is meant to verify the performance of the fleet, not the technical capability of individual, identical devices. As such, a lower sampling rate than 50ms is sufficient to verify the performance of the fleet since, as per the MASS v6, Fast FCAS are verified based on energy provided over the 60s following the FDT.

...

### 6.4 Updates to MASS based on recommendations above and VPP Demonstrations

...Pending AEMO acceptance of our recommendations it is increasingly clear that there are a number of issues that need to be considered more fully ahead of AEMO releasing the MASS review, If AEMO does not accept the recommendations put forward by industry in the Final Determination, we believe that there needs to be an interim step where further analysis is done on the following:

- AEMO acceptance of error band risk at fleet level as well as for individual assets (which has been the only work done to date).
- Further consideration of measurement resolutions alternative to 50ms and 1s and/or consideration of bidding discounts that could be introduced for 1s resolution (this point would necessarily be linked to the first dot point above), and
- Updates to the verification tool to reduce risk.

## 7 Power system security risks

The Draft Determination also considers a range of power system security risks associated with DER.

While Tesla acknowledges the existence of each of these risks, with the exception of the oscillation risks (covered in section 6.2), we do not consider the risks flagged in the Draft Determination to be linked to MASS review process. These risks currently exist and will continue to exist regardless of whether the MASS is updated or not.

These risks should be addressed through concentrated efforts of AEMO, NSPs and industry. This also ties into the need for ongoing collaboration to create a scalable and sustainable market framework for VPPs that provides the optimal set of outcomes for all relevant stakeholders. If designed well, VPPs provide significant market and network benefits – rather than risks. However, to achieve this, there needs to be ongoing collaboration, and iterative work done to ensure suitable settings.

Below, Tesla provides an outline of the forums we think could be used to manage these concerns, as well as providing our own technical insights into the power system security risks flagged by AEMO in the Draft Determination.

...

### 7.2 Addressing the risks flagged in the Draft Determination

Tesla has experience with assessing and managing the concerns directly raised by AEMO in the Draft Determination. While we do not think these concerns are at all relevant to the MASS review, we've provided some insights into each of the concerns raised by AEMO (with the exception of the oscillation risks covered above):

1. 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.
2. 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 overactive power (FCAS response)
3. 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.

We also include our suggested plan for managing ongoing power system security risks – noting that this work will be iterative, and will need a sustained effort from AEMO, NSPs and industry in order to develop a sustainable and scalable future framework for VPPs in Australia.

### 7.3 Unexpected disconnection

As noted by AEMO in the Draft Determination it appears that the risks associated with unexpected disconnection will likely be resolved through the introduction of the new AS4777.2:2020. As noted above, Tesla supports mandating compliance with AS4777.2:2020 for both new inverters based DER looking to provide FCAS, and retrospectively requiring it for the existing fleet.

Tesla is working closely with the AEMO DER team to provide data from major disturbance events and consider any leading indicators that may lead to disconnect. We will continue to do so with the view that any learnings can be developed as new DER technical standards and mandated as part of the FIT-D requirements.

### 7.4 Behaviour during network disturbances

Tesla has been working closely with SAPN throughout the deployment of our VPP in SA to ensure that network requirements are prioritised over market access, and that VPPs minimize network risks.

In practice what this means is that network requirements should always be prioritised over market participation. Figure 19: Example of coincident volt-var and FCAS event shows a Tesla SAVPP site that is enabled for FCAS market participation. This site has a 5kW solar PV system and a Tesla Powerwall installed and operates in the Contingency FCAS markets under the VSSEL1V1 DUID with a 0.7% droop curve.

1. Stepping through the three dot highlighted points in the Figure:
2. Contingency frequency event occurs – site enabled to provide FCAS response.
3. Volt-var requirements triggered. Actual FCAS response is tapered down from the expected FCAS response to enable the site inverter to instead provide volt-var response.

Once the Required FCAS response subsides below the max apparent power capacity of the inverter, both Freq-Watt and Volt-Var operate in parallel.

What is clearly demonstrated is that as soon as 250V limit is reached, the Powerwall immediately reduces the real power FCAS response to instead provide reactive power support and reduce the VPP impact on local voltage. The reduction in FCAS response is demonstrated by the green "Actual FCAS" response being lower than the blue "Expected FCAS response". The prevention of additional voltage rise is evidenced by the plateau of the inverter voltage readings at ~250V.

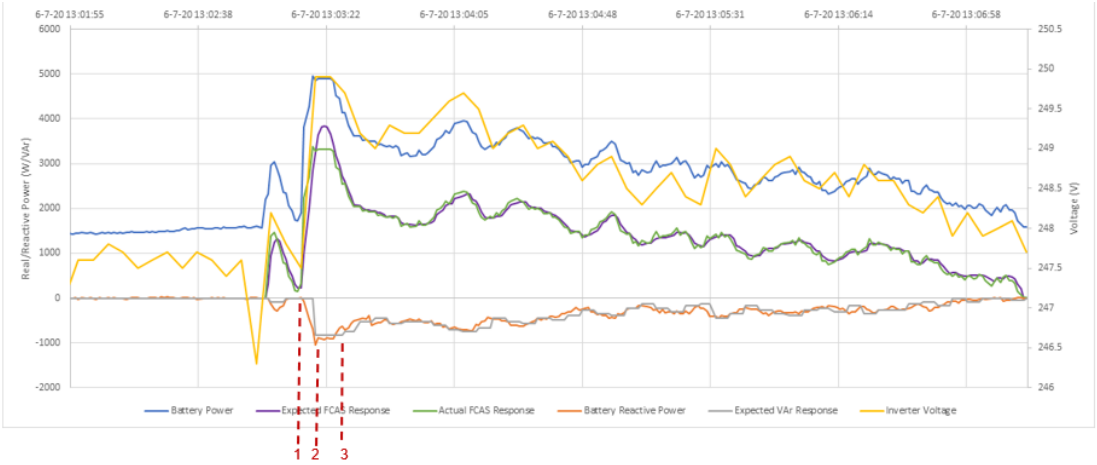



Figure 19: Example of coincident volt-var and FCAS event

### 7.5 Risks of exceeding network operating limits

The Draft Determination also flags concerns associated with VPP systems exceeding site export limits set by DNSPs.

As a starting point, it is important to note that these site export limits were introduced primarily to manage the network risks associated with extended periods of electricity export during solar generating hours – not to manage short duration (sub-cycle, second and minute) level response to system security issues.

Breach of site export limits is also generally considered to be a fringe risk given breaches of site export limits only occur in very specific circumstances:

1. Battery must be fully charged so solar is exporting
2. The event must be a raise event.
3. The event must happen during solar generation hours.

Even then to create an actual network risk:

4. The contingency event must be large enough to cause the solar export + PW output to drive up site voltage
5. Voltage on the site must be on the high end prior to the FCAS event.

For the purposes of the SAPN Advanced VPP Integration Plan, Tesla analysed the VPP performance to look for examples of site export limits being breached and could only find the single example, Figure 20.

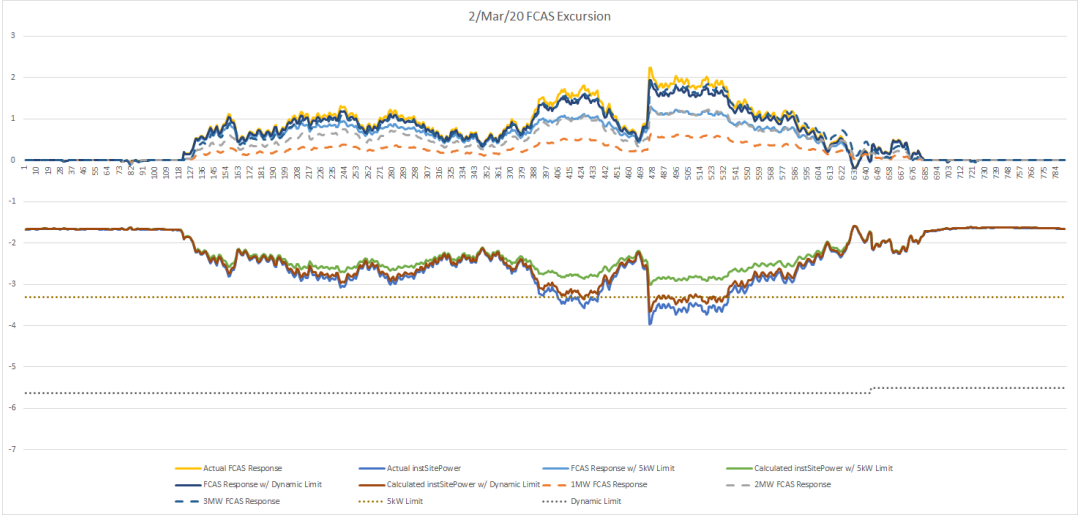



Figure 20: Example of site export limit breach

Tesla has been through the concerns regarding site export limits with SAPN to ensure appropriate arrangements are in place for providing FCAS. We will continue to support both AEMO and NSPs in developing the most appropriate co-optimised approach to DER market participation.

**8 Summary of recommendations**

… Tesla is committed to working closely with AEMO on the future development of appropriate VPP frameworks for Australia. As AEMO has acknowledged, this work will not be easy, so it's important to continue to make gains.

The power system security concerns identified in the Draft Determination are a separate issue to the MASS reforms and need to be addressed through a different forum. Treating these as two separate tranches of work will be important and our recommendations below are based on this separation of work.

| Topic | Recommendation |
|---|---|
| Measurement resolution | • AEMO should allow for Fast FCAS measurement resolution of 100ms as an alternative to the 50ms resolution currently required and included in the Draft Determination. This should be done on a conditional logging basis, with 1s measurement resolution maintained outside of frequency deviations (before a frequency deviation, and after the 60s following a frequency deviation).<br>• AEMO should update the FCAS Verification Tool to use the trapezoid measurement resolution approach.<br>• The combination of these two recommendations creates a near zero error risk for AEMO – well under the 2% allowable error range for fast FCAS currently allowed within the MASS.<br>• Tesla's analysis also highlights that for fleets of >200 systems, the error risk associated with 1s measurement resolution is also less than 2%. Tesla recommends that AEMO further consider options for larger fleets to operate with a less granular measurement resolution (see detailed analysis in Attachment B – [Application Note immediately after this table]). |
| Other MASS related reforms | • AEMO should reinstate the API set up for the VPP Demonstrations and make API integration a specific requirement of VPP registration within the MASS.<br>• This API provided clear benefits to AEMO in terms of increased visibility of DER in real-time, as well as setting the framework for forecasting.<br>• Tesla supports providing AEMO with ongoing DER visibility. Maintaining the API would result in AEMO receiving 100ms data during frequency deviations (for compliance purposes), and 1s data provided at all other times.<br>• VPP operators could either be required to provide this data as a MASS condition of registration or provide it on an opt-in basis.<br>• This breadth of data will help enormously with the power system security concerns raised by AEMO as it will provide real-time data to help identify a range of different inverter responses to different fault level conditions.<br>• Conversely, maintaining the MASS as it currently stands will provide AEMO with 50ms data only during a contingency event. This doesn't help with any other system disturbance, or to more broadly analyse how inverters behave in response to distribution level fault issues. The API does support that. |

…

**APPLICATION NOTE:**

**POWER MEASUREMENTS ERROR**

**Methodology**

**Frequency Measurements (20ms)**

This study uses 20ms frequency measurements in Queensland and New South Wales during the frequency disturbance that happened at 14:06 on 25 May 2021 following the loss of Callide C coal plant. These measurements were provided by AEMO. They show that the frequency disturbance lasted about 15s in QLD and 2s in NSW. Therefore, the 60s period following the FDT considered for the verification of performance for Fast FCAS, as per section 3.7.1. (a) (i) of the MASS, covers the entire duration of the frequency disturbances observed in QLD and NSW on 25 May 2021.

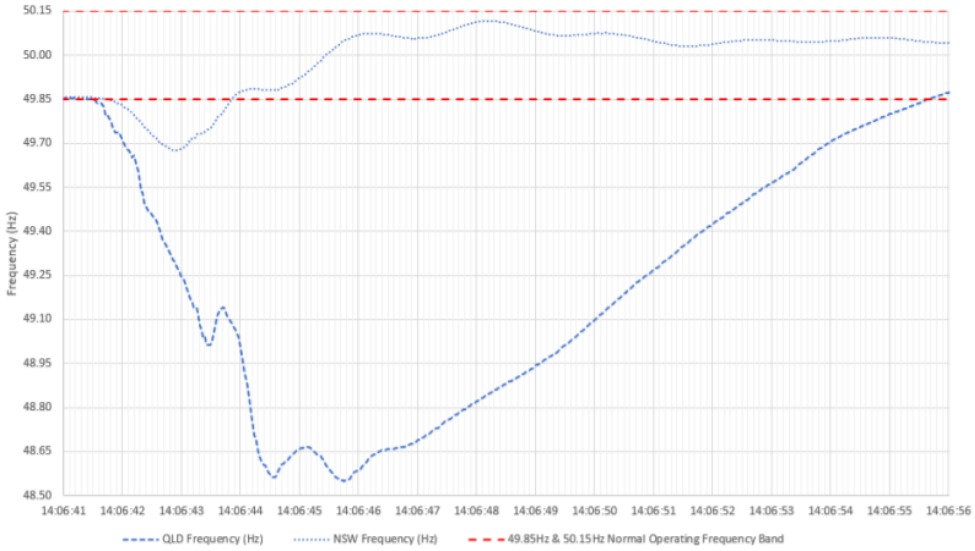



*Figure 1 - AEMO's frequency measurements in QLD and NSW during the 25 May 2021 events (20ms sampling rate)*

**Power Response (20ms)**

The response from a 5kW Tesla Powerwall 2 ("Powerwall") registered under DUID VSSEL1V1 is calculated using the 0.7% droop setting provided to this DUID by AEMO upon registration. The capability of the Powerwall to respond to a frequency deviation was demonstrated during a frequency injection test performed in a laboratory. Figure 2 shows that the Powerwall provides a proportional raise response of 5kW from 49.85Hz to 49.5Hz, and Figure 3 shows a proportional lower response of 5kW from 50.15Hz to 50.5Hz. Both responses start within less than 250ms of the frequency deviation outside of the 49.85Hz-50.15Hz NOFB. Therefore, a 240ms response time (multiple of 20ms) between the start of the frequency deviation and the start of the power response is introduced in this study.

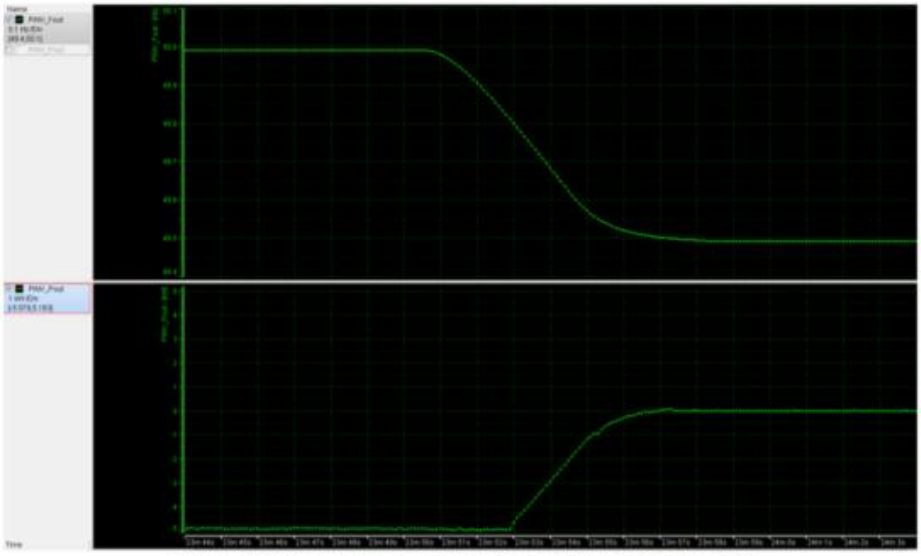


Figure 2 - Tesla Powerwall 2 Frequency Injection Test Results: 5kW Raise Response

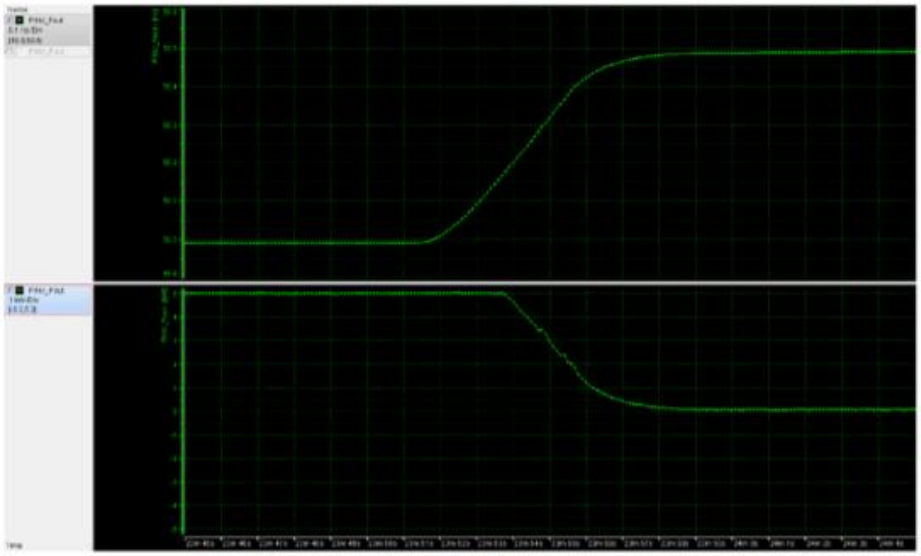


Figure 3 - Tesla Powerwall 2 Frequency Injection Test Results: 5kW Lower Response

The Powerwall uses open loop controls to provide Contingency FCAS, whereby the grid-tied Powerwall inverter initiates a power response as soon as it detects a frequency deviation. The Powerwall power response therefore does not depend on frequency measurements from a meter. As a result, no random variable is introduced to account for frequency measurement margin of error. However, a random variable is introduced for each site to account for a ≤2% of measurement range margin of error for power measurements ("error random variable") as allowed by the MASS. For a 5kW Powerwall, a ≤2% of measurement range margin of error corresponds to a ≤100W margin of error. The 20ms resolution power response is then calculated for 1000 Powerwalls.

**Sampling Rates (100ms, 200ms, 500ms and 1s)**

For each of the 1000 power responses, another random variable is introduced to determine when power is polled ("polling random variable"). For a given Powerwall, in the 100ms sampling rate scenario, the first polling happens randomly during one of the first five 20ms intervals, and every 100ms after that. The response of all 1000 Powerwalls is then aggregated using one of two aggregation methods:

- The truncated method adds the responses with a time stamp of 20ms, 40ms, 60ms, 80ms or 100ms under time stamp 100ms, the responses with a time stamp of 120ms, 140ms, 160ms, 180ms or 200ms under time stamp 200ms, etc…
- The rounded method adds the responses with a time stamp of 60ms, 80ms, 100ms, 120ms or 140ms under time stamp 100ms, the responses with a time stamp of 160ms, 180ms, 200ms, 220ms or 240ms under time stamp 200ms, etc…

There are three other sampling rate scenarios, which all use the same method: 200ms, 500ms and 1s. Figure 4 illustrates the 1s sampling rate scenario using the truncated method at three sites without introducing a 240ms response time and the error random variable, for clarity. Polling for each site happens at random and distinct 20ms intervals within a 1000ms interval. The 1s power response is then calculated as the average of the three distinct 20ms measurements for illustration purposes – as described above, to calculate the aggregate response, these values are actually *summed*.

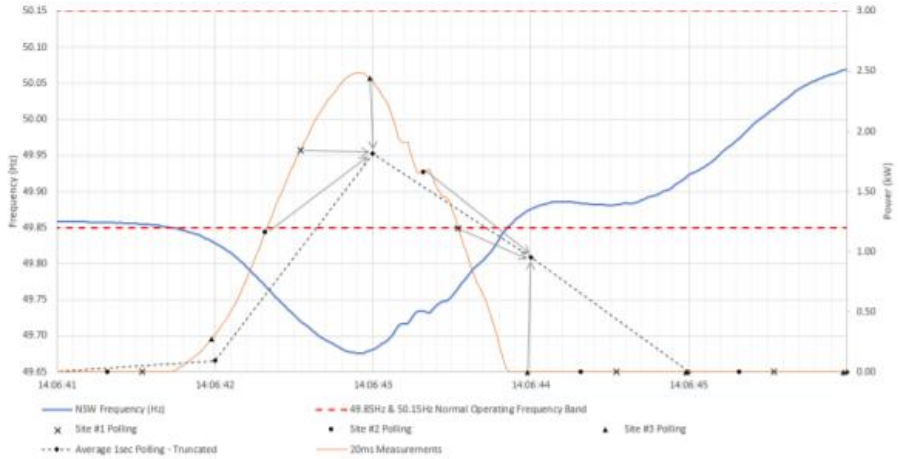



*Figure 4 - Aggregation method for three sites (random 20ms polling, 0ms response time, no error random variable, truncated)*

Figures 5 and 6 compare the target response – which has 0ms response time, and no error and polling random variables – to the *actual* responses with varying sampling rates for 1000 Powerwalls using the truncated method. For avoidance of doubt, the 20ms *actual* response includes the 240ms response time and the error random variable, but it cannot include the polling random variable, contrary to the 100ms, 200ms, 500ms and 1s scenarios.

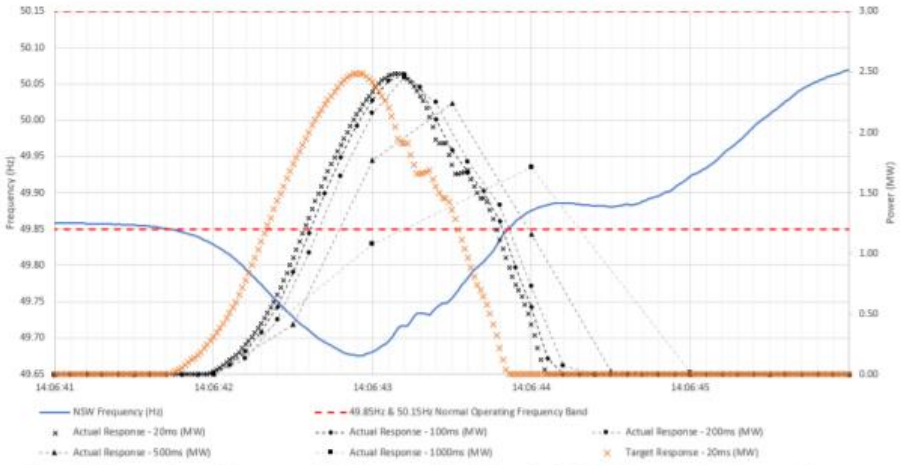



*Figure 5 - Target and actual responses of 1000 Powerwalls in NSW to the 25 May 2021 events (varying sampling rates, truncated method)*

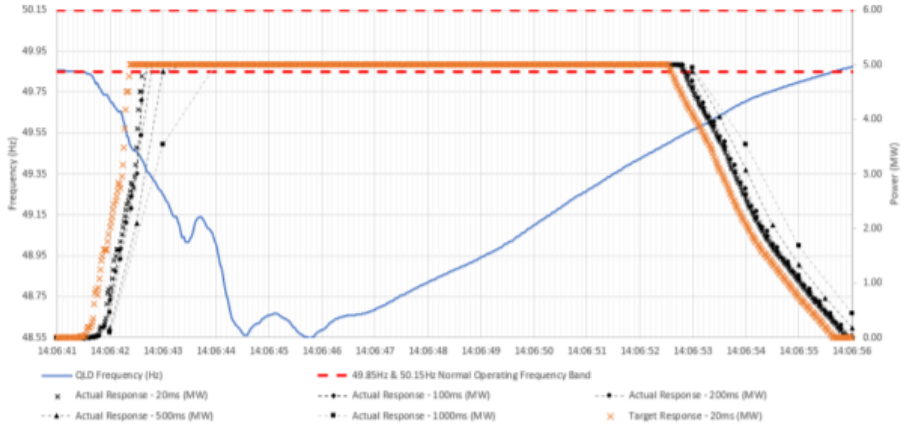



*Figure 6 - Target and actual responses of 1000 Powerwalls in QLD to the 25 May 2021 event (varying sampling rates, truncated method)*

For frequency deviations of short duration, the maximum power measured decreases as the sampling rate decreases due to the aggregation method, as illustrated in Figure 4. This is not the case for longer frequency deviations below 49.5Hz or above 50.5Hz lasting multiple sampling intervals. Indeed, QLD frequency deviation required a full 5kW response over 15s, which means that there were multiple 1-s intervals during which the 5kW response of all 1000 sites could be measured.

**Evaluation Metrics**

Two metrics are used to estimate the measurement error between the actual response and the target 20ms response:

- $$Energy\ Error_n = \frac{\left(\sum_{i=1}^{q} Actual\ Response_i\right) / \frac{1000\ ms}{Sampling\ Rate} - \left(\sum_{i=1}^{p} Target\ Response_i\right) / \frac{1000\ ms}{20\ ms}}{\left(\sum_{i=1}^{p} Target\ Response_i\right) / \frac{1000\ ms}{20\ ms}}$$
- $$Power\ Error_n = \frac{\max(Actual\ Response) - \max(Target\ Response)}{\max(Target\ Response)}$$

where:

- n = number of Powerwalls (1, 10, 25, 50, 200, 500 or 1000)
- p = 750, which is the number of 20ms intervals over 15s
- Sampling Rate = 20ms, 100ms, 200ms, 500ms or 1000ms
- q = 750 / (Sampling Rate/20ms), which is the number of intervals over 15s for a given Sampling Rate
- Target Response is the 20ms power response of n Powerwalls calculated using the 20ms frequency measurements and 0.7% droop settings. It does not include the 240ms response time or the error and polling random variables.
- Actual Response is the power response of n Powerwalls calculated using the sampling methodology described above. It includes the 240ms response time and the error and polling random variables, except for the 20ms scenario which cannot include the polling random variable.
- max(Target Response) is the maximum target power response over the 15s interval
- max(Actual Response) is the maximum actual power response over the 15s interval

The energy error formula uses the right Riemann sum method, similar to the FCAS Verification Tool, as AEMO mentions in section 4.1.2. of the draft MASS.

A 50ms sampling rate scenario is also introduced since the MASS currently requires ≤50ms sampling rate to provide Fast FCAS. For this scenario, the 20ms frequency data is first up-sampled to 10ms using linear interpolation. It is then down-sampled to 50ms by polling the 10ms frequency data every five intervals starting with time stamp ending in 0ms. A 250ms response time (multiple of 50ms) is then introduced, along with the error random variable, but no polling random variable was introduced since this methodology uses 50ms frequency data.

**Monte Carlo Simulations**

Monte Carlo simulations were run in order to assess the impact of the error and polling random variables on the energy error and power error metrics, for each of the six sampling rates and seven quantities of sites. The tables below show the average value of the absolute error in 500 different simulations for each sampling rate x site quantity scenario (that is 21,000 distinct simulations).

**Energy Error (%)**

| | | Queensland | | | | | | New South Wales | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sampling rate (ms) | | | | | | | Sampling rate (ms) | | | | | |
| | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 |
| Truncated | 1 | 1.01% | 1.02% | 1.01% | 0.99% | 1.03% | 1.13% | 1 | 1.04% | 0.98% | 0.98% | 1.03% | 2.11% | 5.04% |
| | 10 | 0.29% | 0.31% | 0.29% | 0.29% | 0.30% | 0.35% | 10 | 0.29% | 0.29% | 0.30% | 0.29% | 0.62% | 1.43% |
| | 25 | 0.18% | 0.19% | 0.20% | 0.19% | 0.19% | 0.21% | 25 | 0.18% | 0.18% | 0.18% | 0.19% | 0.39% | 0.88% |
| | 50 | 0.13% | 0.14% | 0.12% | 0.13% | 0.14% | 0.15% | 50 | 0.13% | 0.13% | 0.13% | 0.14% | 0.28% | 0.66% |
| | 200 | 0.07% | 0.06% | 0.07% | 0.07% | 0.07% | 0.08% | 200 | 0.06% | 0.07% | 0.07% | 0.07% | 0.14% | 0.31% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.05% | 500 | 0.04% | 0.05% | 0.04% | 0.04% | 0.09% | 0.20% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.07% | 0.14% |
| | | Sampling rate (ms) | | | | | | | Sampling rate (ms) | | | | | |
| | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 |
| Rounded | 1 | 0.99% | 0.98% | 1.00% | 1.01% | 0.97% | 1.17% | 1 | 1.01% | 0.99% | 0.98% | 1.00% | 2.14% | 4.99% |
| | 10 | 0.31% | 0.29% | 0.27% | 0.29% | 0.30% | 0.34% | 10 | 0.29% | 0.30% | 0.30% | 0.30% | 0.63% | 1.39% |
| | 25 | 0.19% | 0.19% | 0.18% | 0.17% | 0.20% | 0.22% | 25 | 0.19% | 0.18% | 0.18% | 0.20% | 0.42% | 0.87% |
| | 50 | 0.12% | 0.13% | 0.13% | 0.13% | 0.13% | 0.14% | 50 | 0.13% | 0.13% | 0.13% | 0.13% | 0.29% | 0.61% |
| | 200 | 0.07% | 0.07% | 0.06% | 0.06% | 0.07% | 0.08% | 200 | 0.07% | 0.07% | 0.07% | 0.07% | 0.14% | 0.32% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.05% | 500 | 0.04% | 0.05% | 0.04% | 0.04% | 0.09% | 0.19% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.06% | 0.14% |

*Figure 7 - Monte Carlo simulation results for absolute value of energy error (500 simulations)*

**Power Error (%)**

| | | Queensland | | | | | | New South Wales | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sampling rate (ms) | | | | | | | Sampling rate (ms) | | | | | |
| | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 |
| Truncated | 1 | 1.00% | 0.99% | 1.00% | 1.06% | 1.04% | 1.04% | 1 | 0.96% | 1.01% | 0.99% | 1.51% | 5.89% | 16.83% |
| | 10 | 0.30% | 0.30% | 0.27% | 0.30% | 0.27% | 0.30% | 10 | 0.29% | 0.30% | 0.34% | 1.23% | 9.30% | 30.22% |
| | 25 | 0.18% | 0.18% | 0.19% | 0.18% | 0.18% | 0.19% | 25 | 0.18% | 0.19% | 0.24% | 1.25% | 9.21% | 30.62% |
| | 50 | 0.14% | 0.13% | 0.13% | 0.13% | 0.13% | 0.13% | 50 | 0.13% | 0.13% | 0.19% | 1.26% | 9.33% | 30.64% |
| | 200 | 0.07% | 0.06% | 0.06% | 0.06% | 0.06% | 0.06% | 200 | 0.07% | 0.07% | 0.16% | 1.26% | 9.35% | 30.82% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 500 | 0.04% | 0.04% | 0.16% | 1.25% | 9.35% | 30.96% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 1000 | 0.03% | 0.03% | 0.16% | 1.25% | 9.37% | 30.86% |
| | | Sampling rate (ms) | | | | | | | Sampling rate (ms) | | | | | |
| | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 |
| Rounded | 1 | 0.99% | 0.98% | 0.99% | 1.01% | 1.02% | 0.99% | 1 | 0.99% | 1.00% | 1.07% | 1.42% | 5.69% | 16.44% |
| | 10 | 0.30% | 0.30% | 0.28% | 0.29% | 0.30% | 0.31% | 10 | 0.29% | 0.30% | 0.70% | 1.51% | 8.89% | 20.50% |
| | 25 | 0.19% | 0.20% | 0.19% | 0.17% | 0.19% | 0.18% | 25 | 0.19% | 0.19% | 0.75% | 1.50% | 9.07% | 20.10% |
| | 50 | 0.13% | 0.13% | 0.13% | 0.13% | 0.13% | 0.14% | 50 | 0.14% | 0.13% | 0.78% | 1.54% | 8.96% | 20.04% |
| | 200 | 0.06% | 0.07% | 0.06% | 0.06% | 0.07% | 0.07% | 200 | 0.06% | 0.07% | 0.81% | 1.55% | 8.98% | 20.12% |
| | 500 | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 0.04% | 500 | 0.04% | 0.04% | 0.81% | 1.54% | 9.02% | 20.03% |
| | 1000 | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 0.03% | 1000 | 0.03% | 0.03% | 0.81% | 1.54% | 8.98% | 20.03% |

*Figure 8 - Monte Carlo simulation results for absolute value of power error (500 simulations)*

The energy error is less than the 2% allowable margin of error for power measurements for all scenarios except single sites in NSW with 500ms or 1000ms sampling rates. This means that a sampling rate of 200ms or less ensures that for any number of sites, both energy and power error remain less than 2% for the QLD and NSW frequency deviations, and for the truncated and the rounded methods. A minimum of 1MW is required to register a VPP in the FCAS markets, i.e. no fewer than 200 Powerwalls.

The power error is less than 2% except for 500ms and 1000ms sampling rates in NSW. The power error for 1000ms sampling rate in NSW is lower for single sites than for multiple sites because:

For single sites, the power error can range:

- from +2% if a) the 1sec polling happens during the 20ms interval when the power measurement is highest (2.48kW for a 5kW Powerwall), and b) the power measurement error is +2%
- to -41% if a) the 1sec polling happens during the two 20ms intervals when the maximum value across these two intervals is the lowest (1.50kW), and b) the power measurement error is -2%
- and given the NSW frequency measurements, it is slightly more likely that the 1s polling of a single site yields a maximum power measurement closer to 2.48kW than to 1.50kW
- as a result, the average absolute value of the power error for a single site is around 17%

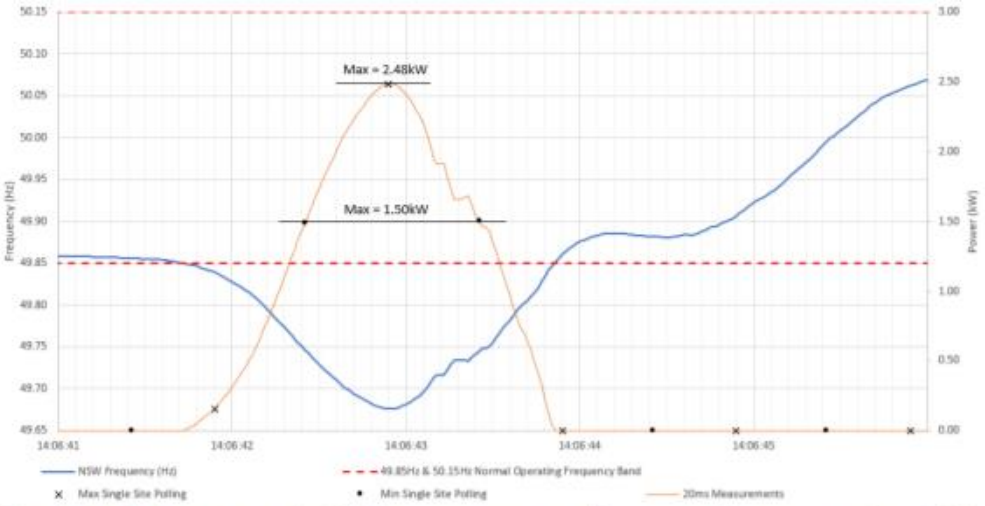



*Figure 9 - Single site power error using NSW frequency measurements (0ms response time, no error random variable)*

For multiple sites, the error depends on the average measurements across these sites, as shown in Figure 4, and varies based on the method (rounded or truncated) and the response time. With the truncated method and a 240ms response time, given that the power response starts with time stamp ending in 20ms (i.e. beginning of a 1s interval) and lasts for 2s, the power error is a function of the max of:

- the average of the fifty 20ms power measurements over the first 1-s interval (1.03kW), and
- the average of the fifty 20ms power measurements over the next 1-s interval (1.75kW)
- as a result, the average absolute value of the power error for multiple sites is around 31%.

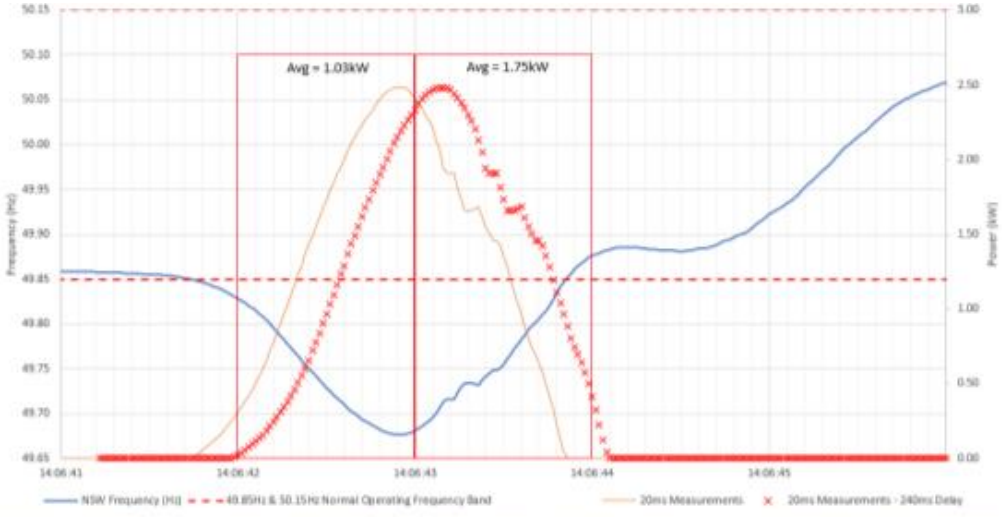



*Figure 10 - Multiple sites power error (NSW frequency, 240ms response time, no error random variable, truncated)*

Lastly, Figures 7 and 8 show that the difference between the truncated and rounded methods is negligible (<0.5%) except for power error with 1s sampling rate scenario in NSW, as explained above.

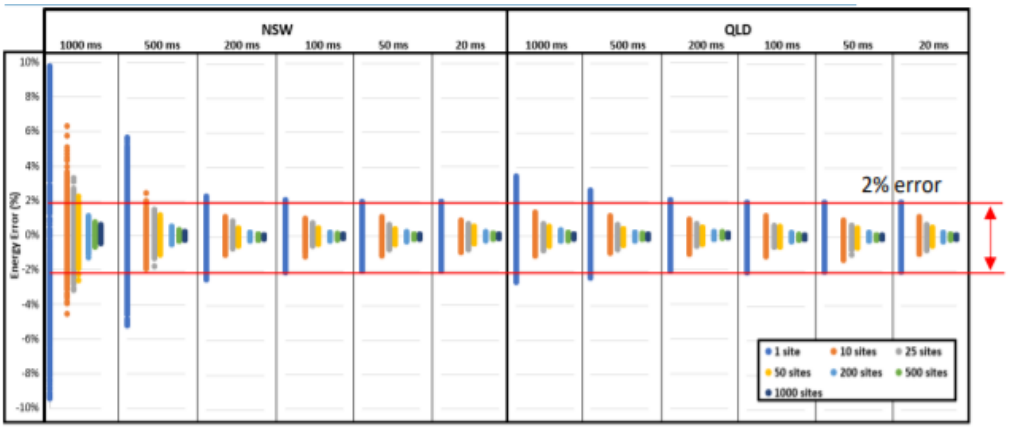



*Figure 11 - Energy error distribution of Monte Carlo simulation using rounded method (500 simulations)*

Figure 11 illustrates the energy error of the 500 Monte Carlo simulations across different sampling rates using the rounded method. As the number of sites and the sampling rate increase, the variance of the energy error reduces significantly. Interestingly, the number of sites has a larger impact on the energy error variance than the sampling rate. Indeed, with 1000 sites, the energy error calculated for each simulation stays well within ±0.5% for any sampling rate, and with 200 sites (the minimum number of 5kW Powerwalls required to register in FCAS markets) it stays within ±1% for any of the 500 simulations. For comparison, in NSW, where the duration of the frequency deviation is short, the energy error for a single site is reduced from ±10% with 1s sampling rate to ±2.5% with 100ms sampling rate; in QLD it is reduced from ±4% to ±2%.

**0.125Hz/sec Synthetic Frequency Disturbance**

A synthetic frequency disturbance was created to estimate the energy error over the first 6 seconds of a frequency excursion (grey area in Figure 12). The frequency starts at 49.85Hz, – the lower band of the NOFB – stays there for 500ms and drops at a rate of -0.125Hz/sec – the Frequency Ramp Rate of the MASS – for 2.8s until it reaches 49.5Hz. It was assumed that when the frequency reaches 49.5Hz, it does not recover and remains at this value. Given that the Right Riemann sum method over-estimates the energy delivered (i.e. area under the curve) for a raise service (i.e. power response with a positive slope), this can be considered as a scenario illustrating the largest expected energy error.

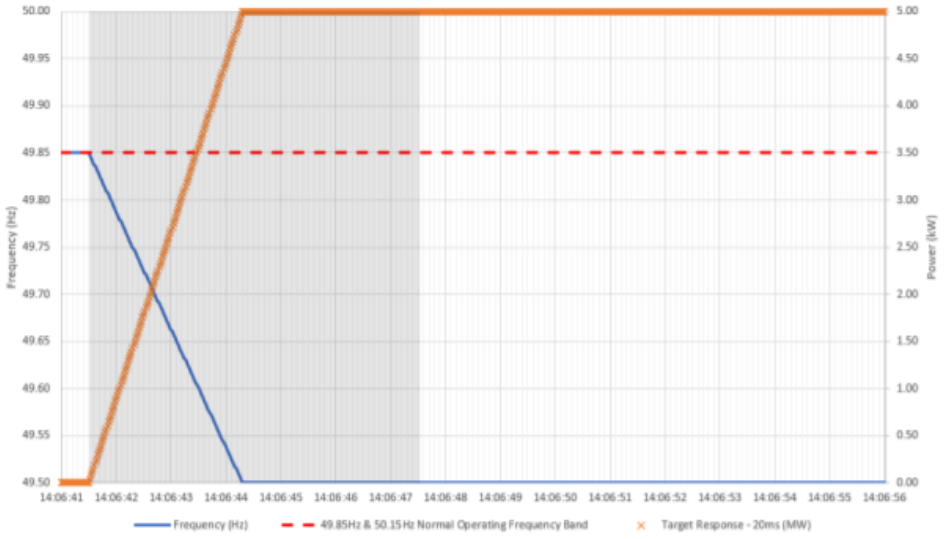



*Figure 12 – Synthetic frequency disturbance using 0.125Hz/sec Frequency Ramp Rate (20ms sampling rate)*

The same method as in the previous sections was then used to estimate the energy error, with a response time of 0ms, in order to isolate the impact of the error random variable and polling random variable as the number of sites increases. Figure 13 captures the energy error of 500 Monte Carlo simulations for each sampling rate x site quantity scenario (21,000 distinct simulations), for both the rounded and the truncated methods. It is worth noting that the largest possible over-estimate for a single site is of the same order as the over-estimates identified by AEMO in section 4.1.2. of the draft MASS. This largest possible over-estimate error of 25% for any response time faster than one second is the result of: - +2% power

measurement error, and - 23% maximum error from a) the random 1-s polling happening at millisecond 480 while b) the frequency excursion starts at millisecond 500, c) the 0ms response time assumed, and d) the rounding method being used.

However, regardless of the method used, the Monte Carlo simulations show the same trends as for the NSW and QLD frequency excursions: as the number of sites and the sampling rate increase, the variance of the energy error reduces significantly, with the number of sites having a larger impact on the energy error variance than the sampling rate. As such, with 200 sites (the minimum number of 5kW Powerwalls required to register in FCAS markets) and 100ms measurements, all Monte Carlo simulations are within the ≤2% of measurement range margin of error for power measurements allowed by the MASS. And as shown on Figure 14, the average value of the absolute error for 500 Monte Carlo simulations is less than 2% for both methods with sampling rate of 200ms or faster, and for 10 sites or more.

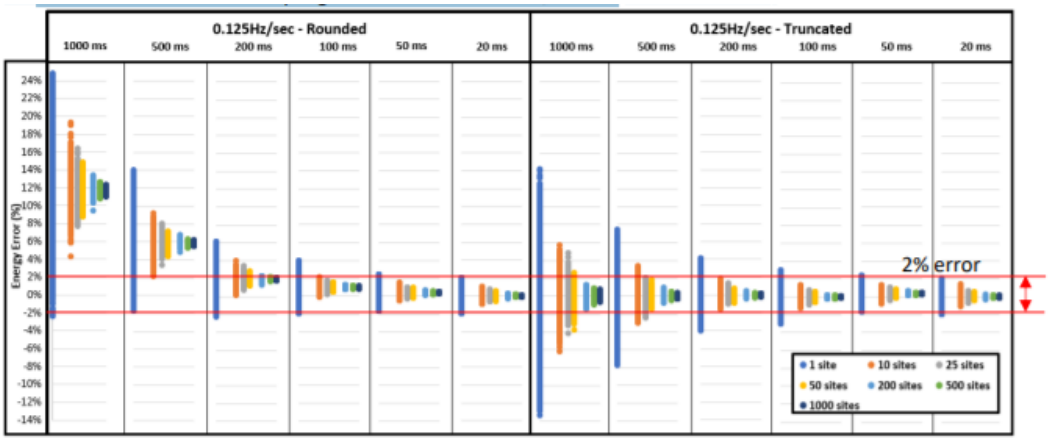



*Figure 13 - Energy error distribution of Monte Carlo simulation (500 simulations, 0ms response time)*

| Energy Error (%) | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0.125Hz/sec | | | | | | | |
| Truncated | | Sampling rate (ms) | | | | | |
| | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 |
| | 1 | 1.00% | 1.06% | 1.16% | 1.47% | 3.11% | 6.13% |
| | 10 | 0.30% | 0.42% | 0.36% | 0.46% | 0.96% | 1.65% |
| | 25 | 0.19% | 0.38% | 0.22% | 0.28% | 0.60% | 1.07% |
| | 50 | 0.13% | 0.37% | 0.15% | 0.22% | 0.40% | 0.78% |
| | 200 | 0.06% | 0.36% | 0.07% | 0.10% | 0.21% | 0.38% |
| | 500 | 0.04% | 0.36% | 0.05% | 0.07% | 0.13% | 0.24% |
| | 1000 | 0.03% | 0.37% | 0.03% | 0.05% | 0.09% | 0.18% |
| Rounded | | Sampling rate (ms) | | | | | |
| | Nb of sites | 20 | 50 | 100 | 200 | 500 | 1000 |
| | 1 | 1.00% | 1.06% | 1.36% | 2.18% | 5.74% | 11.32% |
| | 10 | 0.30% | 0.43% | 0.99% | 1.96% | 5.89% | 11.69% |
| | 25 | 0.20% | 0.38% | 0.99% | 1.94% | 5.83% | 11.62% |
| | 50 | 0.14% | 0.36% | 0.98% | 1.95% | 5.84% | 11.68% |
| | 200 | 0.07% | 0.37% | 0.98% | 1.94% | 5.85% | 11.69% |
| | 500 | 0.04% | 0.36% | 0.97% | 1.95% | 5.83% | 11.67% |
| | 1000 | 0.03% | 0.37% | 0.97% | 1.94% | 5.84% | 11.68% |

*Figure 14 - Monte Carlo simulation results for absolute value of energy error (1000ms sampling rate, 500 simulations)*

### Conclusions

Errors of less than 0.5% are considered negligible. Errors between 0.5% and 1% are considered minimal. Errors between 1% and 2% are considered acceptable given the ≤2% of measurement range margin of error for power measurements allowed by the MASS.

### 0.125Hz/sec Synthetic Frequency Disturbance (6-s assessment)

The synthetic frequency disturbance, which illustrates the largest expected errors, shows a significant reduction in energy error as the number of sites and the sampling rate increase. Even with the rounded method and a combination of factors leading to the largest possible over-estimates, the energy error with a 200ms sampling rate is acceptable for 10 sites and it is minimal with a 100ms sampling rate.

### 25 May 2021 Events, NSW and QLD Frequency Measurements (3-s and 15-s assessments)

- Energy error: For any sampling rate and both frequency deviations, the energy error is negligible for 200 sites and more. It exceeds 2% only for a single site, when sampling rate is 500ms or 1s.
- Power error:
  - Maximum actual response is lower than maximum target response for multiple sites.

- In QLD, where the frequency deviation exceeds ±500mHz for multiple seconds, the power error is negligible for 10 sites or more and for any sampling rate.
- In NSW, where the frequency deviation is only ±350mHz for fewer than 3 seconds, the power error is minimal with 100ms measurements for 10 sites or more, and it is acceptable for 200ms measurements for any number of sites.

<table>
<tr><td>20ms...</td><td rowspan="6">...sampling rate keeps power and energy errors <0.5% for...</td><td>...10 sites and more...</td><td colspan="4">...for both the QLD and NSW frequency deviations, and for both the truncated and the rounded methods.</td></tr>
<tr><td>50ms...</td><td>...10 sites or more...</td></tr>
<tr><td>100ms...</td><td>...10 sites and more...</td><td rowspan="4">...for both the QLD and NSW frequency deviations, and for both the truncated and the rounded methods...</td><td rowspan="4">...except for the power error for NSW frequency deviation where it is between...</td><td>...0.5% and 1%...</td><td>...using the rounded method.</td></tr>
<tr><td>200ms...</td><td>...10 sites and more...</td><td>...1% and 1.6%...</td><td rowspan="3">...whether the truncated method or the rounded method is used.</td></tr>
<tr><td>500ms...</td><td>...25 sites and more...</td><td>...9% and 10%...</td></tr>
<tr><td>1000ms...</td><td>...200 sites and more...</td><td>...20% and 30%...</td></tr>
</table>

Viotas:

> **1. Measurement resolution and location for FCAS delivery:**
>
> VIOTAS supports the Draft Determination that the metering requirements within the MASS (in terms of both data resolution and measurement location) should not be amended to accommodate alternative measurement arrangements for FCAS provision from DER. This is in line with the detailed first stage consultation submission made by VIOTAS, recognising the importance of high resolution power and frequency metering for the provision and verification of Fast FCAS.

### 4.1.2. AEMO's assessment

AEMO understands that some stakeholders were concerned that they had already offered or were in the process of offering grants and rebates to customers on the basis of participation in the Fast FCAS markets. While AEMO clearly stated that the VPP Demonstrations FCAS Specification was for the purposes of those demonstrations only and that any changes to the MASS would go through a NER-based consultation process, there was a view among some stakeholders that changes would be made to the MASS to reflect the VPP Demonstrations specification or similar.

A number of submissions provided a broad technical analysis on alternative time resolution options, and 15 submissions requested AEMO to consider alternative measurement time resolutions for Fast FCAS of 100 ms and/or 200 ms. As with first stage submissions, there was no consensus on either the desired outcome, or the reasons for the desired outcome.

The following table summarises Consulted Persons' preferences for each measurement time resolution option:

| Preferred Outcome | Consulted Person |
|---|---|
| **50 ms** | AEC[29], AER, CS Energy[30], EA[31], ECA, Empower Energy, Intellihub, Origin Energy, Redback[32], Reposit Power, Rheem & CET, Viotas[33] |
| **100 ms** | CEC, Dreambox, Empower Energy, Enphase Energy, New Energy Ventures, Shell[34], SolarEdge |
| **200 ms** | Quinbrook, Simply Energy, SwitchDin |

[29] AEC indicated that they accept it on an interim basis.
[30] CS Energy indicated AEMO's approach was prudent without indicating a preference for a particular resolution.
[31] EA indicated it accepted AEMO's decision.
[32] Redback indicated it was ambivalent but indicated 50 ms was achievable.
[33] Viotas indicated that it accepted AEMO's decision on resolution.
[34] See extract in section 4.3.1.

| Preferred Outcome | Consulted Person |
|---|---|
| 100 ms or 200 ms | CPUE[35], DEMSA[36], ENA, Energy Locals, Hydro Tasmania, PIAC, , Tesla |
| 1 second (s) | ACF[37], Evergen, Hydro Tasmania[38], Members Energy, Powerledger, , Social Energy, Solar Analytics, sonnen[39] |
| No preference | AGL[40], CPUE, DELWP – V, Discover Energy, Enel X, SAPN |

### Inadequacy of 1 second (s) Sampling Rate

As can be seen from the table, several Consulted Persons were still not persuaded of AEMO's reasons for not amending the measurement time resolution in the MASS to 1 s.

The MASS requires measurements of power flow to have a measurement range appropriate to the Ancillary Service Facility enabled in the Fast FCAS markets, an error ≤2% of the measurement range, and a resolution of ≤0.2% of the measurement range. The error is for the measurement of power flow for each data sample, not for the total energy exported or imported. AEMO must ensure that Fast FCAS Providers respond in time and in line with the settings determined by AEMO (deadband, droop or frequency deviation trigger) to arrest the frequency decline/incline, as opposed to under-delivering when the frequency disturbance starts and over-delivering close to 6 s after the frequency disturbance time (**FDT**).

Figure 8 in Tesla's submission (application note[41]) shows that the absolute value of power error (not energy error) associated with a 1 s measurement time resolution will still be over 20% if a VPP consisted of 200 sites or even 1,000 sites. AEMO considers that the error for 200 sites is very relevant, as an aggregator needs a minimum of 200 5 kilowatt (kW) battery systems to meet the minimum threshold of 1 megawatt (MW) to participate in the FCAS markets. While the error would be materially reduced after the implementation of the changes under Section 6 to improve the verification methodology, it still remains that data captured at 1 s intervals is not adequate to verify the response from devices highly sensitive to frequency and voltage changes.

The FCAS response from DER whose power is sampled at 1 s intervals is limited in that:

- the immediate response cannot be identified after a network disturbance; and
- the power error associated with that measurement time resolution is significantly more than the allowable tolerance in the MASS.

Evergen suggested that the VPP Demonstrations indicated that "VPPs can deliver compliant FCAS bids". However, other studies show that an FCAS response captured with 50 ms metering data is more likely to indicate whether FCAS was under-delivered than measurements captured at 1 s intervals. The UoM's analysis demonstrated that 1 s metering data does not enable AEMO to identify oscillatory behaviour, or an under-delivery of FCAS that could otherwise be detected by a higher measurement time resolution, as explained in AEMO's assessment of oscillatory behaviour below.

Some Consulted Persons considered a 1 s sampling rate to be adequate in light of the slower rates exhibited by Automatic Generation Control (**AGC**) and SCADA, however, these systems are not relevant in the assessment of Contingency FCAS response. Moreover, they are not the only means by which AEMO

[35] CPUE indicated it would prefer a cheaper alternative to 50 ms.
[36] DEMSA indicated that these two options should be investigated further.
[37] ACF indicated that AEMO should amend the MASS to remove burdensome reporting obligations.
[38] Hydro Tasmania indicated that it would accept 200 ms.
[39] sonnen indicated that AEMO was wasting money by not implementing Option 2.
[40] AGL stated indicated its preference that AEMO deferred its decision pending further evidence.
[41] Tesla's Application notes, available at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/submissions/tesla_additional-information---late-submission.pdf?la=en

monitors power system performance. AEMO has access to data through other means that update much more frequently than the 4 s capability of AGC and SCADA.

Hence, AEMO considers a 1 s sampling rate to be inadequate when DER is providing FCAS as a near instantaneous response to power system conditions, especially when it is participating in the Fast FCAS markets.

### Conflation between settlement and power system security/distribution network constraints issues

PIAC commented that "system security issues are not directly relevant in considering whether VPPs can effectively participate in the FCAS market". This is not an accurate observation. Power system security depends on many things, one of which is the effective provision of FCAS. In this context, effective means that the FCAS is available when it is needed and in the right quantity, and it is provided when it is needed in the right quantity. AEMO's plans for meeting the National Electricity Market's (**NEM**'s) energy needs also entail planning for adequate quantities of each type of FCAS to be available at all times.

All of this means that potential FCAS Providers need to meet strict technical requirements before being registered to operate in the FCAS markets, and provide FCAS in accordance with their bids when called upon. Uncertain delivery of FCAS or undesirable plant behaviour during delivery has the potential to cause other material problems on the power system.

It is in this context that market settlements and power system security intersect, with metering providing the link. Accurate metering data not only ensures that producers of electricity and ancillary service providers are paid for the amount of energy or service they deliver, but also establishes how their facilities respond to changing power system conditions, particularly after contingencies. FCAS, in particular, is something that AEMO considers in all planning timeframes, from pre-dispatch to the 20-year outlook of the Integrated System Plan.

There is no conflation of issues. Accurate measurement allows AEMO to maintain confidence that the power system is operating within the technical parameters specified in the NER at the transmission network level and, likewise, with DNSPs at the distribution network level.

### Oscillatory behaviour and power system security concerns

AEMO's first Draft Determination highlighted the importance of sufficient visibility to detect undesirable response, and particularly an under-damped oscillatory response. While it is always important for AEMO to be able to identify oscillatory behaviour, it is especially so when the system is under stress, such as during an FCAS event. As the system transitions to increased reliance on DER to provide crucial system security services, it is necessary for AEMO to ensure that adequate visibility is preserved so that problematic system behaviour can be identified and rectified.

Issues associated with the provision of FCAS that have the potential to adversely impact power system security include:

- The need for greater visibility in real time (or close to it) of what is happening on the transmission and distribution networks.
- DER behaviour and its potential impact on network stability, including under-damped oscillatory behaviour.
- Control hierarchy and impact on distribution network operation, including the impact on distribution network limits and the use of distribution operating envelopes (DOEs) to manage these.

AEMO agrees that most of the power system security issues mentioned in the first Draft Determination have to be resolved outside of a MASS consultation, and has included them in the roadmap referred to in section 4.4.3. While the key issues associated with FCAS provision from DER need to be resolved, the

measurement time resolution is directly linked to the identification of under-damped oscillatory behaviour. The UoM's study has defined a methodology to identify oscillatory behaviour and has investigated an adequate measurement time resolution to detect such behaviour. Anonymised high-speed data from ancillary service facilities following a voltage disturbance was shared with UoM for this analysis. To summarise UoM's concluding remarks, the measurement time resolution needs to be at least one-fourth of the oscillation period to capture the maximum magnitude of the oscillation, which can be used to define whether a response should be considered as an oscillatory one. UoM determined that a 1 s sampling rate is not suitable for capturing oscillatory response, which have a 1-3 s period seen from the examples considered. The under-damped oscillatory behaviour was able to be identified using measurements of power flow at 100 ms and 200 ms intervals.

The purpose of this analysis was to confirm if any oscillatory behaviour present, irrespective of technology type, can be identified using measurements captured at 100 ms, 200 ms and 1 s intervals. The analysis was not intended to specifically determine the response characteristics of DER.

### Relationship with AS/NZS 4777.2:2020

AEMO's preference is to specify a measurement time resolution of 200 ms or higher for the capture and storage of data to verify the Fast FCAS delivered by aggregated ancillary service facilities with no inertial response.

The measurement specifications of AS4777.2:2020 are not relevant with respect to the MASS, as they serve two separate functions. The measurement time requirements specified in AS/NZS4777.2:2020, of 100 ms for frequency and 200 ms for active power, are intended to provide minimum capabilities to ensure stable input data for utilisation in protection and control functions. The MASS, on the other hand, requires measurement for data logging and capture, specifically power and frequency captured on a common time scale and stored for the purpose of post-disturbance analysis/auditing.

### FCAS verification and assessment methodology

The FCAS Verification Tool currently uses the Right-Riemann method when calculating the amount of FCAS delivered by an enabled FCAS Provider, but some submissions suggested that the trapezoid method should be implemented, as it would decrease the error associated with slower sampling rates and improve the accuracy of the FCAS Verification Tool's results.

Another suggestion to improve the accuracy of the results from the FCAS Verification Tool came from Evergen, which considered alternative methods to determine the FDT. The FCAS Verification Tool sets the start of the disturbance (t=0 second) based on the first measurement of frequency outside the Normal Operating Frequency Band (**NOFB**). UoM was asked to consider the options proposed and to assess the most accurate way to determine the FDT and improve the calculation of the FCAS Verification Tool. The UoM analysis concluded that the rate of change of frequency (**ROCOF**)-based approach to identify the FDT was more accurate, due to the smaller error distributions over multiple FCAS assessments compared to the average and midpoint methodologies.

Some Consulted Persons suggested that the verification of FCAS delivery at the National Metering Identifier (**NMI**) level would improve the overall error associated with slower sampling rates. AEMO is working with the University of New South Wales (**UNSW**) through Project Match[42] to build a tool that allows AEMO to process and review NMI-level data. In the meantime, AEMO will continue to assess the FCAS delivery of aggregated ancillary service facilities using the aggregated fleet response.

[42] Available at: https://aemo.com.au/en/newsroom/news-updates/modelling-distributed-pv-to-improve-power-system-security

### Assessment of adequate measurement time resolution

AEMO's first Draft Determination considered the error introduced in the FCAS calculation process if measurements at a lower measurement time were used to calculate the amount of FCAS delivered. For the purpose of this analysis, the aggregated FCAS response from DER FCAS providers with high-speed measurement capability was down-sampled to 1 s intervals.

A number of Consulted Persons suggested that the overall error would be lower if data from individual NMIs was used in this study. UoM was tasked to confirm whether there is a correlation between the number of NMIs in a VPP and the error associated with a lower measurement time resolution. The NMI level data used by a DER FCAS provider in their analysis was provided to UoM for this study.

The UoM analysis concluded that the error introduced in the FCAS verification process would decrease as the number of NMIs in a fleet increases. Using a sampling resolution of 200 ms, errors up to 4.3% were observed depending on the number of sites sampled within an aggregated ancillary service facility, with error magnitude inversely proportional to sample size. The measurement error associated with 200 sites capturing data at a 200 ms measurement time resolution is considered to be less than 0.5% for a single credible contingency. The exact error depends on the number of sites and the required FCAS response following a network disturbance.

The analysis also determined that there is no additional benefit in specifying a measurement time resolution of 100 ms over 200 ms, as the difference in the errors associated with both was less than 1%, irrespective of the number of NMIs in a fleet, as shown from the extract below from the UoM's report.

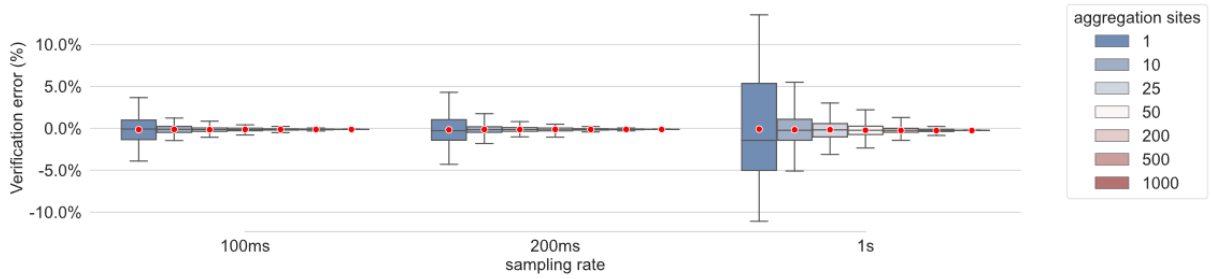



*Figure 3.13. Verification error (without compensation response) of different aggregation levels under different sampling rates, using **"RoCoF-based"** method and trapezoidal rule, for NSW event*

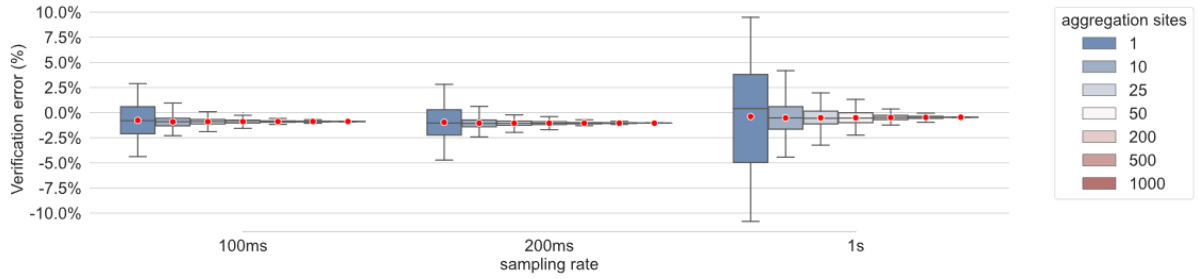



*Figure 3.16. Verification error (without compensation response) of different aggregation levels under different sampling rates, using **"RoCoF-based"** method and trapezoidal rule, for QLD event*

Another important consideration was whether AEMO would still be able to identify oscillatory or unexpected behaviour if the measurement time resolution was lowered. As noted above, based on the methodology developed by UoM to identify an under-damped oscillatory response, a measurement time resolution of 1 s would be inadequate to identify such behaviour, but a resolution of 100 ms or 200 ms would identify the oscillatory behaviour from the examples considered.

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AEMO also considered whether to revise the measurement time resolution for all Fast FCAS providers. Based on UoM analysis, the inertial component cannot be calculated with the sufficient level of accuracy using data captured at 100 ms or 200 ms intervals, therefore AEMO proposes to leave the measurement time resolution unchanged for FCAS providers with inertial response. As per section 2.4 of the MASS, FCAS does not include the impact of inertia. The UoM therefore considered whether inertial response could be determined accurately using measurements captured at a slower sampling rate and offset accordingly from the change in active power from a synchronous generator providing Fast FCAS. UoM concluded that a lower measurement time resolution would result in a smoother frequency curve, which would fail to capture the ROCOF, and minimum or maximum frequency reached following a power system incident. In some cases, the change in active power as a result of inertia action would be under-estimated, resulting in an over-estimation of the amount of Fast FCAS delivered. As per the UoM's analysis, the average verification error introduced for synchronous generators is in the range of -20% to +10% with a 200 ms measurement time resolution and -5% to +5% with a 100 ms resolution.

### 4.1.3. AEMO's conclusion

For the reasons specified in section 4.1.2:

- AEMO will not consider the 1 s option for Fast FCAS any further.
- Following additional analysis by UoM and further consideration by AEMO, a measurement time resolution of 200 ms has been deemed adequate to verify the Fast FCAS delivery of aggregated facilities with no inertial response. AEMO has therefore determined to lower the Fast FCAS measurement time resolution for aggregated ancillary service facilities with no inertial response to 200 ms.
- A discount of 5% will apply if the aggregated ancillary service facility comprises less than 200 sites. This discount reflects the associated verification error when an aggregated ancillary service facility comprises less than 200 sites and captures data at a lower measurement time resolution than 200 ms.
- AEMO will implement a number of changes to the FCAS Verification Tool before the updated MASS becomes effective. These changes will improve the accuracy of the results from the verification tool and are detailed in Chapter 6 of this document.

## 4.2. Location of measurement point for FCAS provided by DER

### 4.2.1. Issue summary and submissions

AEMO concluded in the first Draft Determination that 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.

As with the decision to not change the measurement point from the connection point, Consulted Persons were divided on this issue.

Extracts from submissions on this issue are cited below.[43]

AEC:

> The AEC generally accepts as part of an interim approach:
>
> - The decisions not to change the measurement time resolution and measurement location point.

AGL:

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

AGL supports AEMO's proposal to mandate measurement at the connection point. In our view, this approach is consistent with current market arrangements and mitigates the risk of inaccuracy and gaming between multiple parties that could otherwise impact overall system balancing.

CBP:

AEMO has stated a preference to retain a connection point metering approach for FCAS, rather than the asset-based alternative discussed as part of the consultation.

We are concerned that retaining a connection point metering approach is a missed opportunity for sites like ours and many others. As our Condong and Broadwater sites already host a third-party industrial load, we are concerned that retaining a connection point approach limits our ability to invest in assets that could provide FCAS when these services would not be competing on an equal basis with other FCAS facilities in the market. Our initial analysis suggests that the cost of managing our collocated loads as part of providing an FCAS would be a material negative factor in our investment process.

Our preference is to have more options and less constraints regarding the long-term use of our sites. We believe AEMO has missed an opportunity to ease the transition of legacy generation sites of yesterday into the energy hubs of tomorrow by making it easier to invest in new technology and repurpose existing infrastructure.

We believe updating the MASS to allow device level metering is also consistent with the ESB's NEM2025 reform objectives. The ESB has set the objective goals of "enabling access to products and services that innovation offers"[44] and "integrating flexible DER and demand-based assets into the market at all levels"[45] which we read as including sites such as ours.

Our preferred position is that the MASS is updated to require measurement at the inverter or controllable asset (Option 2[46]). We do not believe this would exclude any existing business models and would reduce barriers to entry, increase business model innovation and FCAS supply, and ultimately reduce system costs and prices to customers while improving the long-term efficiency of the NEM consistent with the NEO.

Alternatively, connection point metering could remain the default approach with device level metering allowed wherever qualifying measurement equipment is installed to ensure the same beneficial outcomes can be captured. This approach would be less interventionist but may result in reduced system visibility on the margin compared to our preferred approach (but significantly higher visibility compared to the Draft Determination).

CEC:

**Measurement at the inverter**

Measurement at the inverter has the benefit of reducing the cost to customers associated with the purchase and installation of a meter approved for Fast FCAS participation.

A key risk associated with measurement at the inverter arises when there are multiple controllable devices BTM. It is worth noting that only one MASP can register a NMI. This mitigates some of the issues and risks associated with measurement at the device.

We understand there might be other scenarios involving multiple controllable devices BTM with one enabled for FCAS participation. We have not attempted to analyse every situation and would recommend AEMO and the industry undertake some scenario analysis to understand whether there is a need for regulation to protect customers from risks arising from multiple aggregators controlling different devices behind the same NMI.

**Measurement wherever FCAS is provided**

An alternative proposal suggested during CEC consultation with its members is that performance should be verified at the point at which the FCAS is delivered. Site-based control should require verification at the site. Asset level control should require verification at the asset. This enables differentiation between closed-loop and open-loop controls.

If aggregators are using site-based (closed-loop) controls to manage one or more devices BTM, the performance should be verified using site level data. These sites should also be required to provide asset level data for compliance checks. For example, if one asset is overperforming and a second asset is underperforming then it could be problematic if AEMO were to approve the installation of the second asset independently at another site.

[44] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p55.
[45] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p55.
[46] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014, p8.

If aggregators are using device-based (open-loop) controls to manage performance for an individual device, then the performance should be verified using device-level data. These sites should also be required to provide site level data for completeness.

This solves for the issue of "what if there are multiple systems registered to provide FCAS at a single site". At least where those devices are registered under the same DUID, using the same aggregator.

We acknowledge that a gap in this solution is if a second aggregator (say an EV charging aggregator/hot water heater aggregator) approaches a customer who is already registered to use device-based control and wants to install a system under a separate DUID. This could be solved using a registration process. AEMO already registers NMIs for all ancillary services load registered, so an additional flag on the system could be used to indicate that this site is already registered for FCAS. The implication of this approach is that the customer would be required either to choose one provider or move to site-based control. This could be influenced by policy recommendations regarding whether and how multiple aggregators are allowed at a single site. The ESB post-2025 market design for DER might provide further guidance on this matter at a policy level.

**4.1 Availability of Grid Flow Measurement**

AEMO has requested confirmation of whether the grid flow is already captured when a hybrid system (battery plus PV) has been newly installed or where a battery system has been retrofitted, or would the grid flow only be measured if a site were participating in the FCAS markets?

Grid flow is always measured on sites that have export limiting or that have a battery. A separate meter needs to be installed if an inverter requires export limitation or has a battery installed. The meter is not required to be revenue grade. The issue is the frequency of measurement, not whether measurement occurs.

Most DER sites will have an external meter that should be located or reading a point which is close to the incoming mains. This means all voltage, current and frequency data is reported close to the point of supply and the import, export, production, and consumption of the site can easily be determined

Discover Energy:

**3. Measurement of the whole site (at grid connection point) for ancillary services**

AEMO has expressed a concern regarding control of multiple devices BTM and as a rationale for measurement at the connection point. Discover energy supports this concern but asks AEMO to consider the implications of this principle and its implementation

**3a. Metering hardware and measurement principles**

Measurement of all loads BTM is possible without an additional dedicated meter at the connection point. In seeking to procure ancillary services at the lowest possible cost, AEMO should consider that its technical requirements do not lead to redundant hardware installations where other options would deliver an acceptable outcome for grid security. This could be through calculating the total load based on separate measurements or through use of existing smart meters, already a requirement for all DERs and soon to be ubiquitous in the network. Virtual strategies should be given adequate opportunity to demonstrate equivalent performance – as yet, all options have not been explored and tested to this effect.

**3b. Implications for whole site metering ancillary services**

If all controlled and/or uncontrolled loads can mitigate the FCAS response as is the concern of AEMO, then by the same principles they can also enhance the response. The implication of this is that, for example, controlled curtailment of PV would be able to provide or contribute to a lower response service, and that Regulation FCAS is technically able to be provided by units that do not have set-points. Highly accurate "baseline" methods are used to obtain similarly accurate predictions of future load for the purpose of services that provide demand response or are the same as Regulation FCAS - for example in Germany where wind farms produce the equivalent of the lower service.

Rules and specification governing the participation in grid services should be technology and size neutral and based entirely on the results that can be achieved through control mechanisms, and not impose unnecessary specification on the control mechanisms themselves. If AEMO is not satisfied that this is currently achievable, there are many organisations that are able to help them investigate and prove this principle.

Dreambox Co.

While we agree that metering at the connection point is the best solution for sites with multiple DERs, we do not believe this is necessary for sites with a single DER (sites with a battery but no solar, or sites with DC-coupled battery and solar connected to the grid via a single inverter, for example).

Allowing metering at the asset level for sites with only one DER, will decrease installation complexity and ultimately cost to consumer. Asset-level metering will also improve AEMO's visibility of DER behaviour during events of interest: rather than a summation of all power flows from each appliance at the site, the measurements will only be of the power flow of the asset.

Empower Energy:

We also support AEMO's contention that connection point metering is essential to system management. As recent incidents have indicated, the quality and volume of net frequency response across the NEM is essential to power system security. Whilst metering arrangements at DER device may have some scope under certain conditions to serve as indications of some elements of frequency response, it has (at the present time) not been adequately demonstrated that these provide a sufficiently complete indication of response as to fairly and competitively attribute value (or to adequately negate gaming potential), particularly in a competitive DER market that, by virtue of the NEO, should not adversely favour one particular technological approach (e.g. DER behind-meter topology) over another.

Energy Locals:

As has been demonstrated through the VPP Demonstrations, we argue that device-level metering allocates risk to where it is best managed. This also reduces barriers to entry and improves business model innovation. With better customer uptake of innovative energy storage propositions, AEMO would naturally have more FCAS supply at its disposal, reducing the system costs. These outcomes are consistent with the NEO.

…

We believe the Draft Determination is not only inconsistent with the NEO but inconsistent with AEMO's own stated position on related issues. As part of its 2020 Renewable Integration Study AEMO surveyed all DNSPs and found:

> "very little direct monitoring of DER generation output. Net metering arrangements mean that only the total site is monitored"

AEMO concluded:

> "This limited visibility makes it difficult for DNSPs to quantify the secure technical operating envelope of their LV networks, necessary to determine where constraints exist or where they are likely to develop in the future."

Given the Draft Determination requires measurement only at the meter, the problems previously documented by AEMO will be compounded as more BTM assets are deployed.

AEMO has also previously stated that it:

> "… considers that it is no longer appropriate to base performance standards on the registered participant category as we are expecting to see more ESS and 'hybrid' facilities. A registered participant's performance standard should be based on its assets."

We agree with this conclusion with regard to performance standards. Adherence to FCAS enablement targets is one element of such performance standards, creating an inconsistency with the MASS.

The Draft Determination is inconsistent with the ESB's NEM2025 reform objectives, which have a core workstream dedicated to developing two-sided markets. The ESB has set the objective goals of "enabling access to products and services that innovation offers" [47] and "integrating flexible DER and demand-based assets into the market at all levels" [48].

Updating the MASS to allow device level metering is, in a number of cases, a necessary pre-condition to aggregators being able to offer innovative services to customers.

The ESB also states that "DNSPs need visibility of DER to manage the variability of energy production and system security within their operating limits and facilitate wholesale market integration of aggregated DER resources."[49]

Updating the MASS to allow device level metering for the provision of FCAS is consistent with these objectives and the wider NEM2025 reform.

Recommendation

[47] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p55.
[48] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p55.
[49] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p57.

Our recommendation is that the MASS is updated to require measurement at the inverter or controllable asset (Option 2[50]). We do not believe this would exclude any existing business models and would reduce barriers to entry, increase business model innovation and FCAS supply, and ultimately reduce system costs and prices to customers while improving the long-term efficiency of the NEM consistent with the NEO.

Alternatively, connection point metering could remain the default approach with device level metering allowed wherever qualifying measurement equipment is installed to ensure the same beneficial outcomes can be captured. This approach would be less interventionist but may result in reduced system visibility on the margin compared to our preferred approach (but significantly higher visibility compared to the Draft Determination).

Enphase Energy:

**2.2 DC Coupled Vs. AC Coupled Storage Systeme**

The Draft Determination has assessments and determinations (Section 4.1, 4.2 etc) that are largely based on DC coupled systems (including Hybrid[51]). There is also analysis of older generation (AS/NZS4777.2:2015) inverters with limited AGF[52] presented that have limited relevance given the rapid development cycle of the DER industry.

Whilst DC coupled storage systems were common during the initial deployment of ESS[53] last decade, the current ESS market in Australia has swung rapidly to AC coupled ESS. Almost 90% of the domestic DER storage, installed so far in 2021, is AC coupled. By not providing equal consideration for AC coupled ESS, the MASS draft determination would effectively kill 90% of the available DER for VPP's.

There are several reasons for the shift from DC coupled systems, not the least of which is the challenge to safely combine a battery and inverter from different OEMs. This involves extensive testing for DC coupled systems whereas AC coupled systems provide an already tested combination from a single vendor.

DC coupled systems have a lower overall efficiency as performance is compromised using the same inverter for both PV and Battery storage. An AC coupled solution has an inverter optimised for storage or PV only, resulting in greater power output availability across the entire operational envelop.

Field experience has, in addition, long shown that relying on a single Inverter for the entire system lowers reliability by introducing a single point of failure.

**2.2 Externally Metered Solutions**

The proposal to use 3rd party OEM metering for controlling DER also introduces additional challenges. There is a range of generic metering and control products that have been adapted for use with DER as a "quick" solution. For most, there is a real risk of early product redundancy should requirements or standards change. The PV and storage industry has a long history of companies that could not afford to provide on-going support or simply disappeared when a product failed, in order to avoid financing a full recall.

There are also some technical gaps between DER and general metering standards that will impact the integration of DER with 3rd party metering/control. All 3rd party metering products will need to be fully tested to DER standards to ensure they maintain accuracy and integrity when used with DER. There are already examples of "add on" metering products suffering from degraded accuracy when subjected to DER frequency and harmonic injection testing.

To provide the best system integrity and compliance when controlling DER, device level metering, fully integrated to the control loop, is the clear solution. The technical and accuracy requirements of the new AS/NZS4777.2:2020 standard means "Smart" DER systems with metering will meet requirements when set to provide 100ms reporting. Using third-party metering equipment simply introduces unnecessary extra costs and risks for consumers to participate in VPPs and the FCAS market.

**2.3 Multiple Agents**

[50] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014, p8.

[51] A Hybrid inverter is one that is designed to provide DC to AC conversion from more than one energy source using a single inverter with common electronics to perform both functions, e.g., converting PV Solar (~600 VDC) and Battery (48 - 400 VDC) to 230 VAC

[52] AGF = Advanced Grid Functions. AS/NZS4777.2:2015 mandated limited AGF. In 2018 IEEE & IEC standards introduced more prescriptive grid stability and measurement requirements. Australia currently has a mix of inverters built to 2018 standards and AS/NZS4777.2:2015 and largely accounts for the wide performance variations found during industry grid stability testing of inverters.

[53] ESS = Energy Storage Systems (IEC definition)

The Draft Determination also raises concern that multiple agents could cancel each other out when utilising DER for VPPs and grid stability services, such as FCAS. A solution has already been trialled and implemented in SA.

The SA system uses the NMI number to identify a "Relevant agent" responsible for coordinating all DER on that site. The system ensures that each site (NMI) has only one corresponding agent (aggregator or OEM). This ensures that all DER associated to that NMI is connected to a single energy management device to effectively control all DER assets.

…

**4.0 Meter Measurement Location**

As suggested by AEMO, device level metering is required however site metering should also be deployed. Both device and site level metering should be located as close as possible to the utility meter (i.e., just after the incoming mains) to ensure that the site DER can best aid the stability of the grid.

We see that AEMO's primary concern for measurement location is to address the risk of multiple assets enabled for FCAS as well as site and device level metering providing the same outcome for VPP operators. This can be managed by utilising a single energy hub or control system that is able to control all DER onsite as well as provide control over designated loads.

Device level metering could still be deployed if site metering at the incoming mains is unfeasible due to site-specific issues. The alternative metering location could then be offset by any marginal loss factors (MLFs), as the site can no longer guarantee what is happening at the point of supply.

Evergen:

Specific additional recommendations

…

5. Persist with AEMO's original suggestion of adopting 'Option 2' assessment at the DER inverter rather than the site connection point, since this aligns with the NEO by affording greater visibility of registered assets and reduced costs of compliance.

…

**4. Measurement Location**

In the Draft Determination AEMO elected to retain measurement at the connection point (Option 1) rather than asset level measurement (Option 2). Issues contributing to this decision include:

1. The possibility of gaming with asset level measurement;
2. Poor orchestration of multiple assets at one site with asset level measurement;
3. The objection to connection point metering was one of cost, but the VPP demonstration program already required connection point metering.

Before addressing these points, Evergen would like to clarify what the issues are.

Whether measured at the connection point or the asset, FCAS delivery is assessed against a baseline. For example, if a 5kW battery were discharging at 5kW to meet household load immediately prior to a low frequency disturbance, it would have no possibility of delivering an assessable FCAS raise contribution, since its baseline is already at maximum discharge. If a site were already exporting at a 5kW export limit on a sunny day due to PV output, then there would be no net FCAS raise response possible because 5kW is already being output at the connection point.

Given this, it is of no relevance to FCAS assessment that particular assets at a site might be doing different things, or that the end user's load might absorb a battery discharge without any resultant grid export. A battery discharge in response to an FCAS event that is absorbed by the load BTM still contributes an FCAS response to the grid if the battery response results in a net change in grid import at the site in response to the frequency disturbance.

**The possibility that does need addressing relates only to the much narrower circumstance that different assets on site might respond near simultaneously to the same frequency disturbance event.**

**4.1 Is 'gaming' a possibility with asset level verification?**

Evergen assumes that by 'gaming' AEMO is suggesting that a VPP operator might deliberately seek to avoid offering a material response to a frequency disturbance, while maintaining the appearance of compliance.

For 'gaming' to occur, a VPP operator would need to:

1. Detect a frequency disturbance;
2. Have one asset (such as a battery) respond to that disturbance; and
3. Implement a control such that a second asset (e.g., a controlled load) would also immediately act to counter the first device response.

While technically possible to execute this, the idea that a VPP operator would deliberately do this is, as Energy Queensland highlighted in their first MASS Review submission, an implausible scenario. FCAS Providers are paid on enablement, not on their actual response to an event. The only benefit of gaming and risking the regulator's ire and associated penalties, would be to avoid any costs to the customer associated with import/export for the duration of the FCAS bid period. These costs, given the sparseness of actual frequency disturbances and their duration, are insignificantly small. Motivated gaming of the system makes no sense.

### 4.2 'Gaming' and connection point verification

**Measuring FCAS response at the connection point is not immune to gaming. It is arguably more susceptible than for asset level measurement and verification.**

With connection point verification, battery-based VPPs will be able to bid very comfortably into the raise market on sunny afternoons, because a low frequency event will result in a DER transitioning from a starting condition of solar charging the battery with no grid import/export, to a condition where the combined output of both the uncontrolled solar and battery discharging will contribute to grid export and measured FCAS response. Despite registering an FCAS fleet based on battery capacity alone, the VPP operator will be able to use solar generation unrelated to their registered ancillary service load to deliver a compliant response.

Similarly, VPPs will be able to bid very comfortably into the lower market in the evenings when local uncontrolled load is likely to be high. The DER will transition from a starting condition of battery discharging to meet load, with low grid import, to a condition where the combination of battery charge + load will result in a large grid import. The VPP will be able to rely on unregistered and uncontrolled load to achieve compliance.

The 'gaming' here is perhaps not really a concern, because the VPP would still be delivering to the grid what it had promised. However, the challenge with these scenarios is that AEMO will be registering ancillary service loads based on battery capability (for example), but it will not necessarily be the battery that delivers the FCAS response. There will be a clear and readily 'gamed' disconnect between AEMO's ancillary services load registration process and subsequent verification. The result is that AEMO has less control and visibility over the actual devices participating in the provision of FCAS.

### 4.3 'Solar sponge' hot water system controls and interaction with batteries for FCAS

There are hot water systems (HWS) on the market and already in the field that include the useful function of minimising solar export by instead diverting any export to the hot water load. In effect, the hot water heater acts somewhat like a 'solar sponge'. This is an extremely attractive capability for solar-only households, particularly where the grid feed-in price is much lower than the import price, which will increasingly be the case as more rooftop solar is deployed.

This facility is somewhat less useful for end users who have a separate battery installed on site, particularly if they are on a TOU tariff and the HWS is on a separate controlled load circuit/tariff. Batteries can both charge and discharge, meaning they can shift load from peak to off-peak times while soaking up solar. Batteries can more readily replace avoided solar export (e.g. 10c/kWh) with reduced peak-tariff import (e.g. 50c/kWh), for high-value benefit, while a HWS system on a controlled load tariff would be replacing a solar feed with reduced controlled-load import (perhaps 16c/kWh), which is less benefit to the customer per kWh.

A potential conflict occurs for customers that have a solar sponge HWS and also seek to use their battery to export to the grid for whatever purpose. A customer wish to do this for arbitrage purposes (e.g. if they are on a spot-price tariff), or because the end user is contributing their battery to a VPP for grid services (FCAS raise or otherwise).

Since the HWS likely will not differentiate types of grid export, the scenario presented is that a battery might be triggered by a low frequency disturbance to discharge, but the HWS then immediately responds by soaking up the attempted grid export. This is not so much 'gaming' the system as simply two incompatible operations: battery-based FCAS + HWS solar-export sponge.

AEMO has suggested that measuring at the connection point will allow them to verify FCAS response regardless of this behaviour. However, it will not solve the problem. A battery-based FCAS fleet where a substantial portion of sites include an export-responsive HWS will be non-compliant whether assessed at

connection point or asset, and there has been no suggestion that AEMO will consider this as part of battery-based VPP ancillary services load registration.

This is a practical difficulty. It is resolved via customer preference and VPP terms and conditions: if a customer wishes to participate in a battery-based VPP for delivering FCAS, then they can be granted entry to the VPP on the proviso that their HWS does not have an active HWS solar sponge function enabled. Alternatively, if the customer wishes to retain the HWS export sponge function then they could be precluded from participating in a battery-based VPP for FCAS. AEMO can require VPPs to demonstrate that they address this specific issue in their terms and conditions with customers at time of registration as an ancillary service provider.

Evergen stresses that this is not an issue of unfair competition or exclusion, an idea raised in some AEMO–industry forums. Rather, it is just a practical conflict that two devices performing two competing functions behind the one connection point (FCAS raise vs. solar sponge) cannot operate in unison. The customer themselves is free to select which mutually exclusive offering they wish to adopt.

This issue is not resolved by verifying FCAS at the connection point, and should not form a rationale for the draft determination decision on verification measurement point.

### 4.4 Multiple controlled devices behind the one connection point

The Intellihub submission to the first round of consultation suggested FCAS assessment at the connection point was preferable in case of sites containing multiple controllable assets that may each contribute an FCAS response.

Such a scenario relies on some big commercial assumptions. Namely, that it is commercially viable for end users to install a complex piece of hardware to collect telemetry, control and orchestrate multiple devices for delivering compliant FCAS responses, while balancing multiple uses for each device. Alternatively, for a 'no additional hardware required' VPP operator such as Evergen, orchestration would involve developing commercial arrangements and API integrations with each appliance vendor at the site to facilitate cloud-based monitoring, control and orchestration. The costs and complexities of these multi-device-at-one-site orchestrated arrangements may preclude them in the short term, certainly when the financial case for even the straightforward case of battery-based VPP's for FCAS is still subject to a good deal of uncertainty (see Section 6).

In the short-term, a much more likely scenario is that sites will only have a single DER involved in FCAS, and where there are multiple devices at a site that are looking to participate in VPPs, they will quite possibly be independently operated by separate VPPs (e.g., a HWS-based VPP and a battery-based VPP).

Given this, a more conservative verification approach would rely on individual asset monitoring to afford AEMO maximum visibility of each asset on the site. Connection point monitoring could be used instead at AEMOs discretion for the yet-to-be demonstrated case of multi-asset orchestration at each site by a single VPP.

Evergen suggests AEMO would still want to retain visibility of asset-level telemetry if this eventuates, since developing an assessment methodology for registering FCAS capability for a VPP composed of multi-asset orchestrated sites may prove challenging, and maintaining visibility of each asset could prove important for fostering confidence.

### 4.5 Do Trial Participants already meter at the connection point?

AEMO suggested that Trial Participants are already required to measure power at the connection point, and that this would alleviate any concerns with the requirement to verify FCAS at the connection point.

Although this is the case, there are several factors that mean additional hardware is still required for participating in the Fast FCAS market if FCAS is verified at the connection point:

1. Existing power meters at the connection point are capable of 1-s sampling, but the Draft Determination mandates 50ms sampling for fast market participation;
2. Even if the meters are capable of sensing power every 50ms, they would need to communicate this back to the inverter, and the inverter+internet gateway would need appropriate control software and on-site memory to allow the handling of far greater volumes of telemetry to support 50ms verification;
3. existing connection point meters for the VPP Demonstrations sample power but not necessarily frequency. The draft MASS requires that frequency also be measured at or close to the connection point. This means that existing VPPs will not even be able to participate in slow or delayed markets

without additional hardware, contrary to what AEMO implies across facts #1, #2 and #3 of their MASS consultation information sheet[54].

Therefore, although Trial Participants already measure power at the connection point at 1s sample rate, this does not alleviate the cost of complying with the Draft Determination requirements. Evergen is currently unaware of any off-the-shelf solution to metering both power and frequency at 50ms at the connection point that is affordable, given the possible revenue per NMI from participating in Fast FCAS. Costs are further covered in section 6.

Hydro Tasmania:

In principle, Hydro Tasmania supports the consideration of the FCAS metering point to be close or at the connection point. Hydro Tasmania believes this requirement can be achieved by two approaches:

1 Directly measure the active power at the connection point.

2 As the alternative, if direct measurement at the connection point is not available, the net flow also can be mathematically calculated based on measurement points including but not limited to battery, solar and load terminals.

Intellihub:

We maintain that the ideal 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.

We do however acknowledge 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 maintain our view that the measurement point is defined as the NMI is retained, however we do not oppose exemptions for small-scale DER installations where this is deemed inappropriate.

Members Energy:

Our colleagues, Evergen and Tesla, have also submitted comprehensive technical arguments in favour of metering at the device level rather than at the point of connection, at least in the case of a simple VPP connection involving a single battery and solar PV array. We support their findings in relation to simple systems, allowing device level metering. We also support an approach where the VPP must ensure that more complex systems involving more than one appliance, must bid conservatively in order to ensure the vector sum of responses from the various appliances BTM are accurately reflected in the bid, and that this be allowed by various means including metering at the point of connection or other reasonable means.

New Energy Ventures:

We agree that settlement needs to be done at a connection point level but the issues raised can be dealt with through a series of practical measures to allow for metering at a device level:

1 Measurement location should be at the point at which the FCAS response is being provided:

- If an aggregator is controlling all systems at a site as a single asset through a site level control, then the FCAS verification should occur at the site level.
- If an aggregator is providing an FCAS response from a single device then the verification should be at the device level.

2 If losses exist between the device and the connection point, this can and should be addressed by measuring the losses and applying a discount factor to the energy dispatched. There is precedence for this approach with the use of Marginal Loss Factors (MLFs) in the broader NEM. Generators at the end of a long skinny line will only get paid for what reaches the market, not what is generated at the terminal or connection point thereby accounting for the losses. The same approach could be applied where the losses between the asset providing FCAS and the connection point of the site are applied as a discount to the volume of services. Alternatively, AEMO could propose a standard, conservative, value for this for small DER devices to avoid the overhead of measuring losses at every new FCAS installation.

3 If multiple participating devices at a site could present an issue, limit participation to either whole-of-site level or a single device. This at least gives some flexibility about how to meter for

[54] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/second-stage/aemo-fcas-verification-uom.pdf

FCAS and for vendors to offer their services. Trying to solve for multiple participants BTM is pre-emptive and well beyond the current status of the market and should be considered in the future.

4 Regardless of where the device is in the system, it is electrically connected to part of the system. Once accounting for losses is configured (see point 1), an asset should be compensated for its services. Metering at a site level can mask a low-cost, high value contribution to FCAS where the participating asset is significantly smaller than the load of the site it's located within, especially in a C&I context.

5 Gaming the market can be dealt with through clear requirements and penalties that already exist ...[55] Frankly, there is a strong incentive anyway to actively participate in rather than game the system if you have that much control of your load.

Not adopting asset level metering has been made unnecessarily more difficult than it needs to be and limits important innovation in VPPs. In the context of the NEO, making it harder for VPPs to participate in the market is not a good outcome for consumers. Specifically:

- Allowances for asset level metering will bring more resource options into the mix. More supply with fixed demand ultimately means reduced prices for FCAS and therefore prices in the grid. VPPs have the advantage of not needing to recover all their costs through wholesale market and FCAS markets' participation as grid scale batteries do. Therefore they should be able to supply FCAS at much lower cost.
- Reliability of the grid is potentially impacted because we have services delivered by a small number of assets. The strength of VPPs is the diversification of their resources. Diversification ultimately leads to more resilience and better security of supply. (If you need a case study for grids without good diversification of resources, look no further than the recent history of blackouts in South Australia.)
- Quality and safety of supply should not be impacted if AEMO deals with losses as we outline above.

Origin Energy:

measurement point – again, we understand the concerns raised about the measurement point and understand that AEMO needs to rely on robust data. However, there may be circumstances when relying on device level data is sufficient and this should not be precluded as the market develops. One option would be to allow device level measurement when only one device is being orchestrated BTM. We would suggest that AEMO test verification at both the metering and device level as part of ongoing trials.

Powerledger:

**Measurement point location**

As mentioned by various stakeholders, changing the point of measurement to the grid connection point for aggregated DER results in excluding various current and potential future FCAS providers.

Even with appropriate hardware at meter level, it will be challenging for aggregators of BTM DERs to ensure appropriate response to frequency fluctuations due to uncontrollable load devices which can lead to an insufficient response at the connection point of individual households. The result can be under- or over-delivery depending on consumer behaviour. However, the FCAS response is still delivered, as measured at device level, irrespective of prosumer behaviour behind the connection point. The FCAS enablement should also only be paid for capacities not satisfying the household load or charging from the PV system. With sufficient fleet size, a heterogeneous VPP should balance the behaviour of single units, so individual units do not have such a strong impact.

We recognise the problem presented by controllable devices reacting to surplus solar PV energy, which do not distinguish between solar excess and a battery discharge for VPP purposes. This presents an opportunity for the asset owner for targeted behaviour during FCAS events to utilise balancing energy for controllable devices through a load increase during a contingency. If not accounted for, this will result in no positive impact on the grid from those end-consumers during contingencies and potential damage with increasing fleet sizes.

We do however, want to emphasize that the total amount of energy delivered for FCAS events is quite small, which therefore does not present an incentive for gaming between various behind-the-meter devices for small-scale customers.

To minimise the response of controllable devices to solar or battery output on delivery for FCAS, ways to coordinate them with capacities enabled for FCAS need to be introduced.

[55] Text removed in republished document.

This would also provide opportunity for multiple assets behind a connection point, such as batteries and various controllable loads to provide FCAS if controllable response of devices to surplus is taken account of.

The key arguments in support of the interim solutions are:

- The tightened requirements complicate the market entry for a wide range of available capacities.
- The interim solution of additional delivery for assets that measure at a slower rate could be an ongoing solution that incentivises investment in more accurate sampling.
- Accurate FCAS measurement at the grid connection point is challenging to provide for small-scale assets. With increasing fleet size, the FCAS delivery going to the grid will be sufficiently balanced.

Quinbrook:

**Location of measurement**. We believe allowing device level metering allocates risk to where it is best managed, reduces barriers to entry and business model innovation. This change is likely to increase FCAS supply, reduce system costs and prices to customers while improving the long-term efficiency of the NEM. These outcomes are consistent with the NEO.

…

AEMO has stated:

> "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."[56]

We disagree that device level measurement is inconsistent with the NEO on several grounds.

The issue relates to the proper allocation of risk for BTM FCAS resources which share a common meter with other uncontrollable generation or load resources (solar PV or onsite load respectively). It is worth considering arrangements for a load with and without a co-located FCAS resource:

- Without FCAS resource: In the case of a load and in the absence of the FCAS resource, variations in load will contribute to system level demand fluctuations. FCAS will be procured at the system level to manage frequency deviations arising from aggregate system level generation and load fluctuations. Procuring FCAS resources at the system level is least cost as frequency is a system property and localised supply and demand fluctuations cancel out at the system level (reducing requirements, minimising demand) whilst providing access to the greatest number of FCAS resources (maximising supply). The cost of FCAS procurement (for some services) will be recovered proportionally from load.
- With FCAS resource: In this case load variations still occur, are still managed at the system level and costs are still recovered in part from the load. The addition of the storage FCAS resource should, other things equal, reduce system level FCAS costs for all users on the margin by increasing the supply of FCAS resources. However, under AEMO's proposal, this specific FCAS resource is also responsible for managing local demand fluctuations (which are uncontrollable) such that FCAS delivery at the connection point meets enablement targets. This is highly inefficient as the site specific resource is now required to absorb load fluctuations on a specific load which would cancel out in whole or in part at the system level. It also limits the ability of the FCAS resource to provide services on an equal basis to stand-alone FCAS resources that do not have to account for local variability behind a common meter.

…

We believe the Draft Determination is not only inconsistent with the NEO but inconsistent with AEMO's own stated position on related issues. As part of its 2020 Renewable Integration Study AEMO surveyed all DNSPs and found:

> "very little direct monitoring of DER generation output. Net metering arrangements mean that only the total site is monitored"

AEMO concluded:

> "This limited visibility makes it difficult for DNSPs to quantify the secure technical operating envelope of their LV networks, necessary to determine where constraints exist or where they are likely to develop in the future."

[56] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014 (sic), p27.

Given the Draft Determination requires measurement only at the meter, the problems previously documented by AEMO will be compounded as more BTM assets are deployed.

AEMO has also previously stated that it:

> "... considers that it is no longer appropriate to base performance standards on the registered participant category as we are expecting to see more ESS and 'hybrid' facilities. A registered participant's performance standard should be based on its assets."

We agree with this conclusion with regard to performance standards. Adherence to FCAS enablement targets is one element of such performance standards, creating an inconsistency with the MASS.

The Draft Determination is inconsistent with the ESB's NEM2025 reform objectives, which have a core workstream dedicated to developing two-sided markets. The ESB has set the objective goals of "enabling access to products and services that innovation offers" [57] and "integrating flexible DER and demand-based assets into the market at all levels" [58].

Updating the MASS to allow device level metering is, in a number of cases, a necessary pre-condition to aggregators being able to offer innovative services to customers.

The ESB also states that "DNSPs need visibility of DER to manage the variability of energy production and system security within their operating limits and facilitate wholesale market integration of aggregated DER resources."[59]

Updating the MASS to allow device level metering for the provision of FCAS is consistent with these objectives and the wider NEM2025 reform.

Recommendation

Our preferred position is that the MASS is updated to require measurement at the inverter or controllable asset (Option 2[60]). We do not believe this would exclude any existing business models and would reduce barriers to entry, increase business model innovation and FCAS supply, and ultimately reduce system costs and prices to customers while improving the long-term efficiency of the NEM consistent with the NEO.

Alternatively, connection point metering could remain the default approach with device level metering allowed wherever qualifying measurement equipment is installed to ensure the same beneficial outcomes can be captured. This approach would be less interventionist but may result in reduced system visibility on the margin compared to our preferred approach (but significantly higher visibility compared to the Draft Determination).

Redback:

Redback agrees with the assessment of the MASS review that the correct measurement point for FCAS and other grid services is at the point of connection. Any other location could make settlement unnecessarily complex for sites with multiple active DER devices BTM

Reposit:

**1.2 Measurement location**

Reposit agrees with AEMO that moving the metering point for FCAS delivery does not benefit the power system or improve the integrity of the FCAS markets. This is consistent with Reposit's initial submission.

Reposit reasserts that moving the metering point increases FCAS delivery uncertainty and creates perverse incentives for FCAS Providers.

**1.2.1 Measurement at the connection point is correct**

Reposit agrees with AEMO's assessment that changes in DPV and uncontrollable loads are not significant on an aggregate level during frequency disturbances, and that net flow across the connection point is the optimal method to analyze and ensure compliance for all FCAS Providers.

Furthermore, AEMO is correct in its statement that all FCAS Providers should establish appropriate processes to ensure the capacity bid in FCAS markets is representative of the actual capacity that can be delivered and not simply the nameplate registered capacity.

[57] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p55.
[58] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p55.
[59] ESB, Post 2025 Market Design Options – A paper for consultation Part A, April 2020, p57.
[60] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014 (sic), p8.

Reposit believes that AEMO's determination will appropriately prevent gaming of the FCAS markets through assets absorbing energy behind the connection point during frequency disturbances.

Additionally, this will further reduce requirements for additional meters at the asset level, which would have contributed to global inefficiencies in the market, the costs for which would ultimately be borne by electricity consumers.

Reposit considers AEMO's assessment that measurement at the connection point is optimal, and AEMO's position that there are no gains to FCAS service integrity are well considered.

**1.2.2 Measurement at asset level is problematic**

Reposit supports AEMO's assessment that there is no evidence confirming that FCAS measurement at the asset level would benefit the power system or improve the integrity of the FCAS markets.

Reposit firmly believes that measurement of FCAS at the asset level would be a departure from the Connection Point measurement of electricity services that has been used throughout the NEM since market start.

There is significant and profitable gaming that is possible where metering is not conducted at the connection point. Reposit asserts that gaming is inevitable because of this profitability.

Reposit suggests to AEMO that there has been large amounts of work done by all market bodies and others (ARENA, ANU, DNSPs) into the issues created by having multiple service providing devices behind-the-meter. This issue will be resolved in time, and it is pre-emptive for AEMO to move away from connection point measurement where this work is ongoing.

…

**2.1.2 Connection point visibility**

Only energy that crosses the connection point can be considered as being applied to a contingency event. Measurement of power transfer at any other point introduces new uncertainty to the maintenance of a contingency event.

FCAS measurement and verification for a site cannot be done where the connection point is not being analysed. Laboratories exist for the analysis of inverters and other power electronics, and they can be used to determine inverter responses at the AC terminals. But the net effect of the interactions behind the connection point are what is important for FCAS.

Interactions between devices behind-the-meter are becoming increasingly complex. This complexity is not for AEMO to manage, but it does and will increasingly affect FCAS delivery. AEMO must have visibility of the connection point to understand when and by how much this is happening.

Reposit considers the increasing number of site-level, no-interruption, battery backup installations to create particular problems for AEMO. These installations will show a "valid" FCAS response at an asset level even where the connection point becomes de-energised after the frequency event. This is because the FCAS enablement will trigger an FCAS response that will most likely be absorbed by assets behind the now islanded connection point. This response does not contribute to the maintenance of the contingency event, but will present asset-level data that indicates a power transfer.

Reposit reasserts that only measurement at the connection point presents AEMO with the correct data required to manage system security.

Rheem & CET:

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

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

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

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

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

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

The underlying assumption behind this question is that FCAS will only be provided by household batteries. It ignores the even greater contribution that other household DER could have in the delivery of FCAS services. Our field experience with household DER has shown that separately orchestrated DER can conflict during an event response if not coordinated from a whole of home perspective. This conflict has resulted in both inferior financial outcomes for the householder, and an FCAS response that is nullified by the device conflict.

To underline the proposition that DER other than batteries could provide FCAS, Rheem/CET posits that smart water heating could quickly become the dominant grid interactive DER given that water heating is ubiquitous in nature, and that storage water heaters represent a low-cost method for storing energy. Importantly, water heaters represent an affordable entry point for consumers wishing to participate in the monetisation of demand management. Based on cost alone, we believe that the deployment of smart water heating could rapidly accelerate and far exceed that of storage batteries in coming years.

Shell Energy:

Shell Energy strongly agrees with AEMO's proposal not to change the FCAS measurement point in the MASS. We agree with AEMO that power measurement at the connection point (or as close to as technically achievable) is the least distortionary way to accurately measure the FCAS delivered to the power system. We also consider that whilst the MASS allows for alternative measurement methodology, where AEMO rejects the alternative methodology, good regulatory practice would require AEMO to detail its reasons for doing so.

We recommend that section 5.3.1 of the MASS be amended to indicate:

> *All measurements of Local Frequency, Generation Amount and Load Amount must be taken at, or as close to as technically achievable, a relevant connection point.*
>
> *If an FCAS Provider considers that an alternative measurement methodology can provide AEMO the required data more simply and accurately, the FCAS Provider must request AEMO's approval prior to using it. AEMO may approve any alternative measurement methodology on such conditions as AEMO considers appropriate. Where AEMO withholds such approval, AEMO must provide the reasons for doing so to the FCAS Provider.*

Simply Energy:

**The MASS should permit measurement at the asset level**

In the Draft Determination, AEMO considered that power measurement at, or close to, a relevant connection point would be more accurate than measurement at the asset or inverter level.

While Simply Energy considers that asset level metering should be sufficient to validate an appropriate response, connection point data could also be provided to provide certainty that the device response was positive. The VPP Demonstrations showed that measurement at the asset level alongside the grid power flow metering was sufficient to show that the FCAS response was having a positive effect on the grid.[61] With these findings, it is not clear why this power measurement cannot continue under the amended MASS.

Setting the point of measurement at the connection point would likely limit the number of potential ancillary services that can be provided at each connection point. Simply Energy supports multiple parties and types of DER being able to provide FCAS BTM, as this would promote both competition and diversity in the market. Simply Energy urges AEMO to ensure that its amendments to the MASS do not preclude future innovations, including allowing multiple parties to provide services behind-the-meter. This approach would ensure that customers' can continue to choose how they derive benefits from their DER investments

Social Energy:

**2. Location of measurements**

AEMOs primary concerns about measurement location centre mainly around three issues:

[61] AEMO 2021, Market Ancillary Service Specification Consultation – Issues Paper, January, pp.10-11.

AEMO is not satisfied that asset-level measurement accurately measures FCAS delivered to the grid due to absorbed response energy which might lead to a significant under-delivery and an adverse impact on power system security in the future. We have referred to this as absorbed energy in our response.

AEMOs assessment is that changes in DPV and uncontrollable load are not significant on aggregate during a frequency disturbance, which we have referred to as baseline stability in our response.

Incentives to game FCAS verification and compliance processes by intentionally negating the FCAS response measured at the asset level. We have referred to this as gaming in our response.

**A) Absorbed energy**

The concept and impact of absorbed response/energy as described in the Draft Determination is not one that we recognise. In our view it is entirely acceptable for response energy delivered by the asset to be absorbed by changes in other uncontrolled load or generation co-located behind the Connection Point. To consider that this "absorbed energy" in some way diminishes the overall response delivered because it is not delivered to the Connection Point is flawed. It fails to treat co-located loads equally to any other load connected elsewhere to the System. Provided co-located loads behind the Connection Point would have been present and identical in the absence of the responding asset they can be considered to be contributing to the frequency disturbance and it is legitimate that response energy flows to and is absorbed by them as the effect of offsetting them is felt beyond the connection point. This is especially true when the size of such loads is large compared to the size of the responding asset as can be the case with residential sites.

We acknowledge that a key requirement is that the co-located loads do not respond in a manner that is negatively correlated with that of the FCAS asset. This risk is easily handled and we address the point in our comment on gaming below.

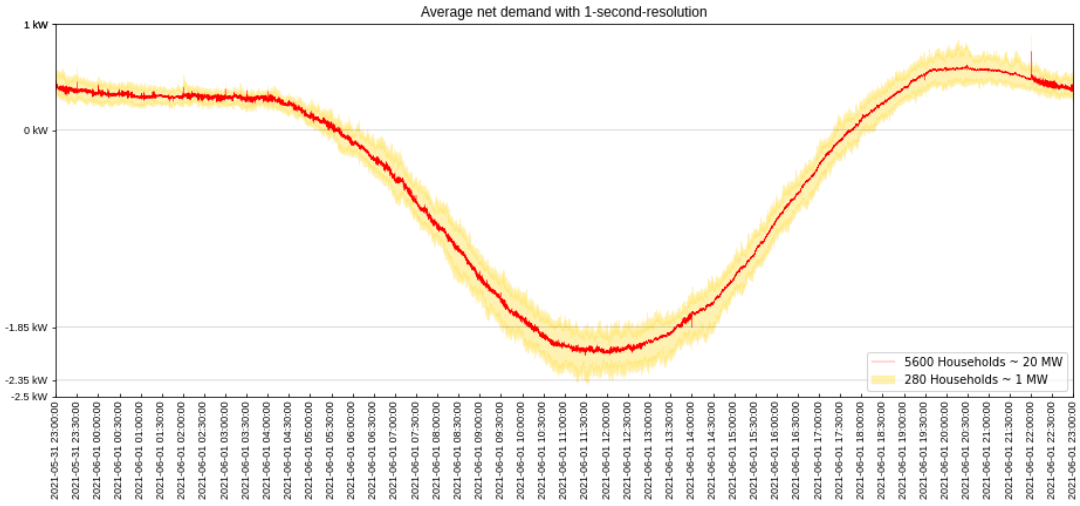
It is our view that measurement of the FCAS response delivered at the asset level is the only accurate methodology for doing so when other loads are co-located behind the connection point., and so-called 'absorbed energy' should not be considered as under-delivery.

**B) Baseline stability**

We strongly disagree with AEMOs assertion that changes in DPV and uncontrollable load are not significant on aggregate during a frequency disturbance. To demonstrate this we have analysed the effect of the current FCAS baselining rules using 1-s-resolution data available from a sample of 5,000 of our own customers taken on 1st June 2021. All customers within the sample have rooftop solar and lithium-ion batteries, which have been removed from the net demand shown. This is possible as additional measurements were available at the grid connection point, as well as the battery and solar inverter output. No filtering or data wrangling was performed, and measurement data as recorded by the meters were used. In the case of the aggregated 5,000 households, the entire dataset was used.

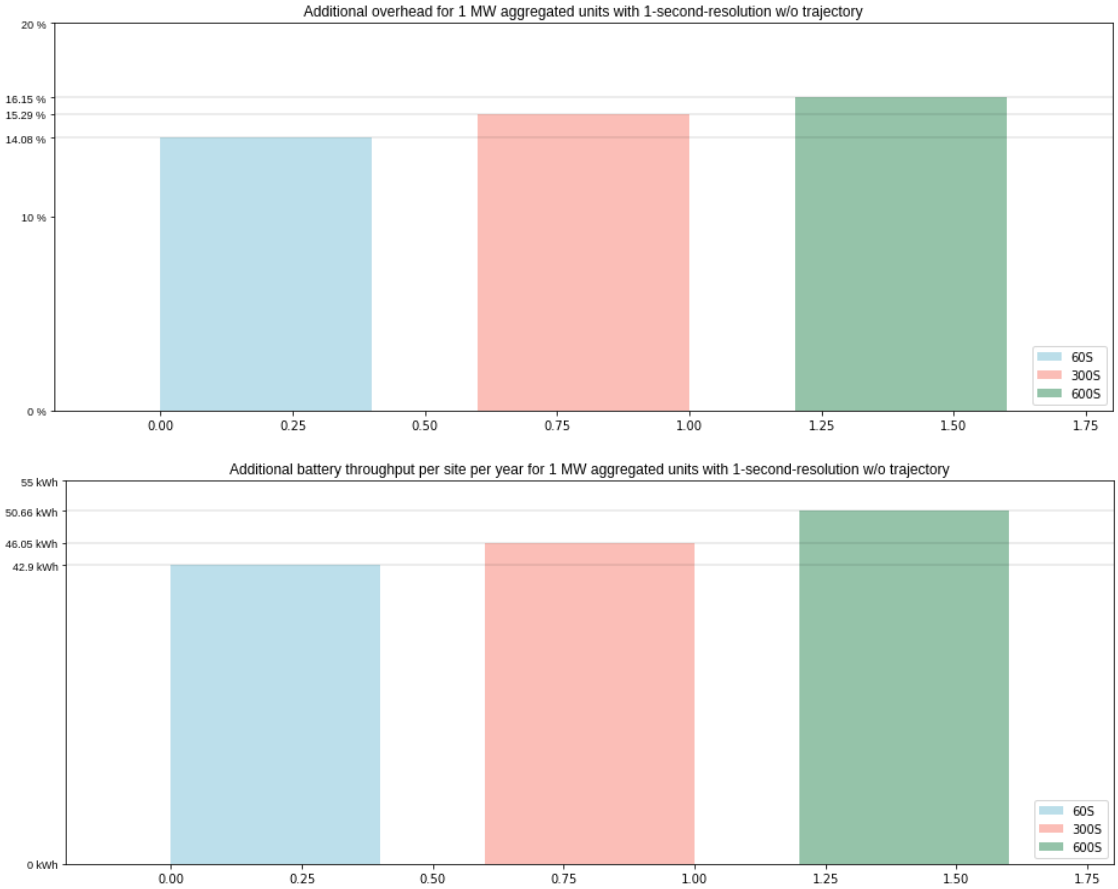
The data was aggregated into ~250 household samples (~1MW). To avoid bias, households were selected uniformly without replacement to produce 30 different sets and derive averages for the additional capacity overhead requirement and extra cycling per battery within the VPP in order to maintain a flat baseline.

As depicted below using the average net demand, 1MW-aggregated units exhibit considerably higher embedded noise compared to the larger aggregation of over 5,000 households. This is despite the smoothing effect of aggregation which is well-known in residential power time-series, even in high resolution data.



Both the high embedded noise and the trajectory of the net demand profile (particularly during high solar ramp rates) means there is a significant, adverse operational impact on FCAS assets that are co-located with uncontrolled load and solar if FCAS delivery is measured and verified at the connection point. This is because an additional 'overhead' capacity per VPP is required to be able to accommodate all variations in net demand in order to maintain a flat baseline at the grid connection point. Failing to do this will result in being penalised due to under-delivery. The magnitude of required overhead is determined by the capacity of on-site demand or generation installed.

Furthermore, additional battery energy throughput per site will be required to accommodate the fluctuations which reduce the lifetime of the assets and is costly for householders as it implies additional losses and possibly additional import (both depicted below).



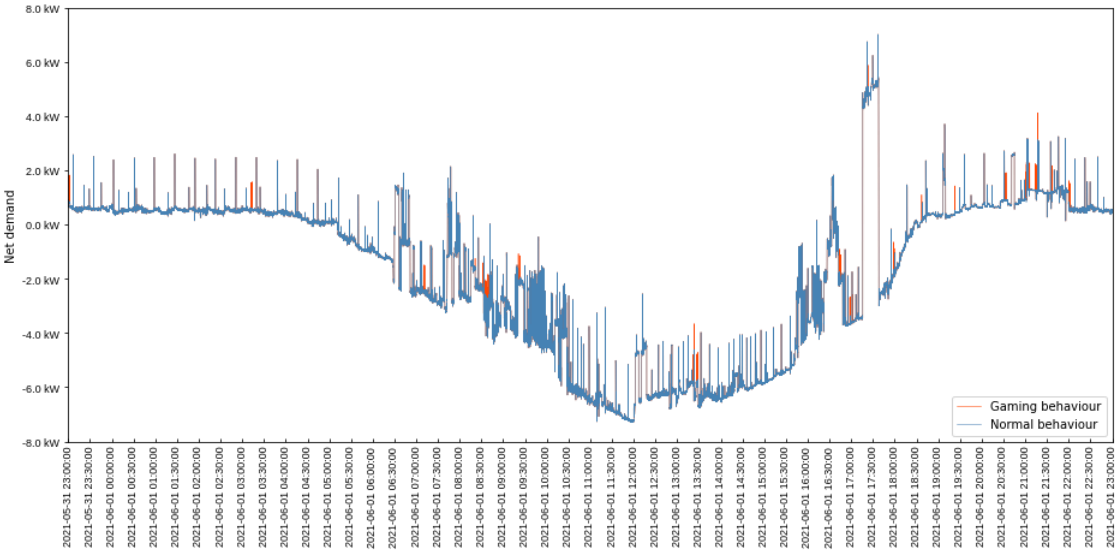

In addition to our contention that measurement at the asset level is the only truly accurate measure of FCAS delivery, measurement at the connection point leads to inefficient utilisation of valuable DER assets to the detriment of residential electricity consumers that own them, through:

- Increased battery cycling
- Increased energy usage
- Reduced capacity for self-consumption

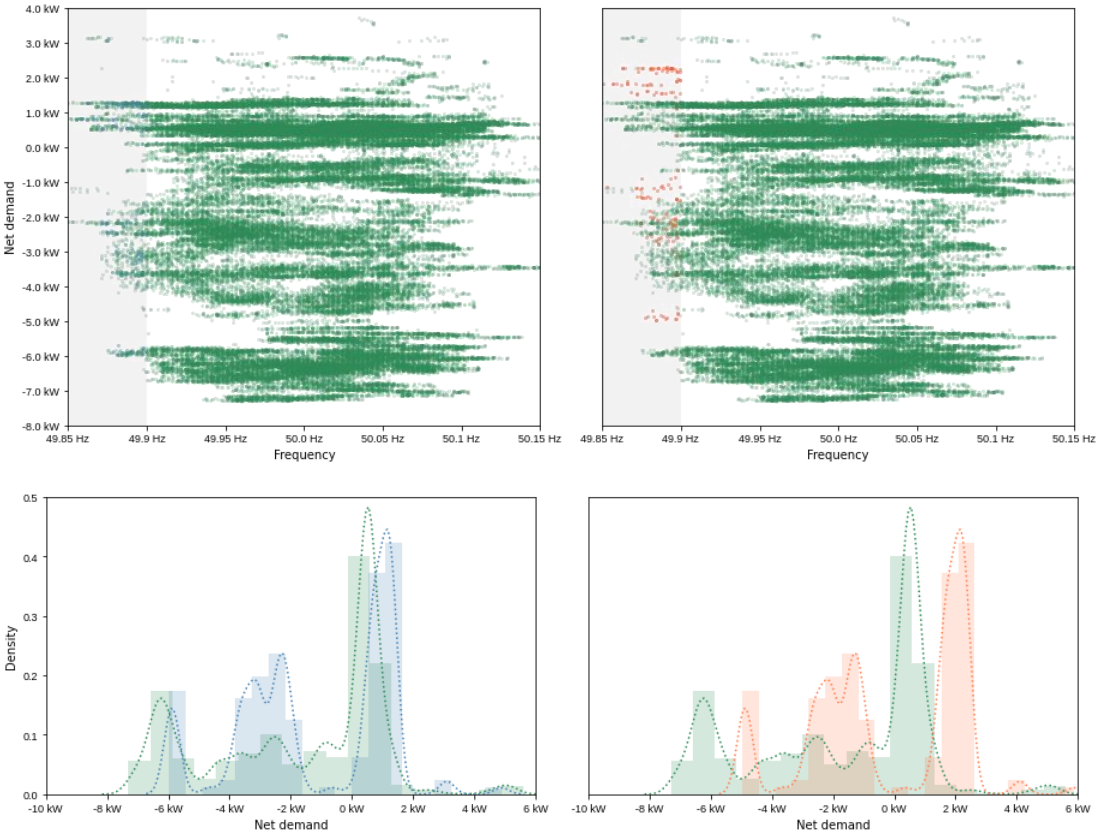
Perhaps more importantly, it represents an unfair competitive barrier to which non-residential providers do not have to deal, especially when trying to ramp up to reach higher market penetration. This is in conflict with AEMOs commitment to the NEO.

**C) Gaming**

We believe it is trivial to use statistical analysis to detect and flag providers that are gaming the system by using other controlled assets behind the connection point to negate FCAS response. To demonstrate this, we have captured 1-s-resolution data from a dwelling with similar characteristics as the Australian units, also from 1 June 2021. To simulate gaming behaviour we injected a 1 kW additional load 10% of the time whenever the frequency was below 49.9 Hz. This reduces the response delivered whilst making the net loads with and without gaming nearly indistinguishable when looking at their time-series, as depicted below.




Nonetheless, as frequency and net demand are independent, the distribution of net demand values should be the same regardless of the frequency. Thus, when comparing the region below 49.9Hz versus the rest of the frequency range, the distribution and their parameters should remain constant. As depicted in the charts below comparing normal and gaming behaviours, the correlated-demand clearly results in a different frequency distribution. Hence, when analysing the data with a rudimentary significance test one can reject the null hypothesis that their mean and standard deviations are the same, and their distribution is invariant. This implies that gaming behaviours can be trivially detected using the demand-frequency independency and assets that attempt to game can be excluded from participation in FCAS contracts.




* Note the blue & orange are distributions below 49.9 Hz whilst green in the rest. Also, only the right side is required in real life operations.

SolarEdge:

**4. Location of the measurement point for FCAS**

DER is always BTM, so it is the vector sum of the Customer load, Generation (typically PV), and DER response that determines the site level response. Measurement at the site level creates risks for VPP aggregators and reduces the visibility that AEMO has on the DER response. Based on these risks, measuring FCAS performance at the site level does not provide the same outcomes for VPP aggregators as measuring at the asset level. Furthermore, not all DER will behave the same. Some DER may charge a battery based on a short variation in frequency whereas another may discharge due to the characteristics of additional local loads, the net outcome being the measurement at the connection point may be far less accurate than assumed.

A primary concern in respect of measurement location appears to be driven by the risk of multiple assets enabled for FCAS at a single site, as well as a belief that measuring at the site and measuring at the device level provide the same outcome for VPP operators.

Ideally there should be an equal basis for DER and utility scale assets providing FCAS. At the utility scale, the connection point and device measurement point are one and the same. For BTM DER, they are not. This creates challenges for DER aggregators especially where there are multiple FCAS enabled devices at a single site as the aggregator must demonstrate suitable metering for each asset and must demonstrate that the performance of the multiple devices is complementary.

In the event that AEMO maintains site level verification, aggregators should also have the option of using device level data to confirm performance in the event that AEMO claims under-delivery (and this under-delivery is due to uncontrolled load or solar). Measurement at the AC terminals of the DER device, provides precision in measurement and accountability in terms or correctness of operation. Multiple assets at the site require their own metering response.

Measuring FCAS response at the connection point rather than at the battery inverter will add significant costs to VPPs. This will not be a good value proposition for customers. The upfront and ongoing costs would very likely exceed revenue from FCAS market participation. The result will be that VPPs do not participate in FCAS markets in future. If FCAS participation barriers are too high as compared to the available pool of value, the non-participation of DER, particularly as aggregated assets working in concert, has the potential to create system issues due to lack of visibility and effective control.

Performance should be verified at the point at which the FCAS is delivered. Site-based control should require verification at the site. Asset level control should require verification at the asset.

We urge AEMO to consider the merits of measurement at the DER AC terminals rather than the NMI. This approach would mean that when multiple DER devices are installed behind one NMI they can all participate, which would help to address system upgrades where different DER may have different response times.

The issue of control of multiple devices BTM has been put forward as a rationale for measurement at the connection point. However, only one MASP can register a NMI. This should mitigate the issues and risks associated with measurement at the device, rather than at the connection point.

**7. Recommendations**

…

8. AEMO should consider the measurement for FCAS at the DER AC terminals rather than the NMI.

…

sonnen:

**Point of Measurement**

For small aggregated loads the physical relationship between a load and a specific connection point is not a significant factor in the aggregate response experienced by the power system in a region. Rather, the system wide aggregate characteristics of all loads, particularly those that are frequency sensitive, influence the dispatch and performance requirements of ancillary services such as FCAS.

sonnen suggests that AEMO revisit the assessment of the potential system wide magnitude of adverse correlations between small controlled and uncontrolled loads under dynamic frequency conditions. Efficient evidence-based assessments should not be built on a single example of an adverse correlation observation unless there is an intolerable cost associated with the single observation. Rejecting measurement configurations that on aggregate may provide a cost effective FCAS response without the prior examination of a representative data set raises questions regarding the degree of risk aversion in the decision-making process.

sonnen is wary that the degree of adverse correlation between small controlled and uncontrolled loads may be overstated by an individual respondents' experiences. Business models are often adapted to specific load classes and do not necessarily capture a broad representative sample.

To facilitate efficient use of the available DER resource sonnen sees merit in linking the measurement point requirement to the types of devices installed at the connection point and the degree of confidence the metering configuration provides. For example, where only one controlled device exists behind a connection point the risk of adverse uncontrolled responses is no different as if the uncontrolled load is behind or in front of the connection point.

**Recommendation**

Permit DER device level measurements where it can be demonstrated in the registration process that device level measurements adequately address controlled responses behind the connection point. If necessary adopt discount factors to achieve an efficient (typically 90%) confidence level of delivery.

Tesla:

**6.3 Measurement location**

**Statement of concerns**

AEMO's position in the Draft Determination is that "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". This position appears to be based on the following points made by AEMO:

- "AEMO analysis of the FCAS response … indicates that changes in DPV and uncontrollable load during a frequency disturbance are smoothed out on an aggregate level".
- "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 approach…"; and
- "Extra hardware would be required if there is more than one controllable asset behind a connection point".

AEMO concludes that "no supporting evidence was presented to confirm that measuring FCAS delivered by DER at the asset level would benefit the power system".

**Summary overview – Tesla position**

Tesla does not agree with the analysis undertaken by AEMO nor with the approach proposed in respect of the measurement location. AEMO's final position seems to be primarily based on concerns around multiple assets providing FCAS at a single site. Tesla considers this to be a fringe issue which can easily dealt with.

Our recommendations to AEMO, which are dealt with in more detail below, are:

- All VPP providers provide AEMO with both site and asset level data to maintain a complete dataset.
- The point of verification (data used for verification) should be at the point at which the FCAS response is delivered:
  - If the FCAS response is provided by a single technology, using an open loop response, or a closed loop response using device level meter, FCAS performance should be verified using asset level data (with site level data provided as well).
  - If the FCAS response is provided by a site level controller (for one or more technology types sitting behind the meter) then FCAS performance should be verified at the site level (with data provided for individual assets as well)
- In the event that AEMO maintains the requirement to verify performance at the site level, rather than the asset level, then Tesla asks that aggregators are given the opportunity to use device level data in the event that AEMO considers a VPP to have under-delivered during an event (driven by the impact of non-controllable load/ generation on site).
- Tesla also believes that where a single NMI has more than one FCAS enabled technology then device level measurements should only be allowed where AEMO has sufficient confidence that the metering at the device level is sufficient and the two assets are compatible in response.

Our recommendations above are based on the following points:

- AEMO will benefit from having both site and asset level data whilst also providing optionality

- Tesla's analysis shows that there are risks of DPV and uncontrollable load impacting on the measured FCAS output of DER where the measurement is done at the site level. Even if FCAS providers reduced their bids to account for uncontrollable changes in solar and load, they would still unfairly be exposed to non-compliance given that the magnitude of these changes is unpredictable.
- The risks associated with multiple assets providing FCAS at a single site are largely fringe-case and/or theoretical and can be easily managed.
- AEMO's decision to lock in measurement location at the site, ignores the primary driver for the VPP Demonstrations – which was to level the playing field for DER when compared with utility scale assets providing FCAS.

In respect of the concerns around multiple assets providing services at a single site, Tesla also thinks that there is a broader piece of work that needs to be done in respect of the customers' ability to select a single aggregator versus their ability to work with multiple aggregators for different systems behind the meter. This position is not yet settled and there needs to be further work done on both DER interoperability, and on customer protection frameworks – this needs collaboration from industry, AEMO, the AER and the ACCC. It is important that AEMO does not use the Draft Determination as a proxy for locking in one method ahead of this work being done.

Lastly, the concern raised by respondents around perverse incentives to game the FCAS verification and compliance approach seems to be based on a misunderstanding of the primary application of a battery which consists in increasing solar self-consumption. This is currently the default mode of operation of most residential batteries and consists in charging from solar production when it exceeds home usage and discharging to serve the home usage when it exceeds solar production. As a result, if an aggregator implements an FCAS response at the site level by which it increases loads for instance, a battery in self-consumption mode will compensate by almost instantaneously reducing its charge power or by discharging, in order to maintain 0kW imports and exports. And similarly, if the aggregator decreases load, the battery will reduce its discharge power or charge. Such behaviour should not be assimilated to gaming; instead it highlights the inappropriate configuration of the battery by the aggregator.

Besides, there are proven technical solutions currently available commercially that enable aggregators to control fleets of batteries such that they deviate from their self-consumption behaviour during frequency excursions and provide FCAS services either from an open loop proportional response, or from a closed loop step response.

More detail on each these points is provided below.

**Justification of position**:

AEMO benefits from both site and asset level data

A core principle backing our recommendations above is that it makes the most sense to verify performance at the point at which FCAS is delivered, and that AEMO will benefit from multiple data sources from all VPP aggregators. In practice we see this working as follows:

- **Aggregator A**: manages a fleet of batteries, uses open loop controls to manage the FCAS performance. Across the fleet there is also a combination of uncontrollable loads and solar system. The aggregator is required to provide battery data (FCAS device level data), as well as solar and load data. Performance is verified using the battery level data to ensure that the load and solar outputs do not impact on the verification.
- **Aggregator B**: manages a fleet of batteries using a close loop site level control system. Across the fleet there is also a combination of uncontrollable loads and solar system. The aggregator is required to provide battery data, as well as solar and load data, and total site data (FCAS level data). Performance is verified using the site level data.
- **Aggregator C**: manages a fleet of batteries and controllable air-conditioners using a close loop site level control system. Across the fleet there is also a combination of uncontrollable loads and solar system. The aggregator is required to provide battery data, air conditioner data, as well as solar and load data, and total site data (FCAS level data). Performance is verified using the site level data.

Having multiple data points is important for AEMO to ensure performance is compliant. Looking at the example of Aggregator B there is a risk of that aggregator taking credit for changes in load/solar production that they don't control. For instance, if during a lower event, a customer turns his/her kettle on, the aggregator may in response turn off one of the loads it controls (and if they don't, they can still claim the load increase as a legitimate FCAS response). Given that the customer would have turned on the kettle regardless of whether there is a contingency event or not, the aggregator should not be allowed to claim this additional load as a contribution towards its FCAS enablement. If AEMO asks for only site level data rather than also collecting data from FCAS enabled devices BTM.

In the example of Aggregator C, there is the potential that one FCAS device will over-perform and one will under-perform. If AEMO only asks for site level data for verification, they will have no visibility on this variance in performance and therefore will not be able to identify under-performing FCAS devices.

Interference from distributed PV and uncontrollable customer load

Related to the above, and the need to create a level playing field, Tesla does not agree with AEMO's position that "changes in distributed PV and uncontrollable load are smoothed out on aggregate level".

Tesla's analysis of data across individual sites shows that there are clear instances where a shift in solar output or a change to the uncontrollable load pattern has a demonstrable impact on the overall site profile.

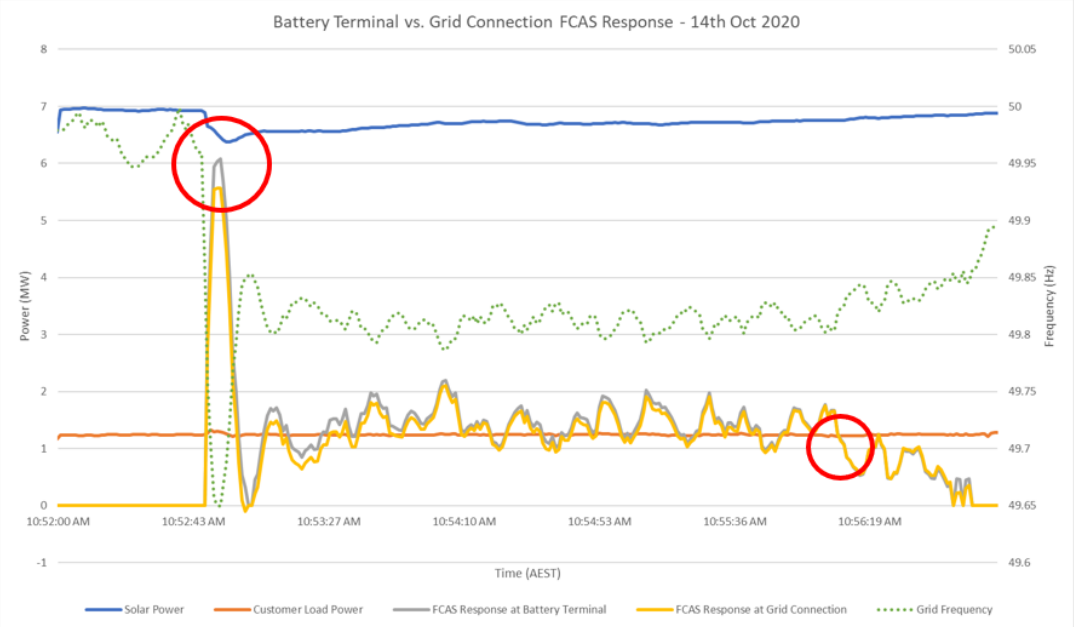



Figure 18: Impact of reduced solar output on site level output

As demonstrated in Figure 18, a decrease in solar output, which is not uncommon over an extended contingency frequency event, creates a noticeable difference between the measured battery output (actual provided FCAS response – yellow line) and the site level output (verified FCAS response if AEMO elects to maintain site connection level measurement requirements – blue line). In effect this will mean that aggregators will either need to bid conservatively, apply a haircut to their aggregated bids to manage the impacts of uncontrollable loads and/or changes in solar PV output, or risk facing action from AER and/or AEMO in respect of non-compliant bids.

During this particular event, SA VPP would not have been considered as under-delivering even if the site-level measurements had been used. However, this is only because at the time, Tesla used a conservative bidding approach with a large haircut as we were still gaining confidence in our ability to exceed required FCAS delivery for each and every 5-min enablement in all 6 markets. Tesla has since reduced its haircut while maintaining compliance and would most likely be considered as under-delivering during a similar event if only site-level data was used for FCAS assessment and non-controllable solar inverter behaviour was ignored. More importantly, in absence of battery and solar measurement, AEMO would have had no visibility whatsoever into the solar system trips, which is precisely one of the major challenges that AEMO has identified in Behaviour of DER during power system disturbances (June 2021): "There remain areas where evidence is sparse, particularly around DPV behaviour during frequency disturbances."

This reiterates the lack of level playing field between aggregated DER providing FCAS and utility scale assets providing FCAS. Utility scale assets do not have to adjust their bids to account for externalities such as other generation or load profiles.

In the event that AEMO maintains the requirement to verify performance at the site level, rather than the asset level, then Tesla asks that aggregators are given the opportunity to use device level data in the event that AEMO considers a VPP to have under-delivered during an event (driven by the impact of external load/ generation on site).

Risk of multiple assets providing FCAS from the same site

If more than one asset is providing FCAS at a connection point, then this creates concerns for AEMO. Tesla believes that this is likely to be a fringe issue and can simply be resolved through providing

optionality to measure at site level vs asset device to start with – this means that if a MASP or market customer submits an ancillary services load registration form (single DUID) where there is more than one type of plant listed for a particular NMI then the aggregator is required to use site level measurements to verify performance unless the aggregator can demonstrate suitable asset level metering for each FCAS enabled plant. This position will be further enforced by the fact that only one MASP is able to register per NMI.

If an existing NMI has an FCAS enabled asset registered under a second DUID later, then this should create an immediate flag for AEMO.

Need for an even playing field

Building on Tesla's analysis above on the VPP Demonstrations, it is again worth pointing out that the reason that AEMO considered measurement resolution at the asset level (rather than the site level) for the VPP Demonstrations, was not to give undue advantage to VPPs, but to address the fact that the MASS was written with utility scale assets in mind, and as such the current settings can passively discriminate against how aggregated fleets of assets compete in the market.

For utility scale assets providing FCAS, the connection point and the device measurement point is one and the same. Taking utility scale batteries as an example, AEMO currently requires all utility scale battery storage systems to be registered as a scheduled generator and a scheduled load. Even when co-located with a wind or solar farm these are two separate assets.

For the purpose of providing FCAS, in a utility scale model it will be the battery that is registered as an FCAS generating unit. As such the "connection point" will always just measure the performance of a single asset.

Applying this logic to a fleet of aggregated assets installed behind the meter is misleading. Measuring at the "connection point" implies that everything behind that connection point is contributing to the FCAS response, rather than the single asset that is registered with AEMO to provide the FCAS response.

Tesla does not suggest that AEMO should provide preferential treatment for aggregated DER providing FCAS, just that they should be treated with some level of equivalence to utility scale assets. In that respect, it would make sense that for the purposes of verification, the measurement location is at the device level.

To ensure that AEMO has the most complete dataset available, it is not unreasonable for AEMO to expect VPP aggregators to provide both asset level and site level data, however in order to support a level playing field verification should be based on asset level data.

Tesla has also considered AEMO's conclusion that:

> "no supporting evidence was presented to confirm that measuring FCAS delivered by DER at the asset level would benefit the power system"

This should not be the threshold test applied to whether new technologies should have alternative settings and requirements applied to them. The threshold test should be whether the equivalent settings – developed for transmission connected utility scale assets – make sense when applied to DER. In this case they don't, and they actively disadvantage DER providing FCAS when compared with utility scale assets. Utility scale assets will never have to account for uncontrollable load or generation externalities in their bids and it is unreasonable to expect DER to do so.

## 8 Summary of recommendations

...

| Topic | Recommendation |
|---|---|
| Measurement location | • Tesla understands AEMO's concerns about measurements at the site level, however Tesla believes that the FCAS measurement location should be the same as where the FCAS response is implemented. Some VPPs implement a closed loop response at the site level while others, like Tesla, implement an open loop response at the asset level. For simplicity, Tesla recommends that AEMO:<br>o Where FCAS is provided by a site level, closed loop device the performance of that site should be verified at the site level (with the VPP operator required to provide data at the device level for FCAS enabled devices, as well as site level data).<br>o Where FCAS is provided using open loop device level controls, or closed loop controls at the device level, the performance should be verified at the device level (with the VPP operator required to provide both site and device level data)<br>• If AEMO maintains site level measurements resolution for all sites, then Tesla suggests that in the event of AEMO assessing under-delivery of FCAS, FCAS Providers are able to demonstrate compliance using device level data, to show that the perceived under-delivery was caused by uncontrollable load or solar.<br>• Tesla believes that AEMO should not disregard asset level measurement for the following reasons: |

| | |
|---|---|
| | ○ Measurement at the site level creates risks for VPP aggregators in accounting for uncontrollable loads and changes in solar PV output. Based on these externalities, measurement at the device level provides a more accurate method of verification of FCAS performance.<br>• Where there are multiple FCAS enabled devices at a single site, then the aggregator must demonstrate suitable metering for each asset and must demonstrate that the performance of the multiple devices is complementary. |

### 4.2.2. AEMO's assessment

Fifteen submissions were in favour of leaving the location of the measurements of power and frequency 'at or close to' the connection point, and an equal number of submissions opted for alternative arrangements. Thirteen submissions had no clear preference in regard to the measurement location but were focused on the measurement time resolution.

The alternative arrangements proposed to AEMO were as follows:

- Measurement location at the asset level.
- Measurement location dependent on the number of BTM assets responding to a frequency disturbance, e.g. the FCAS response should be measured at the asset level if there is only one controllable asset per NMI, or at the connection point level if there is more than one asset per NMI or if the net flow itself is being optimised.
- Measurement 'at or close' to the connection point to verify the FCAS delivery, but AEMO should be open to accept data captured at the asset level when investigating potential non-compliances

The following table gives a summary of which measurement point was preferred by each Consulted Person:

| Preferred Measurement Point | Consulted Person |
|---|---|
| Connection point | AEC, AGL, Empower Energy, Hydro Tasmania, Intellihub, Redback, Rheem & CET, Shell Energy |
| Device | CBP, CEC, Discover Energy, Energy Locals, Evergen, Members Energy, Powerledger, Quinbrook, Simply Energy, SolarEdge & Social Energy |
| Other | Dreambox, Enphase Energy, New Energy Ventures, Origin Energy, sonnen & Tesla |

While AEMO will not be persuaded by the popularity of one preferred outcome over another, the submissions address several relevant issues that need to be considered when identifying an appropriate measurement point.

#### The need to maintain metering at the connection point

FCAS is necessary for the power system to manage disparities in supply and demand on a continuous basis. AEMO needs to know how much energy is being produced and consumed at all times, and these measurements are taken at the connection points.

While clause 3.8.7A(c) of the NER requires the MW quantities specified in a bid for any type of FCAS to apply at or close to the connection point, AEMO could agree that a different metering point in the relevant electrical installation or on the network applies. AEMO, however, is not inclined to agree to a different metering point.

The introduction of a separate metering point for DER that provides FCAS would introduce uncertainty in the quantity of FCAS provided, especially if there are other devices BTM that might be triggered by the operation of one device. In certain circumstances, they could counter each other's contribution to FCAS, negating any benefit to the power system which, as DER penetration grows, could have a significant impact

on power system operation. This did not have a noticeable impact during the VPP Demonstrations, but it does not mean that this is not a concern.

If AEMO was to specify a different measurement point based on the number, or type, of devices BTM for the purpose of providing FCAS, AEMO would need to be aware, at all times, whether a battery or controllable load is installed or removed. AEMO is particularly concerned with Rheem's experience observing the conflict where devices are separately orchestrated, resulting in the FCAS response from one device being negated by another. Without net flow measurements at the connection point, AEMO would not be able to confirm whether mixed DER sites comply with the NER and the MASS.

Measurement of FCAS 'at or close' to the connection point will not resolve the competing functions between two or more controllable assets, such as a battery and a hot water system, but AEMO needs to understand whether any FCAS is being delivered in the first place. FCAS is a service that is being provided to balance the power system, so AEMO needs to identify the net flow through the connection point to identify whether the FCAS Provider has met its NER and MASS obligations through the proper orchestration of DER. Device level metering will not assist in identifying whether the FCAS response from the facility that is being used to provide the FCAS has been countered by other load BTM, and does not confirm whether the FCAS provided by the facility correlates with what was received into the power system.

All devices operating BTM need to be orchestrated to ensure that the FCAS AEMO expects to be provided is, in fact, provided, and the only place it can be measured accurately is the connection point.

### The MASS does not preclude device metering

The short answer to the question of whether device level metering is permitted is that the MASS only prescribes what is necessary for AEMO to operate the FCAS markets. If FCAS Providers wish to use additional metering, there is nothing to prevent them from doing so.

Indeed, AEMO considers that there is a benefit in FCAS Providers retaining device metering because it permits them to present additional data to AEMO where there is an issue over compliance, but the types of circumstances in which this might be necessary are not so great as to require the prescription of device metering in addition to connection point metering.

### The benefits of more than one metering point

AEMO has not identified any scenario where the difference between the power flow measured 'at or close' to the connection point and at the device level would be large enough to result in a non-compliance during the VPP Demonstrations. AEMO understands that, under certain circumstances, changes in distributed photovoltaics (DPV) output or uncontrollable load can have a small impact on FCAS if measured 'at or close' to the connection point.

Moreover, a case could be made for metering at the connection point and at the devices BTM where there is more than one device that can impact the provision of FCAS at a connection point.

### Is AEMO being inconsistent?

Energy Locals has pointed out statements made by AEMO in other contexts that appear to be inconsistent with the Draft Determination:

The first statement was extracted from Appendix A[62] of AEMO's 2020 Renewable Integration Study. AEMO cited the results of a survey of DNSPs by the Australian Energy Market Commission (**AEMC**) and ENA on page 25, and made some observations about the implications of these results on page 26. The statements refer to a lack of granularity in information available to DNSPs in their low voltage networks about the

[62] Available at: https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-a.pdf?la=en

operation of DPV and other BTM assets, which has nothing to do with measurement of power flows into and out of their networks.

AEMO was making observations about the survey, not suggesting that measurement of energy flows into and out of the power system should be anywhere else other than at the connection point.

The second statement cited by Energy Locals has been extracted from page 18 of AEMO's rule change request titled: Integrating Energy Storage Systems (ESS) into the NEM[63]. The quoted statement is referring to the technical performance standards applicable to generation in the NEM (commonly referred to as generator performance standards (**GPS**)) under Chapter 5 of the NER. These cover performance requirements, such as frequency response to changes in power system conditions.

AEMO was not suggesting that it wishes to see measurement at the device level. The suggestion was that the specification of the minimum technical performance of assets connected to the power system should be by reference to the type of assets, not by reference to the three categories of Generators (Scheduled, Non-Scheduled and Semi-Scheduled), because AEMO is seeing an increase in 'hybrid' facilities, such as solar PV and a battery connected at the same connection point.

The GPS are specified in Schedule 5.2 of the NER, while performance standards for load are specified in Schedule 5.3. These legacy arrangements are no longer proving to be a good fit for 'hybrid' facilities.

AEMO was not suggesting that energy flows into and out of the power system should be measured at the asset. This is especially important for frequency control, because its measurement is directly related to the energy flows at the connection point.

**Relationship with other reform objectives**

Three submissions suggested that the Draft Determination is inconsistent with the Energy Security Board's (**ESB**'s) Post 2025 Electricity Market Design (**NEM2025**), which has the development of two-sided markets as a core objective.

Quinbrook and Energy Locals suggested that allowing device level metering is "a necessary pre-condition to aggregators being able to offer innovative services to customers". The relevant issue to the MASS is not whether device metering will facilitate the development of two-sided markets per se, but whether they will do so in a way that promotes the NEO, which is discussed further in section 4.5.

Another issue raised by Quinbrook and Energy Locals is the ESB's concern that DNSPs need additional visibility of DER to manage "the variability of energy production and system security within their operating limits and facilitate wholesale market integration of aggregated DER". AEMO agrees with this objective, and it will be one of the issues addressed by the consultative forum discussed further in section 4.4.

### 4.2.3. AEMO's conclusion

AEMO will not exercise its discretion to nominate a different metering point under clause 3.8.7A(c) of the NER, which means that FCAS bids will apply 'at or close' to the connection point to ensure the proper orchestration of DER and to verify the amount of FCAS delivered to the power system more accurately.

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

The measurement of power flow from/to an asset is not a requirement of the MASS, and the FCAS Provider may continue to capture this data at intervals of 1 s.

[63] Available at: https://www.aemc.gov.au/sites/default/files/2019-09/ERC0280%20Rule%20change%20request%20pending.pdf

## 4.3. Trial Participant transitional issues

### 4.3.1. Issue summary and submissions

AEMO's proposal to not amend the measurement requirements for DER necessitated the making of rules for the orderly transition out of Trial Participants who would be unable to meet the MASS. These rules were included in section 11.3 of the draft MASS published with the first Draft Determination. Briefly, they were:

- The VPP Demonstrations would end on 30 June 2023.
- Trial Participants could not change the capacity of their Fast FCAS, or the device types or controller types used to provide it.
- AEMO would apply a discount to the quantity of Fast FCAS provided by DER, as follows:
  - 5% where the sampling rate is >50 ms but ≤200 ms; and
  - 20% where the sampling rate is >200 ms but ≤1 s.
- Trial Participants must either meet the MASS from 1 July 2023 or exit the Fast FCAS market.

Extracts from submissions on this issue are cited below.[64]

AEC:

> The AEC has been supportive of AEMO amending the MASS to enable the VPP Demonstrations to continue in the market. However, the Draft Determination is concerning to us and those of our membership who expect it will have a significant impact on the viability of their VPP projects going forward, along with impacts on incremental VPPs during the transition period due to the discount factors that are proposed to apply. We observe that metering changes will also need to be engineered and implemented, and we are concerned this will also increase the costs of VPP participation. In short, our membership is concerned with the commercial impacts arising from the Draft Determination.
>
> In a more detailed reflection of our memberships concerns, the AEC:
>
> - Is disappointed that AEMO has significantly altered its position at this late stage. If the measurement issues were identified earlier then these could reasonably have been tested through the VPP Demonstrations.
> - Would prefer that AEMO deferred this decision and extended the VPP Demonstrations until June 2023 to better understand the identified measurement risks and any potential mitigation strategies.
>
> …
>
> - Is concerned that the proposed penalties on Trial Participants over the next 2 years are excessive and unjustified, given that:
>   - AEMO stated that the relatively small size of the current registered VPP fleet is having no adverse impacts on power system security and AEMO is not having to procure additional FCAS due to the measurement error. In that context, the proposed discount factor appears disproportionate and unreasonable.
>   - The proposed discount factor is based on the maximum possible error – rather than an average or some other more appropriate estimate.
>
> Further to the above, the AEC proposes that in any extension of the VPP Demonstrations to June 2023 that the extension would allow;
>
> - New participants to join the program up to six months before its conclusion;
> - Trial Participants to increase the maximum FCAS bids (i.e. to take on more customers and grow their portfolio bearing in mind this will still be a relatively small fleet); and
> - Trial Participants to enter new regions and FCAS.

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

In our view these concessions remain necessary for the program to both generate enough data and test a diverse range of technologies, as well as for AEMO to have confidence in any path going forward.

AER:

… we note that AEMO proposes to not amend the MASS to accommodate alternative measurement arrangements. AEMO's analysis indicates that the lower meter sampling rates currently allowed for Trial Participants results in some uncertainty as to the behaviour and response of their inverters. AEMO is therefore proposing transitional arrangements that provide a window of time for them to either comply with the MASS, or exit FCAS markets.

Given AEMO's analysis showing the uncertainty of the response of VPP inverters we support the proposed transitional arrangements so there is confidence that these critical services are being delivered when called upon. Some relevant VPPs are likely to face increased costs and complexities of compliance with the increased time resolution requirements in the MASS. These costs may be offset in the future as technology improves, power system stability increases and system service requirements may be tempered accordingly. We consider AEMO's proposed approach will help to prepare the power system for increased participation in FCAS by DER, including for FFR and PFR.

AGL:

… we would recommend AEMO defer this component of the MASS [sampling rate] and commission further test analysis to confirm whether 100 or 200ms measurement granularity is satisfactory for the purposes of AEMO's market settlement systems.

Empower Energy:

The emergence of solutions at lesser performance than the MASS should not displace devices complying to the MASS; an ideal future scenario respecting relevant tenants (sic) of the NEO (favouring technology agnosticism) may incorporate e.g. discount rates for devices contributing at lesser rates of overall accuracy. We believe the transitional arrangements for Trial Participants are, in principal (sic), directionally-correct.

Energy Locals & Quinbrook:

**Transitional arrangements**

Subject to any changes to AEMO's determination on metering frequency, we propose that the transitional arrangements proposed by AEMO (MASS, Section 11.3) for the VPP Demonstrations are made permanent and opened to all participants, or at least be made permanent for Trial Participants. This would be on the basis of the considerable time and expense provided as part of the demonstrators which is at risk of non-recovery in the event there are requirements to change metering arrangements and incur additional costs.

Evergen:

**Specific additional recommendations**

…

12. If implemented, the interim arrangements should omit the proposed penalty on Fast FCAS participation since there is no barrier to adequate verification.
13. If implemented, interim arrangements should allow Trial Participants to increase their fleets to a maximum of 10MW (or existing size if already larger).
14. If implemented, interim arrangements should allow new participants, new technologies and also allow new retailers to engage in FCAS via Trial Participants.
15. If implemented, interim arrangements should waive the cost of adding additional NMIs to replace churn if not re-enrolling at a larger biddable fleet size, in recognition of the costs and practicalities faced by Trial Participants compared to traditional FCAS Providers.

…

**7. Proposed interim arrangements for VPPs**

It is our strong belief that the VPP Demonstrations alternative requirements should be adopted as a formal requirements specification for all DER-based VPP participation in FCAS. However, should AEMO finalise the Draft Determination without change, their approach would put in place transitional arrangements for existing VPPs participating in the VPP Demonstrations. As we have argued, Evergen does not accept that the Draft Determination is justified. Nevertheless we wish to comment on the draft transitional arrangements in the interests of completeness.

**Evergen does not believe that the draft transitional arrangements are fair or appropriate.**

Evergen seeks a path that nurtures the excellent collaboration and data gathering that has occurred to date due to the relaxed rules of the VPP Demonstrations, rather than the Draft Determination and interim arrangements that will extinguish it entirely and undermine the path to innovation that the energy system in Australia and internationally so badly requires.

### 7.1 No justification for penalising Fast FCAS participation in the interim

AEMO proposed that VPPs participating in fast markets should have a 20% reduction applied to their verified FCAS delivery in light of measurement error, as part of interim arrangements.

Evergen demonstrated (see Section 3) that there are sufficient measurements for verification, and the shortcoming is not one of measurement, but one of verification methodology. There is therefore no justification for penalising Trial Participants who sample at the device level at 1s.

Evergen therefore recommends that no discount be applied to Trial Participants in the Fast Contingency FCAS markets as part of interim arrangements.

Further, Evergen recommends AEMO take the opportunity to work with Trial Participants an improved approach more widely after testing via the VPP Demonstrations. AEMO's current approach is outdated and not fit for the purpose of verifying FCAS delivered by VPPs.

There is no indication from the VPP Demonstrations that Trial Participants cannot deliver an effective Fast FCAS response, and it is entirely within AEMO's power to develop an improved approach to verification to more effectively maintain visibility of this.

### 7.2 A cap on fleet size rather than a freeze

AEMO proposes that existing Trial Participants should not be able to increase their FCAS registration size. This disproportionately impacts newer, smaller Trial Participants who have nevertheless still invested significantly and in good faith to be able to work with AEMO to drive progress on VPP-based FCAS.

AEMO has disallowed the addition of NMIs to these fleets for the last 8 months unless as part of a re-enrolment at larger FCAS load size (in 1MW increments). That is, AEMO has not allowed addition of NMIs to cover customer churn without re-enrolment.

The result has been that newer, smaller VPPs have been operating at a significant loss while working to accrue sufficient customers for re-enrolment at 2MW.

As of June 2021, AEMO now also disallows re-enrolments at increased size for Trial Participants. This leaves newer Trial Participants who originally registered with a base level 1 MW fleet with an increasingly marginal fleet as customers churn. If the draft interim arrangements come into force, churn could be replaced at a fee of $2,000. Even should this fee be waived, the small fleet size is not sustainable. The significant investments made by VPP operators to establish control, integrate with AEMO and undertake the expense of customer acquisition will not be recouped. This is especially disappointing given that VPP operators have been working with AEMO in good faith and are in position to continue to contribute telemetry and knowledge sharing to AEMO.

Given AEMO's MASS review proposed Option 2, and first round feedback was a majority in favour of incorporating either Option 2 or a hybrid of Option 2 into the MASS as AEMO proposed, it is arguable that AEMO has disregarded the trust, lessons and momentum for the transition towards two-way markets it has built together with VPP operators and the broader community.

Rather than freeze re-enrolment at larger sizes for these VPPs, Evergen recommends that AEMO instead put a cap of 10MW (or else current fleet capacity if it is already above 10MW) on Trial Participants. This is a more equitable arrangement while still meeting AEMO's overt intention of limiting in the short term the penetration of DER-based VPPs into the FCAS market.

### 7.3 New participants and new device types

With a fleet size cap in place, AEMO should continue to permit new entrants and new device types (e.g. new battery models) to the interim arrangements. Learning by doing is the way forward for progressing VPP-based FCAS delivery. The barriers to entry under the Draft Determination aside from being unnecessary and driven by flawed analysis, are also too high to facilitate extensive VPP participation in the FCAS market. AEMO cannot present itself as a facilitator of grid modernisation and DER enablement if it actively thwarts industry being able to learn and progress solutions.

Even the arrangements for the VPP Demonstrations still represent a hefty barrier to entry for new participants. AEMO can readily see this by comparing the large number of interested parties focused on the VPP Demonstrations versus the comparatively small number of participants, and the time required to become operational. Allowing new Trial Participants, especially with a cap on fleet size, will not result in sufficient volume of DER-based FCAS Providers entering the market to cause issues - that is assuming that

there even would be any issues presented, an assumption that Evergen has challenged in the preceding sections of this submission.

Hydro Tasmania:

Hydro Tasmania would also like to suggest reducing the proposed discount for 1s or 200ms metered assets for Trial Participants. This aligns with AEMO's comments on the negligible impact on system security without having 50ms metering, and enables further testing of 1s data of current Trial Participants.

Members Energy:

There are technical reasons why the current concerns of AEMO, used to justify retaining the MASS for VPPs, are either unfounded or at least overstated. These concerns can be addressed by using statistical methods (in relation to the proposed 50ms measurement) and other rules (in relation to the point of measurement). These are explored below and detailed in submissions by our partners and competitors in the VPP industry including Evergen and Tesla. Even if AEMO proceeds as planned, despite good technical reasons not to, commercial and social considerations require a longer transition period for the VPP industry to adapt. This would provide time to investigate the technical requirements and adapt to them if possible or pursue other revenue sources to move the current business model away from FCAS provision if necessary.

…

We therefore suggest continuation of the VPP Demonstrations, with more stringent requirements detailed to commence several years hence if necessary. This is the best way to balance short and long term system security and minimise risks to the energy transition. If necessary, AEMO could also impose a maximum size on Trial Participants during the transition period (with more stringent specifications required if the size is exceeded or by the end of the transition period, whichever occurs first). This will keep the risk to system security low, while allowing the sector to mature in technical sophistication while growing social licence – effectively an incubator approach to the VPP industry – which will maximise its benefits and minimise its risks.

The transition conditions should also include the ability of VPPs to increase their current fleet size up to a specified maximum and allow new VPP entrants to enter the market. Limiting access to only Trial Participants and at their current registered capacity inhibits competition as very few currently have a sustainable business model due to their small fleet size. Allowing Trial Participant fleets to increase to a sensible maximum and welcoming new entrants, provided they can demonstrate appropriate competence, would maximise competition and increase the number of consumers participating (hence building social licence) without adding undue risk to system stability. Providing such competition and a sustainable business model would allow Trial Participants to move quickly to add other revenue sources which will greatly benefit the energy transition, including demand response generally, and EV smart charging in particular.

Origin Energy:

We also understand that some Trial Participants have made significant investments in the VPP Demonstrations and believe that some form of transitionary arrangements should be supported. We would encourage AEMO to work with stakeholders to provide for a smooth transition and facilitate the residential market to participate in FCAS provision through aggregation.

One suggestion is to defer a decision and allow further market testing through the VPP Demonstrations. This could provide a better understanding of the identified risks and any potential mitigation strategies.

Reposit:

**4.3 VPP Demonstrations extension**

Reposit does not support the extension of the VPP Demonstrations. AEMO has not articulated a NEO-based reason for the extension of this trial.

Reposit points out that this extension will see the VPP Demonstrations run for a total of five years. This equates to half of the operating life of the assets included in this trial. Reposit asserts that the VPP Demonstrations cannot be considered a trial any longer.

It is Reposit's opinion that the VPP Demonstrations has delivered any learnings it is likely to deliver and that to maintain its operation creates unnecessary costs that will be ultimately borne by consumers. AEMO has not articulated what additional learnings AEMO is looking to gain with the extension of the VPP Demonstrations.

Reposit recognises the limitations on Trial Participants in Section 11.3 of the Proposed MASS as an attempt to recognise and compensate for the degraded service being provided by Trial Participants.

Reposit also notes that clawback provisions should be applied to Trial Participants if the VPP Demonstrations is to continue. The clawback mechanism must be equitably applied if Trial Participants are to be subject to the same incentive mechanisms as full Market Participants.

Reposit is of the opinion that AEMO should be seeking a Regulatory Sandbox Trial Waiver should it wish to continue the VPP Demonstrations. Section 11.3 should not be in the MASS, but included in the Trial Waiver given that it is only applicable to Trial Participants.

Also, Reposit does not consider the extension of the VPP Demonstrations to be an issue that should be dealt with in a MASS Consultation. Reposit continues to consider the confluence of the MASS Consultation and the VPP Demonstrations evaluation processes to be inefficient and highly unusual.

SAPN:

We understand there is some disagreement between VPP proponents and technology vendors as to the likely cost of 50ms metering, and the extent to which this cost would present a material barrier to VPP adoption, or a material erosion of value to VPP customers. We understand from the Draft Determination that there is some consensus that 100ms or 200ms metering would be sufficient to address the market validation accuracy issue, and that this could be widely supported using existing equipment at lower cost than 50ms metering. As a DNSP we are not experts in these matters. As a general principle, however, we consider that the NEO will be served if the MASS specifies the least-cost metering standard that satisfies market settlement requirements, as this will encourage the highest level of market participation and minimise the cost to customers. On that basis we consider that it would be prudent to undertake further investigation into this issue before a final decision is made.

...

11. VPPs should be encouraged and enabled to participate in the provision of fast frequency support services, not discouraged, or else we risk wasting a tremendous opportunity to unlock the value these extremely fast-acting resources can provide to the wider system.
12. We note that while VPPs will form a material part of the energy system in future, especially in SA, they are only operating at small scale today, and hence the risk to broader system arising from the issues identified is relatively small. There is the opportunity for further investigation of these issues, including a second phase trial to answer some of the questions raised in the MASS review that were not answered through the VPP Demonstrations, without material risk to system security. Any short term risk to local network performance or system security could be managed through technical limits on the total VPP capacity in a region, and specific limits on the number of market-participating devices allowed within a local distribution network area (an approach we have taken to managing risks in our trials to date).
13. We would, therefore, urge AEMO to consider deferring its decision on the MASS until further work can be done with all stakeholders. This could include some additional trials as required, to put in place a pathway forward that is effective in mitigating the system security risks identified while still encouraging and enabling DER to participate in the provision of FFR, synthetic inertia and other high-value system services.

Shell Energy:

The data presented by AEMO are clear that the error rate in using 1s metering is significant compared to 50ms metering. However, the difference in maximum error between 100ms metering and 50ms is less significant. This is apparent in AEMO's proposed discount rates to apply during a transition period to 30 June 2023. AEMO proposes applying a 20% discount to the quantity of Fast FCAS where the metering resolution is lower than 200ms but higher than or equal to 1s, and a 5% discount to the quantity of Fast FCAS where the metering resolution is lower than 50ms but higher than or equal to 200ms.

Given the small discount applied to 50–200ms metering range, Shell Energy considers it would be reasonable to allow all participants– not just Trial Participants – to deploy meters with a resolution of 100ms on an ongoing basis with the discount rate applied. This should be permissible beyond Trial Participants (which is now closed) and available beyond the end of the proposed transitional period to 30 June 2023.

Simply Energy:

Simply Energy makes the following observations and recommendations:

- AEMO should have used the VPP Demonstrations to test the identified system security concerns prior to publishing the Draft Determination.
- We urge AEMO to extend the end-date of the VPP Demonstrations until 30 June 2023 to test whether there are alternative solutions to address system security concerns.

...

- AEMO should grandfather the fleets registered under the VPP Demonstrations FCAS Specification.
- The VPP Demonstrations showed that measurement at the asset level alongside the grid power flow metering was sufficient to demonstrate that the FCAS response was having a positive effect on the grid. Setting the point of measurement at the connection point would likely limit competition and fleet diversity as well as limiting the number of potential ancillary services that can be provided at each connection point.

...

**AEMO should use the VPP Demonstrations to test system security issues**

As a Trial Participant, Simply Energy is disappointed that it was not given fair notice of AEMO's altered position and the significant changes being proposed. The Draft Determination would impose significant costs on Trial Participants and would likely remove the future value for existing VPP customers. If AEMO had shared these concerns and risks with Simply Energy earlier, it is unlikely that we would have invested significant resources into expanding the VPPx fleet. For example, as AEMO provided Trial Participants with a dispensation from the existing 50ms measurement resolution requirement, we would have expected AEMO to conduct some analysis on the impacts of this dispensation.

Trial Participants invested significantly with the understanding that the trials would assess the suitability of different approaches and inform the consideration of any changes to regulatory frameworks. Before publishing the Draft Determination, AEMO should have leveraged the VPP Demonstrations to test the concerns raised in submissions. This also would have provided Trial Participants, who invested in the demonstrations in good faith, with an opportunity to develop an evidence-based case on how the current trial fleets could continue to provide FCAS accurately and without compromising system security. At this late stage, it is challenging to provide data-based evidence to refute the highlighted system security concerns.

AEMO has suggested that there would be no adverse impacts on power system security if Trial Participants continue to provide FCAS for the next two years with the existing fleets.[65] In that context, it is not clear why AEMO is proposing to rush through amendments to the MASS rather than extending the current trials to test the significance of the issues raised through this consultation. The discussion at the public forum on 23 June 2021 highlighted that many issues are not yet settled, and additional consultation and testing is required before any decision is made on amendments to the MASS. Simply Energy is concerned that the Draft Determination has been overly influenced by technology providers with vested interests, who have not been involved in the demonstrations and the outcomes from the trials.

To ensure that an appropriately balanced approach is taken, Simply Energy recommends that AEMO extend the end-date of the VPP Demonstrations until 30 June 2023 to test whether there are alternative solutions to address any system security concerns. In the meantime, AEMO should pause the DER component of the MASS review and proceed solely with the proposed improvements to the readability and usability of the MASS.

...

For the existing VPP fleet, Simply Energy urges AEMO to grandfather the current requirements rather than penalising the existing registered fleets by imposing a 20% discount on Fast FCAS provision and transitioning the Trial Participants to the MASS requirements on 1 July 2023. This approach would recognise the significant investments that have already been made by Trial Participants s and would reflect the minimal risk to system security that is posed by the small size of the existing fleet.

...

**The proposed discounting factor on Fast FCAS does not appear to be justified**

Simply Energy does not support the proposal for AEMO to apply a discount to the quantity of Fast FCAS measured at all connection points in a Trial Participant's fleet until 30 June 2023. The proposal to apply a discount to address measurement errors does not appear to align with AEMO's suggestion that the current VPP fleet does not impact the overall provision of FCAS ' and the security of the system.

[Note: confidential information removed]

While not applying a discount may result in Trial Participants slightly over-recovering revenues for FCAS provision, Simply Energy considers that any additional revenue is overshadowed by the forgone investments and APIs associated with the VPP Demonstrations that will arise under AEMO's proposals.

[65] AEMO 2021, Market Ancillary Services Specification Consultation – Draft Determination, June, p.72.

Ultimately, any discount factor would reduce the viability of providing new customers with VPP offers and the continued benefits for existing VPP customers at the conclusion of their current benefit period.

If AEMO is committed to applying a discount, it should be based on average error values rather than the maximum errors. The UoM analysis suggests that the average error for a measurement resolution of 1s is 15% and the average error for a measurement resolution time of 200ms is 2.8%.[66] As AEMO is proposing to apply discount factors to ranges of measurement resolutions, the actual discounts applied should reflect the outcome within the range. For example, the discount applied for a measurement resolution that falls between 200ms and 1s could be set at 8.9% (that is, the midpoint between 15% and 2.8%).

**The existing VPP fleet should be grandfathered under the VPP Demonstrations FCAS Specification**

Simply Energy does not support the proposed transition of the Trial Participants to the MASS requirements on 1 July 2023.

AEMO stated that 'the impact of FCAS provision by existing Trial 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'.[67] As the VPP fleet is prevented from increasing the amount of FCAS offered to the market, Simply Energy considers that the fleet will not pose a risk to system security over time.

Simply Energy recommends, in recognition of the significant investments that have already been made by Trial Participants, that the VPP Demonstrations FCAS Specification be preserved for them. Simply Energy considers that it would be poor regulatory practice to change the rules governing investments that have already been made, especially where the benefits of doing so are not commensurate with the costs. Grandfathering the requirements that existed at the time of these investments would give 'early adopters' of VPP products a degree of certainty over what could be offered to them on renewal of their contracts with a market participant. This would also set the right tone for AEMO's future market trials.

sonnen:

The proposed period of grandfathering of the Trial Participants portfolios will do little to move the industry forward together and incentivise innovation in a competitive environment. sonnen does not believe 'squatters rights' support market development and maturity. Rather, to facilitate the rapid uptake of alternative and 'cost effective' DER technologies we expect AEMO to provide leadership in evidence-based market design.

sonnen suggest the contribution of DER to FCAS markets will develop faster if the grandfathering proposal is withdrawn and replaced with targeted work programs open to broad participation that leverages the contribution from the VPP Demonstrations and inputs to the current MASS consultation.

**Transitional arrangements for Trial Participants**

AEMO has proposed to implement a transitional arrangement for Trial Participants to come into effect when the revised MASS becomes effective and to close on 30 June 2023.

Trial Participants knew that the VPP Demonstrations brought no future guarantees of market access outside of the MASS measurement requirements at the end of the trial. sonnen participated in the trail (sic) on the expectation that the trial would be used to inform the development of FCAS markets and the MASS to better utilise the rapidly growing resource of distributed storage assets.

If as suggested by AEMO in the Draft Determination the VPP Demonstrations arrangements are distortionary and place power system security at risk then there is little to justify the continuation of the temporary arrangements unless specific objectives to further refine DER capability and expand the range of participation are being pursued.

As the proposed transitional arrangements do not include elements to further inform market development and integration of DER into FCAS frameworks the benefit to a few Trial Participants comes at the cost of:

- suppressing competition from better performing technologies
- providing less favourable market opportunities to equipment conforming with the MASS.

**Recommendation**

Maintain focus on developing DER FCAS capabilities from a broad range of providers.

…

[66] AEMO 2021, Market Ancillary Services Specification Consultation – Draft Determination, June, p.16.
[67] AEMO 2021, Market Ancillary Services Specification Consultation – Draft Determination, June, p.72.

sonnen notes that AEMO's proposed transitional arrangement incorporates the principle of discounting a contribution from DER based on the achievable accuracy based on the numerical analysis commissioned by AEMO from UoM. This analysis provides useful guidance to further developing appropriate discount factors, however the additional quantitative assessment of the consequence of deviations in FCAS scheduling and delivery quantities has not been established.

SwitchDin:

**4. Grandfathering Arrangements for Existing VPP Demonstrations Sites**

The Draft Determination requires that VPP Demonstrations sites will need to comply with the new MASS requirements by 1 July 2023.

Trial Participants have already invested significant capital to participate in the trial and the change in measurement arrangements will incur further significant cost as each site will require a new meter, plus truck roll/installation. ARENA have acknowledged that a change in measurement resolution will not have any effect on FCAS power delivery, only visibility of the delivery of a response. Given this, the additional cost of compliance, for no change in quality of power delivery, seems like an unnecessary burden for Trial Participants.

We suggest that, rather than requiring monitoring compliance for Trial Participants by a particular date, that meters or inverters are upgraded through the standard replacement and warranty programs to limit additional cost. We also suggest that any additional technical requirements for inverters for participation in the FCAS markets are only applied at the time of registration for FCAS, and not retrospectively applied to registered units.

Tesla:

- Tesla also believes that the transitional arrangements proposed for existing Trial Participants should be extended from 30 June 2023 to 30 June 2031. This 10-year transitionary period is more aligned with investment timeframes and ensures that private investment is not placed at risk.

…

BAU settings for VPP:

- Tesla recommends AEMO establish a strong framework setting out the BAU expectations for VPPs registering with AEMO.
- The work done during the VPP Demonstrations provides the basis for what the future market integration can and should look like.
- Tesla has developed a set of guiding principles – based on both the VPP Demonstrations key findings, as well as our response to the points raised in the Draft Determination. This is provided to AEMO as Attachment A of this response.

### 4.3.2. AEMO's assessment

The submissions raised several issues which, despite AEMO's amended measurement time resolution, are still relevant. These will be addressed in turn.

#### Grandfathering of VPP Demonstrations specification

The AER is supportive of AEMO's transitional arrangements and approach as the power system will be better prepared for increased FCAS participation from DER, while Reposit does not support the extension of the VPP Demonstrations. Reposit's view is that they are unlikely to deliver further learnings and that further extension would result in unnecessary cost to consumers.

Several Consulted Persons[68] submitted that AEMO should extend the VPP Demonstrations to permit further testing to occur in an attempt to address the issues AEMO has identified, while SwitchDin suggested that Trial Participants be permitted to upgrade their metering through their existing replacement programs. Other Consulted Persons would prefer that the VPP Demonstrations be made a permanent feature of the FCAS markets for all DER FCAS Providers[69].

[68] AEC, Members Energy, Origin Energy, SAPN, Simply Energy, SwitchDin & Tesla.
[69] Energy Locals, Evergen, Quinbrook & Shell Energy.

While AEMO appreciates the time and effort Trial Participants have dedicated to their participation in the VPP Demonstrations, they were participating in a *trial* arrangement. By definition, and by the explicit terms of the VPP Demonstrations, this means that the conditions of participation were never guaranteed to become a permanent feature of the FCAS markets.

AEMO is inclined to agree with sonnen's submission:

> sonnen suggest the contribution of DER to FCAS markets will develop faster if the grandfathering proposal is withdrawn and replaced with targeted work programs open to broad participation that leverages the contribution from the VPP Demonstrations and inputs to the current MASS consultation.

AEMO will not be making any decisions about any further trials requiring FCAS from DER until it has carried out the work detailed in the Roadmap (see Appendix D). AEMO's work program beyond 2021 is discussed further in section 4.4.

### Discounting

Several Consulted Persons[70] commented that the proposed discounts were unreasonable as they were based on the maximum error margin, or that they should be lower due to the minimal impact of the Trial Participants' assets on power system security, while sonnen suggested more analysis was required and Evergen suggested the real problem was the FCAS verification methodology which, as noted in sections 4.1.2 and 4.1.3, AEMO intends to address.

Shell Energy, on the other hand, considered that the discount to be applied to those Trial Participants using sampling rates of >50 ms but ≤200 ms was small enough to be made a permanent feature of the MASS.

Through the analysis on whether the error associated with slower sampling rates would decrease as the number of NMIs increases, and the changes to the FCAS verification methodology under Section 6, UoM concluded that the error associated with a measurement time resolution of 1 s would be significantly lower than 20% for an aggregated ancillary service facility. In particular, UoM's results show that for a VPP consisting of 10 NMIs capturing data at intervals of 1 s, the error would be approximately 5%. The FCAS Verification Tool would need to be updated to use the trapezoid method and the FDT would need to be identified using the ROCOF-based method to achieve this accuracy, which is intended by AEMO as discussed in section 6.

### Expanding the scope of VPP Demonstrations

Several Consulted Persons[71] asked that AEMO expand the VPP Demonstrations by:

- Allowing new participants to join the VPP Demonstrations.
- Allowing Trial Participant maximum bids to increase.
- Allowing Trial Participants to expand their participation in the FCAS markets.

The VPP Demonstrations are at an end, and between now and 30 June 2023 there will be a transition period for VPP Demonstrations participants to align to the MASS. There will be no further increases in the number of Trial Participants, and the total capacity for which they have been permitted to participate will be capped at the current maximum FCAS capacity each Trial Participant has been registered for, for the purposes of the VPP Demonstrations.

[70] AEC, Evergen, Hydro Tasmania, Simply Energy.
[71] AEC, Energy Locals, Evergen, Members Energy & Shell Energy.

### Commercial impact on Trial Participants

Tesla suggested that the Trial Participants be permitted to operate their VPP fleets for the remainder of their investment timeframe, while several other Consulted Persons commented on the investments made to participate in the VPP Demonstrations.

Simply Energy considers it is poor regulatory practice to change the rules governing investments that have already been made. As noted in section 4.6, the VPP Demonstrations documentation made it clear to Trial Participants that the VPP Demonstrations FCAS Specification was for the trial only, that the trial would end, and there was no guarantee that there would be any changes to the MASS.

The commercial impact on Trial Participants is addressed further in sections 4.5.2, 4.5.3, 4.6.2 and 4.6.3.

### 4.3.3. AEMO's conclusion

The VPP Demonstrations are at an end and AEMO is not proposing any substantive changes to its determination of the transitional provisions in the MASS, other than the discount factor to be applied to those Trial Participants whose Ancillary Service Facilities continue to capture data with 1 s measurement time resolution.

Based on the analysis from UoM and the proposed changes to the FCAS Verification Tool and methodology, AEMO has determined to amend the discount rates for VPP Demonstrations participants to 5% where measurement time resolution is lower than 200 ms but higher than or equal to 1 s.

## 4.4. Consultative Forum on the provision of FCAS by DER

### 4.4.1. Issue summary and submissions

In its Draft Determination, AEMO indicated its intention to continue to work with industry on identifying ways in which the provision of FCAS by DER could be addressed, an issue that several Consulted Persons made submissions on.[72]

AEC:

> The AEC generally accepts as part of an interim approach:
>
> …
>
> - That further collaborative engagement with industry via the consultative forum to facilitate progress towards a truly two-sided and customer centric DER market is required. This will provide the opportunity for further discussion on key issues. In this context the AEC believes that the possibility of using separate DUIDs and minimum bid levels to support a lower cost and more flexible future residential DER regime could be considered and explored.
> - The key role policy makers and ongoing policy work will have to play, along with iterative actions with the ESB, and the DEIP program for example

AGL:

> More, broadly we consider that the Draft Determination presents a range of important power system security concerns that warrant further attention by industry to support the development of appropriate measures.
>
> We would therefore recommend establishing a formal work program with industry to continue consultation on system security concerns. This could be managed in partnership with the DEIP.

Ausgrid:

> We welcome the acknowledgement that further work is required before changes are made to the location of where FCAS response is measured and are supportive of the establishment of a Consultative Forum. We

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

urge AEMO to consider how this Consultative Forum will interact with and leverage other mechanisms such as the ESB's recommendations and subsequent Maturity Plan, DEIP and various existing committees and working groups looking at standards and interoperability.

Ausgrid remains supportive of changes that allows for greater participation of diverse resources in markets and look forward to working collaboratively with AEMO and other stakeholders in the supply chain as we transition to a decentralised and renewable energy system.

CEC:

We note AEMO's intention to consult with industry outside of this consultation on the need for further studies of DER inverter behaviour and we will continue to support AEMO in this area of its work. However, it is important to consider separately the issues regarding issues specific to FCAS market participation by VPPs (specifically measurement resolution needed for verification of Fast FCAS performance, and measurement location) and the issues regarding inverter behaviour. It would be unhelpful if these issues are unnecessarily conflated. We welcome the proposal to establish a Consultative Forum as a vehicle for collaboration between AEMO and interested stakeholders. This submission outlines how AEMO and the industry could work together to address AEMO's power system security concerns.

…

**2.3 Risks of exceeding the limits of secure network operations**

The Draft Determination expresses concern regarding "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" and describes this as one of the risks "associated with the behaviour of DER inverters".

This is not a risk associated with DER inverter behaviour. It is a risk associated with management of distribution networks. In the short term, it could be managed with a process of registration of FCAS Providers to ensure that no feeder is at risk of being overloaded.

CEC members who are DNSPs have indicated that in the longer term this issue will be addressed using DOEs and that consideration is being given to long-duration operating envelopes for wholesale market exports co-existing with short-duration operating envelopes for FCAS. The work by SAPN undertaken as part of the Advanced VPP Grid Integration trial has demonstrated that the use of dynamic operating envelopes provides a model for safe and effective integration of large market-participating VPPs with the network, enabling VPPs to bid into FCAS markets and dispatch with confidence and without risk of breaching local network constraints.

The risk of exceeding secure network operations will not be limited to VPPs. Batteries responding to price events or other events recognised by algorithms will present the same risks for network operation. The solution to this lies in network management and dynamic operating envelopes. Leaving the MASS unchanged does nothing to address this risk. Nor would amending the MASS exacerbate this risk.

Recommendation 4: AEMO should work with DNSPs and other CEC members on measures to mitigate the risk of exceeding the limits of secure distribution network operation limits during FCAS response.

**2.4 Measurement of unexpected responses using low granularity measurement**

The Draft Determination expresses concern that unexpected responses from inverters might not be identified using low granularity measurement and cites the example of an oscillatory response going undetected if measurement is done at 1s intervals.

We are aware of the concerns outlined previously by AEMO[73]. We share AEMO's concerns regarding the risk of uncontrolled oscillations in response to grid disturbances. Devices that demonstrate this behaviour should be ineligible for FCAS participation, regardless of their measurement resolution.

We are not aware of any actual examples of oscillatory behaviour apart from the example reported by Reposit. Moreover, we understand that the inverter in question was never approved for FCAS registration.

The risk of oscillatory behaviour is not an argument for retaining the MASS in its current form. It is an argument for reviewing the laboratory test requirements for FCAS registration.

Any oscillatory behaviour of a particular asset type should be detected during the frequency injection test that every system is required to undertake as part of the FCAS registration process. If AEMO is concerned that oscillatory behaviour is not being detected, it should review the laboratory test requirements for FCAS registration.

[73] See Behaviour of distributed resources during power system disturbances, here

The process of testing inverters for FCAS participation would benefit from increased transparency, development of a set of agreed testing protocols, and publication of a list of all meters approved by AEMO for Fast FCAS. This could be undertaken as a best practice guide for industry, with a view to moving toward an Australian standard in future. The CEC would be happy to collaborate with AEMO in such a process.

...

Recommendation 5: AEMO should review its inverter testing and certification requirements for FCAS registration so that inverters that display oscillatory behaviour are excluded.

**2.5 Proposal for a process to address power system security concerns**

We welcome the proposal to establish a Consultative Forum as a vehicle for collaboration between AEMO and interested stakeholders.

The CEC recognises that one of the key issues that AEMO is currently facing is the lack of reliable data from DER which can better help AEMO plan for the high DER scenarios. This creates issues both for AEMO, and for CEC members as this lack of consistent and accurate data with visibility into what is happening on the low voltage networks has resulted in some rushed solutions and risk-averse actions in the last few years. The most telling example of this was the recent VDRT test requirements. These were released by AEMO and rushed through the SA Smarter Homes program in 2020 with limited consultation. This resulted in industry investing tens of millions in compliance costs. We have now been informed by AEMO that this test has been ineffective in solving for ride-through issues and has not created any noticeable system security outcomes. A collaborative process of trials and industry provision of data could have achieved a better outcome with minimal expense and lack of negative industry impact.

During the VPP Demonstrations, AEMO developed an application programming interface (API) to capture real-time fleet and asset level data from Trial Participants and DER that had previously been invisible to AEMO. This data was invaluable for fault detection and forecasting behaviour, however AEMO has opted not to maintain the API. This is a bizarre decision and raises concerns about the future alignment of AEMO processes with DNSPs who are primarily looking at API-based interfaces. If AEMO uses a different system for asset visibility, forecasting and dispatch, it is unclear how this is can be properly coordinated with the work being done by DNSPs.

We propose to set a joint work program to both address DER specific power system security concerns, and better understand the data needs of AEMO. This process should look at all the ongoing work that AEMO has underway currently that would benefit from DER datasets (the CEC is aware of Project Match and Project Edge as priorities) as well as identifying key data gaps and potential concerns from AEMO's perspective. This joint DER data work program could then be presented to industry with clearly defined goals and measurable outcomes clearly outlined and prioritised. As a starting point we believe that this forum could be used to convene DNSPs, industry and AEMO to address the power system security concerns flagged in the Draft Determination to better enable full DER market development. This approach will naturally lead to a better articulation of the data needs of AEMO and understanding how industry can better support. The process could also involve an additional phase of VPP trials, designed to address the power system security concerns that AEMO has identified in the Draft Determination.

Recommendation 6: AEMO and CEC should formalise a collaborative work program to address AEMO's power system security concerns relating to DER inverter behaviour.

CS Energy:

Understanding the behaviour and response of any market participant is crucial to the secure, reliable and efficient operation of the power system and concessions should not be made for any technology or business model. CS Energy considers the approach outlined in the Draft Determination to be prudent, placing the stability of the power system as the priority while outlining a pathway to address the technical concerns of DER participating in FCAS markets. FCAS play an integral role in system security and AEMO needs to have confidence in the performance of all participants as stipulated in the MASS.

DEMSA:

The Draft Determination indicates AEMO intends to establish arrangements for further industry consultation about the development of FCAS, including to determine how to progress DER participation in the FCAS markets. We welcome this commitment and encourage AEMO to provide more detail about the proposed process, including a timetable and indicative work program based on priority issues raised in this review, with its final determination.

Several stakeholders made suggestions for alternative technical solutions, with many pointing to the possible suitability of 100ms or 200ms sampling rates, noting the potential for alignment with ASINZS 4777.2:2020, which commences later this year. The Draft Determination indicates AEMO is not confident that a reliable evidence base exists to support adoption of technical solutions other than the two options

presented. We note that some submissions have queried whether the existing 50ms requirement itself should be reviewed. Given the degree of convergence around 100/200ms sampling rate offering a potential pathway, it would seem opportune for this to be further investigated as a priority in a DER FCAS work program or trial.

The Division therefore also supports continued provision in the MASS for trials of new technologies. This current consultation has highlighted the VPP Demonstrations have not sufficiently resolved questions to support the long-term integration of its alternative measurement requirements. As new technologies and solutions emerge, together with the imminent requirement to develop new the specification for the new 'very fast' service, it is reasonable to expect the need for trials could be greater in coming years than in the past.

The provisions for the conduct of trials would benefit from greater clarity of requirements and conditions under which any new trials might proceed. The MASS (v6.O) contains minimal but important statements about possible boundaries for trials, including being time-limited and subject to conditions such as caps on capacity. It is not clear that these create any "artificial barriers" to the commencement of trials, as evidenced by the VPP Demonstrations. We consider that these are important basic terms to retain in the reformatted MASS and recommend re-instating and enhancing the existing provisions, with discretion continuing to rest with AEMO to authorise a trial and to identify the particulars on a case-by-case basis.

This consultation has also highlighted the need for investigations to be in close collaboration with industry participants, to build wider understanding of DER capabilities and any changes to MASS requirements. A criticism received through this process related to the lack of visibility of the data and detailed technical results Of the VPP Demonstrations VPPs for stakeholders to provide an informed assessment Of Option 2. Consideration therefore might be given to how to improve transparency around the initial design of trials and other investigations, as well as wider sharing technical performance, data, and other results with market participants. This would support improved stakeholder confidence in any future MASS amendment.

In the next 18 months, AEMO will be required to revise the MASS to specify two new 'very fast' FCAS, as per the recent determination by the AEMC.

These services will be specified for the first time and the development process potentially could offer the opportunity for further investigation of many of the issues raised in this consultation.

DEWLP–V:

The Victorian Government recognises AEMO's role is to manage the system security and reliability of the NEM. We strongly support this objective and acknowledge AEMO must be satisfied that aggregated DER participation in FCAS maintains a secure and reliable power system. However, our view is that the draft determination could have unintended longer term impacts that may not have been fully incorporated into the analysis. The Victorian Government encourages AEMO to consider how its Draft Determination could be revised to ensure we continue to adapt to unprecedented changes to consumer preferences and our energy supply mix, without compromising system security.

**DER participation in ancillary services markets is key to addressing system security issues and capturing the value of DER for all energy users**

AEMO's 2020 Integrated System Plan notes DER generation capacity across the NEM could double or even triple by 2040, holding grid demand relatively constant. Based on data from the Clean Energy Regulator, there are now more than 554,000 small-scale solar installations in Victoria, and residential rooftop solar capacity is forecast to increase 400% from 2020 to 2050.

Battery storage will become a key part of the electricity system going forward, as they can provide a wide range of social, economic, and technical benefits. Depending on the battery type, these benefits include network support, renewable energy integration, provision of wholesale energy and ancillary services, reliability in outage prone areas and virtual storage services for customers. Battery aggregation offers a competitive alternative to services from larger resources, with the added benefit of encouraging energy users to make decisions which support the stable operation of the electricity system. Realisation of these benefits will often depend on the effective integration of batteries in ancillary services markets, as FCAS is a primary revenue stream for many batteries.

...

**A roadmap with clear milestones would help provide confidence on AEMO's strategic intention to effectively integrate DER into markets**

System reliability and security is a key priority for the Victorian Government. As renewable energy comes online and thermal generators retire, the electricity system will need to evolve to meet sudden changes in generation. DER offer a unique opportunity to manage some of these challenges, but this is subject to the right market and regulatory conditions.

The Victorian Government's view is that if AEMO were to maintain the requirements in its draft determination, it should also provide industry with confidence that it has an intention to support DER market participation in a timely manner. While it is recognised that there are unresolved questions, such as the underlying power security issues posed by inverter behaviour and the impacts of measurement accuracy, more work is required to fully understand these issues.

While the Victorian Government supports AEMO's proposal to establish a Consultative Forum to progress issues related to FCAS and DER inverter behaviour, the final determination would benefit from more clarity on the way forward. The Victorian Government encourages AEMO to consider publishing a roadmap for DER participation in FCAS, or ideally, a broader pathway to integrate DER into its energy and other ancillary services markets, such as the upcoming fast frequency response FCAS. This roadmap could outline what further work needs to be undertaken to have confidence in inverter behaviour, as well as what interim arrangements could be put in place, and include a commitment to reconsider amendments to the MASS if supported by findings. The roadmap could also consider the impacts of emerging technology, such as dynamic operating envelopes, which can support DER market participation within network limits. Critically, the roadmap ought to include clear milestones, which provide industry confidence on the timing of next steps.

In parallel, AEMO could consider a transition period for aggregators outside of the VPP trial. This could be supported by an accuracy penalty and require VPPs to meet stricter requirements over time. It could also seek to 'meet industry in the middle', for example, by relaxing some of the conditions of the MASS while not completely mirroring requirements in its VPP Demonstrations.

**The Victorian Government's Solar Homes Program Battery Aggregation Pilot could be used to further test DER participation in ancillary services markets with the right protections**

Solar Victoria has allocated 2,000 battery rebates over the 2021-22 financial year to support consumer participation in approved battery aggregation projects. From early 2020 Solar Victoria has undertaken extensive market research and engagement to inform the program's design, which will encourage technology and market innovation, while creating additional value for Victorian consumers and the broader community.

The pilot program was officially launched in April 2021 with an Expression of Interest (EOI) process that closed on 14 June 2021, before AEMO released its draft determination, which received keen interest from small and large industry players.

The Victorian Government is concerned that AEMO's draft determination would have unintended consequences on the types of projects that could be trialled under the program, impacting its viability as well as the delivery of key Victorian Government objectives. For example, the current requirements make it more expensive for VPPs to participate in certain FCAS markets. Many aggregators rely on 'value stacking' to make their service offerings attractive to energy users and financially viable, and FCAS is a key component of this value.

The Victorian Government requests AEMO to allow Solar Victoria's aggregation pilot program to have the same conditions as the VPP Demonstrations for a transition period. The Victorian Government also encourages AEMO to consider whether other pilots in the short term could be subject to a transition period. This would allow pilot projects to make the transition to MASS requirements over time, without impacting DER innovation. These trials could deliver mutual benefits by informing some of the questions raised in the MASS draft determination, for example studying the impact of different measurement sampling rates, measurement locations or the effect of system disturbances. In the case of Solar Victoria's pilot program, the DELWP would also collaborate with AEMO to set appropriate safeguards, which could include knowledge sharing, accuracy discounts, or specific technical requirements.

Discover Energy:

**1. System security provisions should recognise the role of flexible DERs in mitigating their own integration risks.**

In both the draft MASS and its justifications presented through the consultation process, AEMO has indicated that it has several concerns with regards to system security and the role of DERs in the network. At this stage it appears that the process for evaluating the DER contribution in this regard has not been completed and Discover Energy would suggest that major changes to the MASS are not made until better, more collaborative and forward thinking assessments of the role of DERs are completed.

DERs are part of the network, and will become increasingly so as cost effectiveness and electrification of transport increases. AEMO should adopt an approach that incentivises the implementation of flexibility mechanisms that support DER integration as their hitherto unrecognized potential to support the grid exceeds the potential risks they pose to system security.

AMEO's concern with "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" highlights the general risks of network management. This is not unique to controllable DERs, but conversely is exactly the argument that there is value in the ability to control the flexibility of DERs.

This sentiment has been echoed by the AEMC, who recently recognised the importance of harnessing the flexibility of DER operation through VPPs and other forms of aggregation and its Draft Determination on integrating energy storage systems into the NEM. DER control is the solution, not the problem, and as such mechanisms for control should be monetarily incentivised through access to grid services.

**2. A comprehensive redesign of ancillary services is required: DNSPs are also working in this area.**

Redevelopment of the ancillary grid services market is required and should be conducted in coordination with DNSPs (amongst others) to ensure that services reflect local as well as global grid security requirements without conflict. Conflict has already been identified with the incoming AS 4777 standard requirements, and DNSP initiatives to control local loads and limit exports dynamically will complicate these issues further.

This is a critical aspect for the consideration of DERs as they are typically connected at low voltage network levels in contrast to larger assets which the MASS (FCAS and other ancillary services) have been primarily designed to service. This is not a criticism of the design of the current regime, merely an acknowledgement that it has been designed for large, high voltage resources of which DERs are not. Acknowledging that this is beyond the remit of the current MASS review, underlines our position that it is better to make changes to the MASS only when such a comprehensive review as we are suggesting can be completed.

…

**4a. Testing and Standardisation for DERs**

Within this context, it should be reflected that it is either highly difficult or impossible to conduct tests based on frequency injection for DERs, and as such their testing outside of lab testing is, currently, determined by the availability of grid conditions that replicate their intended implementation. The bottom line is that it is not sustainable for testing to be dependent on a "worst/extreme case" scenario occurring in the grid to prove aggregated DERs' limits of response as these events are far too infrequent. An alternative to this method of determining the response of aggregated DERs should be investigated and determined.

EA:

EA is appreciative of AEMO's efforts to investigate whether current MASS settings are appropriate in light of ongoing and significant market, technological and operational change. Broadly, EA understands and accepts the Draft Determination, including the decision not to change the measurement time resolution and measurement location point at this time. However, we consider collaborative engagement and discussion of these issues with industry must continue via the Consultative Forum. This is so that an economic, competitive and customer-centric, two-sided DER market results. Further detail on these and other determination elements are provided below.

…

EA also notes that solving these technical issues is only half of the challenge in delivering robust, competitive and efficient DER solutions to customers. Final ESB recommendations on integrating DER and flexible demand into the future NEM have not yet been endorsed by Government. Similarly, the AEMC has not finalised how hybrid energy systems, co-located BTM assets and integration of other energy storage solutions should be regulated. Unfortunately, lacking complementary, coherent and pragmatic regulatory frameworks, the value from even with the most optimal DER technical settings for customers will not be fully realised.

Given these factors, EA agrees that the MASS measurement time resolution and location settings should not be changed at this time. However, we consider it critically important that continued collaborative engagement on these issues with industry occurs via the mooted Consultative Forum and other regulatory processes. This is so that DER market development, innovation and competition continues to advance. To this end, EA has included a list of potential future topics for discussion further below.

…

**Consultative Forum**

As noted above, EA strongly supports the proposal to establish a Consultative Forum to investigate other MASS issues that could not be fully addressed in this consultation. For example:

- inverter behaviour and related measurement concerns, including whether using a variety of frequency set-points and different DUIDs for small customers would help to alleviate system security concerns;

- the case for separating frequency controllers and FCAS metering requirements;
- whether adjustment of minimum bid and other market settings might facilitate greater DER market innovation and participation;
- limits guidance and management of non-frequency responsive FCAS;
- how delayed FCAS could better support NEM frequency outcomes;
- how Fast Frequency Response is best incorporated within the MASS;
- continued development of Regulation FCAS specification elements;
- how the technical envelopes and operating conditions of distribution networks can be adjusted to facilitate greater DER penetration and service provision; and
- whether greater alignment with specifications in other standards such as AS/NZS 4777.2:2020 is warranted.

Beyond promoting more considered deliberation of technical concerns, we consider regular issues assessment and engagement via the Consultative Forum will make future MASS updates easier and swifter. In this regard, we look forward to working with AEMO as part of the Consultative Forum and would be happy to discuss that initiative and this submission further with you as required.

ECA:

We support changes that encourage and enable DER to participate in providing these fast frequency support services and which would unlock the value these resources can provide to the wider system. We ask AEMO to consider if further analysis can establish a pathway that mitigates the system security risks that their Draft Determination identified, while also supporting DER to participate in the provision of FCAS and other system services.

We believe our future energy system should be modern, resilient, and flexible, whereby the decentralised system can safely and reliably provide flexible energy supply, storage, and demand. It is a consumer priority that we balance objectives concerning system transition with system reliability and security. As AEMO acknowledges, VPPs can play an important part of the future energy system and a two-sided marketplace. Options for their participation in the FCAS market that are stable and fair need to be investigated.

Empower Energy:

We note that AEMO has undertaken some significant and positive steps to understand the value potential of DER and potential adjacent issues. The VPP Demonstrations and the UoM report on metering accuracy are strong pieces of work that should serve to help shape and define future MASS reviews and any adjacent regulation. With a subsequent MASS review likely to commence (per discussions with AEMO) in 2022 – and seeking to incorporate FFR – these recent work pieces should be front-of-mind in helping shape future MASS considerations. It is noted that if UoM's contribution had taken place earlier in the MASS review process it may have proven more impactful in shaping MASS outcomes, and we would urge AEMO to consider earlier contributions of this nature in future MASS reviews.

We also note that MASS review forum discussions often concerned notions of averaging in digital signal processing and metering costs. Signal processing is a well-established science and the cost of MASS-compliant metering, once researched, is established in the literature. Accordingly neither matter should be continually treated in open forum as subjective in nature. We respectfully suggest in future that AEMO undertake to guide stakeholder discussions to effective and factual ends such that key matters may be discussed as effectively as possible.

…

DER participation in established markets is a complex and wide-ranging matter that raises a number of questions which at the present are not completely or sufficiently answered. Some matters raised throughout this MASS review and VPP Demonstrations that remain open include:

- What sampling frequency and accuracy specifications are adequate minimum requirements to characterise quality of response to FCAS market participation (particularly with inverter-based devices),
- The degree of trust that can be placed in RoCoF-based triggering schemes (particularly where e.g. internal PLL circuitry is used to sense RoCoF events as opposed to higher-accuracy instruments used to measure response) and what effects imperfect responses may have at high DER penetration,

- Whether assets complying to metering specifications less than the current MASS can adequately respond in manners addressing power system security issues, and if so (or not) from what perspectives can these responses be judged to be competitive,
- What appropriate compliance mechanisms should be for response and measurement, particularly given that the MASS was originally implicitly written for specialist power quality measurement instrumentation – typically being calibrated in a traceable manner pre-use – and cost-effective DER necessitates (despite significant cost reduction since the advent of the NEM) inherently lower-cost approaches.

The above are a limited selection of open issues requiring resolution prior to a structural review of the MASS allowing DER integration at performance standards below those currently in place, some of which may shift in magnitude and relevance pending the inclusion of FFR in the MASS and whatever access requirements may be enacted for participation in relevant markets.

Empower Energy remains committed to working with AEMO towards a future where DER is better integrated into the NEM in ways realising its ultimate potential in an ever-more-distributed, more intelligent and resilient power system offering customers lower cost and greater value. We embrace the notion that access barriers better reflecting the state and potential of DER industry are worthy of consideration, particularly where adjacent issues essential to power system operation can be met. Whilst an adequacy of outcomes was not met in the current process to justify structural change to the MASS, we look forward to working with AEMO in future processes leveraging knowledge recently gained in the current MASS review and other concurrent activities.

ENA:

We must ensure AEMO's work on the MASS (and by extension the wider implementation of VPPs) is evidence-based, consultative and consistent with industry reforms being undertaken through the ESB P2025 program and others.

**Key messages**

- As the energy transition progresses, system services will need to be implemented cooperatively and sourced from a larger variety of stakeholders such as VPPs and networks
- The use of DOE has been demonstrated as an effective way of increasing customer participation, providing market benefits while still operating within the physical limits of the network
- We agree that metering does need to be accurate

**A cooperative and collaborative future**

As the mix of where generation is increasingly sourced from the distribution network, it will be critically important to ensure a robust framework of cooperation is established between AEMO, DNSPs, traders and customers.

As customer owned DER plays an increasing role in supporting the local and entire power system, while delivering customer aspirations, it is essential that those parties best placed to manage the transition and any risks to the safe, secure and reliable operation of the distribution and wider power system, do so.

It is unlikely to be technically feasible or economically efficient to plan, manage and operate the entire power system centrally. Distribution networks are already collaborating with AEMO on ways to deliver optimal power system outcomes in a way that minimises the need for duplication and avoids increased costs to customers.

Networks in both Distribution and Transmission are getting ready for this by envisaging a future where system services are also offered by network assets where there is a shortfall in the competitive market and when it is economically efficient to do so.

**Dynamic Operating Envelopes are a key step**

To maximise the impact and participation of VPPs while still operating a stable distribution network is end the goal and DOEs are a key capability to achieve this.

The SAPN Knowledge Sharing Report[74] concluded that DOEs "…enabled higher levels of export power than would be otherwise possible while participating in the wholesale energy and FCAS markets, while still remaining with the safe operating capacity of the local network."

Importantly, VPPs must ensure that their separate dispatch engines are capable of interacting with the API of the relevant network and that their bids take into account the distribution systems capacity limitations.

[74] https://arena.gov.au/projects/advanced-vpp-grid-integration/.

While SA currently leads the adoption of VPPs, ENA believes that eventually they will continue to be developed as DER adoption continues to grow nationally. This is a field where networks are actively collaborating and devoting significant resources to understanding the role of VPPs and DOEs, particularly to ensure that the customer-facing aspects of DOEs are as nationally consistent as practicable.

Enphase Energy:

The power system security concerns raised in the Draft Determination go beyond just the security concern of VPPs and the provision of Fast FCAS.

Enphase recommends that concerns be raised and addressed via a national forum and through the adoption of standards around DER security. For example:

- DEIP, Maturity Plan with the aid of the Australian Standards committee
- EL-054 – Demand response capabilities and supporting technologies for electrical products
- EL-064 – Decentralised electrical energy and grid integration of renewable energy systems
- EL-065 – Management of Network Assets in Power Systems.

AS/NZS 4777.2:2020 will improve power system security with the implementation of strict VDRT and AGF requirements.

The higher accuracy resolution requirements for frequency, voltage, and power measurement will better align with grid stability requirements once mandated on 18 December 2021.

PIAC:

**The path to the future energy system**

AEMO's CEO, Daniel Westerman, recently outlined AEMO's goal to be able to handle 100% instantaneous renewable energy on the grid by 2025, an ambitious goal that will require the optimisation of all tools at AEMO's disposal. Unlocking the value of flexible demand and DER will be essential to achieving this and was a priority for the ESB in its Post-2025 market design process. Mechanisms such as VPPs and demand response will need to be mature and widely used, requiring a clear development path well before this time. The Draft Determination does not provide a clear path for a mature VPP FCAS market in 2025.

Shell Energy:

Shell Energy supports AEMO's proposal to develop an industry working group to further examine issues relating to FCAS. We recommend that AEMO re-establish the ancillary services technical advisory group that has previously informed AEMO's work. We consider that this group can bring valuable expertise and raise issues that warrant deeper consideration. It will be important for group participants to be able to bring issues forward for AEMO to respond to. Shell Energy would be eager to participate in such a group.

Solar Analytics:

We support efforts to continue to understand issues around DER response to system disturbances, including with our participation in the ARENA-funded MATCH project with AEMO and UNSW.

**Conclusion**

In summary, we accept there are concerns around changing the MASS at this time, but we believe these concerns have not been sufficiently analysed with the available evidence. We encourage AEMO to do so, such that we can have a meaningful consultation as an industry on whether they form a material risk to FCAS delivery under Option 2, compared to Option 1, and if so, how we can overcome them.

SolarEdge:

Critical components of the review process such as perceived power system security concerns were introduced late in the review process as a barrier to amendment of the MASS. We note that the CEC has also been working closely with AEMO to address the power system security concerns cited in the draft determination and that AEMO has articulated an intention to consult with industry outside of this consultation on the need for further studies of DER inverter behaviour and as such SolarEdge are very willing to offer continued support to AEMO in this area of its work.

…

SolarEdge support the CEC proposal to set a joint work program to both address DER specific power system security concerns, and better understand the data needs of AEMO. The process should look at all the ongoing work that AEMO has underway currently that would benefit from DER datasets (such as

Project Match and Project Edge as priorities) as well as identifying key data gaps and potential concerns from AEMO's perspective.

This joint DER data work program could then be presented to the broader industry with clearly defined goals and measurable outcomes clearly outlined and prioritized.

As a starting point this forum could be used to convene DNSPs, industry and AEMO to better understand the power system security concerns flagged in the Draft Determination to hopefully enable full DER market development.

This collaborative approach will naturally lead to a better articulation of the data needs of AEMO and understanding how industry can better support.

SolarEdge welcomes the proposal to establish a Consultative Forum as a vehicle for industry collaboration between AEMO and interested stakeholders.

**7. Recommendations**

1. AEMO should proactively look to establish a Consultative Forum via the CEC with AEMO as a vehicle for collaboration between AEMO and interested stakeholders.

…

Tesla:

AEMO is at a point where increased focus needs to be given on how to best integrate DER as a critical part of Australia's energy mix. We cannot plan for 100% renewable energy by 2025 if DER is not considered. And planning for DER cannot occur without considering how to best integrate DER into existing and emerging markets Tesla believes that the best pathway for AEMO is achieved by moving DER from being predominantly passive (as is the case today) to actively controlled and participating in markets. The MASS Review can provide a tangible investment signal to accelerate the development of technology that benefits consumers whilst enhancing AEMO's obligations under the NER.

The alternative scenario, which will largely be driven by the lack of available market incentives and clear pathways for market integration of DER, is that in 2030 AEMO has >50GW of uncontrollable, passive, invisible DER serving the needs of individual customers, and creating system security concerns for the rest of the NEM.

From a first principles perspective the outcomes of the Draft Determination do not appear to support an active DER future – rather it may set the basis for the alternative scenario where the NEM is dominated by passive, customer serving DER. Tesla is concerned that the approach proposed in the MASS Draft Determination will significantly limit the development of innovative VPPs in Australia and as a result will remove a number of the incentives that currently exist for consumers to invest in BTM storage that positively contributes to the electricity market.. It will also reduce the incentives for OEMs to invest in the development of fast, price-responsive EV charging infrastructure capable of providing FCAS response.

Tesla is committed to working with AEMO to establish a scalable, sustainable market framework for VPPs participating in all markets. We recognise that this is a structural shift from how all market frameworks and infrastructure was set up. While this will take time and concerted effort, Tesla believes that this is critical for the future of the NEM to best manage the growth of DER including Electric Vehicles.

…

**7.1 Plan for managing power system security risks**

As noted above, Tesla believes that the best approach for managing these power system security risks, is through an ongoing, iterative work plan. These risks will not, and should not, be addressed through the MASS review process. Tesla recommends considering the range of forums that currently exist that can be used to bring together the expertise of AEMO, NSPs and industry.

In the long-term, Tesla believes that the DER Governance Committee approach proposed by the ESB in their DER Governance Rule Change[75] proposal. In the interim, Tesla believes that the following forums could be utilized to provide oversight on governance arrangements, and assist with the ongoing management of these power system security risks flagged in the Draft Determination:

- ESB Maturity Plan,
- A new DEIP committee, or

[75] https://www.aemc.gov.au/sites/default/files/2020-09/ERC0319%20RRC0040%20Rule%20change%20request%20pending.pdf

- A fit for purpose industry and AEMO committee – Tesla supports the Consultative Forum idea and would be happy to work with AEMO on dealing with the bigger DER concerns that AEMO has flagged.

AEMO should be a key stakeholder in supporting reforms, education, and behavioural change to manage these power system security risks. However, we do not expect AEMO to be the lead organization. This should be a joint work program from all stakeholders that have interests in achieving sustainable VPP growth and supporting scalability of a VPP work program. Maintaining the MASS in its current forum will not resolve these issues.

### 4.4.2. AEMO's assessment

While all the expressions of support for a Consultative Forum are welcome, AEMO notes that the matters that need to be addressed are technical as opposed to policy issues, so AEMO will primarily request technical experts to attend.

Several Consulted Persons have provided suggestions of issues that the Consultative Forum needs to address, including power system security concerns, inverter behaviour, the impact on distribution network limits, the application of AS/NZS4777 2:2020, and collaboration with other working groups. The Consultative Forum may also explore other technical issues associated with FCAS provision from DER if participants become aware of further relevant material considerations.

The Consultative Forum will address these and other technical issues, so AEMO intends to invite technical experts to assist its deliberations. Policy issues will be determined only after these technical issues are addressed to AEMO's reasonable satisfaction. It is also noted that these issues extend beyond the scope of the MASS and their investigation and resolution is likely to span multiple AEMO and Participant projects or initiatives. The intent of the Consultative Forum is to 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 NEM and address the concerns with DER inverter behaviour, although MASS development alone will not resolve these issues.

Some stakeholder submissions also questioned why the API to receive operational telemetry from VPP Demonstrations participants was shut down when the knowledge sharing reports showed the value of this data. The API was developed to meet the VPP Demonstrations objectives, and specifically to enable AEMO to observe how VPPs respond to wholesale energy price signals. It was not related to VPPs delivering FCAS. As the VPP Demonstrations close there is no requirement for VPPs to share operational telemetry with AEMO, so there is no case for market participants to fund the continued support of the API and related systems. The VPP Demonstrations have shown[76] the need for this data to be available to AEMO going forward, and the appropriate regulatory pathway to obtain it is the Rule change proposal for Scheduled Lite that AEMO is currently developing.

### 4.4.3. AEMO's conclusion

AEMO is publishing a road map with this document to indicate the work that needs to be carried out in considering the provision of more FCAS by DER. This can be found in Appendix D.

[76] See page 61 and the recommendations on pages 9-10 of the VPP Demonstrations Knowledge Sharing Report #4. Available at: https://aemo.com.au/-/media/files/initiatives/der/2021/vpp-demonstrations-knowledge-sharing-report-4.pdf?la=en.

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

### 4.5.1. Issue summary and submissions

As noted in the Draft Determination and repeated in section 2.1, when making any determinations, such as whether to amend the MASS, AEMO is required to have regard to the NEO. Several submissions touched on the application of the NEO, which warrants further discussion. Extracts are cited below.[77]

ACF:

> DER will play a key role in supporting Australia's transition to renewable energy. Unlike grid-scale developments, DER enables everyday Australians to participate in renewable energy generation. This has the joint benefit of enabling private citizens to directly invest their capital in renewable energy projects, while reducing their household electricity costs. For many Australians, batteries only become viable when coupled with the financial benefits realised by participation in a VPP.
>
> Under the VPP Demonstrations we have already seen a number of significant social equity programs involving VPPs that expand the reach of renewable energy to marginalized community members. The SA VPP, designed and managed by Tesla, supported by the SA Government, ARENA and the CEFC, is enabling thousands of SA Housing Authority tenants to receive access to renewable energy, battery backup and cheaper energy rates.
>
> In addition, AGL, Simply Energy and Sonnen (amongst others) all have VPP market offers that appropriately reward customers for the use of their systems in electricity markets. The Victorian Government has just launched a battery aggregation (VPP) pilot with the express intention of benefiting both individual households as well as the broader Victorian public.
>
> ACF's Economic Recovery Plan, released on 14 May 2020 provides a clear pathway to create secure, sustainable jobs and industries centred on clean energy. To achieve this, the Government of Australia, AEMO and the AEMC must ensure that restrictive and burdensome barriers to DER and VPPs are removed unless justifiable on social equity or system security grounds.
>
> **Renewable Energy Transition**
>
> ACF is concerned that incumbent fossil fuel generators and some retailers are 'gaming' the NEM in a way that maximises their own profits at the expense of consumers. As Australia's electricity system was progressively privatised, governments lost the ability to operate them in the public interest. DER, such as solar PV and battery systems, enable consumers to fight back and alter market forces back towards consumers. These systems are especially beneficial when aggregated under a VPP.
>
> VPPs enable consumers to receive financial benefits for providing grid support services. These financial benefits help incentivise the purchase of battery systems that store excess solar generation and help with minimum demand constraints faced by the NEM. By reducing minimum demand issues VPPs will ensure that governments do not have to increasingly resort to blunt instruments like SA's Smarter Homes regulations that may penalise households that invest in residential renewable energy generation.
>
> ACF believes that the MASS should be amended to enable VPPs to provide the full suite of FCAS without burdensome reporting requirements. This would provide policy certainty that will drive increased investment in home energy storage and VPPs, helping to reduce overall energy costs for consumers and lower Australia's carbon emissions. These changes would also be consistent with the recent rule changes published by the AEMC that acknowledge the benefits and challenges of our evolving two-way electricity grid.
>
> AEMO must not just consider the current capacity registered to provide FCAS, but potential future capacity and investment that will be curtailed if the MASS isn't adequately improved. Increasing incentives for Australian households to invest in household solar and battery systems in a way that benefits the community will ensure that we are able to remove polluting coal and gas from our energy system. This will reduce Australia's impact on global climate change and help protect nature across our planet.
>
> **ACF Recommendations**
>
> 1. AEMO should be supporting DER and VPPs where possible as they are a low cost and democratic way for consumers to reduce their carbon emissions and transition Australia's electricity grid to net-zero emissions as soon as possible.

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

2. The MASS should be updated to ensure that it does not include unnecessarily burdensome reporting conditions for VPPs to provide Fast Frequency Response (sic) services.

AEC:

… the AEC:

- Is concerned that the Draft Determination would impose significant costs on Trial Participants and would directly impact the value that can be passed through to VPP customers in the future.
- Believes that the identified measurement risks are manageable, with some time and effort, and of minimal impact to system security. Whilst the AEC supports in principle the interim retention of measurement time resolution the proposed requirement to provide 50ms measurement resolution for Fast FCAS response may be uneconomical for Trial Participants.

…

The AEC understands that some of its members involved in VPP trials have already met with AEMO to discuss their concerns with the Draft Determination. We also understand that they have shared some preliminary information VPP costs and revenues and how the Draft Determination would impact the viability of their VPP. We urge AEMO to be mindful of the commercial impacts of the draft given the disclosures made to them by our members to ensure they are aware of the potential, if unintended, consequences.

AGL:

To determine appropriate technical specifications for BAU operations, AEMO will need to effectively balance the system security needs with the strategic intent to facilitate DER participation in FCAS markets. In this regard, we would urge AEMO to consider the potential for alternative options to address any systems security risks that may prove more effective and cost-efficient for market participants.

…

**Sampling Rate**

To guard against the risk of limited competition as the DER services market matures, we would recommend AEMO carefully consider the extent to which Trial Participants are able be able to meet the proposed specifications, having regard to hardware costs, and whether such additional costs are justified based on the anticipated system security benefits.

…

We also consider a range of alternative options may be more effective in address system security concerns whilst also proving more cost-efficient for market participants. Potential options include more rigorous management of AEMO's frequency injection test and system firmware coupled with a discounting of fleet capacity. The Draft Determination does not appear to have sufficiently considered these alternatives.

…

… we would recommend AEMO … commission further test analysis to confirm whether 100 or 200ms measurement granularity is satisfactory for the purposes of AEMO's market settlement systems. Following the conclusion of that analysis and before confirming the sampling rate specification for DER assets, AEMO should undertake a robust cost benefit analysis of all available options, considering:

- The diversity of OEMs seeking to participate in FCAS markets and the cumulative cost of the uplift of their hardware, software and cloud-based systems that will ultimately be borne by customers;
- The anticipated benefit in FCAS market cost reduction and commensurate savings for consumers that would result from scaled DER participation in frequency control markets;
- The likely cost impact of upgraded metering technology, including insights from providers such as AGL that:
  - Many consumers are unlikely to purchase a more expensive battery system upfront (if the upgraded meter is an add-on cost);
  - Adding a new meter after install will increase the cost of a compliant metering system significantly; and
  - Including the improved measurement devices in all systems regardless of whether the customer chooses to have them or not will increases costs for all consumers and amount to some customers cross subsidising the purchase of others.

CEC:

The CEC strongly supports initiatives to enable VPPs to have full market access and participation by customers on an opt-in basis. The risk of leaving the MASS unchanged is that the additional costs involved will dampen VPP uptake resulting in a high proportion of passive DER. It is important that the market enables large and small owners of energy storage to access the full value stack to facilitate investment in energy storage within the energy system. Residential batteries aggregated in VPPs have the potential to add enormous value in maintaining system security and frequency stability due to their ability to provide extremely fast frequency response and synthetic inertia.

…

### 3.3 The cost of high-speed data capture and storage

The requirements proposed by AEMO would necessitate installation of a separate high-speed meter as the data capture needs to be based on measurement at the connection point. AEMO has requested clear evidence of the additional costs of becoming compliant with the current MASS – noting that the diverse range of statements on costs (without much supporting evidence) in the first round of submissions did not provide a clear picture on this.

We have been advised by AEMO that some submissions to the consultation paper suggested that HSM meters capable of meeting the MASS for high speed FCAS can be purchased for as little as $120. CEC has sought quotes or price lists from metering providers who can supply meters compliant with the MASS for high speed FCAS. We have been unable to source anything for as little as $120. The cheapest quote we have been able to obtain for an FCAS-compliant meter is from Reposit and is priced at $599 plus installation costs. An invoice from Reposit is included as Attachment 1. This invoice has been reproduced with their permission. We have also received a quote from Combined Energy Technologies (CET) for a meter which CET believes will be compliant with the MASS and which is available for $385 (ex GST) plus installation costs. However, we understand that CET's meter has not been approved by AEMO as compliant with the MASS for Fast FCAS and is being assessed by AEMO as part of the Rheem Smart Water project which proposes to trial a fleet of water heaters for the Fast FCAS market once the 1MW capacity is reached. The quote from CET is included as Attachment 2. The total cost to the end customer must also include the cost of meter installation. This can vary depending on the installation circumstances. SolarEdge has informed CEC that when a Reposit system is added to a SolarEdge system, the additional equipment and installation costs are about $1,350 for a single-phase system and $2,000 for three-phase. In addition, another meter is still required for export control and monitoring.

Some suppliers have indicated that in future it might be possible that a compliant meter could be available for as little as $200 retail[78] by 2022. There would still be installation costs and costs associated with integration of the meter with the inverter.

Installation costs will vary according to the circumstances of the site, whether the site requires installation of a meter to limit exports, whether the installation requires swapping an existing meter, whether a whole new installation is needed, whether the work involves running cable or using a wireless meter, whether the configuration uses a current transformer instead of a meter, in which state the work takes place and the amount of labour needed for installation of a particular product (noting that installation of some products can be much more time-consuming than others). Suffice to say that at about $160 per hour for an electrician's labour plus call out fees[79], the cost of installation can exceed the cost of the meter.

Recommendation 7: Analysis based on the minimum cost of an FCAS-compliant meter should assume an equipment price of $599 (rather than the $120 estimate cited in earlier submissions to AEMO) and, including installations costs, the cost to the consumer is about $1,350 (single phase) and $2,000 (three phase).

### 3.4 Impact on the business case for VPPs

VPP operators have indicated that metering solutions would need to be less than about $200 to ensure there are incentives for households to invest in participating in a VPP[80]. Forecast FCAS revenues on a site-by-site basis (based on third party curves, in-market experience and third-party due diligence checks assessed by the Clean Energy Finance Corporation (CEFC)) estimate FCAS revenues in the $180 (low/ investment case) to $280 – 330 range (base case), depending on the state.

…

The cost of requiring OEMs to move to 50ms is difficult to estimate. It would require hardware changes for 50ms metering as AS/NZS 4777.2:2020 only requires sampling at 100ms intervals. Hardware changes are very hard to quantify as they involve the cost of research and development, prototypes, production, testing, and deployment. There is also the option of integration with a third-party meter (e.g. SwitchDin or

[78] Redback, personal communication (no documentary evidence provided).
[79] Ibid.
[80] Tesla, personal communication (no documentary evidence provided).

Reposit. However, this again takes time, money and effort and makes OEMs dependent on another company. For some companies, this will be an unacceptable business risk.

**4. Location of the measurement point for FCAS**

There are costs, benefits and risks associated with each choice of measurement point, as outlined below.

Measurement at the connection point

The primary concern expressed by some VPP operators in relation to measuring FCAS response at the connection point is that it could add significant costs to VPPs. There are varying views regarding how much additional costs would be added. As noted above, there is currently only one meter approved for Fast FCAS, which can be purchased for $599[81] and can cost the customer an additional $1,350 in total for single-phase connections once installation costs are accounted for[82]. There are concerns that the upfront and ongoing costs would very likely exceed revenue from FCAS market participation. The result will be that VPPs do not participate in FCAS markets in future. However, some suppliers anticipate they will have cheaper metering solutions suitable for Fast FCAS available in future years.

CPUE:

Currently, the MASS is a cost barrier for small scale DER by requiring high resolution meters to participate in the FCAS market. Amending the MASS would mean it would be less costly for small-scale DER to particulate in FCAS markets and as such, they would have easier access to additional value streams without incurring significant costs. This has the potential to accelerate market-led investment in small-scale DER systems and promote industry innovation.

The Draft Determination is to keep the measurement time resolution of the metering for small-scale DER at 50ms, rather than increasing it to 1s as per the learnings from the VPP Demonstrations. This requires high-resolution metering that costs materially more than lower resolution metering.

We understand this is to give AEMO close to perfect visibility of activity at the small-scale DER and VPP level, for power system security assessments.

We consider AEMO's approach overly conservative, which will result in unnecessary costs for consumers. A more cost-effective, risk-based approach is more appropriate for managing power system security at small-scale DER level. This could include either lower resolution metering, with adjustments for margin of error, or a small number of individual DER customers in VPPs having a high-speed metering—for example, a metered aggregated capacity of 250kW could be sufficient to provide enough visibility. We encourage AEMO to further assess all possible risk-based options before adopting what appears the highest cost solution.

We also encourage AEMO to share the results of the research provided in the Draft Determination on the low-cost metering currently available in the market. This will assist stakeholders to better evaluate the actual cost of the proposed changes and assist market participants in sourcing the lowest cost solutions.

CS Energy:

CS Energy is supportive of DER and their participation in the market, as well as the removal of any barriers to this participation where it is appropriate. Market opportunities should not discriminate between supply or demand-side resources, and neither should the associated obligations.

DEMSA:

The significant stakeholder interest in this consultation has drawn out often widely divergent and conflicting feedback as to the feasibility, technical merits, and costs of the two options presented. The Division acknowledges the difficulties this has presented AEMO to evaluate submissions and formulate its draft determination. The Division also agrees that the integrity of FCAS arrangements needs to be at the forefront of AEMO's considerations. However, the Division is concerned that AEMO's position that it is not prudent to amend the MASS now has the potential to delay the participation of an increasingly significant resource.

For SA, with already high levels of DER and reduced system inertia, it is important that FCAS can be harnessed from a large and diverse pool of technologies and providers, including VPPs.

The SA Government has had a significant focus on incentivising the deployment of VPP-enabled energy storage, as well as supporting development and trials of smart appliances. Aggregated DER stand to be an important contributor to reliability and grid security as rooftop solar deployment continues at a rapid pace and thermal generation retires. The opportunity for aggregation and control over a large proportion of

[81] See invoice provided by Reposit, included as Attachment 1.
[82] SolarEdge, personal communication (no documentary evidence provided).

distributed storage and other devices is significant, especially in the context of the minimum operational demand challenges and renewable energy generation goals.

The Division estimates around 1000 MW of current fast raise (R6) capacity could be withdrawn over the next 15 years due to plant closures. At the Same time this registered capacity is expected to reduce, the needs of the power system are increasing. Through the RIS, AEMO concluded that, under low inertia conditions, there is a need for more and faster frequency reserves and has already increased its procurement of Contingency FCAS volumes due to changes in load relief.

As increased volumes are needed to compensate for changing power system conditions, a substantial proportion of replacement and new capacity will most likely need to come from batteries, VPPs and demand response. Although there is a healthy pipeline of announced utility-scale batteries, other potential sources such as aggregated DER also will be important to ensure a competitive and diverse market. DER have the advantages of becoming ever more ubiquitous and being geographically distributed, which is important where regional FCAS is required.

Greater uptake of distributed battery storage can assist the minimum demand challenge in SA; however, the economics of battery storage is a key challenge. especially for residential consumers. Through the Home Battery Scheme (HBS), the SA Government is assisting households to invest in VPP-capable battery systems by providing upfront subsidies, with around 15,000 systems installed or awaiting installation to date. VPPs can help provide a better pay-back by rewarding consumers for access to their batteries, with their ability to do so linked to access to markets and Other revenue streams. FCAS markets have the potential to be a significant value stream for VPPs allowing more value to be shared with consumers and, in turn, improving the investment case.

The Division notes that some VPPs and DER already do, or expect to be able to, meet the requirements of the MASS. Notwithstanding this, we consider AEMO should continue to investigate service specification requirements for DER to ensure the barriers to entry in Contingency FCAS markets are as low as possible to maximise participation and promote greater competition.

DELWP–V:

VPPs are an important vehicle to encourage households and other small energy users to install active DER. If designed appropriately, VPPs can help gain consumer trust and willingness to participate in markets, delivering benefits to both energy users and the electricity system. Without this trust, and opportunities for participation, there is a risk that energy users will be locked out of the system's transformation and will be increasingly penalised for seeking to maximise their own utility, rather than being incentivised to become an integral part of the solution. The Draft Determination may make it more costly for DER to deliver FCAS, and may create barriers to VPP development, viability and market entry; thereby reducing both the value generated for customers and choice in the way they use energy, as well as benefits to the broader market.

AEMO has raised system security issues related to increasing DER uptake, such as falling minimum demand. AEMO has also noted the importance of DER visibility to its operations. The Victorian Government is concerned that the Draft Determination could work against this objective, by reducing incentives for batteries (and potentially other forms of DER) to become visible and 'behave' in ways that benefit the energy system. Furthermore, with proposed changes such as AEMO's 'backstop mechanism', there is an increasing need to offer opportunities for consumers to become part of the solution.

The Victorian Government agrees security should not be compromised but encourages AEMO to consider undertaking a more comprehensive and transparent analysis of the costs and benefits of its Draft Determination. This could include, for example, consideration of the severity of power system risks, versus the potential short and longer-term impacts of reduced VPP participation on system security or reduced competition in ancillary services markets. Further consideration could also be given to how the draft decision could affect business confidence and investment sentiment for VPPs.

The Victorian Government also encourages AEMO to consider whether this decision could result in an unequal treatment of large and small generation. FCAS requirements were not originally developed with the capabilities of DER in mind. In recognition of this, measurement standards should evolve, where required, to reflect changes in technology mix and harness the value of DER for customers and the broader market. Making DER adhere to the same measurement standards as large generators, without recognition of the higher relative cost, could result in inequitable treatment of large and small systems.

EA:

EA is strongly supportive of innovation, competition and the development of new energy markets and services to increase value to customers. However, based on the evidence presented to date, we do not consider it likely that the benefits of the proposed changes to measurement time resolution and the measurement location point would outweigh their costs. No competition issue has been demonstrated with current FCAS markets. Neither has any evidence been presented to suggest that lowering technical

requirements and moving from measuring net responses at the connection point to the asset level would improve FCAS delivery or cost outcomes. In contrast, the technical evidence presented by AEMO and others has all concluded that the proposed changes would increase measurement error, negatively impact market efficiency and power system security outcomes and, thereby, increase risks and costs to customers.

ECA:

Our vision is for a future energy system that is consumer-centred, whereby consumer values, expectations, and needs are both the instigating factor and central concern of system reform. To this end, we broadly support the proposed amendments and AEMO's intention to review the MASS, which we see as progress towards this vision.

The FCAS market plays a vital role in ensuring the stability of the electricity network, acting as a secondary market to the electricity wholesale market to maintain system security. To date, FCAS has traditionally been supplied by utility-scale plant which can meet the required technical specifications (the MASS). However, the rapid growth of DER and potential of VPPs means there is an opportunity for DER to play an important role in the FCAS market if the current specifications were to change to allow and reward this capability.

There are two transitions underway in the energy system. The first, is a transition away from traditional thermal generation to variable renewable generation and storage. The second is the immense move being made by 10 million homes and small businesses across Australia to take up new energy technologies on their rooftops and in their homes and offices. Both of these transitions present challenges and opportunities to the system.

In recent years we have seen increased challenges and complexity in providing power system security, resulting in higher FCAS costs. From 2015 - 2019 costs rose fourfold, rising further in 2020 to $350 million.[83] With FCAS costs making up to 3% of household energy bills, these rising prices are ultimately borne by consumers.[84]

In light of this, we support the Draft Determination to maintain the current measurement time resolution for Fast Contingency FCAS which we consider will help to avoid any reduction in the efficacy of an FCAS response and the associated increase in costs for consumers. While we are sympathetic to the view that loosening this standard would allow greater rates of participation in the short-term we are not persuaded that this benefit outweighs the potential costs.

We acknowledge that some providers have indicated that manufacturing high-speed metering capability to meet this requirement could lead to significant increases in the cost of production. However, we note that there are existing providers who are able to meet the higher requirements, without passing on significant costs to consumers.

In the long term, we consider that enabling small consumers to participate in the FCAS market, would help to lower these costs for all consumers and would encourage AEMO to consider other options to facilitate participation in the longer term. It would also unlock value for individual consumers, providing an opportunity for households with DER to receive further value from their DER investment by providing system support services and being appropriate compensated.

Empower Energy:

Follow-up discussions with AEMO indicated some acknowledgement that certain vendors had achieved metering solutions under $500 (per six channels) as part of DER gateway solutions (less than half of this for the metering infrastructure costs alone) whilst meeting existing MASS requirements for time resolution and accuracy. Importantly, AEMO indicated that even at that relatively low cost, a compliant solution may not be affordable in a value context.

Leaving aside the fact that no DER device evaluated in the VPP Demonstrations offered a zero-marginal-cost approach to FCAS participation (whether complying to the MASS or to the draft option presented), the latter point is important. Ideally, DER participation seeks maximum value generation, minimal cost, and maximum value transfer to customers. In practice DER participation typically bears platform costs by way of third-party DER management solutions – however packaged (e.g. bundled as capital costs, sold as subscription, etc) – per the NEO it is, arguably, incumbent on AEMO to minimise costs and maximise affordability where possible.

DER integration in the NEM will ultimately require market access constructs that are sufficiently flexible as to be able to incorporate devices with varying degrees of metering performance, triggering capabilities and measurement capabilities.

[83] State of the energy market 2021 (aer.gov.au)
[84] Understand your retail energy bill | energy.gov.au

ENA:

**Balancing the need for accuracy and promoting a competitive market**

While ENA has not been party to the more technical aspects of this review it is our understanding of the review that it concluded slower measurement frequencies of 200ms or 100ms may be a viable alternative to the current high speed 50ms sampling frequency.

Potentially lowering the current 50ms sampling requirement (which is a current barrier to entry for many proponents) could be effective at promoting a healthy marketplace of alternative products and providers while still delivering the desired technical outcomes for the power system.

Energy Locals:

We disagree that device level measurement is inconsistent with the NEO.

The issue relates to the proper allocation of risk for BTM FCAS resources which share a common meter with other uncontrollable generation or load resources (solar PV or onsite load respectively). Without FCAS resource, customers with load and no FCAS assets will contribute to system level demand fluctuations. FCAS will be procured at the system level with the cost recovered proportionally from load.

With FCAS resource, load variations will still occur and be managed at the system level. More FCAS-enabled storage naturally provides greater supply of FCAS services, thus reducing the overall system cost (consistent with the NEO). However, requiring the storage device to also manage BTM demand will be inefficient as the storage needs to manage local variations in load which would cancel out wholly or partially at the system level.

This treatment creates several issues which we believe are inconsistent with the NEO.

AEMO's proposed approach requires the FCAS operator to also manage all other generation and load BTM and we're not sure the implications of this for customers and operators are fully understood.

The Draft Determination could effectively end the new business models that have been warmly received by customers, create barriers to the uptake of new technology, and reduce or delay the deployment of FCAS – with knock on impacts to system security and the objective of lower cost. These outcomes are in direct conflict with the NEO.

The AEMC states that successful application of the NEO "considers the prospects for having the right mix of resources, to produce the maximum amount for the minimum cost, over time. Such markets are characterized where there are no barriers to innovation, the exit of technology or the uptake of new technology and efficient long-term investment."[85]

AEMO's Draft Determination imposes significant barriers to innovation in conflict with the NEO.

Furthermore, the AEMC states that when applying the NEO "Risks should be allocated to those best placed to manage them"[86]. BTM FCAS resources are not best placed to manage uncontrollable variations in the output or consumption of local generation and load.

Fluctuations in supply and demand are best managed at the system level where aggregation cancels out many of the fluctuations at more localised levels of the market. Allocating risks to FCAS resource operators simply because they share a meter with other assets does not allocate risks to those best able to manage them. AEMO's determination is therefore in conflict with the NEO.

Requiring FCAS resources that share a meter to meet unique conditions creates an unlevel playing field for those resources, reducing competition – especially between different BTM FCAS resources. Two identical assets, with the same technical ability to provide FCAS, would be treated materially differently from a market perspective if the metering requirements in the Draft Determination are to stand.

…

AEMO states that "changing the measurement time resolution requirement to 1s may increase competition in the short term, the distortionary impact on the Fast FCAS markets does not promote the NEO."[87]

As outlined above, we do not believe AEMO has made the case that there is in fact a "distortionary impact on the Fast FCAS markets" related to any change in metering resolution. AEMO's ability to safely and securely operate the system in real-time is not contingent on metering resolution below 4s (the resolution of SCADA monitoring). AEMO's ability to analyse the system ex post gives access to many other resources

[85] AEMC, Applying the energy market objectives, 8 July 2019, p12.
[86] AEMC, Applying the energy market objectives, 8 July 2019, p14.
[87] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014 (sic), p20.

(such 10ms distribution feeder data) and could be complemented by bench-testing and field testing of specific, not all, devices.

Putting aside these system security concerns, we agree with AEMO that these is likely to be an "increase competition in the short term" for similar reasons to those outlined with regard to the metering location issue.

Moving to a lower metering resolution would likely:

- reduce barriers to entry and innovation; and,
- increase supply of FCAS resources, resulting in reduced system costs.

This would reduce prices to consumers both short-term and long-term and result in a more efficient market consistent with the NEO.

Evergen:

**Specific additional recommendations**

…

9. AEMO should adopt in its decision-making a minimum of $500 as an estimated cost of compliance with option 1 (assuming no install cost), plus operational expense of $48-$120 per NMI per year.
10. AEMO should note an opportunity cost as high as $465 per year to each customer should their DER capacity be reserved to maximise FCAS participation and revenue when evaluating the cost/benefit of imposing additional compliance requirements.

…

We also address the financial considerations and impacts of this decision on consumers in section 6, impacts that would render Contingency FCAS participation for VPPs comprising fleets of small DER unviable for the time being.

Evergen contends that Australia needs to continue to utilise the best minds from across the industry to jointly work together to engineer two-way electricity grids that are capable of running at 100% penetration of renewables by 2025, the recently stated objective of AEMO's CEO Mr. Westerman.

Evergen firmly believes all Australians should benefit from energy diversity and energy security across a wide portfolio of assets.

…

**4.6 Can utility meters perform measurements for FCAS verification?**

In theory utility meters can sample power and grid frequency at 50ms, a fact reiterated in several submissions to the first round consultation on the MASS review. This service will not be provided by utility meter vendors at zero cost to VPP operators.

Most residences do not have a smart meter for remote data collection, so the cost of smart meter installation will need to be borne (whether by customer, retailer or VPP operator).

50ms data sampling, local storage, transport to the cloud, storage in a database, filtering to only retain frequency disturbance relevant telemetry, and availability via API or otherwise are functions that represent additional costs to smart meter providers. They will seek to recover from VPP operators, plus a profit to motivate participation. Evergen estimates that smart meter providers looking to offer FCAS data as a service will charge in the vicinity of $4-$10 per NMI per month ($48-$120 per NMI per year), and/or a percentage of the revenue from FCAS participation. There will be additional costs for both parties to negotiate and maintain commercial relationships. These costs will be extracted from the payments to the end user.

Costs might become more economical for larger fleet sizes. However, that assumes that every site in a VPP uses the same company's smart meter. This assumption would not hold for existing VPPs, necessitating either commercial agreements and API integrations with multiple smart meter vendors, or else prohibitively expensive smart meter retrofitting.

It is Evergen's current position that at best the notion that smart meter providers can play a key role in facilitating Fast FCAS VPPs is 'hopeful', not yet commercially tested. The jury is out on whether the arrangement could deliver a realistic value proposition for all participants, including end user customers, VPP operators, and battery/inverter control platform providers, who would each be required to work with the smart meter vendor to deliver the FCAS verification capability.

**4.7 Isn't there already a DER-based VPP complying with the existing MASS, so compliance with Option 1 must be economically viable?**

Evergen is aware of only one VPP-based FCAS Provider (Reposit) who has a hardware-based solution that bundles battery monitoring and control with FCAS metering at the connection point to achieve Option 1 requirements. Reposit is to be commended for this accomplishment, which no doubt required a lot of effort, technical expertise and expense to achieve. However, their example can not be regarded as an unambiguous indication that installing hardware to facilitate Fast FCAS for VPPs is economically viable, for the following reasons:

- Reposit received $445,000 in ARENA funding to develop and roll out their product. For a 10MW fleet averaging ~4kW per device, that amounts to $178 per device. https://arena.gov.au/projects/intelligent-storage-for-australias-grid/
- The cost per hardware device has, at least to date, been borne by the customer. This cost would be prohibitively expensive if the only justification for it were the revenue from Fast FCAS participation.
- Purchasing a Reposit device offers benefits beyond Fast FCAS market participation, however, these other benefits (such as monitoring, battery optimisation, non-FCAS VPP-based grid services etc) do not require additional hardware. Evergen offers similar benefits to end-use customers at no charge. So it is arguable that for most VPPs the costs that Reposit spreads across multiple customer benefits would instead be borne solely for Fast FCAS market participation.
- When Reposit bundles their hardware with a full solar-battery installation, the subsidies, credits or interest-free loans such installations attract can be used to offset the cost of the monitoring hardware.

AEMO should gain no reassurance in their determination from the existence of one VPP provider complying with the existing MASS. It is almost certainly the case that winding back the VPP Demonstrations and deferring on modifying the MASS in recognition of DER-based VPPs will simply bring the growing momentum for DER-based Contingency FCAS to a halt, causing stagnation and thwarting AEMO's own publicly stated intention to assist in transitioning towards a two-way market for electricity services.

…

**6. Customer value for VPP participation**

**6.1 Business case for a battery**

The expansion of DER has proceeded on the back of excellent customer returns. Rooftop solar is 'in the money' due to avoided grid offtake and feed-in revenue paid by retailers. Batteries, an essential component for the ongoing stability of the grid, are typically more marginal than a stand-alone PV system, though this varies from customer to customer. VPP participation has been hotly pursued by installers and innovative retailers as a way to tip the economics in favour of batteries.

Batteries typically have a 10 year warranty, thus the initial capital outlay warrants a ten year payback period. Applying additional hardware requirements makes it less likely that a customer can achieve this payback period. Following discussion with our hardware partners, Evergen calculates up front cost of additional hardware at $500[88] plus install costs. Further, there will be additional monthly costs of $4-$10 per month per NMI (or $48-$120 per year per NMI) for handling data volumes, increased system monitoring, additional cloud infrastructure, and charges from either the inverter or revenue meter company to provide a service that offers remote access to 50ms FCAS data. Thus, applying additional hardware requirements to participate in the FCAS market has a chilling effect on battery uptake.

The business case for batteries is at its best when there is value-stacking, combining the savings from reduced grid-offtake, exports at high prices and FCAS enablement. Households, markets and hardware are highly diverse, so there is no single business case for investing in battery systems. FCAS revenue alone will not cover the capital outlay of the battery for many customers. It is a combination of savings and revenues that make batteries a solid investment.

**6.2 Overestimating FCAS value**

FCAS revenues are variable. While the inclusion of FCAS revenue helps the business case for investing in batteries, AEMO may be overestimating the value of FCAS for a VPP FCAS Provider and thereby overestimating customers' willingness to invest in costly high-end metering. There are a few reasons for this overestimation.

[88] Advice from our hardware partners aligns broadly with reported pricing for the Reposit hardware solution of $700-$1,800 depending on install costs https://www.techguide.com.au/news/renewable-energy/reposit-can-help-pay-less-electricity/.

High FCAS revenues have been demonstrated (see VPP Demonstrations knowledge sharing report #1[89]) in SA with some customers estimated to be earning $1000+ per NMI per year. This is partly due to system events in SA, such as the February 2020 SA islanding incident. FCAS earnings are lower in other NEM regions. However much of the VPP learnings have been gained in SA, skewing the results published in the knowledge sharing reports. The adjustments to PFR requirements in October 2020 combined with a mild Summer has meant that FCAS revenue was low over late 2020 and into 2021. A realistic appraisal of future FCAS earnings in regions outside SA are likely to be much lower than $1000, even for an 'ideal FCAS enablement' scenario, where batteries are prioritised for FCAS. The 'ideal FCAS enablement' is in itself quite unrealistic.

Customers have differing capacity to provide FCAS. A customer with an oversized battery can readily provide their excess capacity to the FCAS market and the customer will suffer no reduction in savings arising from self-consumption. Customers with a smaller battery would need to often make a trade-off between self-consumption and FCAS enablement. This trade-off also applies for a customer with a battery that doesn't allow FCAS enablement to be run concurrently with other battery modes. The value of self-consumption differs by distribution network (network tariffs being a key driver of peak retail rates), by household load and hardware capability. In many examples, self-consumption is far more valuable than FCAS enablement.

As shown in Table 3, reserving capacity for FCAS represents a significant opportunity cost to the end user, which might be as much as $465 per year, if the customer reserves 3kWh of a larger battery, which would otherwise have been used to store solar and avoid peak tariff imports. Thus the 'ideal FCAS enablement' scenario is not in the best interest of customers and is unlikely to persist into the retail marketplace.

***Table 3**. This shows the cost to the consumer if part of their battery (storage + headroom) is reserved to maximise the availability of the battery to participate in FCAS. If no battery capacity is reserved, then the battery will often be unavailable for raise services (battery empty) or unavailable for lower services (battery at full charge).*

| | Low impact scenario | High impact scenario |
|---|---|---|
| kWh of battery capacity reserved for FCAS | 1 | 3 |
| Solar export tariff per kWh | $0.020 | $0.095 |
| Off-peak tariff per kWh | $0.13 | $0.18 |
| Shoulder tariff per kWh | $0.17 | $0.27 |
| Peak tariff per kWh | $0.35 | $0.52 |
| | | |
| *Yearly opportunity cost, assuming 1 cycle per day:* | | |
| If customer use/generation happened to not draw on reserve | $0* | $0* |
| If reserve had replaced solar export with avoided off-peak import | $40.15 | $93.08 |
| If reserve had replaced solar export with avoided shoulder import | $54.75 | $191.63 |
| If reserve had replaced solar export with avoided peak import | $120.45 | $465.38 |

* This occurs in the event that the customer's normal PV generation + consumption would naturally keep the battery within the reserve limit (very rate condition), or else the customer opted to reserve both storage and headroom for their own purposes anyway (customers reserving headroom does not happen).

The upshot is that many households have limited battery capacity to offer to the FCAS market, they aren't situated in SA and they will not be able to earn $1,000 per year. They may be earning $50 per year. That $50 per year could form part of the business case for the battery, but it is unlikely to warrant investment in high-end metering equipment with the sole benefit of granting Fast FCAS participation.

FCAS revenue can also be overestimated by failing to differentiate between FCAS revenue at the portfolio level and FCAS revenue apportioned to customers. Revenue from FCAS participation is divided between customers, and the parties that make that participation possible. This may include VPP facilitators such as Evergen, VPP operators such as Members Energy, the market customer (e.g., Energy Locals, who is the market customer for multiple VPPs in the VPP Demonstrations). If monitoring for FCAS verification were provided from an additional party, such as a revenue meter provider (who would need to deliver cloud

[89] https://aemo.com.au/-/media/files/electricity/der/2020/aemo-knowledge-sharing-stage-1-report.pdf.

infrastructure to pipe data to the FCAS provider), this would be an additional party who's contribution would need to be funded from FCAS revenue.

Customers are unlikely to invest in high-end metering (estimated $1,500 over ten years) when FCAS revenue won't cover that outlay.

**6.3 Summary**

The VPP Demonstrations allowed a diverse range of VPP retail offers to be created. Revoking the rules governing the VPP Demonstrations will lead to fewer customers being able to participate, as both batteries in general, and an FCAS-ready battery in particular, are less likely to be 'in the money'. This reversal of fortunes will thin VPP participation and investment from retailers and a decline in innovative retailer competition is likely to result.

By enforcing the need for high-end meters, a large number (likely the majority) of battery owners will be barred from contributing to system stability. AEMO is effectively undermining a key component of the business case for small scale asset VPPs. **This is not the appropriate course of action if genuinely preparing for a decentralised and renewables-powered electricity system that is stable, flexible, and equitable.**

…

**8. Conclusion**

Evergen strongly requests that AEMO reconsider the Draft Determination, and seeks a path that nurtures the excellent collaboration and data gathering that has occurred to date, rather than one that extinguishes it.

We feel that accepting the Draft Determination as it currently stands:

- is unnecessary on the basis of the technical reasons stated (measurement time resolution, location measurement point and system security);
- represents a bad outcome for energy consumers by removing a route for their participation in the market;
- represents a bad outcome for network operators by reducing visibility to DER;
- represents a bad outcome for industry collaboration by pushing a whole disruptive and innovative section of the industry to one side indefinitely; and
- represents a bad outcome for Australian leadership and innovation in the energy space.

Evergen presents this proposal in the spirit of open collaboration, and a genuine desire to continue innovating and accelerating the energy transition with the Australian energy industry for the benefit of all Australians.

Members Energy:

The ultimate trajectory of VPPs in the FCAS market is unknown but what is widely accepted, including by AEMO, is that there will be an ongoing role for VPPs in the electricity network. We suggest that role includes at least orchestration of demand response and data provision to AEMO and DNSPs, and possibly also provision of FCAS and grid stabilisation related services to DNSPs. It is also clear that VPPs are providing improved return on investment (ROI) for residential battery installations already, and that incentivising residential battery installation is essential for the energy transition and system security broadly. Batteries address the challenges of excess rooftop solar PV generation and may also provide system security services to the wider network.

The AEMO CEO has noted (Daniel Westerman's CEDA keynote address: 'A view from the control room' of 14 July 2021) Australia leads the world with solar PV penetration, which inherently moves power from incumbents to prosumers, requiring AEMO to foster social licence to facilitate the energy transition. We suggest VPPs are an essential part of that social licence. To destroy the current business model of multiple VPPs, and the aspirations and ROI assumptions of their members, for disputable technical reasons, would not be acting to protect and enhance social licence. It would therefore be a risk to the energy transition.

The likely steep uptake of battery electric vehicles (EVs) in the near future poses an additional significant risk to system security if smart charging is not widespread. VPPs provide an ideal way to provide smart charging to residential EV owners and commercial charging infrastructure and to provide visibility to AEMO and DNSPs of this emerging risk.

The VPP Demonstrations have:

- begun establishing social licence

- demonstrated visibility for AEMO
- demonstrated FCAS value for AEMO and prosumers.

The current AEMO position on VPPs via unchanged MASS requirements:

- reduces social licence with prosumers by pricing VPPs out of the market in favour of incumbents for disputable reasons
- abandons visibility of the sector for AEMO
- reduces FCAS value for AEMO and prosumers by increasing barriers to entry at a very early stage of VPP development (when the network stability risk they pose is low) and thereby removes an essential revenue source in the early stages of the VPP development lifecycle.

We suggest AEMO's rulemaking should protect the current business model of VPPs as well as the stability of the electricity network. This would ensure VPPs can continue to mature, protecting social licence while their ongoing role is revealed. This will allow existing VPPs and new entrants to protect and grow their customer base while the energy transition progresses, the ongoing role of VPPs is clarified, and technical and marketing efforts have time to move VPPs towards a long term sustainable business model. All while protecting the interests of existing customers to ensure that AEMO's social licence is protected, while also incentivising uptake of residential batteries and smart EV charging.

...

Our research, including with our international battery supply partners, indicates a wide range of possible costs which would be incurred by moving to 50ms, with an effective sliding scale between 1s and 50ms, with less granular options being cheaper and more granular more expensive. Our findings are:

- Meters in the 500ms – 1s range $150 – $250
- 50ms meters range $500 - $3000
- Variation also exists based on connection type (single phase vs 3 phase), accuracy, RS 485, Modbus-RTU input/output peripherals
- In addition, there are the developmental costs associated with meter/inverter compatibility (passed on by OEMs in the price), installation costs, and in-situ costs including possible increased data storage (although it may be possible to reduce storage of other data points which are not required and thereby negate this additional cost).

Our current revenue from FCAS is dwarfed by these meter costs. Notwithstanding the fact that our fleet is currently marginal, given the VPP demonstration transition requirements, it is likely that requiring 50ms metering at the point of connection would make FCAS participation uneconomic even with an acceptable fleet size. This would require us to quickly explore other revenue options for our VPP fleet, with the unavoidable and undesirable policy impact of reducing visibility of our fleet data to AEMO.

...

The VPP Demonstrations is an excellent example of working with a fledgeling industry to identify an excellent opportunity to foster innovation, support the energy transition, and bring with it significant public support at minimal system security risk. We suggest AEMO take heed of what has been learned and built with this project, capitalise on its achievements and learn from the minor risks identified.

Maintaining the VPP Demonstrations technical settings relating to point of metering and metering resolution is the best way to grow this industry and allow it to support the energy transition both technically and by harnessing significant social licence. If strong technical reasons are proven which require sensible transitions to more stringent settings (noting that we don't believe this has occurred yet) then this should be done slowly enough to allow the industry to transition to new revenue models while protecting the legitimate interests of the customer base and continuing to incentivise customer uptake of residential batteries. This approach will also provide a foundation to build demand response capabilities which will be essential in the near future, especially for anticipated EV charging uptake, and capture distributed data which will be invaluable to both AEMO and DNSPs in the transition.

To do otherwise would be counter to the NEO and squander the opportunity provided by the VPP Demonstrations to advance the energy transition.

PIAC:

PIAC considers integrating DER into the energy system is critically important. Proper integration of DER benefits all consumers through lower network and wholesale costs, improved reliability and lower emissions and helps individual consumers better manage their energy costs. It is necessary for the energy system to become zero-emission, flexible and decentralised.

Allowing consumers to maximise value from their DER assets through participation in markets like Fast FCAS is key to increasing investment in these resources and unlocking their benefits. It is in the consumer interest for DER to participate in all markets where they can offer value and AEMO should reflect this imperative and its role in facilitating it in its approach to amending the MASS.

...

**Metering costs**

PIAC is not in a position to determine whether the costs of meeting the current 50ms metering requirement are a barrier to VPPs participating in the Fast FCAS market. We note some stakeholders who participated in the trial consider the 50ms requirement to be expensive, in some cases prohibitively so. Sonnen notes requiring 50ms will force them 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' and AGL similarly considers the costs to a VPP operator of participating in the FCAS market under the stricter metering requirement would likely be greater than the benefit.

PIAC notes both the existence of the VPP Demonstrations and its use of the lower resolution metering to encourage participation, suggests costs were preventing otherwise capable businesses participating in the Contingency FCAS market. PIAC also highlights while the 50ms requirement may not be prohibitively expensive, it increases the cost and reduces the overall value of providing Contingency FCAS, and consequently consumers' DER.

As AEMO notes, several stakeholders have indicated the 100ms measurement resolution is currently achievable with various hardware setups currently in use, and it is likely that 50ms will also be achievable in the near future. It is logical to make use of this available technology rather than require further, potentially unnecessary investment.

Quinbrook:

**Foreclosure on business models**. The only way to operationally manage AEMO's proposed approach on measurement is to control net injections at the connection point such that FCAS enablement targets can be met accounting for any other variations in generation and/or consumption behind the connection point meter.

This requires that the operator of the FCAS resource is also the operator of all other generation and load behind the connection point. This requirement has far reaching consequences. It forecloses on business models where one party operates and is responsible for the FCAS resource, and another party or parties operate and are responsible for generation and load at the same site.

This approach locks in 'whole of site control' business models (e.g. Reposit Power) but effectively blocks all multi-partite aggregation models (e.g. EV charging VPPs which are separate from customer retail arrangements for household supply).

Such an approach is a severe and unnecessary constraint on evolving innovation in business models. It impacts small scale aggregations (EV charging VPPs), commercial sites with third party solar and storage resources BTM, industrial load sites with co-located solar and storage and many hybrid generation sites.

The AEMC states that successful application of the NEO "considers the prospects for having the right mix of resources, to produce the maximum amount for the minimum cost, over time. Such markets are characterised where there are no barriers to innovation, the exit of technology or the uptake of new technology and efficient long-term investment."[90] AEMO's Draft Determination imposes significant barriers to innovation and conflicts with the NEO.

**Risk allocation**. The AEMC states that in applying the NEO "Risks should be allocated to those best placed to manage them"[91]. BTM FCAS resources are not best placed to manage uncontrollable variations in the output or consumption of collocated generation and load. Fluctuations in supply and demand are best managed at the system level where aggregation cancels out many of the fluctuations at more localised levels of the market. Allocating risks to FCAS resource operators simply because they share a meter with other assets does not allocate risks to those best able to manage them. AEMO's determination is therefore in conflict with the NEO.

**Barrier to entry**. Requiring that FCAS resources at hybrid sites must have operational control of all site assets creates a significant barrier to entry to bring these FCAS resources to market. At the household scale, this means FCAS resource operators need to also have arrangements with retailers (or be retailers).[92] At the commercial and industrial scale this means that supplying a battery to a big box retailer or a data

[90] AEMC, Applying the energy market objectives, 8 July 2019, p12.

[91] AEMC, Applying the energy market objectives, 8 July 2019, p14.

[92] For example, whilst not purely related to FCAS, Reposit had to pivot its original aggregation business model to a retail partnership model in order to gain control of sites.

centre means also convincing them to give you their bulk supply contract. This significantly increases the complexity of new product offerings as FCAS can only be bundled with other retail and wholesale services, creating high commercial barriers to adoption.

To the extent that such barriers to "the uptake of new technology"[93] reduce or delay the deployment of FCAS resources this will reduce supply and increase the cost of meeting FCAS requirements. Reduced supply of FCAS resources may also jeopardise "the reliability, safety and security of the national electricity system"[94] to the extent that shortfalls in FCAS resources occur. Such outcomes are in conflict with the NEO.

**Price**. Creating barriers to entry and innovation will, other things equal, reduce supply and increase costs. The result will be higher prices for customers in conflict with the NEO.

**Unlevel playing field**. Imposing unique conditions on FCAS resources that share a meter creates an unlevel playing field for those resources, reducing competition. This is clearly the case for competition between FCAS resources. Two identical assets, with the same technical ability to provide FCAS would be treated materially differently from a market perspective as a result of imposed metering arrangements.

...

AEMO states that "changing the measurement time resolution requirement to 1s may increase competition in the short term, the distortionary impact on the Fast FCAS markets does not promote the NEO."[95]

As outlined above, we do not believe AEMO has made the case that there is in fact a "distortionary impact on the Fast FCAS markets" related to any change in metering resolution. AEMO's ability to safely and securely operate the system in real-time is not contingent on metering resolution below 4s (the resolution of SCADA monitoring). AEMO's ability to analyse the system ex post gives access to many other resources (such 10ms distribution feeder data) and could be complemented by benchtesting and field testing of specific, not all, devices.

Putting aside these system security concerns, we agree with AEMO that these is likely to be an "increase competition in the short term" for similar reasons to those outlined with regard to the metering location issue. Moving to a lower metering resolution would likely:

- reduce barriers to entry and innovation; and,
- increase supply of FCAS resources, resulting in reduced system costs.

This would reduce prices to consumers both short-term and long-term and result in a more efficient market consistent with the NEO.

Reposit:

In its first submission, Reposit provided empirical evidence that showed how proposed changes to the metering requirements in the MASS would increase the uncertainty of Fast FCAS response. This uncertainty must result in either:

1. Decreased effectiveness of the Fast FCAS services and degraded system security; or
2. Increased Fast FCAS costs through additional Fast FCAS procurement to compensate for the increased uncertainty.

Both outcomes result in a decrease in the efficiency of the NEM and are clearly detrimental to the achievement of the NEO.

...

Reposit provided information in its first submission that a single phase of FCAS compliant metering costs less than $120. Reposit currently sells its controller for $599 to selected partners. This includes three phases of FCAS-compliant metering, an additional three phases of non-FCAS compliant metering, 4G hardware, general purpose and vector computing hardware, five communications ports and supporting power supply and protection electronics. The controller (including metering) takes an inexperienced installer less than two hours to install.

Should FCAS-compliant metering for DER cost in the thousands or tens of thousands of dollars as contended by some respondents to the first stage consultation, it stands to reason that Reposit would not be able to retail its controller for under $600.

[93] AEMC, Applying the energy market objectives, 8 July 2019, p12.
[94] National Electricity Objective, see: https://www.aemc.gov.au/regulation/regulation.
[95] AEMO, Amendment of the Market Ancillary Service Specification – DER and General Consultation, 14 June 2014 (sic), p20.

Reposit is also aware of other three-phase, 50ms capable metering that is available in the market at sub-$500 prices.

It is Reposit's opinion that at this point any party that advocates 50ms metering costing thousands of dollars either lacks effective procurement personnel or is intentionally misleading the market for unknown reasons.

Rheem & CET:

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

Our specific responses to the Draft Determination are underpinned by this approach. Our experience and recommendations are supported by empirical data from an existing fleet of thousands of NEM consumer sites of mixed DER. The data from these sites support our technical, architectural and commercial conclusions which are in alignment with the principles of the NEO.

In summary we have not changed our views from our previous submission and support the DER related recommendations in the Draft Determination, in particular:

That current measurement specification requirements should remain unchanged

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

…

That there is no significant cost impediment to requiring power metering capable of measuring power flow and local frequency at intervals of 50ms or less at every site (NMI)

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

We are open to commercial discussions with any party that is having difficulties designing or procuring cost effective MASS compliant metering solutions. To this end CET has recently (3 August) contacted the CEC with details of their low cost meter, with an offer to supply any members interested in purchasing the same. Rheem/CET are also aware that other Australian companies have similar cost-effective power metering technologies available that comply with the current requirement to measure power flow and local frequency at intervals of 50ms or less at every site NMI.

SAPN:

SAPN is committed to supporting the distributed energy transformation to secure a stable future for renewables in SA. We believe that residential batteries aggregated in VPPs have the potential to add tremendous value in efficiently maintaining system security and frequency stability in the high-DER electricity system of the future. It is very important, therefore, that the market rules support and encourage the efficient participation of these resources in the market to the fullest extent possible, in particular in the provision of fast frequency support services.

…

1. SAPN has a strong interest in this issue as SA has been at the forefront of VPP adoption nationally, with the majority of the VPPs that have been actively participating in FCAS markets in AEMO's Market Demonstrations located in SA. In early 2021 there were more than 20,000 small-scale batteries installed in SA with a combined capacity of more than 200MWh, similar to the size of the Hornsdale battery. Of these, more than 6,600 are enrolled in VPP schemes, and this continues to grow. The largest of the nine VPPs operating in the state, Tesla's SA-VPP, has recently commenced a rollout to a further 3,000 Housing SA properties, which will bring the total VPP capacity in the state to more than 35MW. SA Government targets and the government's Home Battery Scheme, which specifically aims to accelerate the adoption of 'VPP capable' batteries through subsidies, could see up to 90,000 batteries enrolled in VPPs in SA in coming years, which would give a total capacity of more than 450MW, which would be a very material resource in the State's 3GW electricity system.

2. We believe that residential batteries aggregated in VPPs have the potential to add tremendous value in efficiently maintaining system security and frequency stability in the high-DER electricity system of the future. This due to their capability to provide extremely fast frequency response and advanced services like synthetic inertia. It is very important, therefore, that the market rules support and encourage the efficient participation of these resources in the market to the fullest extent possible.
3. We believe that energy storage more broadly will be a very important component of a high renewable energy system. It is important that the market enables owners of storage (both small and large scale) to access the full value stack in order to facilitate investment in the growth of storage capacity within the energy system.
4. In our $2 million Advanced VPP Grid Integration trial[96], in partnership with ARENA, Tesla and the CSIRO, we have demonstrated how the use of 'dynamic operating envelopes' provides a model for the safe and effective integration of large market-participating VPPs with the distribution network so that VPPs can bid into FCAS markets and dispatch with confidence, without risk of breaching local network constraints.

Shell Energy:

Shell Energy is disappointed in AEMO's Draft Determination to remove the slightly relaxed metering requirements that were used as part of the VPP Demonstrations for participation in Fast FCAS markets. In our submission on the original issues paper, Shell Energy argued that small facilities (<1 MW) should be allowed to continue using sub 1-s metering as per the VPP Demonstrations as an alternative to high speed (50ms) on an ongoing basis. In our experience, there is a significant cost difference between even 100ms metering and 50ms metering.

Imposing a requirement on small participants to install 50ms metering will act a barrier to their participation in Fast FCAS markets.

AEMO asserts that one reason for imposing the 50ms metering requirement for participating in Fast FCAS markets is that the marginal cost of installing 50ms metering rather than 100ms metering is relatively small and that this cost differential is likely to come down. Shell Energy disputes that this is a certain outcome. There is a real possibility that the marginal cost difference between installing a 50ms meter and a 100ms or 200ms meter remains high. The reason for this is that there are currently gate meters rated to deliver 100ms polling speeds. All 50ms meters currently need to be installed as new sub meters. While the meter cost may be $120 for one market participant, the costs for CTs and other ancillary equipment for a compliant sub-meter blows out the costs of this option materially and ruins the economics of participation for <1MW participants. To the extent that this difference does remain, the requirement for 50ms metering for fast FCAS participation is likely to limit participation from DER where the available DER is <1MW and therefore competition. We consider that this outcome would fail to meet the NEO.

Shell Energy's experience in deploying meters has shown us that the marginal cost of a 50ms meter compared to a 100ms meter is far higher than the $120 suggested in the Draft Determination. While some providers claim to be able to deliver 50ms metering around the $120 marginal cost, we understand that this is not widespread and does not include the costs of the additional equipment required for meter to be a compliant sub-meter with appropriate CTs and ancillary equipment. Further, given that this is a marginal cost, it does not necessarily represent the true cost of installing 50ms metering, which may in fact be far higher.

Although one provider has indicated they can deliver 50ms metering at a notional marginal cost of $120, AEMO must remain impartial and agnostic to technology. By insisting on 50ms metering on the back of this data point, AEMO risks forcing participants to not only develop their own $120 meter but also their enabling software on top. Hardware and software development is outside the core business of the majority market participants, and therefore while technically possible, is not a viable course of action for most. Therefore, the $120 marginal cost is in fact just a small proportion of a far higher cost to ensure the whole system is compliant with AEMO's requirements. This lack of competition from metering providers means that we expect that there will be very limited participation in the fast FCAS markets from small-scale DER, particularly sites with sub-500kW capacity. Further, we consider that AEMO's Draft Determination risks designing a market that solely advantages one participant's business model, rather than a market that fosters competition across technology and providers.

…

Ultimately, if AEMO's concern is that it requires accurate data once there is a critical mass of DER participation in Fast FCAS markets then it needs to consider ways to build on requirements as overall DER or VPP participation increases. We do not consider that such participation will increase if there is a requirement for 50ms metering even for small participants.

[96] https://arena.gov.au/projects/advanced-vpp-grid-integration/

One way to increase participation and also ensure that AEMO receives accurate data could be a staged approach in line with our proposal above to allow for 100ms metering with a discount applied. Small providers (e.g. <5MW) could use 100ms metering on an ongoing basis until 50ms costs are demonstrably lower across the market. Should a provider wish to aggregate more than 5MW in a region then higher speed metering is a reasonable expectation. The rationale for this is that if there are multiple aggregated providers in a region, the combined capacity would be closer to a conventional thermal unit (e.g. gas turbine) and becomes material in the network. This proposal is similar to AEMO's original proposals for Option 1 in the consultation paper.

AEMO's proposed approach in the draft MASS to metering for DER participating in Fast FCAS markets is likely to stymie development of the market and limit participation. Shell Energy struggles to see how this would meet the NEO, even with more accurate metering. Once it is evident that there is a greater degree of competition for 50ms metering and that prices have come down across the board, then it would be reasonable for AEMO to review the use of 100ms metering for small units.

Simply Energy:

Simply Energy is concerned that the Draft Determination does not sufficiently leverage the experience and opportunity of the VPP Demonstrations and has not adequately considered the costs to consumers that would result from the proposed changes to the MASS, particularly in relation to the costs of retrofitting the existing VPP fleet to continue participating in Fast FCAS markets. Without a proper consideration of the costs, AEMO cannot claim that its proposal will promote the NEO.

…

Simply Energy makes the following observations and recommendations:

…

- VPP products will likely be uneconomical under the proposed requirement to provide HSM data samples of 50ms to participate in Fast FCAS markets. AEMO should instead require data samples of less than or equal to 200ms.

…

**If implemented, the draft MASS would undermine the future development of VPPs**

To support the Australian energy system's transition to an increased dependence on renewable energy, it is critical that DER are effectively integrated into the NEM. The VPP Demonstrations have been successful in showing that aggregating DER to provide coordinated services to the energy system can benefit all electricity consumers. AEMO noted that the capabilities shown through the VPP Demonstrations 'represent foundational building blocks to enable AEMO to operate the power system with high levels of DER'[97]. In its knowledge sharing reports, AEMO noted that consumers would likely benefit from the coordination of DER through VPPs in two ways:[98]

- Consumers who own VPP assets would earn value from delivering grid services
- All other electricity consumers would benefit from a more efficient power system.

Through the VPP Demonstrations, AEMO identified the value that VPPs can provide in relation to operational visibility and forecastability.[99] The demonstrations also evidenced that VPPs have the capability to respond to both Contingency FCAS events and energy market price signals.[100]

Simply Energy is concerned that the draft MASS will significantly reduce the commercial viability of VPPs and will undermine the future development of this business model. While VPPs are still in their infancy, they have already demonstrated the value of DER aggregation to consumers and the energy system. AEMO CEO Daniel Westerman recently recognised that 'aggregating rooftop solar and local batteries into virtual power plants can be financially beneficial for homeowners, and can also provide important grid services.'[101]

In its current form, the draft MASS does not appear to align with AEMO's vision for the future of the Australian energy market. While AEMO states that it seeks to increase the diversity of energy sources to deliver reliable and affordable energy for consumers[102], the draft MASS will instead reduce diversity by increasing the barriers for new energy sources to enter the market. These barriers are discussed in further

[97] AEMO 2020, AEMO Virtual Power Plant Demonstrations – Knowledge Sharing Report #2, July, p.6
[98] AEMO 2020, AEMO Virtual Power Plant Demonstrations – Knowledge Sharing Report #1, March, p.5.
[99] AEMO 2021, AEMO Virtual Power Plant Demonstrations – Knowledge Sharing Report #3, February, p.14.
[100] AEMO 2020, AEMO Virtual Power Plant Demonstrations – Knowledge Sharing Report #2, July, p.6
[101] AEMO 2021, AEMO CEO Daniel Westerman's CEDA keynote address: 'A view from the control room', 14 July, accessed at: https://aemo.com.au/en/newsroom/news-updates/the-view-from-the-control-room
[102] AEMO 2021, AEMO CEO Daniel Westerman's CEDA keynote address: 'A view from the control room', 14 July.

detail in the remainder of this submission. Simply Energy does not consider that the draft MASS provides appropriate market incentives or proportionate regulation for VPPs or other DER services in their infancy.

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 battery storage systems, and increased reliability and security of the electricity grid. Simply Energy urges AEMO to reconsider the draft MASS and instead take an approach that balances any imposed costs against the significant consumer and energy system benefits of innovative DER business models.

The Advanced VPP Grid Integration Project in South Australia, led by SAPN in partnership with Tesla and CSIRO, has demonstrated how integrations between aggregators and DNSPs could successfully be used to increase the level of exports from 5MW up to 6-8MW during solar hours without compromising network quality of supply during periods of network congestion or unexpected events. In this project, benefits obtained from exporting were shared equally across all participants, eliminating, or significantly reducing complexity for customers. This appears to be the first demonstration of DNSP-supplied dynamic operating envelopes by a large-scale VPP during real world trading in the NEM. Such projects also rely on there being full access to the value stack or NEM Wholesale Energy and Contingency FCAS whilst utilising standard battery systems. VPPs, such as the one referenced in the SAPN project, may see customers depart the VPP at the end of their initial benefit period if they are faced with significantly lower financial benefits (either directly by non-participation in the Fast FCAS markets or by the cost of a retrofit metering solution needing to be factored into their offer). Should customers choose to depart the VPP, the DNSP is likely to lose visibility, provide virtual inertia, voltage support and the ability to offer additional customer value via increased site export limits.

**A measurement time resolution of 50ms is uneconomical for VPPs**

Simply Energy continues to support Option 2 from AEMO's issues paper, which would allow a measurement time resolution at intervals of less than 1s across all NMIs. As noted in our submission to the issues paper, the VPPx would be uneconomical if required to provide HSM data samples of less than or equal to 50ms for Fast FCAS response. Simply Energy maintains its view that aggregated 1s resolution from the fleet should be sufficient for response verification.

As noted in the previous section, Simply Energy would prefer that AEMO pause the DER component of the MASS review while it further investigates the identified measurement errors. However, if AEMO is committed to making a final determination on an increased measurement resolution, Simply Energy urges AEMO to amend the MASS to include a 200ms resolution. This appears to be a reasonable compromise, as the UoM analysis shows that potential errors would be minimal if this was adopted. This approach would also be lower cost for industry and consumers than the implementation of a 50ms resolution, which is not currently achievable with commercially available units and is unlikely to be commercially viable in the coming years.

…

**The technology to achieve faster measurement times are not currently economical**

While some stakeholders have informed AEMO that a 50ms resolution will be achievable in the short-term with upcoming hardware, Simply Energy's view is that high-speed measurement resolutions will not be commercially viable in the short-term.

Simply Energy has investigated the estimated costs of high-speed metering alternatives to determine whether there are viable options to retrofit our VPP fleet. [Note: confidential information removed]

If AEMO is unwilling to permit a 1s measurement resolution, Simply Energy considers that a sensible compromise would be to allow a 200ms resolution for fast FCAS verification. Simply Energy has been advised by its current suppliers that a 200ms resolution is feasible with some adjustments to existing inverters with minimal impacts on costs.

[Note: confidential information removed]

**The costs of retrofitting sites would be prohibitive and would erode customer value**

[Note: confidential information removed]

With regard to our existing VPP fleet, Simply Energy is concerned that AEMO has not fully considered the impact of its proposals on current VPP customers. The Trial Participants have invested significant amounts directly into the demonstrations and API based on the current specifications. [Note: confidential information removed]

It is also worth highlighting that the proposed approach to FCAS metering would likely impact Simply Energy's ability to re-contract with customers once their initial benefit period has lapsed.

[Note: confidential information removed]

SolarEdge:

A further concern is that AEMO does not outwardly appear to be in line with obligations under the NEO. Primarily, if AEMO has the ability to remove costs to achieve the same technical outcome – as is the case with considering less granular measurement resolution options, then they are obligated to do so.

Our concern is that if FCAS participation barriers are too high as compared to the available pool of value, the nonparticipation of DER, particularly as aggregated assets working in concert, has the potential to create system issues due to lack of visibility and effective control.

An effective, accessible and inclusive market is required to enable a transition to an integrated energy market where system security and commercially responsible outcomes are delivered.

…

As an industry participant and technical contributor to the analysis of AEMO we support the work that AEMO has undertaken in its VPP trials and other initiatives such as Project MATCH as we too support the need for enhanced DER participation in markets. Currently, however, DER policy is lacking a clear framework or agreement on which services should be provided through market mechanisms and which should be provided using regulations and standards. As a general principle, provision of system services and network services should always be paid for and should not be mandated as a condition of grid connection. This should include support for FCAS markets and voltage management on distribution networks. The only exception to reliance on market mechanisms should be genuine, well-defined emergency situations.

SolarEdge strongly supports initiatives to enable VPPs that should have full market access and participation by customers on an opt-in basis. The risk of leaving the MASS unchanged is that the additional costs involved will reduce incentives for VPP uptake resulting in a high proportion of passive DER.

SolarEdge therefore recommends maintaining the position of 1s sampling rate for verification purposes. This is both consistent with experience from international markets and represents a least cost approach for DER to effectively participate in FCAS markets and contribute to system security.

…

**3.5 The cost of high-speed data capture and storage**

No current DER in the Australian market has the ability to meter within the limits proposed under the Draft Determination. To fall within the prescribed requirement all participating DER assets will have to have additional 3rd party devices fitted with their own specific data capturing, storage and transmission functions. To be clear, all DER will operate with metering as prescribed in AS/NZS 4777.2:2020.

Any DER system owner wishing to participate in a VPP under the prescribed metering rules of the Draft Determination will now need to have x3 metering services installed or upgraded to comply. One NMI billing grade meter at the connection point, one DER meter for export and / or load control plus used for a battery to charge once PV production is greater than the load amount, and now additionally one high speed FCAS grade data logger and metering solution.

Currently only Reposit have a solution, circa $599 for a data logger, plus $100 per meter (a single unit for 1Ph DER, x3 required for 3Ph DER)[103], typically the cost to the consumer will be $1,350 for a single phase inverter and around $2,000 ex GST for a 3-ph or multi-inverter installation (including the additional hardware). These costs are in addition to the other metering required and is only there as a prerequisite entry requirement for FCAS participation.

The requirements proposed by AEMO necessitate the installation of a separate high-speed meter as the data capture needs to be based on measurement at the connection point. AEMO requested industry to provide clear evidence of the additional costs of becoming compliant with the current MASS – it is worth noting that the diverse range of statements on costs (most without supporting evidence) in the first round of submissions, and subsequent discussions have not provided a clear outcome on this. The true cost is well in excess of the purported $120 per meter[104].

**7. Recommendations**

…

5. Analysis based on the minimum cost of an FCAS-compliant meter should assume a price of $1350 - $2000 instead of the $120 estimate cited in earlier submissions to AEMO.

[103] Data provided by CEC, 4 August 2021

[104] 2021 AEMO MASS – VPP Trial consultation industry responses.

sonnen:

**Impact of measurement requirements on DER participation in FCAS markets**

FCAS is only one component of the DER value stack. The business case for FCAS market participation is slender and it is important to sonnen's customers that there is a material benefit to them for allowing their assets to be controlled for the provision of FCAS. The current value proposition is acceptable by some, but not all of sonnen's customer base.

Increased equipment and VPP infrastructure development costs which are likely to greater than $2k per installation quickly erode the small benefit to the customer of approximately $30 per month.

sonnen invests heavily in developing the capability of our hardware, however the assets utilised in our VPP are not able to meet a 50ms sampling update requirement without integrating additional hardware to act as an event recorder for fast Contingency FCAS verification. For the reasons outlined below the costs associated with fast contingency services measurement requirements of the MASS are significant.

Submissions to the first stage consultation provided a wide range of views on the costs of meeting the fast Contingency FCAS markets MASS measurement requirements. sonnen believes that the significant variance is unlikely to be explained by direct engineering and material costs which in a competitive environment will most likely converge rapidly if all OEMs were seeking the same narrow technical objectives.

sonnen suggests the diversity in cost expectations arises from vendor specific assumptions including the:

- cost of integration of high-speed event data recovery in a distributed IT environment; and
- variability in the interpretation of the measurement principles in the MASS, particularly the accuracy and resolution of frequency measurement at high update rates.

**Integration of high-speed event data recovery in a distributed IT environment**

The sophistication of control/co-ordination capabilities and end user functionality of a VPP platform have significant impacts on implementation complexity and data flows requirements. sonnen provides our end users high resolution data on the performance of their batteries and power flows at their home while also providing a high degree of real time co-ordinated control of FCAS delivery. Developing and maintaining the sophisticated IT systems that provide a high level of functionality to end users increases the costs associated with implementing additional requirements that have very different data handling characteristics such as the difference between continuous monitoring and 'event driven' data.

SwitchDin:

**Measurement Time Resolution for FCAS Verification and Monitoring Cost**

…

While AEMO cites a cost range from $120 - $15,000 for a compliant meter, lower cost meters need to be considered in terms of reliability as well as their up-front costs. In our experience, quality is a key driver for cost in meters and cheaper and possibly unreliable meters have a significant lifecycle cost (taking into account replacement costs) comparable to higher quality and more expensive meters. A more realistic lower bound for a reasonable quality compliant meter may be in the range of $350-$400. This price does not take into account the potential for additional integration, communications and data storage costs especially where an external meter is required.

Based on information provided in VPP Trial Knowledge Sharing Report #3, the estimated revenue per system per year for FCAS is $200 - $4001 depending on how the systems were operated. This revenue is typically volatile and in general is expected to decrease as more large-scale batteries and VPPs access the FCAS markets. The additional cost for HSM at 50ms, on top of the other costs associated with setting up and running a VPP fleet for FCAS, is likely to severely impact the business case for FCAS using DER (especially smaller systems).

We suggest that AEMO increases the measurement resolution for FCAS verification to 200ms to reduce the cost of compliance for DER. This will not impact on the response from a VPP during an FCAS event as these measurements are used for verification only, not control.

Tesla:

Tesla is concerned that the recommended approach put forward will unnecessarily increase the costs for aggregators looking to register VPPs in the Fast Contingency FCAS markets. This is of particular concern given that that there are lower cost alternatives that should be considered as achieving the same technical outcomes for AEMO. As it currently stands, Tesla can support 100ms measurement resolution for individual Powerwall sites, but cannot meet the 50ms measurement resolution. As such, to maintain

participation in the fast FCAS markets, and subsequently create the most compelling VPP offer for our customers, Tesla would need to install additional metering hardware, capable of 50ms resolution on every VPP enabled site.

In addition, verifying FCAS performance using site level data, rather than device level data, will result in a less accurate representation of performance, and a more conservative approach to bidding to account for both site load and uncontrollable generation externalities.

This creates both cost and efficacy concerns for Tesla:

- Requiring 50ms metering for all VPP sites wanting to participate in fast FCAS markets would add ~$20m in additional metering costs to a 100MW VPP (assuming a mid-range estimate of $1000 per site based on the cost estimates provided by AEMO).
- Measuring at the site connection point rather than at the device level will result in inefficient bidding behaviour and will result in a 5 – 10% reduced revenues across the slow and delayed markets.

In the absence of a cost-effective metering solution the most likely outcome is that many VPPs will not participate in fast FCAS markets. Organisations delivering VPPs to customers to lower energy prices, increase renewables and stabilise the grid may see a reduction of 30 – 50% revenue per site. Due to lack of access to fast FCAS markets the following impacts may be placed on retailers developing VPPs as well as Tesla VPP market goals:

- Considering which jurisdictions are technically viable to introduce a competitive VPP offer.
- Increasing or reconsidering the customer retail rate that may be offered.
- Reconsidering the overall customer incentives that can be offered:

This in turn will reduce the customer uptake of VPP offers, and the stymy the transition from passive to active DER that should be a strategic imperative for AEMO in order to work towards being able to periods of 100% renewable energy by 2025.

**Distributed energy resources in Australia – Tesla principles**

A core principle that Tesla applies to all of the DER development work that we undertake, both locally and globally, is that the market benefits more from active DER than it does from passive DER. Making the transition from passive to active DER is a necessary and key element in achieving AEMO's stated goals of preparing the grid for periods of 100% renewable energy penetration by 2025.

Currently we have >15GW of passive distributed solar in the Australian electricity mix. This compares with ~400MW of BTM storage. Importantly, only ~40MW of this the total DER currently installed in Australia are registered with AEMO and would be considered active – less than 0.3% of the total installed DER capacity – consequently AEMO and Governments more generally are faced with significant social and technical challenges of managing minimum and potentially negative day time demand.

Tesla believes that AEMO can feasibly create a target of 5 – 10GW of dispatchable DER by 2025. This will take dedicated effort and resources to bridge the gap from where we currently are, but the technology exists and both industry and consumers are ready to support this shift. Central to accelerating this transition are the following elements relevant to the MASS Draft Determination:

1. The insights from the VPP Demonstrations have largely being ignored when they should form the basis of AEMO's ongoing DER roadmap; and
2. Broader DER power system security concerns should not be conflated with the MASS and need to be addressed separately.

### 1.3 Tesla Principles for DER Market Integration

…

**The NEM benefits from active DER over passive DER**

The starting position from Tesla is that the NEM benefits more from DER that are actively providing services, and responding to market signals, than from passive DER.

Active DER provides more market competition in both NEM and network services, ensures direct pass through of market benefits to customers, and most importantly encourages aggregation of DER.

With increased aggregation comes increased visibility of system and fleet performance, and increased ability to forecast solar, customer load and battery outputs. Early market integration of DER is critical to laying the groundwork for a more complete shift to active DER which will benefit AEMO and the NSPs.

Importantly, the shift from passive to active DER also means that customer owned, BTM DER can be used to their full potential. These systems will not sit their idle during key system security events at the NEM level or for providing non-network solutions to NSPs.

**If the same technical outcome can be provided at lower cost, this change needs to be made**

A core tenet of AEMO's obligations in respect of the NEO is to reduce costs. If the same technical outcome can be achieved through a lower cost, more readily available technologies, then AEMO needs to consider these changes.

The 50ms measurement resolution requirement for Fast FCAS has existed since the MASS was first introduced in a market context where services were provided by a small number of larger generators, and has not been amended despite the significant shift in the make-up of the generation mix in the NEM. This current MASS review provides AEMO with an opportunity to consider whether updates to the measurement resolution and/or the FCAS verification tool, can satisfy AEMO needs whilst also reducing barriers to entry for new technology types – notably aggregated DER.

Tesla's response below demonstrates the technical compliance of 100ms and 200ms data and we strongly believe that AEMO can move forward with reducing costs for new participants whilst being comfortable with receiving the same level of service. From Tesla's perspective we can achieve a 100ms (or 200ms) granularity in measurement resolution with our additional hardware. Alternatively maintaining a 50ms resolution would require the installation of additional hardware for each participating VPP site. Looking at a mid-range cost of $1000 based on the cost estimates put forward by AEMO in the Draft Determination, this would equate to a cost of $20m in additional metering for a 100MW VPP.

AEMO's obligations under the NEO (which are explored in more detail in section 3) must drive a consideration of a lower cost outcome if it achieves the same technical outcome – in this case an appropriate measurement resolution that is within the allowable error bands considered by the MASS.

**Customer engagement is critical**

From an economic perspective, better integration of DER into the markets provides the most efficient investment because it utilizes customer investments. As such, it is critical that customers are adequately engaged and rewarded for their system being used for market purposes. Where DER is used to provide a value-add service, customers should be compensated for that service.

A major benefit of the VPP Demonstrations is that it showed how willing customers are for their systems to be market integrated where the trade-off is an appropriate incentive package. With more than 30MW of capacity registered under the VPP Demonstrations, this equates to 5000 – 7000 customers who have actively chosen to be a part of a VPP. This can grow at scale, but Australian industry needs certainty of market settings to make investments in building out this capability.

## 2 Benefits of active DER in Australian market

As noted above, the starting view held by Tesla is that a move from passive to active DER provides an overarching benefit to the market and is necessary to address a number of higher order risk factors arising from uncontrolled daytime solar exports, as well as supporting the wider transition to higher levels of renewable energy.

This position seems to be supported by the wealth of information that has been released by AEMO, the AER, the AEMC and the ESB in recent years.

There also seems to be broad acceptance that integrating VPPs into the existing market frameworks is a necessary starting point for accessing these benefits. For instance, the "ESB P2025 Market Design Options Paper[105]" notes the following:

> "By unlocking the value of aggregated DER, this can provide a competitive alternative to large scale generation to deliver low-cost energy and system services, as well as reducing the need for investments in networks. This results in benefits to all customers (not just those with DER)."

Tesla's view is that now is the critical time for industry, AEMO and DNSPs to be collaborating on how to best create the future market settings and regulatory requirements to start treating active DER (and VPPs in particular) as a critical piece of Australia's electricity mix. Ignoring detailed trial findings and the time and investment made by industry in collaborating with AEMO since 2018 does not support these outcomes.

### 2.1 Market outlooks for DER/ VPPs

AEMO clearly views VPPs as being a critical part of Australia's energy mix in the future. This position is reinforced by AEMO's latest Integrated System Plan Draft 2021 Inputs, Assumptions and Scenarios report

[105] https://aemo.com.au/-/media/files/major-publications/isp/2021/2021-inputs-assumptions-and-scenarios-report.pdf?la=en

which assumes somewhere in the magnitude of >25 GW of VPPs operating in Australia by the late 2040s, and up to 5GW in 2030 (as shown in Figure 1).

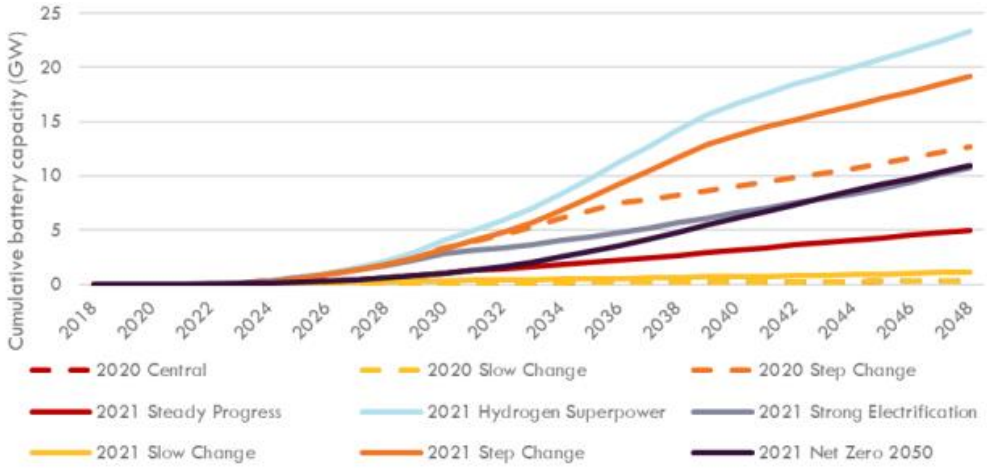



Figure 1: AEMO, "2021 Inputs, Assumptions and Scenarios Report"

It would appear, therefore, that it is critical to get the market access arrangements right to ensure optimal use of VPP systems as they are integrated into the market.

While AEMO's assumptions on the number of aggregated batteries that will providing DER is ambitious, they are also dwarfed by the total passive DER that will be installed and operational by 2040. In total, aggregated batteries are anticipated by AEMO to make up 40% of the installed behind the meter battery fleet by 2030, and 50% by 2040.

In the absence of the MASS Final Determination enabling VPP market access in full, Tesla considers these ratios to be unachievable. With full market integration, and a dedicated plan to growing market access arrangements for VPP, Tesla believes that this ratio could be much higher, and will also start to bring the gap between the level of installed smart VPP integrated DER and uncontrolled solar (with VPP storage expected to be installed at a ratio of 1:6 by 2030 – see Figure 2)

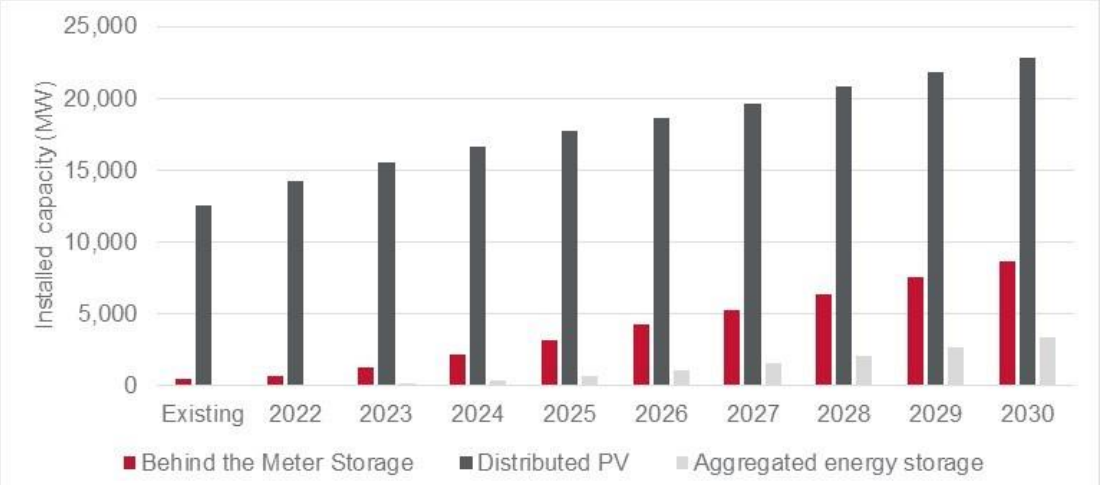



Figure 2: Anticipated solar, battery and aggregated battery uptake[106]

### 2.2 Benefits of active DER

Tesla also believes that better market integration of DER is a starting point to resolving the key DER issues that AEMO is currently concerned about in particular the concerns around minimum demand. These are

[106] Data based on AEMO High DER scenario data with some notes. Note 1. Behind the meter storage and aggregated energy storage figures are drawn from the Draft 2021-22 Inputs and Assumptions sheet. Note 2: Distributed PV numbers are based on the 2020 ISP Generation Outlook for High DER. We consider these numbers to be extremely low given the current installed distributed PV capacity is already more than 15GW. As such the ratio of passive DER to active DER – now and projected, is much, much greater. In addition, we were unable to use the most recent ISP input data (and new scenarios) as there are errors in the AEMO workbook released as there were errors in the released version.

best resolved through increased market integration of DER, removing disincentives for increased storage, and creating frameworks for AEMO to have more real-time visibility and forecasting of DER performance.

There are substantial benefits associated with better market integration of DER, these include:

1. Managing the impacts of minimum demand
2. Additional capacity to respond to disturbances
3. Better real-time DER visibility and forecasting

**Benefit 1: Managing minimum demand**

A major current concern of AEMO and the ESB is minimum demand, and the associated power system security risks that are arising because of it. This is the number one priority for the ESB's DER workstream, and the first topic considered in the DER Maturity Plan work-program.

The installation of battery storage, particularly larger residential battery storage systems right sized for the accompanying solar installation, will play a key role in reducing daytime solar exports and reducing the risk of minimum demand and impacts on the network. Tesla analysis across a fleet of 244 NMIs participating in the SAVPP shows a noticeable reduction in daytime solar exports when battery storage is added to VPP properties (Figure 3).

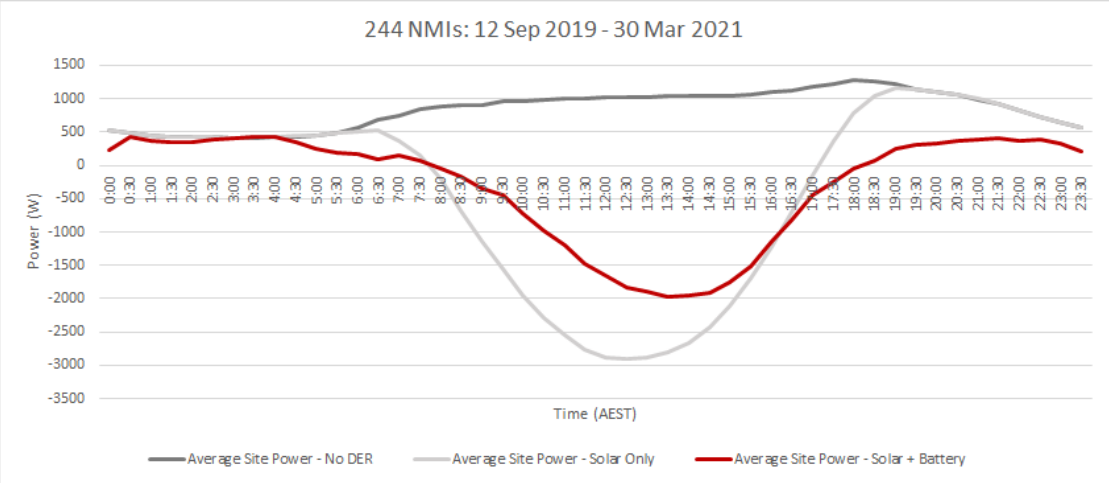



Figure 3: Tesla analysis of VPP fleet in reducing daytime exports

This is even more noticeable when a larger battery or multiple batteries are paired with solar – see Figure 4.

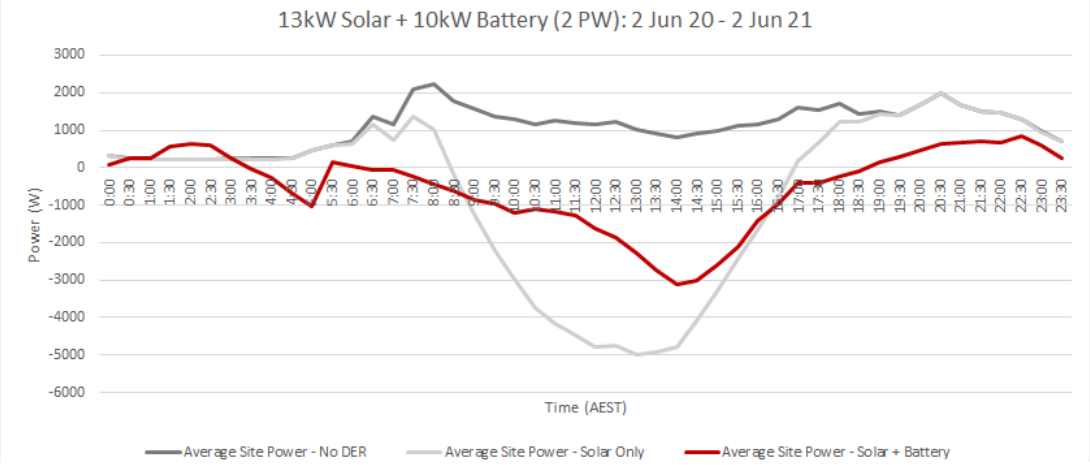



Figure 4: Tesla analysis of larger batteries reducing daytime solar exports

A key driver for customers purchasing battery storage at the moment is the competitive VPP retail offers and associated customer benefits that come from participating in a VPP – up-front hardware discounts,

ongoing grid-credits, competitive electricity tariff rates etc. Limiting access to, or creating additional cost impositions for, participating in Fast FCAS markets will negate most of these benefits that can be offered to customers and reduce the entire VPP value proposition for customers. As such we anticipate less customers opting into VPPs and less dispatchable DER entering the market.

Given the focus on minimum demand, AEMO should not be looking to create disincentives or remove market access for additional storage as this will ultimately lead to less customers installing residential storage and the concerns associated with rooftop solar exports and negative demand will be exacerbated.

**Benefit 2: DER responds to disturbances**

A second major benefit of creating appropriate market frameworks and incentive structures to incentivise DER to actively participate in all FCAS markets is that systems are not sitting idle during an event. During the Callide C event on 25 May 2021, Tesla had thousands of available systems in NSW and Queensland that sat there idle, rather than responding to the rapid frequency drop that occurred.

This is due to the fact that there are no current VPP offers in NSW or Queensland that use the Powerwall. In the event that these systems were part of one or more VPP, they would have provided an immediate frequency injection to help restore the grid and ride-through the Callide event.

More market access for DER results in more VPP offers which results in more systems being visible and useful to the market.

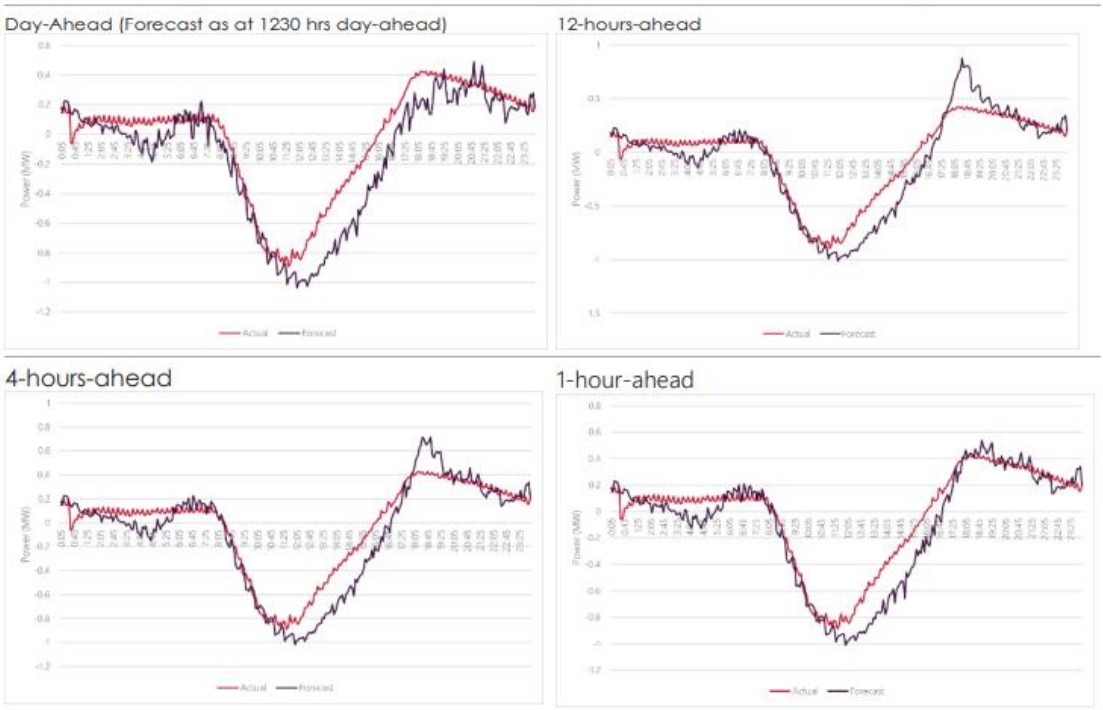
**Benefit 3: Data and forecasting**

A key benefit that AEMO has gotten out of the AEMO VPP Demonstrations is access to real-time asset and fleet wide data, via an API specifically stood up for the trial. Tesla understands that this data has been valuable to AEMO both in analysing DER response during system disturbances, and in assisting the operations team in forecasting.

Tesla was supportive of the development of the API during the trial, and we continue to be supportive of providing real-time fleet and individual asset level data. A key recommendation Tesla makes as part of our response to the MASS Draft Determination, is to maintain the API and have all VPP providers continue to provide data to AEMO. We believe this could be implemented within the MASS as a starting point, and then reinforced through the Scheduled Lite rule change and implementation of the visibility model considered in the ESB P2025 Options Paper.

Tesla believes that the provision of ongoing 1s data – both asset and fleet level – should be a minimum requirement for all VPP providers in the market. In addition, Tesla is supportive of continuing work with AEMO on future DER forecasting needs.

**Figure 11 Average VPP forecast vs actual over a range of forecast time horizons, 1-7 May 2020**



As demonstrated in Figure 5, the AEMO VPP Demonstrations set up a mode of forecasting that was successful to an extent. Given the Scheduled Lite rule change will also, likely include some form of scheduling, Tesla is supportive of continuing to work with AEMO on this approach to determine the best future approach for forecasting.

The key take-away from both points is that AEMO and industry have already collectively begun working on market approaches for VPP/ DER visibility and forecasting. These insights should not be ignored and should form part of the long-term VPP workplan that AEMO needs to lead.

**AEMO obligations under the National Electricity Objective**

As AEMO points out in the Draft Determination the NEO exists 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"

AEMO specifically must carry out its functions, including updates to the MASS with regards to the NEO.

Tesla does not believe that the outcomes put forward by AEMO in the Draft Determination are aligned with either the NEO, nor AEMO's obligations under the NEO.

Where AEMO has an opportunity to reduce costs to entry to increase competition – both in respect of total FCAS market competition and regarding retail competition, with VPP offers increasingly driven by FCAS market access.

Tesla believes that maintaining the 50ms measurement resolution in favour of further consideration of 100ms and 200ms options, or an update to the MASS verification tool is not well aligned to the NEO. The core focus of the NEO is to promote efficient investment in, and efficient operation and use of electricity services. In the Draft Determination, AEMO has considered (for the first time) the options of 100ms and 200ms data resolution. These options have been independently verified by a third-party University of Melbourne.

Tesla recognises that more work needs to be done in considering these alternative measurement resolutions, however we feel that this is valuable in supporting the most efficient approach for market integration of DER. We also believe that this work should be undertaken through this MASS review.

Tesla is concerned that ruling out potential options that would increase competition – both in FCAS markets and in customer retail offerings – when these options have been independently verified by the UoM as creating error band that is well within the 2% allowable error included the MASS, is not well aligned with the NEO. Our recommended changes are below, and we would ask AEMO to conduct further investigation on the options presented during consultation on the Draft Determination, ahead of releasing the Final Determination.

…

Table 1 summarises our concerns and the Tesla business impacts associated with complying with the MASS Draft Determination requirements, as well as our suggested alternative. This is followed with an in-depth analysis as to why we think the proposed alternative should be considered as suitable by AEMO.

Table 1: Impacts of compliance with Draft Determination

| MASS Requirement category | MASS sub-category | Tesla concerns | Impact on Tesla | Proposed alternative |
|---|---|---|---|---|
| Measurement resolution | 50ms requirement during contingency events | Tesla Powerwall cannot currently comply with 50ms data resolution, and there are no internal drivers for hardware/ firmware updates to achieve this compliance – given the lack of international drivers and the existence of reasonable alternatives.<br><br>As such, to participate in Fast FCAS markets, Tesla would need to install an off-the-shelf metering solution for each participating VPP site. There are two options for this:<br><br>• **Option 1:** working with a low-cost commercial option, which would see a different aggregator take on Tesla Powerwall systems<br><br>• **Option 2:** install a genuine plug and play off the shelf HSM to capture 50ms resolution. | **Economics of compliance:**<br><br>Option 1 - is based on the low-cost commercial options (<$200) that AEMO outlined in the Draft Determination. Tesla is yet to confirm a technology solution that exists in the <$200 range and is freely available for use by all VPP aggregators and retailers.<br><br>Option 2 – Tesla has considered both the mid and high range of technology costs presented in the Draft Determination to consider the economic impost of compliance using off-the-shelf metering. A mid-range cost of $1000 per site (no ongoing fees) has been considered, as well as a high cost of $10,000 (no ongoing fees).<br><br>These costs are then applied to Tesla's stated goal of achieving a 50,000 home VPP, with cost impacts as follows:<br><br>• Medium - $50m (payback per site ~6 years[13])<br><br>• High - $500m (payback per site - ~60 years)<br><br>**Technical outcome:**<br><br>High speed, high quality FCAS like those provided by open loop controls from devices such as Powerwalls do not require a meter to provide FCAS. Instead, the FCAS response is implemented directly at the inverter, which constantly monitors the voltage waveform and initiates a near instantaneous real power response. Meters are only used for verification purposes, which means that higher speed measurements won't translate into higher speed response or improve the quality of the FCAS provided. As such, the cost and time associated with installing meters capable of 50ms measurements at every site does not benefit the grid at all.<br><br>**Business outcomes:**<br><br>Considering the overall cost vs benefit of installing a high-speed meter, and an assumed minimum payback of ~6 years, and the fact that customer retail contracts are in place for 12 months, the outcome of the additional cost impost is that Tesla would not register for fast FCAS markets. We would still provide AEMO with a high quality, FCAS response service from open loop controls (as identified through all of the VPP Knowledge Sharing reports) however we would comply with the minimum requirements of the slow and delayed services: start of response 6s after frequency deviation, and 4sec measurements provided for FCAS verification. | Reduce granularity to 100ms data resolution on a conditional logging basis. This aligns with AS4777.2:2020 and is technically sufficient for the purpose of verification (see Application Note).<br><br>AEMO also needs to do further work considering whether less granular resolutions are appropriate on a fleet basis – such as 1s. Consideration needs to be given to whether the error rate is reduced with increased fleet sizes. |

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| MASS Requirement category | MASS sub-category | Tesla concerns | Impact on Tesla | Proposed alternative |
|---|---|---|---|---|
| | | | The loss of around 50% FCAS revenue per site, due to lack of access to Fast FCAS markets will also have some or all the following impacts on broader VPP market goals:<br>• Considering which jurisdictions are technically viable to introduce a competitive VPP offer.<br>• Increasing or reconsidering the customer retail rate that may be offered.<br>• Reconsidering the overall customer incentives that can be offered.<br>This in turn will reduce the customer uptake of VPP offers, and the stymy the transition from passive to active DER. Tesla is happy to work with AEMO to further expand on these scenarios. | |
| | High speed data logging | AEMO notes a single measurement resolution that needs to be recorded for 5s before an event and 60s after an event.<br>In practice this would always mean maintaining a high-speed data log at each VPP site to ensure that the 5s before an event is logged. This is because contingency events are unpredictable, which means that it is the 5s period preceding an event cannot be known until the event happens. | Even with 100ms measurements speed, it will always be extremely difficult for VPP operators to maintain this data resolution. 100ms data resolution for the existing SA VPP fleet of 3500 sites would equate to > 1 trillion data points per signal per year, that is >3 trillion for frequency, asset power and site power.<br>The amount of telemetry data required to be logged and stored is simply not scalable and would come at a significant engineering and data storage cost. The alternative approach of logging at 100ms during a contingency event and for 60s after, and maintaining a 1s at all other times would significantly reduce this data and engineering obligation. To meet the 5s before Tesla suggests using 1s measurement resolution and interpolating between these measurements for the sake of providing 100ms data. We understand that AEMO requires this data to calculate a power baseline which is used to determine the amount of FCAS provided during the frequency deviation. This baseline is an average over this 5s period, and as such 100ms resolution is not justified and 1s is sufficient, especially when considering a fleet-wide response of no fewer than 200 assets. | Require 100ms resolution during frequency deviations and for the 60s after, and 1s data for all other times.<br>Allow for interpolation of 1s data for the 5s before a contingency event.<br>AEMO may also require that the FCAS providers use conditional logging with settings that are narrower than the NOFB, allowing to increase measurement speed to 100ms measurements when frequency is outside a ±140mHz or a ±130mHz dead band for instance.<br>In addition, one HSM (50ms) per region and per technology should be required – see attachment A for more details. |
| Measurement location | Measurement at the connection point | Tesla measures VPP sites at both the connection point and at the individual device level (measuring grid flow, solar and battery performance at each site that a Powerwall is installed). Our preference is to verify performance at the device level as it provides a more accurate assessment of the performance of the device in providing FCAS. | In the event that measurement is maintained at the site connection point, rather than the device level, then Tesla will have to take a more conservative approach to bidding to account for the variability in *uncontrollable* load and generation on a site by site basis. This would require more contingency capacity available for each 1MW of FCAS registered. Tesla estimates that this would result in a 10% haircut on all bids placed (or conversely 10% more sites required to maintain the same bid).<br>Besides the fact that this is an unfair treatment of asset-level procurement of FCAS due to the nature of DER (uncontrollable load and solar generation will vary independently of the FCAS-enabled | Allow for optionality in measuring at the site/ device level and/or allow for device level data to be used in the event that AEMO considers a VPP to have under-delivered during an event (driven by the impact of external load/ generation on site) |

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| MASS Requirement category | MASS sub-category | Tesla concerns | Impact on Tesla | Proposed alternative |
|---|---|---|---|---|
| | | | asset behaviour, and this asset should not be penalized for this variation, nor should site-level VPP operators be allowed to claim procurement of FCAS from uncontrolled variations in load and solar generation), only a 100% bidding haircut can protect asset-level procurement of FCAS from apparent under-delivery if the response is assessed at the site level. Fig 20 illustrates a real-world impact of solar inverters tripping during a contingency event due to no fault of the Powerwalls behaviour, and for reasons outside of Tesla's control and scope. | |
| Firmware | N/A | AEMO expressed concerns with firmware updates well as occasional modification of inverter settings which may impact ability of devices to deliver FCAS, | N/A | FCAS providers should provide firmware version along with NMI and Device list and notify AEMO of firmware version updates within [10] business days, highlighting the potential impact on ability to deliver FCAS.<br>In addition, FCAS providers shall be required to check their fleet's inverter settings on a [weekly] basis. If AEMO considers a VPP to have under-delivered during FCAS verification process, AEMO may request the FCAS provider to provide a report of the fleet's relevant inverter settings since the last successful FCAS delivery. Failure to provide such a report will be considered as a breach of the MASS. |

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### 4.5.2. AEMO's assessment

AEMO is required to have regard to the NEO when making changes to the MASS, as outlined in section 2.1. The AEMC's *Applying the Energy Market Objectives*[107] (**the AEMC's guideline**) is a useful tool to guide the application of the NEO in making such assessments.

The AEMC's guideline refers to the specific set of variables in the NEO, and various other components that should be considered when assessing proposals for change. These variables and components are summarised below:

- Specific NEO variables:
  - Price: the AEMC's guideline emphasises that the assessment of various options should be centred on the concept of efficiency, whereby:
    - Prices should reflect the efficient costs of providing energy services.
    - Inefficient costs incurred by market participants should be removed.
    - Barriers to innovation are minimised.
    - Barriers to entry and exit of new technology are minimised.
  - Quality: relating to the technical quality of energy/service being delivered. In this context, a key question is whether the quality of FCAS delivered differs between the options being considered.
  - Reliable supply: means there is a high likelihood of supplying all consumer needs. In the context of FCAS, AEMO must have confidence that resources enabled for FCAS are going to deliver the enabled amount of the service if/when required.
  - System security: means the power system is able to operate with defined technical operational limits, even if there is an incident, which is the very purpose of FCAS.
  - Safety: refers to meeting the general requirements for safety, which is not a differentiating factor in this MASS Consultation.
- Various other components:
  - Consumers: meaning all consumers, and in this context not just those consumers that own assets being used to deliver FCAS.
  - Services: the NEO addresses services, not assets, so the assessment should consider how consumers are involved and participate in the process of service delivery, and whether a proposed change could allow consumers to better engage with FCAS.
  - Long-term: changes may not be appropriate if they undermine incentives to make efficient investments and operational decisions over time. Flexible and resilient market frameworks are those that rely on the least demanding assumptions about how the future may evolve and are robust to a range of different potential futures.
  - Technology: the AEMC's guideline highlights that it is not appropriate to predict which technology will be least cost, but rather to establish frameworks that allow the most cost-effective technologies to be deployed to minimise costs to consumers while ensuring security and reliability.

Any assessment against the NEO should consider these factors in a holistic way. As stated by the AEMC in its Applying the Energy Market Objectives publication[108]:

> When assessing a rule change, we take a holistic view of all aspects of energy markets including the physical operation of the electricity or gas network, the economic forces at play and the financial incentives and arrangements that underpin the market. A rule change or recommendation in a review must work for the entire market and not simply shift a problem or inefficiency from one area to the other, e.g. from the

[107] 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

[108] See section 1.5.2. Ibid.

operational to the financial sphere. This should ultimately promote efficiency in the long-term interests of consumers. The energy markets are a holistic, interconnected set of outcomes, and so any potential changes to those arrangements must be considered in that regard.

Other issues have been raised in stakeholders' submissions, with some outlined below, but AEMO's assessment remains focused on following the variables and components in the AEMC's guideline. Raised issues include:

- **Social equity**: This is a concern raised by ACF. Conceptually, a commitment to fairness, justice and equality in the provision of services and policy implementation is important. The NEO puts the consumer at the centre of AEMO's considerations, so AEMO considers that promoting the NEO is also promoting social equity.
- **Social licence**: Members Energy raised this concern, which is really about stakeholder perception. The NEO is an efficiency test that puts consumers at the centre of AEMO's deliberations. AEMO is not in a position to manage the perceptions of others as to what is socially acceptable or legitimate to them. All AEMO can do is make its determinations in a transparent manner, which means that any other person faced with the same information and lack of bias would have reached the same decision. AEMO cannot make decisions that leave everyone better off. AEMO's decisions must favour the long-term interests of consumers, even if it means that one part of the industry is to bear a higher cost.
- **Protection of existing business models/commercial viability**: Raised by several Consulted Persons[109], these two issues are related. As with social licence, these issues are not relevant in isolation to AEMO's application of the NEO. They would only be relevant if the disruption to a business model applied by a class of participant would result in higher costs to consumers in the long term.
- **Distortionary impact:** Some Consulted Persons assumed that the only real-time data AEMO relies on to manage power system security is 4 s SCADA data, which is not the case.
  - For some time, AEMO has been working with transmission network service providers (**TNSP**s) and others to implement high speed metering (**HSM**) in the power system. This project is ongoing and will become more important as more DER connect to the power system.
  - Although verification of FCAS compliance is a post-disturbance assessment, it is very relevant when determining the quantity of FCAS required to recover from power system disturbances, and whether AEMO has breached the Frequency Operating Standard (**FOS**) as a result of FCAS Providers failing to meet their NER and MASS requirements.
  - Hence, it would be incorrect to assume AEMO does not require high-speed data from Fast FCAS Providers to manage power system security because this data is not available to AEMO in real time.
- **Minimum demand**: AEMO agrees that there are significant benefits in addressing the problem of minimum demand before DPV grows much further. Some Consulted Persons referred to this concern in their submissions[110]; Tesla addressed it extensively. AEMO certainly has considered this issue and continues to do so.

### Application of the NEO to the measurement time resolution for Fast FCAS provided by DER

AEMO acknowledges the different stakeholder views on the cost of metering. However, to remove inefficient costs incurred by market participants to delivery of FCAS, the specifications in the MASS should be at a level needed for AEMO to reliably verify that the enabled amounts of FCAS are delivered, and no more onerous than required.

[109] Energy Locals, Members Energy, Quinbrook, Shell Energy & Simply Energy.
[110] ACG, DEMSA & DEWLP.

AEMO's assessment, supported by UoM analysis, is that a 50 ms sampling rate is not required to reliably verify the delivery of Fast FCAS unless it is necessary to identify how an inertial response impacts the FCAS delivery. The analysis shows that a 200 ms sampling rate can adequately verify delivery of Fast FCAS, and can also identify issues relating to the quality of the service delivered such as oscillatory behaviour.

Another consideration of the quality NEO variable is whether a 200 ms sampling rate introduces unacceptable error in the verification assessment. The UoM analysis indicates that aggregations of more than one site, together with methodology changes to the FCAS verification tool and relevant discount described in section 4.1.2, can adequately reduce this error to a level that minimises its impact on the quality variable.

Lowering the Fast FCAS measurement time resolution for aggregated ancillary service facilities with no inertial response to 200 ms can remove inefficient costs incurred by market participants and minimise barriers to entry/innovation in the MASS.

If more potential FCAS Participants are capable of meeting the updated measurement requirements as highlighted in Section 4.1.3, consumers may experience more opportunities to engage with FCAS, and competition among providers could lead to better consumer experiences in their engagement. Greater competition in FCAS markets could also lead to lower FCAS prices over time that would benefit all consumers.

When assessing whether the issues highlighted in Appendix D could lead to an under-delivery of FCAS and potential system security risks, AEMO considers that the non-compliance risk and clawback of FCAS payments incentivises market participants to establish processes to confirm FCAS availability and employ equipment that minimise these risks. These issues will be monitored and examined further in the Consultative Forum.

AEMO's assessment is that the proposed change to the measurement time resolution for Fast FCAS provided by DER is in the long-term interests of all consumers. This proposed change remains technology-neutral, and maintains a flexible framework that allows the most cost-effective technologies to be deployed to minimise costs to consumers, while enabling FCAS markets to remain secure and reliable.

**Assessment of measurement point location for FCAS provided by DER**

AEMO's assessment is to maintain the measurement point location 'at or close' to the connection point to ensure the proper orchestration of DER and to verify the amount of FCAS delivered to the power system more accurately.

This approach is in the long-term interests of consumers, as it maintains a flexible and resilient framework that relies on the least demanding assumptions about how the future may evolve and is robust to a range of different potential futures. This is particularly relevant when considering FCAS provided by DER could involve multiple technology/devices behind the same connection point or multiple connection points at a site in future. For the reasons mentioned in section 4.2.2 and in line with the NEO, AEMO must set FCAS requirements which would be applicable to single and mixed DER sites alike. AEMO considers that it would be inefficient and costly for market participants to move the location of the FCAS measurement points following changes to the number of controllable devices at every site.

Measuring 'at or close to' the connection point maintains a technology-neutral approach that is focused on the service delivery rather than the assets. The approach to allow device level measurements at 1 s intervals (in addition to the 200 ms data at or close to the connection point) only to assist AEMO in the assessment of potential non-compliance events[111] also aligns with the quality NEO variable to assess the technical quality of the FCAS delivery (i.e. to understand the underlying reasons for the under-delivery).

[111] To confirm whether the change in active power was in line with each Ancillary Service Facility's droop setting, frequency deadband or frequency deviation trigger settings.

### 4.5.3. AEMO's conclusion

AEMO has used the AEMC's guideline to apply the NEO when assessing issues relating to FCAS provided by DER. This process has enabled a robust assessment resulting in proposed changes that align with the long-term interests of consumers.

## 4.6. Importance of VPP Demonstrations

### 4.6.1. Issue summary and submissions

Several submissions alluded to an industry understanding that there would be a smooth transition from the VPP Demonstrations Specification to the MASS. Extracts from submissions on this issue are cited below.[112]

AGL:

> As Trial Participants, we note the strategic intent that has underpinned that program to inform the integration of VPPs into the NEM before they reach scale, including the regulatory arrangements affecting the ability of VPPs to participate and inform new or amended arrangement where appropriate.

Enphase Energy:

> The various gaols (sic) that AEMO set for the VPP Demonstrations were largely met. This included the demonstration of the technical capability of VPPs to provide quality Fast FCAS as reported in the public reports. The VPP Demonstrations engaged over 6,000 customers, representing over 10 MW of FCAS DER capacity on the NEM and other marginal grids within Australia. The DER industry engaged in the VPP Demonstrations on the understanding that if the set goals were achieved then the rules of DER integration for FCAS and VPPs would follow these guidelines.

Evergen:

> Specific additional recommendations
>
> …
>
> 11. As active participation of DER for grid services gradually advances, AEMO should acknowledge that increased visibility and learning-by-doing is preferable to halting progress and neglecting the visibility over real-world data that is on offer.
>
> …
>
> The VPP Demonstrations have enabled industry to come together and solve technical issues, brought new value streams for consumers, and provided near real-time data streams to AEMO to enable the industry to move forward together in exploring how DER can contribute to grid services and deliver a benefit for all parties, from consumers to networks and market operators. Evergen has been a strong supporter of the review of the MASS to better utilise DER and VPPs in FCAS markets, and has been orchestrating VPPs as an active participant in the program since December 2021. Evergen operates the only VPP for FCAS in Victoria on behalf of the retailer Members Energy, and operates the only VPP in the VPP Demonstrations composed of multiple device types. Both Evergen and Members Energy participated at considerable expense, including providing a large volume of valuable data to AEMO at no cost, data not normally accessible to either AEMO or DNSPs.
>
> Evergen did this in good faith, in the interests of learning, and on the assumption that if the VPP Demonstrations proved the capability of VPPs to successfully deliver Contingency FCAS, that this would likely assist AEMO in progressing towards formalising these arrangements more broadly in the MASS.
>
> Evergen was a strong supporter of the initial MASS review Option 2 proposal to adopt the VPP Demonstrations alternative requirements as a formal specification for all DER-based VPP in FCAS markets under the MASS. We believe this would enable continued collaboration with consumers, OEMs, energy retailers, DNSPs and regulators among others, and is in keeping with AEMO's intentions of supporting a transition to a two-way grid where consumers and other asset owners can play a part in delivering services back to the grid. We noted that a majority of submissions to the first round of consultation also supported the adoption of either Option 2, or else Option 2 with some variation.

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

With this in mind we were surprised that the Draft Determination appears to disregard the innovation, lessons learned and industry investment from the 2 year in-market demonstration. Furthermore, it appears to seek to exclude broader adoption of consumer DER participation in Contingency FCAS markets for the foreseeable future, and leaves existing VPPs stranded and uneconomical.

The VPP Demonstrations and associated knowledge sharing reports have clearly shown that VPPs are technically capable of providing FCAS, and that aggregators bid in these markets appropriately, as AEMO acknowledged in their initial MASS Review report.

…

These trials are enabling greater visibility of DER and capture data as to how DER performs and impacts the grid. We should be growing this visibility, not turning it off. Lack of visibility is bad for system security, innovation, and ultimately delays the transition to a lower cost, more flexible, more decentralised energy system.

New Energy Ventures:

FCAS is an important revenue source for batteries and VPPs, making a third to a half of all revenue for batteries and up to 75% for VPPs. VPPs have also proven to be a significant source of contingency reserve. For example, last year Energy Locals and Tesla's VPP achieved the milestone of registering 10 MW into all six Contingency FCAS markets through the VPP Demonstrations.

The industry engaged in good faith with AEMO with VPP Demonstrations working on the basis that if the goals of the trials were met, changes would be made to the MASS making it easier for DER to participate in FCAS markets. Many in the industry have assumed (as we at New Energy Ventures did) that the changes to the MASS to facilitate the VPP Demonstrations would be at least partially adopted into the MASS. AEMO has stated that the goals of the VPP Demonstrations had been met. This is documented by multiple knowledge sharing reports released by AEMO.

Based on our work assisting businesses to set up VPPs, we think the decision by AEMO could have significant ramifications. This will be especially so for VPPs that have been developed on the basis of the VPP Demonstrations FCAS Specification, but also for the batteries and VPPs that have been installed through the VPP Demonstrations and their customers.

Simply Energy:

Innovative business models, such as VPPs, will play a critical role in supporting the transition to an energy system with increased dependence on renewable energy. AEMO produced several knowledge sharing reports that demonstrated the capability of VPPs to provide Fast FCAS accurately and without any negative system security issues.

…

Simply Energy makes the following observations and recommendations:

- The VPP Demonstrations showed that measurement at the asset level alongside the grid power flow metering was sufficient to demonstrate that the FCAS response was having a positive effect on the grid. Setting the point of measurement at the connection point would likely limit competition and fleet diversity as well as limiting the number of potential ancillary services that can be provided at each connection point.

SolarEdge:

Internationally VPP's have been operating in wholesale markets and other services for some years. Frequency support services are currently being provided effectively in live markets and for Australia, without a pragmatic approach, AEMO's stated target of supporting 100% renewable integration by 2025 is at risk. The transition to call upon DER for energy generation, storage, control and enjoyment is accelerating as the electrification of services in homes and businesses continues. The last five years have seen a rise in the sophistication of DER and many trials developed that look to realize the full potential of DER in the aggregated assets.

The VPP Demonstrations, and associated knowledge sharing reports, clearly demonstrate that VPPs are technically capable of providing Fast FCAS and that aggregators appropriately bid in these markets.

By not adopting any of the changes tested during the VPP Demonstrations, SolarEdge believe AEMO is creating market risks for the future of VPP operations in Australia due to implementation of untested methodology.

Tesla:

One of the key concerns that Tesla has with the Draft Determination was the lack of insights from the VPP Demonstrations. Tesla is confident that AEMO undertook the VPP Demonstrations in good faith, and that

current AEMO priorities such as Project Edge support future market integration of DER. However the recommendations in the Draft Determination appear to be driven primarily by potential or perceived risks associated with broader integration of high penetrations of DER into the markets, rather than considering both the learnings of the VPP Demonstrations and steering the future of DER in Australia towards using markets as opposed to regulations to drive consumer and industry investment.

The VPP Demonstrations provided two years of in-market, technical demonstration of VPP performance, and in-depth collaboration between AEMO and industry. From Tesla's perspective this work was leading both from a domestic and an international perspective. Providing a detailed practical demonstration of services is critical when considering major market shifts, and the insights gained by both AEMO and industry are far more valuable than those gained during an equivalent desktop consultation process.

At the conclusion of the two-year demonstration, none of these changes have flowed through to the Draft Determination. AEMO has provided no industry guidance on whether the VPP registration approach used during the trial will be maintained, and there is limited guidance as to how the visibility and forecasting approaches used by AEMO during the VPP Demonstrations will flow through to future market changes.

While there should be further consideration given to the appropriateness of the settings tested during the VPP Demonstrations, Tesla believes that the work done should form the basis of AEMO DER market settings.

…

**5 AEMO VPP Demonstrations**

**5.1 Overview**

… Tesla is particularly concerned with the fact that the Draft Determination appears to ignore all work done, and insights gained, from the two-year VPP Demonstrations.

The VPP Demonstrations first launched by AEMO in December 2018 with an initial consultation paper suggesting the trial to test the technical capability of aggregated DER to provide FCAS.

After consultation, and with support from the majority of respondents, the VPP Demonstrations were officially launched in July 2019 with the following goals[113]:

- Understand whether VPPs can reliably control and coordinate a portfolio of resources to stack value streams relating to FCAS, energy and possibly network support services.
- Develop systems that provide AEMO with operational visibility of VPPs to understand their impact on power system security, local power quality and how they interact with the market.
- Assess current regulatory arrangements affecting participation.
- Provide insights on how to improve consumers experience of VPPs in future.
- Understand what cyber security measures VPPs currently implement and whether VPP cyber security capabilities should be augmented in future.

The VPP Demonstrations now have 2 years of in-market demonstration of the technical capability of VPPs to participate in all FCAS markets. Importantly, all Trial Participants joined the VPP Demonstrations in good faith, and with the assumption that if its stated goals were met then the trial settings would flow through to BAU settings to improve market access for VPPs.

On 19 January 2021 AEMO released an Issues Paper which put two options to industry – Option 1 (make no changes to the MASS); and Option 2 (update the MASS to include those provisions included in the VPP Demonstrations).

Of the 31 submissions received relevant to DER, 18 of those explicitly supported Option 2. Nine submissions supported a hybrid approach or further consideration – but these overwhelmingly supported AEMO making updates to better include DER in the market. Four submissions supported Option 1.

Tesla does not believe that the lack of changes in the Draft Determination are an adequate representation of the work done in the VPP Demonstrations and does not capture its success and the key lessons learnt. We also believe that over the course of the two-year trial there was sufficient time to stress-test some of the new information that has been put to industry in the Draft Determination.

The Draft Determination appears to provide a lot more weight to the analytical responses provided to the first MASS consultation, from those not participating in the trial, than to the 2 years' worth of

[113] https://aemo.com.au/-/media/files/electricity/der/2021/nem-vpp-demonstrations_final-design.pdf?la=en

demonstrated, technical experience and findings that came from the trial, and resulted in three (soon to be four) detailed knowledge sharing reports.

Industry and AEMO collectively invested millions of dollars, and years of effort, in order to "learn by doing" and create optimal market settings for DER and at the end of the process, we have not progressed settings for DER or implemented any findings. This could result in industry being less inclined to invest time and resources into future trials that AEMO run, for fear that this investment won't result in moving the industry forward.

While we understand the concerns raised by AEMO in the Draft Determination – and address these in more detail in sections 6 and 7, we also believe that the lessons learned and outcomes of the VPP Demonstrations are sufficient to support more changes being made to the VPP market arrangements, than have been considered in the Draft Determination. ...

### 5.2 Technical performance

As noted above, the primary goal of the VPP Demonstrations was to assess technical capability of controllable DER to participate in all FCAS markets, and thus better stack market revenues.

Under the VPP Demonstrations AEMO established a new approach to registering VPP systems for the purposes of providing FCAS. Specifically, AEMO introduced a two-step approach:

1. Asset level frequency injection test which effectively required a lab test of FCAS-enabled VPP systems to verify individual asset level performance; and
2. VPP fleet-wide test which was required to confirm the FCAS capacity of the fleet as a whole.

This approach provides two points of verification for AEMO. The first ensures that all types of individual plant registered within a fleet are technically capable of providing all FCAS that the plant is registered for. Figure 6 shows the "raise" frequency injection test provided to AEMO for a 5kW Powerwall for instance.

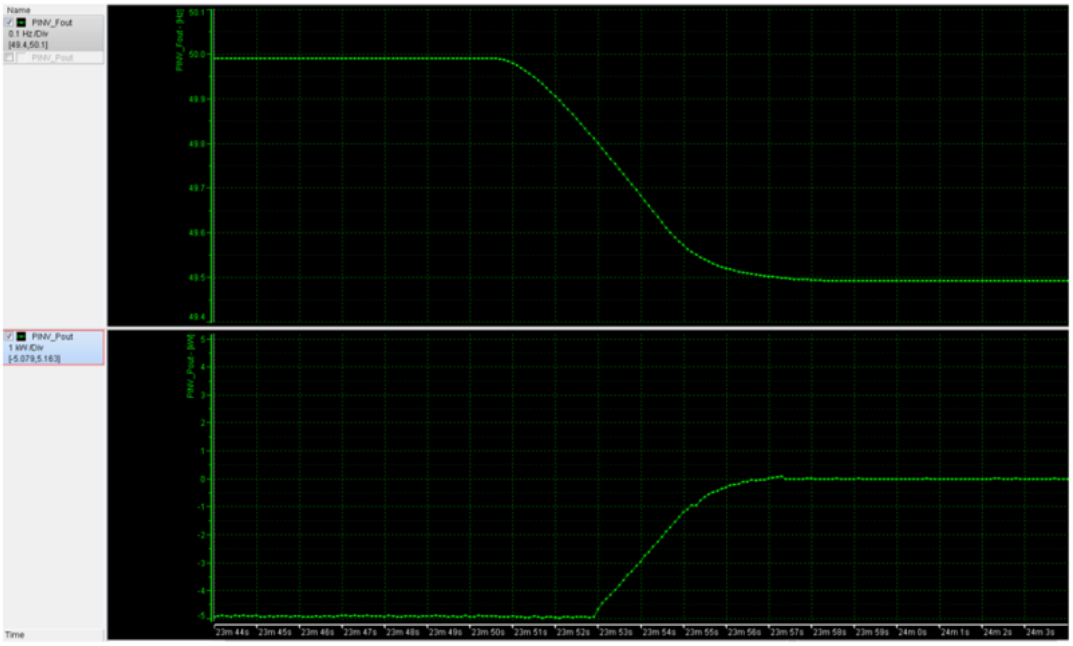


Figure 6 - Tesla Powerwall 2 Frequency Injection Test Results: 5kW Raise Response

The fleet-wide test ensures that fleet is technically capable of delivering the registered capacity. Importantly for the second point, this is a field test. AEMO needs to have confidence that a fleet is capable of delivering 1MW before approving that 1MW registration. This two-step process ensures that the FCAS delivered meets the registered capacity and provides AEMO with confidence that individual assets can meet the AEMO minimum performance requirements.

**AEMO positioning on technical performance**

AEMO's confidence in VPPs demonstrating a technical capability to provide all FCAS appears to have been verified through the three knowledge sharing reports released by AEMO over the course of the VPP Demonstrations, which made comments such as:

- In response to the 9 October 2019, Kogan Creek trip "The SA VPP detected this frequency excursion and responded immediately to inject power into the system and aid frequency recovery"[114]
- In response to 10 December 2019 under frequency event, "The SA VPP responded immediately in both cases to first charge the batteries to lower system frequency, and then discharge the batteries to raise system frequency"[115]
- In response to the January 2020 SA separation event, "To help suppress the high frequency, the VPP very quickly increased its power drawn to beyond the enabled minimum response. Of note is the speed of the response: from zero to approximately 1.9 MW output in under 10s, with a peak rate of change in this period of over 1.1 MW/s."[116]
- In response to s trip of Callide C3 and C4, "The minimum mainland frequency observed was 49.786 Hz, and the data provided in Figure 3 shows that the VPP met its FCAS requirement for a 1 MW enablement."[117]

There were no significant concerns raised by AEMO as to the ability of VPPs to technically deliver FCAS in any of the contingency markets. As such, it appears as though a core goal and stated outcome of the trial has been met by AEMO. In the most recent VPP Demonstrations Knowledge Sharing Report, AEMO released the following traffic light indicators in respect of how well VPP technical performance. Most noticeable is AEMO's "green" ranking of the technical capability of VPPs to "reliably deliver" all contingency services that they bid and are enabled for – including Fast FCAS.


Figure 7: AEMO assessment of VPP technical performance - VPP Knowledge Sharing Report #3[118]

**Verification of performance**

Over the duration of the VPP Demonstrations, the verification of performance under the trial conditions was considered. The second Knowledge Sharing report speaks specifically to the approach taken to verifying technical performance, without raising concerns as to the 1s measurement resolution that was in place for the duration of the trial, including providing a specific example of the verification of a particular event. In the Knowledge Sharing Report, AEMO notes that the Energy Locals / Tesla VPP over-delivers on the committed response. – see Figure 8.

[114] https://aemo.com.au/-/media/files/electricity/der/2020/aemo-knowledge-sharing-stage-1-report.pdf?la=en
[115] Ibid.
[116] https://aemo.com.au/-/media/files/electricity/der/2020/vpp-knowledge-sharing-stage-2.pdf
[117] https://aemo.com.au/-/media/files/initiatives/der/2021/vpp-demonstrations-knowledge-sharing-report-3.pdf?la=en
[118] Ibid.

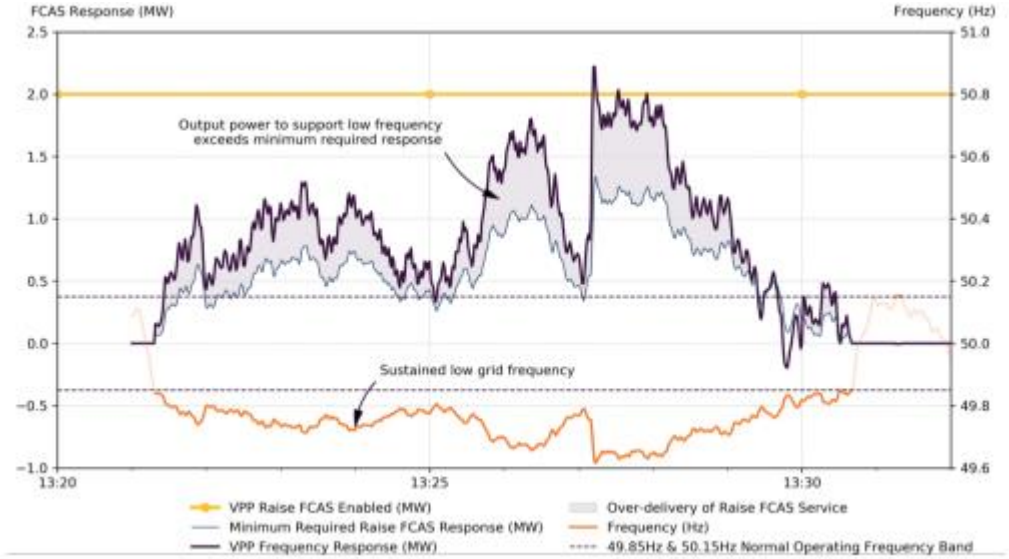



Figure 8: AEMO VPP Demonstrations - Knowledge Sharing #2

**Concerns raised in Draft Determination**

Between the first consultation on the MASS review and the release of the Draft Determination, AEMO has considered some concerns that were not addressed during VPP Demonstrations in respect of the verification approach undertaken. Specifically, AEMO are concerned that the 1s measurement resolution that was deployed during the trial is not sufficient to properly verify performance, and this creates a risk of overpayment for FCAS delivered.

This appears to conflate the issue of technical performance with the approach taken to verifying technical performance. As far as Tesla is aware, the approach implemented by AEMO during the VPP Demonstrations to establish both system and fleet wide technical performance has been sufficient in establishing confidence in the technical performance of VPPs to provide Fast FCAS.

In section 5, Tesla provides additional context on this point. Based on this analysis, plus the two-step technical verification approach that was implemented by AEMO during the VPP Demonstrations, as well as the overwhelmingly positive content provided by AEMO in the knowledge sharing reports in respect of the technical capabilities of VPPs to deliver Fast FCAS, we believe that AEMO has been more than satisfied of the technical capability of VPPs to deliver Fast FCAS.

### 5.3 Assess current regulatory barriers affecting participation

As of June 2021, the trial has gained the following level of participation:

- 7 registered participants.
- 30MW of FCAS registered.
- 5 different DER technology types.
- A mix of switched and proportional controls; and
- Operation in all NEM states with the exception of Tasmania.

Importantly it has resulted in competitive new market retail offers being made available to 5,000 – 7,000 customers. Since launching the program AEMO has run two years' worth of dedicated consultation with more than 30 different stakeholders representing all parts of the DER industry – this consultation should have resulted in a detailed understanding of the barriers to entry and how the VPP Demonstrations has helped resolve these.

Importantly the VPP Demonstrations also considered alternative measurement and metering requirements designed to increase market participation. Tesla's consideration of how the VPP Demonstrations met the stated goals of the program is articulated below.

We note that as a direct result of the VPP Demonstrations, AEMO has seen 30MW of additional FCAS capacity registered, and seven additional market participants. This compares to only a single DER aggregator registered under the existing rules, providing strong evidence that the VPP Demonstrations did

in fact demonstrate that there are barriers to entry that exist within the existing MASS settings, and that the trial settings implemented removed these barriers to entry and increased competition.

### 5.4 Improve operational visibility

In addition to not updating the measurement resolution and the measurement location (the two key areas that the trial was focused on), industry is also left with no further clarity on how AEMO intends to use other insights gained during the trial, including the following:

- Approach to provision of data in real time (both for individual sites and for the fleet as a whole)
- Fleet forecasting requirements
- Registration approach.

Access to live data at both an individual asset level, and from a fleet perspective, gave AEMO distribution level data access beyond what currently exists under any standard frameworks. This information is important both from a market planning perspective and to detect faults (see section above where we discuss the benefits associated with increased visibility in more detail).

Disappointingly AEMO has made the decision to decommission the API that was set up for the purposes of the VPP Demonstrations. These insights will not, however, be wasted as the approach that AEMO has taken to improving operational visibility will feed directly into the development of the Schedule Lite rule change – particularly the "visibility model" proposed in the ESB P2025 Options Paper – Part B[119]. As such we consider that this goal can also be considered to be relatively successful. AEMO also rated the ability of VPPs to provide accurate forecasting information as green in their third knowledge sharing report.

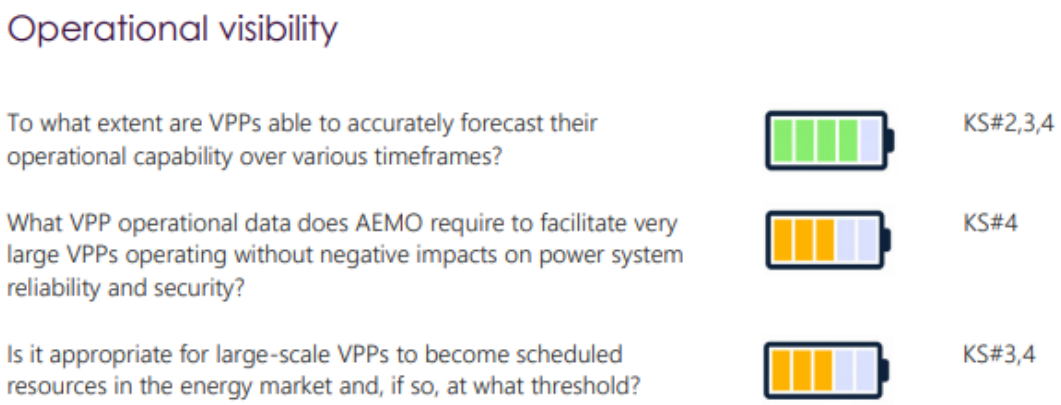



Figure 9: AEMO assessment of VPP operational visibility - VPP Knowledge Sharing Report #3[120]

As with AEMO's assessment of technical performance, the third VPP Knowledge sharing report also highly rates the work done in VPPs providing operational visibility. This raises more questions as to why the API has been decommissioned at the end of the VPP Demonstrations. Tesla recognises that there is ongoing work required to address the broader power system security concerns associated with VPPs participating in the market, and we have addressed these points separately in section 7.

### 5.5 Provide insights into consumer experiences

In addition to demonstrating the technical performance of VPPs to participate in all FCAS markets, AEMO also undertook detailed surveys with customers who were a part of a VPP and published a separate report on consumer insights with their third knowledge sharing report. The third knowledge sharing report provided an amber rating to the work done to date in respect of consumer insights. This is understandable as the work will necessarily need to extend far beyond the remit of AEMO's work plan and will require 5 – 10 years of constant work and industry development to deliver optimal settings for customers.

[119] https://esb-post2025-market-design.aemc.gov.au/32572/1619564172-part-b-p2025-march-paper-appendices-esb-final-for-publication-30-april-2021.pdf
[120] https://aemo.com.au/-/media/files/initiatives/der/2021/vpp-demonstrations-knowledge-sharing-report-3.pdf?la=en

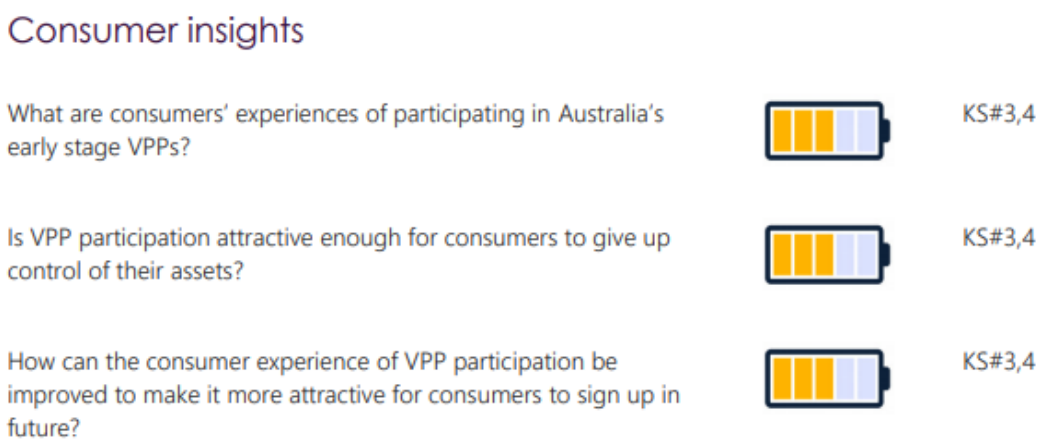



Figure 10: AEMO assessment of VPP operational visibility - VPP Knowledge Sharing Report #3[121]

...

**5.7 Summary**

The take-away of all the above is that all the stated goals of the VPP Demonstrations have been met, yet no findings or work done have been included in the publication of the Draft Determination. Noting the general success of the VPP Demonstrations, and the significant number of additional customers that have benefited from innovative VPP offerings over the last two years, Tesla believes it is in the best interests of both consumers and the DER industry to ensure that the learnings of the trial are implemented.

In Attachment A[122], Tesla provides an overview as to how we think our recommendations on both the points raised in respect of the Draft Determination, as well as the lessons from the VPP Demonstrations, should flow through to the VPP FCAS settings that AEMO adopts in the long-term.

### 4.6.2. AEMO's assessment

The VPP Demonstrations project was an initial step in AEMO's broader DER Program, designed to provide early insights on how to integrate VPPs into market frameworks at scale, and develop empirical evidence to inform related changes to regulatory frameworks and operational processes.

The exploratory nature of the VPP Demonstrations is summarised in the objectives to:

- Understand whether VPPs can reliably control and coordinate a portfolio to stack value streams relating to FCAS, energy and, possibly, network support services. The specification of FCAS that VPPs had to meet was detailed in a customised VPP Demonstrations FCAS Specification,[123] consistent with section 7.3 of the current version of MASS[124].
- Develop API systems to provide AEMO with operational visibility of the impact of VPPs on power system security, local power quality, and how they interact with the market. Trial Participants were to use this to submit operational forecasts and performance data to AEMO.
- Observe VPP operations to help AEMO determine the necessary systems and capabilities to support further FCAS market participation by VPPs at a larger scale.
- Assess current regulatory arrangements affecting participation of VPPs in energy and FCAS markets to inform future arrangements, where appropriate.
- Provide insights on how to improve consumers' experience of VPPs.

[121] https://aemo.com.au/-/media/files/initiatives/der/2021/vpp-demonstrations-knowledge-sharing-report-3.pdf?la=en

[122] Attachment A contains suggestions to improve the FCAS registration and verification process for DER. As such, AEMO does not consider it to be relevant to the MASS. It will be taken up by one of the consultative forums discussed in section 4.4.

[123] Available at https://aemo.com.au/-/media/files/electricity/nem/der/2019/vpp-demonstrations/vpp-demonstrations-fcas-specification.pdf?la=en.

[124] MASS Version 6.0

- Understand what cyber security measures VPPs currently implement, and whether they should be augmented.

There is nothing in the objectives that would suggest any findings would automatically flow to the MASS. For the avoidance of doubt, section 1.2 of the VPP FCAS Specification states:

> Nothing in this document should be taken to represent that these arrangements will continue after the VPP Demonstrations are complete, that any VPP will be permitted to participate in the VPP Demonstrations, or that any VPP will be able to participate in the FCAS markets after the VPP Demonstrations are completed.
>
> Learnings from the VPP Demonstrations and the consultation in connection with MASS consultation will inform the ongoing arrangements for FCAS registration as those processes are completed. This may result in amendments to telemetry/metering equipment requirements for DER in VPPs.

AEMO's DER demonstration projects do not have authority to make regulatory or long-term operational changes themselves. Their purpose is to develop an evidence base to inform change that is driven through the normal channels for reform as those channels involve thorough NER-based consultation processes.

In relation to FCAS specifications, the MASS Consultation process is the appropriate NER-based mechanism to implement change, and this was clearly communicated throughout the VPP Demonstrations.

Reforms relating to VPP participation in the energy market will be driven by the ESB reforms including Scheduled Lite and Flexible Trading Arrangements, and subsequent Rule change proposals to be considered by the AEMC. Learnings from the VPP Demonstrations will continue to feed into the design and implementation of these reforms as they flow through the regulatory processes.

AEMO has delivered four knowledge sharing reports that collectively provide a detailed evidence base to address the objectives and research questions articulated at the inception of the VPP Demonstrations project. The final knowledge sharing report, published in September 2021[125], contains a number of recommendations in relation to each objective that refer to the appropriate processes for changes to be further considered and implemented.

In relation to whether the VPP Demonstrations provided enough evidence to inform appropriate changes to the MASS, the changes proposed in this draft determination could not have been suggested without the VPP Demonstrations, but clearly more detailed analysis and industry engagement has been required during this MASS Consultation process to get to this point.

**What could AEMO have done differently?**

With the wisdom of hindsight, it would have been more beneficial to the MASS Consultation process if some of the VPP Demonstrations participants had chosen the option in the VPP Demonstrations FCAS Specification to implement 100 ms sampling rates at each site, or if AEMO had required one or more participants to implement this. This would have enabled practical evidence to be collected, for instance in relation to measurement error or 100 ms sampling rates detecting oscillatory behaviour, but it could also have restricted participation, which would have impacted AEMO's learning in relation to other objectives.

AEMO should have identified the error between 50 ms and lower sampling rates, and the associated limitations with the existing methodology in its verification tool, either during the VPP Demonstrations or when publishing the issues paper for this MASS Consultation. This would have enabled a more thorough examination of these issues earlier in the process and would likely have shortened the length of this consultation.

[125] Available at: https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations

### 4.6.3. AEMO's conclusion

While acknowledging that some Consulted Persons might feel that the VPP Demonstrations FCAS Specification should have been implemented into the MASS, the matter is not as simple as they suggest.

The exploratory nature of the trial enabled AEMO to set a time-bound VPP Demonstrations FCAS Specification to explore the boundaries of what specifications could reliably verify the delivery of FCAS, while encouraging participation in the VPP Demonstrations to meet AEMO's other learning objectives.

The MASS Consultation has been the correct process, consistent with NER 3.11.2, to thoroughly consider what specification is suitable for DER provision of FCAS at large scale that is aligned to the NEO.

While the VPP Demonstrations provided strong evidence of VPPs' capabilities to deliver Contingency FCAS, the MASS Consultation process has been the correct industry-wide engagement forum to identify and analyse measurement and verification issues associated with applying the VPP Demonstrations FCAS Specification at scale.

## 4.7. Relevance of other market experience

### 4.7.1. Issue summary and submissions

Several Consulted Persons alluded to the operation of frequency control markets in other jurisdictions, pointing to them for AEMO's guidance. Extracts from submissions on this issue are cited below.[126]

CEC:

> We would like to bring to AEMO's attention some procedures used in the UK and the US that could provide valuable lessons for a procedure for testing inverters for FCAS participation.
>
> The UK operator (National Grid) requires a pre-qualification assessment process for all frequency response market participants. The testing procedure includes two predefined tests (pre-set frequency pattern) and an additional live test against natural grid behaviour. Data relating to power and frequency is required at a measurement interval of 100ms for the first two tests and at a 1s interval for the real time event metering. The data is reviewed by an Independent Technical Expert (ITE) and, if approved by the ITE, is then considered by National Grid for final approval. Real time response is open to any device that meets the pre-qualification criteria and can collect and submit 1s data, which is reasonably achievable by many types of generators[127].
>
> The Hawaiian Electric Company (HECO) Fast Frequency Response (FFR) service requires metering at a 5-minute interval. HECO focuses on response time (rather than measurement interval). It requires vendors to provide certification to verify that the end devices can detect the frequency excursion and respond to it within a predefined number of grid cycles[128].

Simply Energy:

> Simply Energy is also aware that other jurisdictions, such as the UK's National Grid, have taken the approach of stipulating a higher frequency of measurement for the initial testing/demonstration phase for DER intending to join the Fast Frequency Response market whilst post-event verification is conducted using only 1s data. AEMO could adopt a similar approach and include pre-defined laboratory testing regimes for DER models/categories to determine whether the response is satisfactory.

SolarEdge:

> **1. Other Frequency market approaches**
>
> SolarEdge participates in frequency markets internationally. We are yet to come across market participation requirements for ongoing operational sampling rates at less than 1s. Australia's market is not that different to other regions that it should differ so greatly for inclusion of DER.

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

[127] See National Grid, Firm Frequency Response Balancing Service, Test Guidance for Providers, here

[128] See Hawaiian Electric Companies' Phase 2 Draft Requests for Proposals, here

**1.1 UK**

The National Grid is the UK's Grid operator as such they impose a pre-qualification assessment process for all frequency response market participants. The testing procedure includes 2 predefined tests (pre-set frequency pattern) and an additional test against natural grid behavior (live test). For test 1&2, any provider must collect Time, Power & Frequency at maximum sample rate of 100ms and at a 1s rate for test 3. Data collected is then provided to an Independent Technical Expert (ITE) to review and approve the validity of the results and later on to National Grid for final approval.

Real time event metering requirement is at a 1s sample rate. This data alone is used by National Grid to confirm the response quality.

As demonstrated above, National Grid has built a detailed qualification process to test and confirm the ability of a device to accurately respond to a frequency event. While the testing requirements are not easy to meet by the typical DER due to a metering requirement of 100ms, this can be managed by many participants as required only for the testing process. Real time response is open to any device that have met the pre-qualification criteria and is able to collect and submit 1s data, which is reasonably achievable by many type of generators.

Table 9 - Limits of error and minimum sample rates for Dynamic Service Testing

| | Limit of error/ Accuracy threshold | Minimum Sample rate Test 1 | Minimum Sample rate Tests 2 and 3 |
|---|---|---|---|
| Frequency (Hz) | ±0.01 Hz | 10Hz | 1Hz |
| Active Power (MW) | Please see pass criteria | 10Hz | 1Hz |

Source: National Grid, Firm Frequency Response Balancing Service, Test Guidance for Providers
https://www.nationalgrideso.com/document/148721/download

Source: National Grid, Firm Frequency Response Balancing Service, Test Guidance for Providers

https://www.nationalgrideso.com/document/148721/download

**1.2 USA**

A pertinent example of FCAS requirements in the USA would come from our experience negotiating with the Hawaiian Electric FFR service and the metering requirements for the service, as described in Exhibit E to their Grid Services Purchase Agreement[129].

For this service, which is step Fast Frequency Response service, the metering requirement is set to 5 minutes interval. HECO cleverly focus on the response time (rather than on the measurement interval) as a way to assure the timely frequency support, and simply require from vendors to demonstrate through a mutually agreeable certification process, that the end devices are capable of detecting the frequency excursion and respond to it within the a predefined number of grid cycles (which is less than the FCAS 1s requirement), as described in section 5.1 of page 242 of that document).

HECO also procure a (bi-directional) proportional (rather than step) frequency response service, which is even more similar to FCAS, with the same metering requirements as the ones described above for FFR, however, at the time of this submission we couldn't find publicly available information which can be referenced).

From our experience in developing this capability and actively delivering the service in Hawaii, supporting such a requirement is achievable within the existing HW and meet the utility's needs.

Another example is the signal-driven Regulation procured by the PJM (District of Columbia RTO[130]; ), which has been procured by PJM for years now. For dynamic resources such as energy storage devices, the system operator is using a calculated regulation signal (regD). In this case the resource is required to report on the level of provided regulation every 2 s (see page 40).

Tesla:

**4 International market settings**

**4.1 International frequency market settings**

[129] See Page 241 https://www.hawaiianelectric.com/documents/clean_energy_hawaii/selling_power_to_the_utility/competitive_bidding/20190401_phase_2_draft_rfp_book_3.pdf

[130] see page 37 https://www.pjm.com/~/media/documents/manuals/m12.ashx

An important consideration for AEMO in determining the final MASS requirements for DER is looking at the measurement resolutions required for existing, comparable frequency or ancillary services markets in international jurisdictions.

The 50ms measurement resolution for Fast FCAS has existed as a requirement since the MASS was first introduced and has not subsequently been revisited. Industry has accepted this requirement without considering whether 50ms provides more valuable information than 100ms or 200ms, whether there are lower cost options available and without looking to guidance from international markets. Given that the fast FCAS measurement resolution is now the topic of the current MASS Review, this position needs to change.

Better alignment with international requirements is particularly critical when AEMO is considering the future of aggregated fleets of assets providing frequency services as it influences asset level design and build-out.

- **Primary Frequency Regulation** (maintain frequency stability for continuous changes). Assets operate within a standard frequency droop curve (±200 mHz). Full activation time 10 - 30s.
  - **UK**: Firm Frequency Response (FFR). Sampling rate: 1s
  - **Ireland**: Primary Operating Reserve (POR). Sampling rate: 1s
  - **Nordics**: Frequency Containment Reserve (FCR). Sampling rate: 1s
  - **EU**: Frequency Containment Reserve (FCR). Sampling rate: 1s
  - **Taiwan**: 100ms power and frequency measurement, with performance assessed using 1s data.
  - **ERCOT**: responsive reserve service – sampling rate 2s
  - **CAISO**: distributed energy resource provider, ancillary services requirements – sampling rate 4s.

Considering international markets is important for two reasons. 1. It provides a secondary reference point as to whether the measurement resolution that has always been included in the MASS remains fit for purpose in the changing Australian energy mix. European markets in particular have been progressing rapidly over the last five years, so the market settings and measurement resolutions have been introduced more recently. 2. If there is no drive internationally for 50ms measurement resolution then updates to hardware to comply with Australian specific requirements is a more challenging ask for international OEMs.

**4.2 Summary recommendations – international experience**

There is no international market evidence to support the roll-out of 50ms data resolution for Fast FCAS markets. As such, for OEMs that operate on an international basis, it is difficult to justify product development to accommodate a 50ms measurement resolution for a single jurisdiction.

### 4.7.2. AEMO's assessment

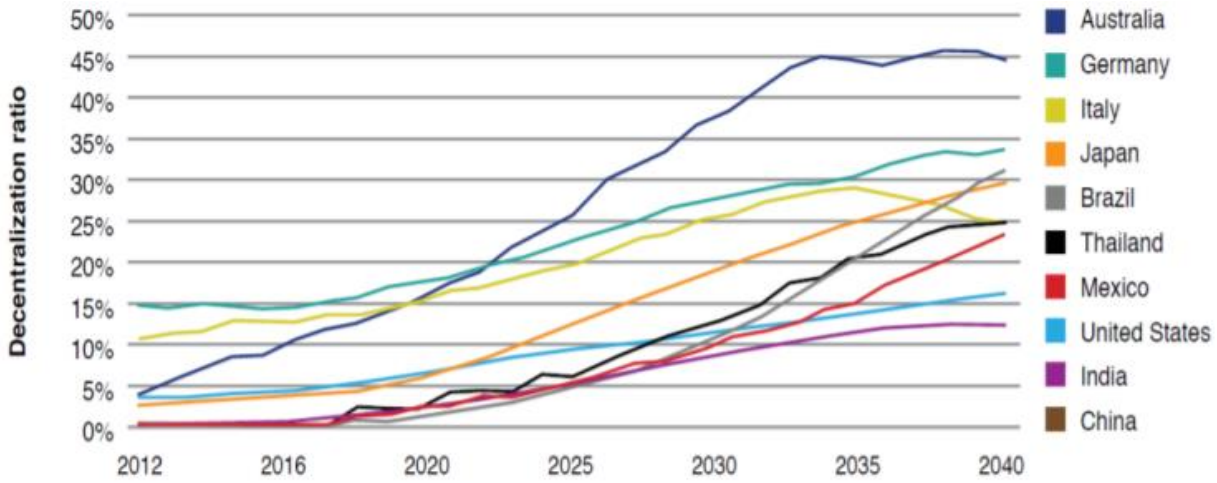
According to the CEC[131], Australia has the highest market penetration of DER when compared with many other countries, such as the USA and some EU countries, as shown in Figure 1, which compares the decentralisation ratio of generation.

While some of the content of the VPP Demonstrations Specification was inspired by what was occurring in other markets, of relevance to this consultation is whether there is much value to be gleaned from considering what other electricity markets are doing, noting Australia's position as a world leader when it comes to solar PV penetration. Are there any special insights that AEMO can glean from other market operators who are not facing the same issues as AEMO?[132]

[131] See page 6 of the CEC's The Distributed Energy Resources Revolution A Roadmap For Australia's Enormous Rooftop Solar And Battery Potential, available at: https://assets.cleanenergycouncil.org.au/documents/advocacy-initiatives/the-distributed-energy-resources-revolution-paper.pdf.

[132] In stating this, AEMO is cognizant of the work being undertaken by its Future Energy team in understanding what learnings from overseas can be considered for the NEM. See, for example, the Maintaining Power System Security with High Penetrations of Wind and Solar Generation report, available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Future-Energy-Systems/2019/AEMO-RIS-International-Review-Oct-19.pdf

**Figure 1 Decentralisation ratio of generation**




While AEMO will consider what other market operators are doing, the fact remains that there can be no easy translation to the NEM, for example, on whether a 1 s sampling rate, discussed in section 4.1, ought to be adopted because it seems to be working fine elsewhere.

Having conducted this consultation, AEMO has sought advice from other market operators to test some of the matters raised in submissions, only to discover that none of the market operators contacted have done such an extensive consideration of FCAS measurements. Moreover, those operators appear to have very different post-registration compliance regimes.

#### 4.7.3. AEMO's conclusion

AEMO thanks Consulted Persons for drawing attention to what other market operators are doing about the measurement of FCAS, or similar services, in other countries. Any decisions about whether to adopt a standard from another jurisdiction requires much more consideration and needs to take into account the unique nature of the NEM and the NER.

## 5. DISCUSSION OF MATERIAL ISSUES – GENERAL

AEMO's Draft Determination was to make most of the general amendments to the MASS, as suggested in the Issues Paper.

Sections 5.1 to 5.8 address the key issues raised by Consulted Persons. Minor issues are addressed in Appendix B, which also lists all issues with cross-references to where they are addressed in this Second Draft Determination.

## 5.1. MASS readability and usability

#### 5.1.1. Issue summary and submissions

The first Draft Determination proposed to adopt the restructured and reformatted MASS, as presented in the Issues Paper. The draft MASS published with the first Draft Determination adopted various suggestions received in the initial stage of consultation.

Submissions to the Draft Determination were, again, generally supportive of the restructure, although Hydro Tasmania urged AEMO to avoid further major changes given the significance of the structural changes already undertaken.

Extracts from submissions on this issue are cited below.[133]

AER:

> The AER supports the redrafting in the MASS to provide increased clarity. We consider that the clarifications proposed will aid in the efficient provision of services and make clear the framework to which participants must adhere. In particular, we welcome the clarifications on concurrent service provision of Regulation and Contingency FCAS, frequency deviation levels, proportional response by switched and variable controlled sources, and references to the FOS in effect on 1 January 2020.

CS Energy:

> CS Energy does, however, maintain concerns related to some of the changes made in the MASS to incorporate PFR:
>
> (a) Definition of Initial Value
>
> The current MASS introduced the following definitions:[134]
>
> - Contingency Event Time - the time at which the contingency event occurred. This is a value determined by AEMO in accordance with the process in the MASS section 2.6; and
> - Initial Value - means the Generation Amount or Load Amount prior to the Contingency Event Time prior to a Frequency Disturbance.
>
> Frequency Disturbance was replaced by Contingency Event Time to remove disincentives to providing PFR within the NOFB. CS Energy expected this change to capture the previous unaccounted initial response provided by CS Energy units with deadbands set at ± 0.1 Hz, although our earlier submission that the Initial Value should be equal to the AGC load demand trajectory at the Contingency Event Time was not accepted. However, with the implementation of PFR, there is potentially significantly more unaccounted PFR from participants that are enabled for Contingency FCAS, because with nominal settings of ±15 mHz deadband and 5% droop, PFR provides up to ± 5.4% load response within the NOFB.
>
> In completing CS Energy's response to the AER's Contingency FCAS Survey and its reconciliation with the MASS protocol for verification of Contingency FCAS performance, it became apparent that the introduction of PFR together with the significant uncertainty of the system frequency at the Contingency Event Time, compromises the previous assessments of Contingency FCAS response. For example, based on MASS section 2.6 (b), a double contingency where a second larger disturbance occurs after one or more smaller disturbances have already moved frequency significantly within the NOFB, would result in the Initial Value not capturing the initial PFR provided before the second larger disturbance. Hence in evaluating available Contingency FCAS, participants would now need to discount up to ± 5.4% of PFR response due to the uncertainty of the frequency at the Contingency Event Time being anywhere up to ± 0.15 Hz.
>
> The definition of Contingency Event Time is itself satisfactory accepting that AEMO has had to deliberately limit the extension of the Fast FACS window in the revised methodology so that it conforms to the existing data recording window. However, concerns regarding the Initial Value were not adequately addressed by AEMO in the Draft Determination.[135] Initial Value needs to be the AGC load demand at the Contingency Event Time, not the load itself, if it is to capture all the PFR already provided. For CS Energy assets, load is tightly controlled by steam turbine governors, and the only normal deviations in load from the AGC load demand are due to either PFR or co-ordinated mode steam pressure error influence. To ensure Contingency FCAS response is not compromised by the latter, CS Energy has added a cross-limiting function to remove any co-ordinated mode steam pressure error influence that could attenuate the PFR after frequency deviations exceed the NOFB, until it recovers inside ± 0.1 Hz, in order to prioritise Contingency FCAS response over steam pressure control. Hence the load deviation from AGC load demand will all be due to frequency response when Contingency FCAS response is required.
>
> The present definition of Initial Value instead rewards poor initial PFR performance. For example, in the case above, if the co-ordinated mode pressure error influence is initially counteracting the PFR, the measured Contingency FCAS response using the verification tool will be greater than if the initial PFR response was unattenuated by the pressure error influence.
>
> (b) Contingency FCAS Response Verification Tool

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

[134] AEMO, Market Ancillary Services Specification V6, Table 1

[135] AEMO, Market Ancillary Service Specification and Causer Pays Procedure Draft Determination, February 2020, Section 3.3

CS Energy has the following concerns about the FCAS verification tool:

- The linear extrapolation of the basic response to compensate for the difference between the Local Frequency and the Standard Frequency Ramp to ± 0.5 Hz ignores:
  - The increase in dynamic response attenuation for larger disturbances and for higher initial loads; and
  - Limits to the available response, hence the extrapolation can exceed the available response at 0.5 Hz. CS Energy's Contingency FCAS bid trapezium needs to be conservative to allow for normal fluctuations in steam pressure throttle margin and dynamic load response attenuation, which are specific to each asset and are generally not linear. This means the tool cannot be used on historical events to generate an expected response characteristic that could be used to verify that Contingency FCAS bids are appropriate. The bid response needs to consider the worst-case scenario of a 0.5 Hz disturbance with appropriate margins;
- As the verification tool requires subtraction of inertial response, this can only be done after fast data is uploaded from the data loggers, not with control system data that is available in real time; and
- The subjectivity of the Contingency Event Time may not translate to the verification tool and may expose participants to compliance risks.

Delta Electricity:

The MASS is by definition meant to be a "specification". The word 'specification' should not need Rules definitions to advise anyone what the word means but it is acknowledged that clarification of the purpose prescribed by Ancillary Services Rules, as included in the Draft Determination, is also relevant. To many engineers, documents that provide a concise description of the activities and materials necessary to effect procurement of a required service are known as specifications. If specifications are inadequate or lacking in detail, design engineers of the service provider make assumptions as are required to effect the outcome. If these assumptions mean the services from competing suppliers do not coordinate well in the overall control of frequency then the MASS can be considered to have been lacking in necessary details.

It is acknowledged that AEMO intends to take further steps in the direction of separating out the requirements for frequency controllers and FCAS metering in future revisions. Delta Electricity looks forward to further revisions that develop the MASS into a more effective specification.

…

**Comments on the Draft MASS**

The MASS has added words in several places that may represent a theoretical view of what the MASS is trying to specify but in application for existing installations, the wording becomes problematic.

Section 2.2 tries to ensure a Unit delivers both regulation and Contingency FCAS simultaneously. It is considered likely that AEMO intended these words to specify that a Regulation FCAS enabled Unit be capable of responding to a Regulation FCAS dispatch instruction before, during and after any detection, response and recovery period associated with a Contingency FCAS event the Unit is also enabled to respond to. The use of the word 'simultaneously' is best avoided as it confuses the reader. e.g. a contingency event is unlikely to occur at the precise moment AEMO dispatches regulation FCAS adjustments to the energy target. It could but it is not necessary to describe the two as being simultaneous. Coincident is perhaps a better word.

Section 3.2 includes new advice about how Regulation FCAS works in tandem with PFR. In theory this represents good control and it would be beneficial to the system if it was the case. In reality, at many coal-fired installations, this is not accurate. Regulation FCAS works in tandem with energy dispatch controllers as the amount is delivered with the energy dispatch target. PFR actually works in tandem with Contingency FCAS controllers which adjust the target sent to the Turbine when conditions require it. Because of the way AEMO dispatches Regulation FCAS, its delivery is inherently delayed, whilst PFR and Contingency FCAS systems are instantaneous in delivery. The wording of the MASS could be modified to recognise existing controllers.

Section 10.3 tries to specify a control diagram that is not in accordance with existing designs of Coal plants to the knowledge of Delta Electricity. The words and diagrams imply a sequence that is not correct. In a continuous control loop, the sequence is more like:

1. AEMO Dispatch Engine determines a Unit energy and Regulation FCAS target after considering existing Network and the latest Unit Actual MW conditions and requirements for FCAS.
2. From the start of a DI to the end of the DI, AEMO AGC dispatches target signals updated every 4s that is the combination of energy and Regulation FCAS delivered in a timed fashion that AEMO tunes when the controls are first commissioned.

3. Local Unit Controllers receive the AEMO target, inclusive of Regulation FCAS amounts dispatched by AEMO.
4. Local Unit Controllers process the setpoint target to ensure plant security limitations are not exceeded.
5. Immediately prior to sending any control action to the turbine, the local unit controller adjusts the setpoint target to include any required PFR or Contingency FCAS action.

The words and diagram in the draft MASS are not easy to relate to. Perhaps the words and diagram should be qualified as being an example only or maybe several existing controllers should be examined to aid in describing systems at the high level being attempted that do not conflict in anyway with systems already constructed if such systems are expected to remain acceptable.

The wording of 10.4, some of which remains from previous versions, is problematic in its English also. It is suggested that the service facility "must have a control system that can" makes more sense than "must have a control system to". The latter phrase makes it sound like the controller has the purposes of doing the things described by a to f when really its purpose is to control frequency in accordance with the MASS and the items described are features to be included for in the controller.

The use of phrases such as "at all times" is problematic. Units will occasionally be unable to do the full specification. Other Rules and clauses of the MASS (e.g. 5.1.) oblige participants to not engage in markets where conditions arise where capability to provide the service is impacted. Therefore, the MASS doesn't necessarily need to reinforce technical requirements with time-based words. The MASS should consider referring to Rules that remind participants of the nature of lawful bids to provide the services. For example, if a Unit cannot maintain some CRD "at all times", it should not mean they cannot be considered for registration to provide MASS related services which should be the focus of the specification. It should specifically mean that when it becomes apparent that they may not be meeting the provision, participants should withdraw bids from the market until they have reestablished the correct technical capability. It may not be possible for any provider to maintain each technical requirement "at all times". Describing capability is more important in the MASS than prescribing expectations for operation "at all times". Rules on dispatch conformance cover the latter.

EA:

**Readability and Usability**

Generally, EA supports the amendments to introduce new definitions and formatting changes into the MASS. However, one exception concerns Table 4 in section 5.3.2 where it is unclear how Settling Time relates to Slow and Delayed FCAS. Reformatting the table, or perhaps providing a definition or example of Settling Time, would help add to the already enhanced MASS clarity and utility.

Beyond this comment, EA suggests that the AEMO testing procedure be included in the MASS as additional reference information. This will help to clarify AEMO and participant obligations and procedures ahead of any tests occurring.

Hydro Tasmania:

Hydro Tasmania is supportive of the continuous revisions of the MASS in order to improve its readability, usability and adapt to emerging issues/opportunities. However, we have also noted that the structure of the MASS has been changed extensively following the first consultation, therefore in the interest of stability and continuity, Hydro Tasmania suggests no further structural changes of MASS in this iteration until another wholesale change is proposed.

The AEMC has provided a timetable of future changes around PFR and FFR. These rule changes are highly likely to be merged into the FCAS markets in the next two years. As such Hydro Tasmania strongly suggests that AEMO should develop a corresponding roadmap regarding any potential MASS modifications in the near future and share this with its stakeholders. This would be helpful for the market participants to understand what is anticipated at different stages as well as aiding the management of current/urgent matters.

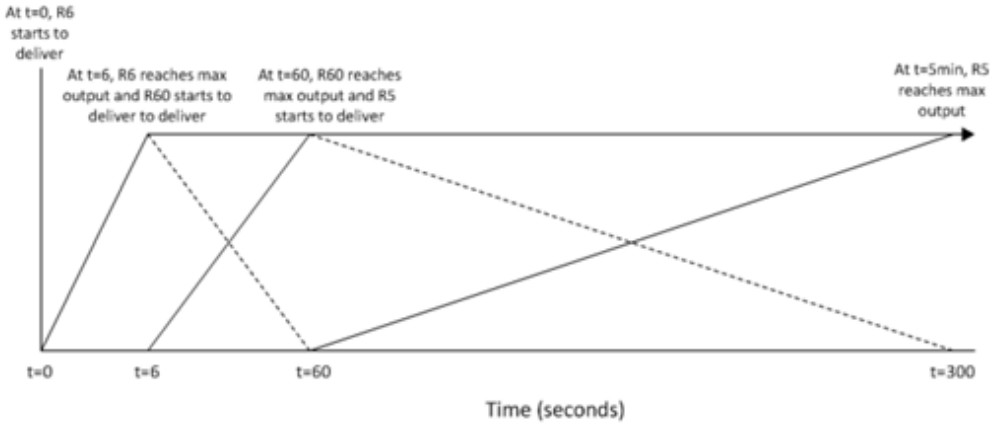
Reposit:

While Reposit generally supports the restructuring of the MASS to improve readability, it does not support the inclusion of multiple consequential amendments which remain unjustified. Changes such as these introduce significant investment uncertainty and without due consideration will have material consequences for the integrity of the standardised FCAS markets.

SwitchDin:

The readability and clarity of the draft MASS is significantly improved from the current MASS, however further clarity on the expected response and interaction between the different contingency markets is still required. We suggest that a diagram, similar to that shown below from the AEMC Frequency Control Frameworks Review - Issues Paper, is included along with accompanying text in order to clearly communicate the desired response throughout the response timeframe and in particular the desired response one the maximum output has been reached.

**Figure 6.1 Interaction of fast, slow and delayed FCAS services**




Source: AEMC Frequency Control Frameworks Review - Issues Paper, Nov 2017

### 5.1.2. AEMO's assessment

AEMO is pleased to note that Consulted Persons generally found the draft MASS published with the first Draft Determination had improved clarity.

Delta Electricity's comments on the appropriate level of guidance in the MASS are welcome, as AEMO's objective is to use each opportunity to make further improvements to the clarity of the MASS, while also retaining enough room for FCAS Providers to offer a range of appropriate FCAS solutions.

The need to avoid too much change at one time is also noted (Hydro Tasmania).

A diagrammatic representation of the different Contingency FCAS has been included in the MASS as suggested by SwitchDin (see Appendix B of the MASS). As described in the accompanying text, it is important to note that the diagram shows the shapes against which a Contingency FCAS response is *measured* to ensure delivery is at least at the minimum required level. This is not necessarily how the active power controls are best configured.

EA's comments on the lack of clarity on Settling Time has been addressed with minor changes in Table 4, including a definition of Settling Time.

### 5.1.3. AEMO's conclusion

The draft MASS has been updated with minor additional corrections and clarifications, which are marked up in the attached draft.

## 5.2. Clarification of references to the Frequency Operating Standard

### 5.2.1. Issue summary and submissions

AEMO concluded in the first Draft Determination that references to the FOS should be clearer, to ensure that references to items such as the NOFB were more precise. Only one further submission was received on this issue.[136]

AER:

> … we consider the MASS would be enhanced with the following clarifications:
>
> a) amendment of the definitions of 'Frequency Disturbance' and 'NOFB' to exclude the application of the FOS table values for islanding conditions so it is clear the normal range (49.85 - 50.15 Hz) is applicable;
>
> b) amendment of the definitions of lower reference frequency and raise reference frequency to state the range of the relevant frequency band that is applicable; and
>
> c) amending other definitions in the MASS that relate to the above.
>
> Our Compliance & Enforcement Priorities 2021-22[137] highlight our focus on registered generators complying with AEMO dispatch instructions following our recent enforcement action regarding compliance with FCAS provisions. Services like FCAS underpin the smooth operation, security and reliability of the power system. Providers must be able to deliver these critical services when called upon. We continue to observe concerning FCAS behaviour and therefore FCAS compliance will be an AER focus during 2021-22 to ensure these obligations are fully understood and complied with. We consider that the clarifications to the MASS will provide a clearer framework that provides certainty to AEMO, market participants and the AER.

### 5.2.2. AEMO's assessment

AEMO agrees that the references to the NOFB should be interpreted as referring to the NOFB under normal operating conditions, as it is necessary for FCAS Providers' settings to respond at the limits of the NOFB under normal operating conditions, regardless of whether the power system operating conditions are not normal.

### 5.2.3. AEMO's conclusion

AEMO has amended the definition of NOFB to refer to Column 1 of Table A1 in the FOS. This change flows through to the other terms the AER was concerned about.

## 5.3. Requirements for non-frequency responsive facilities

### 5.3.1. Issue summary and submissions

In the first Draft Determination, AEMO stated that it would progress general limits on non-frequency responsive FCAS for regional FCAS constraint sets only (constraint sets invoked when the power system is at risk of separation, or during separation), but would not progress:

- general limits on the proportion of non-frequency responsive FCAS during normal system intact operation, and continue to monitor developments and performance; or
- 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 amended section 6.1.2 to encourage frequency FCAS Providers using switched controllers, where

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

[137] https://www.aer.gov.au/system/files/aer-compliance-and-enforcement-priorities-2021-22.pdf.

possible, to adopt a multiple block/multiple frequency trigger approach to spread provision of FCAS over a range of triggers); or

- 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.

AEMO also determined the switching controller trigger ranges but changed the 'default' settings in Table 5 and Table 6 to the narrowest settings.

Extracts from submissions on these issues are cited below.[138]

Enel X:

> **Section 5.3: Requiring non-frequency responsive facilities to deliver FCAS only when enabled up to 150% of enablement amount only**
>
> We agree with AEMO's conclusion that "there is little clear evidence of an urgent need to limit FCAS of this kind" and thus support AEMO's draft decision to not progress:
>
> - limits on the proportion of non-frequency responsive FCAS
> - a blanket requirement for non-frequency responsive FCAS to limit over-delivery
> - a blanket requirement for FCAS providers using switched controllers to only deliver when enabled.
>
> We note AEMO's intention to continue to assess the above, and we support this being done in consultation with stakeholders.
>
> Regarding limits on the proportion of non-frequency responsive FCAS: comments made by AEMO in the stakeholder meeting on 23 June 2021 suggest that the context for the above proposals is a concern that there will not be enough proportional reserve available in the system, not that there could be too much switched reserve. If that is the case, it may be more appropriate to reframe this issue as making sure there is a minimum amount of proportional control available, not a maximum amount of switched.
>
> Regarding limits on over-delivery: the draft determination states that AEMO may require switched 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. As per our comments on the issues paper, it is important to determine the risks and likelihood of over-delivery before imposing such restrictions.
>
> In general, a strict delineation between "frequency-responsive" and "non-frequency responsive" FCAS providers may not be appropriate. An aggregation of switched loads can mimic a proportional response more closely if the trigger set points are spread over a range, and at more granular set points. The MASS already states that AEMO "will negotiate with the FCAS Provider to allocate Frequency Settings to simulate the behaviour of Variable Controllers". If a portfolio of switched loads can simulate the behaviour of a variable controller, it should not be captured by any restrictions on "non-frequency responsive" FCAS.

Enel X:

> **Switching controller trigger ranges**
>
> We support AEMO's draft decision to retain the switching controller trigger ranges as they are.

Hydro Tasmania:

> Hydro Tasmania recognises and understands the challenges of maintaining system frequency control during contingency events. We recall a presentation from AEMO providing a high-level explanation in regards to facilities and equipment that do not respond to system frequency. Hydro Tasmania would encourage AEMO to undertake further analysis, particularly paying attention to extreme system islanding events and share the insights with market participants.
>
> If the issues mentioned by AEMO have raised genuine system security concerns, Hydro Tasmania would be supportive to the approach that progress general limits on the facilities that do not respond to system frequency. However, the general limits proposed should be evidence based and avoid 'one shoes fits all' solution therefore be open to solutions that resolve the issues in an effective and efficient way.

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

Reposit:

### 3.2 Frequency Settings for Switching Controllers

Draft MASS Section 6.1.1:

> Until an Ancillary Service Facility that uses a Switching Controller to deliver Contingency FCAS is allocated one or morea Frequency Deviation Settings under section 6.1.2, the FCAS Provider must apply the default Frequency Deviation Setting shown in Table 5 if the Ancillary Service Facility is on the Mainland or Table 6 if the Ancillary Service Facility is in Tasmania.

Draft MASS Section 6.1.2:

> AEMO encourages FCAS Providers with Ancillary Service Facilities using Switched Controllers to configure them so that different Frequency Settings can be assigned to different parts of their Ancillary Service Facilities.

The effectiveness of existing frequency setting allocation mechanisms should be explored fully before introducing additional complexity and uncertainty created by encouraging pseudo-proportional control of switched facilities. The existing Frequency Setting allocation already provides a mechanism for AEMO to avoid any undesired system behaviour by allocating different settings to each switching controlled facility.

AEMO has not provided quantitative technical justification for switching-controlled facilities to accommodate multiple Frequency Settings. Sections 6.1.1 and 6.1.2 both introduce a pathway to implement multiple Frequency Deviation Settings for a single switching Ancillary Service Facility. These changes in the MASS would introduce significant investment uncertainty for this type of control. Additionally, Reposit asserts that many of the conclusions in the RIS on the limitations of switching controllers are controversial and require additional scrutiny. The RIS input to this MASS review appears to be one of the key motivations for introducing these amendments. As such, Reposit has provided commentary on the key issues with the RIS input below.

### 3.3 Switching Controller Issues

Reposit supports AEMO's draft determination to not progress general limits on the proportion of switching-controlled FCAS and blanket requirements to limit over-delivery of switching FCAS facilities.

We maintain that limitations should be driven by quantifiable requirements for minimum amounts of synchronous, frequency responsive capacity as is the case for TAS1.

We suggest that AEMO investigate the future adjustment or even allocation of Frequency Recovery Settings for managing over-delivery of switched FCAS rather than pursuing seemingly arbitrary limits such as the suggested 150%.

Reposit would also like to flag the distinction between the terms 'switching control' and 'non-frequency responsive' which seem to have become conflated in this recent MASS review.

'Switching control' is specific to the control regime specified in the MASS for responding to contingency disturbances, this control actually follows a simple but dynamic profile where the response must be modulated with respect to the duration of the frequency disturbance and the boundaries of the Fast, Slow and Delayed services.

On the other hand, 'non-frequency responsive reserve' is described in the RIS as achieved by "Removing frequency responsiveness from output completely, [and] forcing a generator to track a static profile"[139]. We believe that maintaining this distinction is important as we work to facilitate the increasing participation and rising value of switching control in the Contingency FCAS markets.

### 3.4 Switched FCAS Misconceptions

Reposit challenges the set of assumptions and conclusions made by the RIS (Stage 1 Appendix B: Frequency Control) on the operation and functionality of switching controlled FCAS.

This study appears to underpin the decisions to introduce multiple Frequency Settings for a single switched facility in the draft MASS and to inform general discussions of switching control in this review. Reposit believes that there are some key misconceptions in the switched FCAS limitations outlined in B4.8.5 of the RIS which we have addressed individually below.

#### 3.4.1 Continuous control

[139] https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-b.pdf

Switching control requires the continuous measurement of frequency coupled with continuous control instructions.

Any switching control implementation needs to be responsive to both trigger and recovery settings so that delivery can be initiated and concluded as per the MASS.

It is incorrect to assert that the switched controller is not 'continuously sensitive to frequency and does not act to control it'. If an underlying asset is not capable of continuous control, Reposit would question the feasibility of adhering to the MASS in delivering a response that can then be effectively recovered once frequency has been restored.

Switching FCAS facilities are not limited to a discrete delivery size. In Reposit's case, assets are continuously and variably controlled to deliver the enabled capacity for the period under the switching specification.

The controllability and continuity of an asset's frequency response is not limited by the specific MASS control regime (variable/switched) but rather the underlying asset and architecture of the facility.

### 3.4.2 Repeatability

Switching controlled FCAS is a continuous frequency-responsive effort to stabilise grid frequency. As addressed in the sections above, it is a misconception that switching control follows a static response profile once triggered and requiring 'some minutes' to 're-arm' demonstrates a technology prejudice.

If multiple complete frequency disturbances do happen in quick succession, a switching controlled FCAS facility will have no more trouble than a variable controlled facility in attempting to respond to the subsequent disturbances.

Reposit notes that it is incorrect for AEMO to assume the source of power modulation simply because that power modulation is switching-controlled. Reposit suggests that this type of assumption has influenced AEMO's consideration of switching control throughout the RIS.

A material issue could arise if multiple disturbances occur within the same dispatch interval as there would be insufficient time to re-bid FCAS capacity. This however is unlikely and affects all FCAS Providers. Should AEMO consider this eventuality to be more probable in the future, Reposit suggests that the MASS should clarify the requirements for any FCAS provider responding to multiple frequency excursions within a single 5 min interval.

### 3.4.3 Over-provision

When managed correctly, over-delivery of Contingency FCAS actually increases system stability and security by providing reserve capacity for 'free'. Reposit suggests that over-delivery can be managed effectively with appropriate frequency recovery and deadband settings, these settings limit the system security consequences of over-delivery.

The RIS refers to the "discrete sized MW" response of a switched FCAS as the potential cause of over-delivery but this is not an inherent issue specific to switching control. The discreteness of a facility's response is determined by the limitations of the underlying modulation of the asset's output and the facilities control architecture.

All providers must also navigate the integer MW bidding limitation of the NEM, this is another discrete enablement problem that affects small facilities most. To ensure delivery of enablements, small providers must underbid by a significant proportion of their available capacity when adhering to the MW bidding constraint. This market structure effect could create significant over-delivery if all FCAS was procured from small facilities who are all having to underbid a sizable proportion of their capacity to remain compliant.

### 3.4.4 Over-response to smaller events

Over-recovery of system frequency due to an unmanaged switching FCAS response to small disturbances can be mitigated by enforcing stringent frequency recovery settings.

Draft MASS section 3.1:

> Ancillary Service Facilities ~~need not provide~~ may cease to provide Contingency FCAS once Local Frequency ~~has recovered~~once Frequency Recovery has occured. For example:

Reposit notes that Section 3.1 of the draft MASS, AEMO only requires delivery of a response up until Frequency Recovery after which a facility "may cease to provide" a response. Reposit suggests amending this section to require facilities to stop responding after frequency recovery if AEMO is concerned about over-response to smaller events.

### 3.4.5 Limiting provision from switched controllers

Reposit believes that minimum requirements for levels of synchronous or virtual-synchronous reserve should be modelled from specific constraints in low-stability NEM regions.

While it is true that maximum limits on the amount of switching control exist in other jurisdictions, Reposit believes that there is little evidence of the detrimental impact of switching reserve in the NEM. Reposit suggests that no limits should be introduced until any such negative impacts of switching control can be quantitatively modelled and characterised.

Initial limits applied to the procurement of switched reserves in other jurisdictions have been incorrect. As described in the RIS, the value of switching reserve was clearly underestimated in ERCOT and initial precautionary limits had to be significantly relaxed over the following decade[140]. Reposit suggests that this experience resulted in inefficient investment in, and operation of electricity services in ERCOT.

VIOTAS:

**3. Managing over-delivery from non-frequency responsive FCAS:**

VIOTAS technology is specifically designed to enable the provision of high speed FCAS using controllable loads, and the validation of the resulting response. VIOTAS can remotely control individual Switched Controllers from providing automatic frequency response depending on AEMO dispatch instructions. It is therefore capable of ensuring that its non-frequency responsive facilities are linked to market outcomes, as opposed to responding if their assigned frequency trigger is breached irrespective of market enablement. As the volume of demand side providers on the system grows this capability is important to ensure over-delivery is limited. VIOTAS believes it is prudent for AEMO to build an over-delivery limit into the MASS, whilst recognising that this should provide an allowable tolerance for over-response (such as the 50% limit highlighted). This would enable service providers to provide the maximum possible certainty that the delivered response will always exceed the enabled amount.

**4. Proposal to move Contingency FCAS frequency triggers closer to the NOFB:**

The potential for variable renewable and demand side resources to provide low cost over-frequency (lower) and under-frequency (raise) services respectively is highly complementary. As the technologies which have historically provided FCAS see their role diminish, facilitating the optimal provision of FCAS from these technologies will yield significant system benefits. Frequency trigger set-points are a critical design element impacting the volume of demand side participants willing to provide services and the associated price, as ultimately, for a controllable load providing contingency raise services, frequency trigger set-points closer to the NOFB will result in a higher likelihood of a controller being triggered more frequently.

Care is required to ensure that power system needs (such as restoring frequency to within the NOFB) are not necessarily directly translated into the minimum technical requirements for the provision of ancillary services, where doing so would result in an inadvertent barrier to the provision of those services by particular technologies. VIOTAS believes it is important to design FCAS technical requirements as broadly as possible (enabling the widest possible range of providers), while ensuring that the price signals incentivise as far as possible the service delivery technical characteristics that are of highest value to the system.

For example, in Ireland the three automatically triggered Operating Reserve Services employ a scalar which applies a payment multiple depending on the frequency trigger. Participants nominate their own frequency set-point in the range 49.3 - 50 Hz, but a provider with a set-point of 49.3 Hz will be paid 50% vs. the same service at 49.985 Hz, with linear interpolation between. This recognises that delivery at frequency set-points closer to 50 Hz is of higher value to the system than at lower frequencies.

A market design which allows providers to nominate their own frequency set-points, but with a strong financial incentive to set these as close as possible to the NOFB, will allow the optimal participation of the widest possible range of technologies. This will, for example, allow some providers to elect to have a wider deadband in return for being triggered less frequently, where other providers may elect to have a narrow deadband (and likelihood of being triggered more frequently) in return for higher payments.

This is particularly important for demand side providers. The underlying industrial and commercial sites which agree to make their electrical loads available to provide ancillary services suffer a degree of disruption each time they are triggered. For these sites, these services are not their core business, and their participation needs to be carefully managed to enable them to provide these critical services to the power system without causing intolerable operational disruption for the facility. If they can be optimally utilised, demand side providers are a very low cost provider of contingency services, utilising existing assets to provide this vital safety net to the power system for relatively infrequent events. Allocating frequency triggers further from the NOFB will reduce the expected frequency of trigger events (and the associated

[140] https://aemo.com.au/-/media/files/major-publications/ris/2020/ris-stage-1-appendix-b.pdf - p.34

disruption), and will encourage greater volumes of demand side participation, ultimately leading to price benefits for all energy consumers. Conversely, allocating higher frequency triggers with a corresponding increase in expected frequency of trigger events and disruption will reduce the volume of customers willing to provide such ancillary services, which will instead need to be procured from other (typically higher cost) providers. This approach is equally applicable in faster services such as FFR.

This is an important element for the design of ancillary services procurement arrangements in any market: ensuring the optimal balance between maximising the participation of all technologies, while at the same time ensuring the correct incentives are in place for the provision of the service characteristics of highest value to the power system. VIOTAS believes that the high speed frequency response services which demand response can provide are especially valuable during the most serious contingency events, and that such providers have the ability to arrest the frequency nadir as quickly as possible. If the ancillary services system design can facilitate the optimal utilisation of demand response assets this will encourage energy consumers to actively participate in the energy markets, with the ability to respond quickly when critically needed by the system and driving significant system benefits as the ongoing decarbonisation transition continues and accelerates.

**5. Uncertainty associated with current frequency trigger allocation:**

VIOTAS would also like to highlight the current uncertainty associated with the allocation of frequency trigger set-points by AEMO. For example, when a demand response aggregator is developing a project with a client with electrical load it is willing to make available for ancillary services, it is not possible to confirm the frequency set-point at which the site will be required to respond until the aggregator applies to AEMO to classify the load. Therefore, despite this factor being critical to assessing the expected frequency of trigger events and developing a pricing strategy at which the client is willing to provide the services, is not allocated until very late in the process of a client site becoming an ancillary services load. In addition, VIOTAS believes that the MASS contains significant ambiguity as to how Frequency Settings will be allocated to Switched controllers. For example, the principle that larger blocks will be allocated to frequencies closer to NOFB, or the provision for a Market Participant to request a change to its allocated Frequency Setting if it can provide a technical reason for this both seem subjective. VIOTAS recommends that, to improve fairness, transparency, and predictability, AEMO either clarifies this section of the MASS or implements a system (see comment above) where providers are able to select their own frequency trigger set-point (within a defined range) but for this to be factored into service payments (with frequency trigger set-points closer to NOFB earning higher payments).

**6. Potential limits on the proportion of FCAS which can be provided by Switched Controllers:**

VIOTAS supports AEMO's conclusion that there are only very limited circumstances where FCAS provision from Switched Controllers is likely to cause problematic power system impacts (such as potentially during system separation events), and its position not to progress general limits on the amount of FCAS services which can be provided by Switched Controllers.

VIOTAS agrees with the points raised by a number of other participants highlighting that there is not currently any evidence to justify limiting the quantity of FCAS provided by Switched Controllers, and any such restriction (which would cause a significant market distortion between different technologies providing FCAS) should only be imposed once a rigorous assessment of potential power system security risks as a result of FCAS provision from Switched Controllers has been completed.

It is also important to reiterate that there are a number of ways to mitigate the risk of over-response – the primary concern raised against Switched Controllers. For example, as highlighted by Enel in its first stage consultation submission, AEMO could stagger the trigger frequencies assigned to switched loads across a more granular range of setpoints to enable switched providers to provide a pseudo-proportional response when considered in aggregate. This seems to be counter to the AEMO proposals to bring the trigger ranges for Switched Controllers closer to the NOFB.

In the Irish market, the design arrangements for the FFR enable providers including VIOTAS to provide a sophisticated response by continually reallocating frequency triggers to individual Switched controllers to provide a multi-"stepped" response that emulates the response that would be delivered by a proportional controller with a fixed droop characteristic. As ultimately approximating a proportional response from Switched providers seems to be the intention of MASS section 7.2, facilitating demand side aggregators to provide this type of service directly would yield significant efficiency benefits. VIOTAS sees significant merit in encouraging FCAS providers using Switched Controllers to adopt such an approach and believes the multi-step response it already provides in the Irish market is a very good example of international best practice in this regard, closely approximating the dynamic response that would be expected from a Proportional service provider. VIOTAS recommends this approach be considered by AEMO in the next MASS consultation if AEMO is concerned about potential negative impacts of large volumes of FCAS provided by Switched Controllers.

### 5.3.2. AEMO's assessment

While AEMO's focus to date has been on potential issues surrounding 'excessive' quantities of switched control, it might be better to focus on ensuring adequate amounts of variable control. Indeed, this is the current approach in Tasmania; constraints are employed to ensure that an adequate amount of variable control is procured, rather than directly limiting the amount of switched control. AEMO will endeavour to focus further work along these lines.

On the matter of potentially limiting potential over-delivery from switched facilities, AEMO notes that Consulted Persons seek to understand why and where this may be required. Their concerns are similar to more general concerns about the balance of switched and variable control. If switched 'blocks' of response are very large, the amendments to the MASS that allow the potential assignment of multiple FCAS trigger points to switched facilities is one way to mitigate the potential impacts. AEMO believes the redrafted MASS published with the Draft Determination gives scope for AEMO and FCAS Providers to negotiate on the size and number of Frequency Settings. AEMO expects that there could be clear advantages to some FCAS Providers to offering multiple trigger points as well. Rather than settling on a single setting closer to the NOFB, a portion of the facility could be utilised less often if it is assigned a wider frequency setting. In response to Reposit's concerns regarding amendments to sections 6.1.1 and 6.12 that introduce a pathway for multiple frequency settings, AEMO notes that these sections state that allocation of multiple frequency settings is subject to negotiation and agreement between AEMO and the provider, therefore AEMO does not agree that they introduce investment uncertainty.

AEMO acknowledges submissions on the use of terms such as switched, non-frequency responsive, or triggered controls. These terms have been used interchangeably, whereas they can have somewhat different meanings and implications. Some submissions (Reposit, Enel X, Hydro Tasmania) suggested that a simple bifurcation of FCAS Providers into frequency responsive/non-frequency responsive is not straightforward, which means considered criteria for defining these types need to be developed and, ideally, included in the MASS. AEMO also acknowledges that discussion about potential impacts of switched control (including in the RIS and the Issues Paper) have been primarily focused on technologies such as large single loads (e.g. pumps or smelters). The controls and capabilities of such technologies are likely to be quite different to that offered by other technologies, and particularly aggregated switched controls where many individually controllable devices are available. There is a case for additional work to further explore the right way to categorise the control characteristics of Contingency FCAS facilities and ensure that FCAS is delivered from an appropriate mix of these control types.

### 5.3.3. AEMO's conclusion

AEMO has revised the draft MASS to use the term 'Variable Controller' consistently rather than a variety of terms, and has revised the circumstances where multiple Frequency Settings might be applied to facilities using switched controllers.

AEMO has also added a clause under section 6.1.2 of the draft MASS to allow trigger settings outside the range specified in the MASS at AEMO's absolute discretion if there is a valid technical reason to do so.

## 5.4. Co-ordination between different FCAS and primary frequency response

### 5.4.1. Issue summary and submissions

The Draft Determination addressed two issues:

- FCAS co-ordination and priority – changes were proposed to section 2.2 of the draft MASS to address this concern.

- Proportional Controller Trigger Ranges – AEMO proposed to defer any decision on refining and clarifying trigger ranges (and service termination settings) for proportional controllers until the rule changes associated with primary frequency response (**PFR**) are made.

Extracts from submissions on this issue are cited below.[141]

### FCAS co-ordination and priority

AGL:

> **MASS Principles**
>
> The proposed amendments to section 2.2 of the MASS require that if an Ancillary Service Facility is enabled for Regulation FCAS and Contingency FCAS, it should deliver both types of FCAS simultaneously. Following the implementation of PFR, any AGC signals received are effectively over-ridden by the PFR controller. For this reason, and due to AEMO's recent improvements in AGC dispatch, we do not have any issues with this proposed amendment. We note however that we intend to monitor the AGC signals and confirm the AGC dispatch does not interfere with or affect the generator's FCAS response.

EA:

> **Coordination of FCAS and Primary Frequency Response**
>
> EA appreciates and agrees with the clarifications on how Contingency FCAS and PFR controls should be coordinated with AGC, including Regulation FCAS. Including Figure 8 from the Issues Paper and amending Section 2.2 to reflect that there is no priority in the provision of different types of FCAS will help to ensure consistency of operation and response across the NEM generation fleet.

Energy Locals & Quinbrook:

> **Ambiguity on service prioritisation**
>
> We believe that a combination of proposed MASS changes create unnecessary ambiguity regarding the priority of response across PFR and FCAS.
>
> Changes to MASS, Sections 2.2 and 10.3 appear to conflict. Section 2.2 includes a requirement to adhere to AGC unless otherwise advised by AEMO. We note AGC instructions are provided with 4s latency.
>
> This would therefore introduce circumstances where responding to AGC (with a 4s delay) exacerbates a real-time frequency event (which has changed dynamically within the 4s delay). Changes to MASS, Section 10.3 outline an unclear process by which Contingency and PFR responses are aggregated with AGC requests. The MASS states "Occasionally, the direction of the Contingency FCAS or PFR response may oppose the AGC request; this is not unexpected."[142]
>
> We are unclear on the outcome that AEMO is trying to achieve with changes to sections 2.2 and 10.3 of the Draft MASS. We further suggest that the proposal could be refined further to remove ambiguity.
>
> Recommendation
>
> We are unclear on the outcome that AEMO is trying to achieve with changes to sections 2.2 and 10.3 of the Draft MASS. We recommend AEMO explain its objectives and revise its proposed changes to clearly achieve those objectives.

Hydro Tasmania:

> Hydro Tasmania notes the statement in 5.4.2 AEMO's assessment, 'AEMO accepts that FCAS Providers should not ignore AGC when Contingency FCAS controls are active'. We request AEMO clarify the basis of this statement and provide more detail.
>
> Hydro Tasmania supports alignment with the existing MASS v6.0, which specifies that an AGC instruction should be suspended during Contingency FCAS responding period. This is due to the potential for the AGC instruction opposing the correction direction of the Contingency FCAS response, causing correction interference and potentially FCAS delivery non-compliance.
>
> In principle, Hydro believes that the Contingency FCAS response should be prioritised in order to address the system security and compliance risks during the contingency periods. The AGC regulation instruction,

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

[142] AEMO, Market Ancillary Service Specification Draft Determination Version, June 2021, p22

which is designed to control the system frequency quality within NOFB, should be suspended in this situation. Thus, Hydro does not support the change proposed, unless further clarification is provided.

Reposit:

**3.1 Priority in delivery of different FCAS Types**

Draft MASS Section 2.2:

~~Contingency Services~~ Unless specifically advised to do so by AEMO[4], there are no circumstances under which an Ancillary Service Facility should ignore ~~and not respond to AGC instructions while~~

Section 2.2 of the draft MASS includes this amended statement that gives AEMO the ability to waive participants from obligations to deliver enabled FCAS. The need for this carveout has not been stated, but Reposit asserts that having a Participant be paid for Regulation FCAS, but not deliver it on instruction from AEMO is inefficient. Reposit suggests that AEMO does not require this carveout in the MASS and can rely on the well-defined NER Chapter 4 mechanisms already governing AEMO directions and instructions.

If a facility were to be enabled for FCAS delivery and AEMO provided advice to ignore AGC instructions, this advice must be in accordance with NER clause 4.8.9 for the facility to receive payment for any delivered services during this time. Reposit would also like to highlight that the MASS section 2.5 requires delivery of enabled services and that any payment for non-delivery should adhere to AEMO's current claw-back procedures.

- NER 2.3.5 (i) 'A Market Customer is not entitled to receive payment from AEMO for market ancillary services except where those market ancillary services are produced using an ancillary service load in accordance with Chapter 3 or pursuant to a direction or clause 4.8.9 instruction.'
- NER 2.2.6 (i) 'A Market Generator is not entitled to receive payment from AEMO for market ancillary services except where those market ancillary services are produced using an ancillary service generating unit in accordance with Chapter 3 or pursuant to a direction or clause 4.8.9 instruction.'

Shell Energy:

We recommend that Table 1 of the MASS include a definition for enablement amount.

It is unclear to Shell Energy that AEMO's amendments to section 2.2 represent a workable outcome and question the need for the change from the long-standing priority to contingency response. Due to the latency of delivery in AEMO's AGC dispatch instructions this amendment introduces an outcome where responding to AEMO's AGC signal could be detrimental to system frequency control. AEMO then sets out in section 10.3, a process that effectively reintroduces priority to contingency response via a complex and convoluted control system response that requires a service provider to effectively ignore signals from AEMO's AGC system if these are detrimental to system frequency. We recommend AEMO abandon its proposed changes to both section 2.2 and 10.3.

In the area of Contingency FCAS, the details as set out in Section 3.1 could be read to imply that the FCAS provider is obliged to continue to provide Contingency FCAS including in excess of its enablement amount until system frequency returns to within the 49.90 to 50.10 hertz range. We strongly recommend this section be amended to set out that service providers are only required to provide the service up to and including their enablement amount.

In the area of Regulation FCAS, we remained concerned that the Draft MASS provided as part of the Draft Determination fails to clearly set out a definition of the service to be provided. In Shell Energy's view the definition for Regulation FCAS must clearly set out that provision of Regulation FCAS is based on allowable deviation from a provider's energy market dispatch instruction. Failing to include a clear definition implies that AEMO's expectation is that a service provider must be able to dispatch to any point in the service provider's controllable range.

Shell Energy notes that the provision of PFR does not require the provision of headroom, foot room or stored energy (reserves). In our view, the provisions laid out in section 10.3 tend to impose a form of mandatory provision of headroom, foot room or stored energy by requiring that Regulation FCAS response be measured excluding PFR. We disagree with this proposed change. Where a service provider provides PFR in response to a frequency deviation, this may entail the use of reserves which have been procured for Regulation FCAS and we consider that this use of Regulation FCAS must be accounted for. As indicated above, in Shell Energy's view the provision of Regulation FCAS must be based on allowable deviation from the service provider's energy dispatch target.

Similarly, Shell Energy remains concerned that AEMO continues to restrict Regulation FCAS response to only that provided in response to an AGC setpoint change request. We contend that PFR is also a suitable response and that regulation FCAS can be provided by combined primary and secondary (AGC) frequency response from the same service provider. This outcome is supported by historical power system frequency

> outcomes in the NEM pre-2010 where power system frequency was managed by a combined PFR/AGC regulation FCAS response.

#### Deferral of decision on proportional controller trigger ranges

AEC:

> The AEC also supports the proposal to delay further enhancing trigger ranges for proportional controllers until the final PFR rule changes have been made.

EA:

> EA also agrees with the decision to delay refining and clarifying trigger ranges for proportional controllers until the final PFR rule changes have been made. As noted in the consultation paper, adjusting frequency response settings can have significant costs. Waiting until the final PFR design outcomes are known will minimise these impacts by eliminating having to change Frequency Settings more than once.

Hydro Tasmania:

> In regards to the intention of deferring the proposed maximum allowable deadband of ±0.1Hz, Hydro is supportive of this approach until the mandatory PFR implementation is fully completed and reviewed.

Shell Energy:

> In the Issues Paper, AEMO proposed 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 asked whether it would be acceptable for response to trigger at ±0.15 Hz but sustain recovery until ±0.10 Hz.
>
> The Draft Determination is to defer changes to proportional controller deadbands until the AEMC completes its work on the PFR incentive arrangements rule change. This is currently scheduled to be completed in December 2021. Shell Energy considers that deferring decisions on deadband settings in the MASS is appropriate given AEMC's work is still underway. We will continue to engage with AEMO on the treatment of deadband settings in the MASS and reiterate that there are likely to be lower cost but still effective options than simply applying a deadband of ±0.1 Hz.

### 5.4.2. AEMO's assessment

#### FCAS co-ordination and priority

AEMO acknowledges the issues raised by Consulted Persons on the lack of clarity in section 2.2 of the MASS, and has proposed further changes that clarify that adherence to AGC is paramount, subject to clause 4.9.4 of the NER and AEMO's directions power under clause 4.8.9 of the NER. Some submissions (e.g. Hydro Tasmania, Shell Energy) queried the logic behind changing the priority of FCAS. The change is needed for the following reasons:

- Use of droop controllers for narrow-deadband PFR: if a Contingency FCAS/PFR controller is continuously active, due to it using a narrow deadband well within the NOFB, ignoring AGC while this controller is active (as some controls would do) means AGC instructions would effectively be blocked almost all of the time.
- Major interference of AGC and Contingency FCAS controls is unlikely, and in any event can be addressed by AEMO through adjusting the controls for any affected unit. Major interference is unlikely because Contingency FCAS response tends to be much greater (especially during a major frequency deviation) and faster acting than Regulation FCAS action. AEMO confirms that requests to follow AGC (so long as they are co-ordinated with Contingency FCAS) will be accounted for in FCAS verification where necessary.
- Advising participants to block AGC according to various conditions causes uncertainty about when to resume AGC control, and what output to move to (and at what rate) when AGC control is resumed.
- Blocking AGC when frequency is just outside of the NOFB is particularly problematic; for proportional Contingency FCAS activated at the edge of the NOFB, response just outside of the NOFB is only very

weak, and AGC is needed at this point to pull frequency back into the NOFB. Note that service that only begins outside of the NOFB cannot pull frequency to within the NOFB without the aid of other measures, one significant one being AGC.

- On occasion even during a frequency event an energy ramp may be needed for system security reasons. For example, a unit may need to be ramped downwards to satisfy a high impact transmission constraint.

It may be that confusion has arisen in the interpretation of the phrase 'follow AGC instructions'. The aim of the MASS amendments is to establish that frequency co-ordinated control means that AGC instructions are subject to frequency. This means that AGC instructions are specified as if frequency is at 50 hertz (Hz), but may be offset by local controls (if those controls are active) if frequency is not at 50 Hz.

Notwithstanding these points, AEMO has responded to the feedback by adjusting the FCAS co-ordination guidance in section 10.3 of the draft MASS, to clarify that it is an example of the principle of co-ordinating Contingency FCAS and PFR controls with Regulation FCAS controls, rather than a required control design. Some examples of co-ordinated control response demonstrating how AGC instructions should be 'offset' by local Contingency FCAS and PFR controls (if they are active) have also been added to Appendix B.

AEMO notes Shell Energy's suggestions to add statements to the MASS that all FCAS expectations are limited to enablement, but considers this is already well covered in the MASS. For example, section 6.2.2(b) states (emphasis added in bold):

> (a) The *control system* may be either a Variable Controller or a Switching Controller, or a discrete combination of both, and must operate so that the Raise Response or Lower Response is:
>
> (i) for a Variable Controller, an amount commensurate with the difference between Local Frequency and Frequency Deadband where the Local Frequency is between the NOFB and the lower limit of the OFTB (for a Raise Response) or upper limit of the OFTB (for a Lower Response) in accordance with the Ancillary Service Facility's proportional response function[143].
>
> For example, if the frequency deviation reaches the OFTB (usually 0.5 Hz**), the facility should deliver at least the amount of FCAS enabled by central dispatch, but if the frequency deviation only reaches half-way between the Frequency Deadband and the OFTB, the FCAS response should deliver at least half of the enabled amount**;

As another example, Table 7, which covers verification requirements for Contingency FCAS, states the following for Fast FCAS (and similar statements for Slow and Delayed FCAS):

> The amount of Fast FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.

For Regulation FCAS, Table 1 of the draft MASS set out definitions for Raise Control Limit and Lower Control Limit and Controlled Quantity which are both specified as subject to the enablement amount (see excerpt below):

| **Controlled Quantity** | **A quantity of *generation* or *load* that is:**<br>**(a) controlled by Raise Signals and Lower Signals; and**<br>**(b) measured at the relevant *connection point*.** |
|---|---|
| Lower Control Limit | The lowest level to which a Controlled Quantity can be controlled in response to Lower Signals, subject to the *enablement* amount. |
| Raise Control Limit | The highest level to which a Controlled Quantity can be controlled in response to Raise Signals, subject to the *enablement* amount. |

In response to Shell Energy's other comments on the definition of Regulation FCAS, AEMO agrees that it is not completely clear that provision of Regulation FCAS involves controlled deviation from a facility's reference trajectory or basepoint; that is, the profile the facility would have been expected to follow in the

[143] Commonly known as a 'droop function' or 'droop curve'.

absence of any frequency response or Regulation FCAS duty. AEMO has revised the descriptions of Regulating Raise service and Regulating Lower service in Table 3 of the draft MASS. For example, the description of Regulating Raise service has been changed to "Increasing generation or decreasing load **relative to the facility's *reference trajectory*** in response to Raise Signals to increase System Frequency". A definition of reference trajectory has been included in Table 1 as "A linear trajectory between two consecutive energy market dispatch values".

Shell Energy also commented on the relationship between the guidance in Section 10.3 and PFR obligations and expected FCAS quantities. AEMO has included a statement in the draft MASS that "the total expected change in output is subject to enabled quantities of each FCAS and a facility's PFR obligations where applicable".

**Deferral of decision on proportional controller trigger ranges**

AEMO is pleased to receive supportive submissions on the deferral of a decision on this issue.

### 5.4.3. AEMO's conclusion

AEMO has determined to:

- Amend sections 2.2 and 10.3 of the MASS to address concerns raised in submissions, as well as introduce new definitions in Table 1.
- Await the outcome of the PFR Rule change before making any decisions on the proportional controller trigger ranges.

Regarding the co-ordination of Regulation FCAS controls with other controls (Contingency FCAS and PFR), AEMO has retained the guidance outlined in the first Draft Determination. However, AEMO has added clarification that the noted design is a suggested control arrangement, not a specific requirement. Alternative control arrangements better suited to particular plant designs may also be used provided the firm requirements of the MASS are met. AEMO encourages FCAS Providers to discuss proposed control arrangements with AEMO's Systems Performance team.

The draft MASS published with this Second Draft Determination includes these clarifications.

## 5.5. Relationship between MASS and other instruments or institutions

In the first Draft Determination, AEMO responded to some concerns about the complexity of the various instruments that impact FCAS markets. There were no further submissions on this issue and AEMO considers this closed.

## 5.6. Requirements for Regulation FCAS

### 5.6.1. Issue summary and submissions

AEMO proposed a number of requirements for facilities providing Regulation FCAS in the first Draft Determination:

- 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 two-year testing cycle.

Extracts from submissions on this issue are cited below.[144]

### Telemetered Data Rate

Shell Energy:

> Shell Energy is pleased to see that AEMO has agreed to several changes in the wording of the MASS similar to those Shell Energy proposed in our response to the consultation paper. In particular, we are pleased that AEMO has recognised that delays from AEMO's systems should not disadvantage FCAS providers. We are pleased that the AEMO has made it clear that the 8s data latency requirement will apply only to internal systems.

### AGC controllable

Shell Energy:

> Shell Energy remains concerned with the proposal that FCAS Providers "maintain at all times a Setpoint Change Deadband greater than or equal to half of the facility's minimum Regulation FCAS offer quantity as defined in Sections 10.1 and 10.2" where Setpoint Change Deadband refers to "A value set for each Ancillary Service Facility in AEMO's AGC which indicates the minimum change in MW output AGC may request from that facility." As defined in Table 1 of the draft MASS. While AEMO has indicated that "AGC would not exceed the stable bid ramp"[145] there is nothing in the MASS to quantify that this is the case. We recommend that AEMO either amend the MASS to clearly indicate that AGC would not exceed the stable bid ramp rate as it applies to Regulation FCAS or amend section 10.4(f) to indicate a minimum requirement of 20% of the facility's minimum Regulation FCAS offer quantity. It is also unclear given the definition of the Setpoint Change Deadband, that the proposed change provides a workable outcome for regulation FCAS. Shell Energy would like to understand whether AEMO's AGC system would be limited by this to provide setpoint change signals above the 50% threshold and how would the AGC system provide setpoint change signal below this threshold.

### Minimum bid size

Shell Energy:

> The Draft Determination originally suggested that AEMO would look to apply a minimum bid size for different technologies. Shell Energy opposed this concept on the grounds that any minimum size should be technology neutral and that there was no clear justification for the change. The Draft Determination helpfully sets out reasons for the change. AEMO has also revised its position and instead propose a minimum bid size of the larger of 1 MW or 1% of the registered maximum capacity (rounded to the nearest MW). Shell Energy is comfortable with this change provided that the amount of response to be provided is a deviation from the energy dispatch target over the DI.

Tesla:

> …Tesla has only one recommendation in respect of the proposed s 3.5 "New Regulation FCAS requirements – minimum 2MW regulation FCAS bid size.
>
> - Tesla believes that the 2MW limit is arbitrary and inconsistent with "no less than half the bid size" (i.e. 1MW/2 = 500kW).

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

[145] AEMO, Amendment of the Market Ancillary Services Specification – DER and General Consultation, Draft report and determination, June 2021, p59.

- We recommend that AEMO removes these thresholds, 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 Control Response Delay (CRD)

Shell Energy:

In a similar vein, we argued that the maximum CRD of 150s should apply from the time the AGC output change request is received at the facility. That is, it should exclude any delays resulting from AEMO's systems. Given this has not been included in the draft MASS, we propose that AEMO should add wording equivalent to that included in 10.4(a). That is, clause 10.4(e) should say:

"maintain at all times a Control Response Delay (CRD) no greater than 150 seconds excluding external processing and communications delays; and".

### Minimum ramp rate

Shell Energy:

We are broadly supportive of AEMO's draft position not to impose a minimum ramp rate requirement on facilities. Shell Energy considers that it would be preferable for AEMO not to enable regulation secondary frequency response above the level which can be achieved by full deployment within 3 minutes rather than impose a new requirement on facilities already supplying the service.

### Required measurements

AGL:

**Control System**

The proposed amendments to section 10.4 of the MASS add additional control system requirements related to telemetered data rate, latency, and data fields. AGL expects that providing these additional data points will cause no issues and should be relatively easy to implement, we therefore accept the proposed amendments to this section.

Delta Electricity:

**New Technical Signals for Regulation FCAS**

The Draft Determination and the revised MASS appear to be requiring new signals, Control Request Feedback, Online/offline status and Remote/Local Status and signal capabilities to be included for in SCADA exchange as improvements to the Regulation FCAS system. Some of these signals and capabilities may already exist in some participant's SCADA set and be complimented by third party SCADA systems and capability. As a result, participants may be uncertain whether or not AEMO requires any new signals from them.

It is recommended that following the publications of the updated MASS, AEMO checks its signal database and writes letters of request to each relevant existing service provider requesting the specific signals and signal quality be confirmed. To avoid the inefficiency and expense in making modifications that may not make any difference to the delivery, discussions as to whether any additional work can be considered optional or not may be useful for both AEMO and the participant. From such discussions agreements can be reached to specific timeframes for modifications before any further action from AEMO might be warranted to ensure controls are adequate.

To expand on this point by example, consider the online/offline status signal proposed by the Draft Determination for inclusion in signals associated with the Regulation FCAS. For plants that are normally in service and only plan to have one outage a year, it hardly seems to be an urgently required modification to include online/offline status in the SCADA else a Unit be unacceptable as an FCAS provider. Some plants may also presently be relying on a signal provided to AEMO by TNSPs. With acknowledgement of clause 2.3, it is unclear whether signals from third parties can provide satisfaction for the purposes of the MASS and hence it is suggested that AEMO write to relevant existing providers identifying clearly any new signals it considers required and, otherwise, excuses existing participants from needing to have the new signals added.

Hydro Tasmania:

**Regulation facility definition:**

Hydro Tasmania would like to seek clarification to the following question: what is the definition/scope of the regulation facility mentioned in this section? This question was submitted in the first consultation but is yet to be clarified.

It seems that a 'regulation facility' has predominately referred to the generator's AGC, but in reality, the regulation FCAS facilities 'from end to end' included: System frequency feedback (presumably SCADA), AEMO AGC, communication systems, generator AGC and local unit controller/governor. A clear definition of the regulation facility will help the participants to well understand the technical implication of the proposal/requirement specified in this section and also technical performance monitoring.

Shell Energy:

With regards to section 10.4(a), we note AEMO's comments at the MASS Consultation Webinar on 23 June 2021 concerning the provision of specific additional SCADA data to AEMO that the data requirements as indicated will be subject to discussion and agreement between AEMO and the service provider. We look forward to seeing clarity regarding this in the final version of the MASS.

### Transitional period

Hydro Tasmania:

**Transitional Period:**

Hydro Tasmania supports the implementation of the regulation transition via multiple stages. e.g. Based on the machine DUID size. A multiple stage approach will help AEMO to prioritise the implementation of the major DUID's. For example, beginning with a threshold over 200MW, and then progressively reaching the units in the smaller categories. It will also allow the participants like Hydro Tasmania with a fleet of 50 units and 29 power stations, to have sufficient time to plan and implement.

### Testing cycle

AGL:

**Tests**

Section 10.6 of the draft MASS adds new testing requirements for regulation FCAS to the MASS and provides rules for the timing of those tests. AGL considers that FCAS systems are effectively already being continually tested because if the AGC system is not followed it will become apparent through metering. With PFR implemented, the amount of noise on the system has greatly reduced, and this will allow for even greater verification of a generators response to AGC signals. Given the availability of the metering data, we consider that other testing should only be required when no real data is available i.e., if a generator has undergone plant changes or has been found not to be following AGC signals. We suggest that requiring additional tests other than in these instances would increase costs for no real benefit. In regard to the proposed testing periods, to minimise any disruption to generator operations we strongly suggest that the timing be more variable to ensure that the testing can be aligned with generator outage schedules.

Delta Electricity:

**Testing for Regulation FCAS**

Regarding the testing proposed for the Regulation services, Delta Electricity considers that relying on participants to plan and initiate tests will be problematic, lacking efficiency in the coordination effort and likely to promote disputation should delays in testing occur or constraints arise because of reasons outside the control of the participant. As described by the MASS clauses 10.5 and the new 10.6, testing effort will require AEMO preparation, coordination, test signal delivery and test report acknowledgement. Participants will therefore be needing AEMO advice and assistance in performing the tests and AEMO will probably prefer consistency in the formats of participant test reports.

Detailed knowledge of the AEMO AGC may be required in order for participants to gain full understanding of the causes of an unsuccessful Regulation test. The AEMO energy dispatch signal delivery process, timing and third-party telecommunication systems may also be possible contributing factors in any service test difficulty experienced by service providers carrying out such tests and actions may need to be assigned to AEMO and/or third-parties which therefore demands coordination in the test process.

Delta Electricity considers that AEMO can probably perform such tests with very limited involvement of Regulation FCAS provider or third-party telecommunication companies and would achieve superior consistency, efficiency and comparability between competing participants in the testing results and command greater authority in addressing detected defective performance. After all, AEMO has the NER obligations of ensuring frequency is adequately controlled and AEMO Regulation FCAS dispatch designs

and dispatch signals and the passage of how those signals reach the relevant service provider are integral parts of the system. Reconsideration on this point is recommended.

Hydro Tasmania:

**Regulation testing cycle:**

As highlighted in our initial submission to the first stage of this consultation, Hydro Tasmania is in a unique position when compared with most generators on the mainland. With a total of 50 hydro units in the fleet, it is challenging to achieve large scale offline regulation tests and associated outages.

The new proposal extends the testing cycle to 3 years, however the effective workload and cost is still significant, involving on average, one and half units tested per month. Therefore, Hydro Tasmania would be supportive to the online approach. As an example

1 Integrating the proposed measurements/tests in normal operation while not participating in regulation FCAS markets with a constant energy target for a short period of time, so that the regulation tests can be carried during normal operating: and

2 After that, the regulation tests will be required only when impacting control system upgrade is undertaken or a system security issues and risks emerges warranting further assessments.

Hydro Tasmania believes that this approach would be advantageous to all market participants as it will:

1 Allow AEMO and market participants to better understand the end-to-end regulation facility performance whilst testing the entire regulation facility; and

2 Reduce cost and minimise the footprint to normal production.

### 5.6.2. AEMO's assessment

AEMO's assessment has been grouped in the same manner as the issue summary and submission section above.

#### Telemetered Data Rate

AEMO has retained the requirements for Telemetered Data Rate as per the first Draft Determination, which stated that required data rates do not apply to systems outside of the facility and FCAS provider's control, including but not limited to AEMO and TNSP systems.

#### AGC controllable

Shell Energy's concerns about the Setpoint Change Deadband and the behaviour of AGC regarding the ramping of facilities have been considered. To provide clarity and assurance of the statements in the Draft Determination, a detailed description of how the NEM Dispatch Engine (**NEMDE**) caters for bid and telemetered ramp rates is contained in AEMO's guide "FCAS Model in NEMDE[146]". For clarity on how AGC also uses telemetered ramp rates, a footnote has been added to section 10.4 of the draft MASS, which states "AEMO's AGC will control facility output within the ramping rates telemetered to AEMO by the facility".

#### Minimum bid size

The first Draft Determination and draft MASS adopted an approach to minimum Regulation FCAS bid size that is the larger of 1 MW or 1% of the registered maximum capacity of the relevant facility. While it may be that some technologies generally have a 'cleaner' output than others, such a generalisation is difficult to translate into a consistent and fair MASS requirement. The 1 MW or 1% of registered maximum capacity approach is a compromise that can be applied across all technologies.

Shell Energy's suggestions regarding deviation from energy dispatch are covered in section 5.4.

[146] Available at: https://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Dispatch/Policy_and_Process/2017/FCAS-Model-in-NEMDE.pdf

### Maximum CRD

AEMO's considered position is that a CRD of 150 s is the maximum that could deliver satisfactory Regulation FCAS control. AEMO's internal review and independent AGC advice has suggested that 150 s should be readily achievable by all relevant technologies, and any external processing and communications delays should be a relatively small proportion of this time. An alternative approach would be to specify a lower maximum CRD (e.g. 90 s) and make this exclusive of external processing and communications delay. The disadvantage of this approach is AEMO would then have no assurance as to the quality of the Regulation FCAS that can be derived (as the effective maximum CRD would then be unbounded) and consequently AEMO would be obliged to purchase ineffective Regulation FCAS.

### Minimum ramp rate

As per the first Draft Determination, AEMO has not adopted the proposal to specify particular minimum Regulation FCAS ramp rates.

### Required measurements

Submissions were focused on the model for rolling out new explicit measurement requirements for Regulation FCAS. AEMO and Consulted Persons noted that some facilities may currently meet all requirements, while others may not. AEMO has amended wording in 10.4(a) of the draft MASS to now state that the set of telemetered measurements will be agreed between AEMO and the Regulation FCAS Provider. AEMO agrees that it is likely best placed to determine how current facilities fulfil these requirements and so will initiate the process with existing providers by way of a letter or similar. Newly registering parties will be expected to provide evidence of meeting these requirements through the registration assessment process. In both cases, this is subject to the Transitional Period stated in the MASS.

Regarding the feedback from Hydro Tasmania on the scope of the guidance in section 10.3 of the draft MASS, AEMO has amended that section to clarify the intent of the guidance. AEMO acknowledges that actual plant controls vary considerably, and may include various intermediate controllers (e.g. internal AGC or aggregation layers) and limits.

### Transitional period

An implementation approach based on dispatchable unit identifier (**DUID**) size (as with mandatory PFR implementation), or perhaps Registered FCAS capacity across a two-year timeframe, is likely a good way to implement, but AEMO considers that introducing multiple thresholds explicitly into the MASS adds unnecessary complication. AEMO expects that, as with mandatory PFR implementation, there will be opportunities to avoid duplication of work for identical units.

### Testing cycle

AEMO has considered the points Consulted Persons raised on the effort and cost involved in a regular Regulation FCAS testing regime, and where the responsibility should lie. AEMO suggests that a reasonable testing regime is in the best interests of AEMO, FCAS providers and ultimately considers that unidentified non-compliance can have material impacts for other providers. AEMO notes that FCAS providers have a clear responsibility to ensure compliance with the MASS. However, given the level of dependency Regulation FCAS has on AEMO's systems and on other third party systems, this is a more complicated matter than Contingency FCAS.

Noting these concerns, AEMO has made two changes to the test requirements set out in section 10.6 of the draft MASS:

1. The general test cycle has been increased from three to four years.

2. The applicable timeframes now refer to when a provider must *initiate engagement* with AEMO to plan and conduct tests, rather than necessarily requiring the tests to be concluded in the stated timeframes.

### 5.6.3. AEMO's conclusion

Refinements to the Regulation requirements have been made in the draft MASS published with this report, making the changes described in section 5.6.2 above.

## 5.7. Clarification of requirements for Delayed FCAS

### 5.7.1. Issue summary and submissions

In the first Draft Determination, AEMO indicated its intention to 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. There was only one submission on this issue.[147]

Hydro Tasmania:

> Hydro Tasmania agrees that a synchronous machine droop and deadband response can result in steady state errors, thus an additional correction is needed to bring the system frequency back to 50Hz (and not the edge of the NOFB). Hydro Tasmania supports the deferral of any amendment to Delayed FCAS requirements in the MASS and agree with AEMOs consideration that further understanding and analysis is needed in order to find a workable and fair approach.

### 5.7.2. AEMO's assessment

AEMO will consider this matter further, with a view to form a proposal for the next consultation on the MASS.

AEMO will focus on how different control arrangements can support the aim of returning system frequency back to 50 Hz, and how pure proportional controllers should be valued for this FCAS.

### 5.7.3. AEMO's conclusion

There will be no change from the Draft Determination.

## 5.8. Issues associated with pending Rule changes and matters for separate consultation

### 5.8.1. Issue summary and submissions

In the Draft Determination, AEMO decided to make no changes to the MASS to address pending NER changes or other matters, apart from the following:

- Incorporate the interim arrangements for FCAS provision from DER into the MASS.
- Include various references to PFR in the MASS for the sake of clarification, notably Table 7 in section 6.3 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.

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

Extracts from submissions on these issues are cited below.[148]

Enel X:

> **Incorporating the interim arrangements for FCAS provision from DER**
>
> We support AEMO's decision to update the MASS to reflect the interim arrangements for FCAS provision from DER – that is, 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.

Hydro Tasmania:

> **Coordination between the proposed transition periods and the new FFR markets:**
>
> Hydro Tasmania notes that on 15 July 2021, the AEMC published a final determination to introduce two new market ancillary services, to help control system frequency and keep the future electricity system secure. As detailed by the AEMC, the MASS needs to be revised by 19 December 2022 in order to specify the detailed description and performance parameters for FFR.
>
> To best coordinate the FFR timeframe as well as the VPP initiative, Hydro Tasmania suggests that AEMO create two transitional time frames:
>
> 1 A 1st initial stage VPP transitional time frame in the middle of 2022 before the MASS FFR update and ensure VPPs are included in the FFR consideration.
>
> 2 A 2nd stage VPP MASS transitional time frame remaining on 30 June 2023 as currently planned in order to ensure the technical specifications are specified are well implemented.
>
> …
>
> AEMO's assessment in Section 5.8.2 excludes PFR from the consultation. Hydro Tasmania understands that currently PFR within the NOFB is outside of the existing FCAS markets, however, PFR forms the technical foundation of power system frequency control from both a regulation and contingency perspective and therefore has a strong technical connection with all other frequency control mechanisms.
>
> Hydro Tasmania suggests that if AEMO deems the MASS an inappropriate place to accommodate the coordination and specification between PFR and FCAS, then the creation of a dedicated technical artefact should be considered to address this matter. Consequently, the MASS could refer to this artefact and reflect the significant changes in the PFR area that has occurred over the last year, as well as providing necessary technical guidance to participants to refer to.

Shell Energy:

> Finally, we accept, but are disappointed in AEMO's rationale for not making any proactive changes to the MASS to enable the inclusion of FFR. We also note that AEMO has indicated it will undertake a separate consultation to give effect to new FFR once the AEMC has released its final determination on the FFR rule change. Shell Energy looks forward to engaging with AEMO on revisions to the MASS to enable the participation of FFR.
>
> Following the release of the final determination on the MASS, we consider that AEMO should begin developing the requirements for FFR. We maintain that preliminary discussions on integrating FFR could have formed part of this review. We look forward to engaging with AEMO on the development of the two new FFR services.

### 5.8.2. AEMO's assessment

#### Incorporating the interim arrangements for FCAS provision from DER

Having received only one submission in support of the change, AEMO considers the matter closed.

#### Incorporate PFR into MASS

While AEMO understands Hydro Tasmania's concern, the issue remains that, at this stage, PFR is not a part of the FCAS markets and there is no legitimate basis for incorporating PFR technical requirements in the

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

MASS. There is a separate document, the Interim Primary Frequency Response Requirements (IPFRR)[149], which addresses the technical requirements, and this document is prescribed by a different part of the NER.

**Fast Frequency Response**

The process of developing and consulting on changes to the MASS, along with the development and implementation of recent and ongoing frequency-related Rule change processes, requires the dedication of specialist resources. Further extension of the present MASS consultation reduces the time and resources AEMO has to prepare and consult widely on the next consultation, which is to incorporate Fast Frequency Response (**FFR**) and is time-constrained by the NER. However, the detailed attention that has been given to FCAS measurement in this consultation will be invaluable for developing the measurement and verification requirements for FFR FCAS.

### 5.8.3. AEMO's conclusion

AEMO will not make any further material changes to the draft MASS on these matters. Guidance on PFR and FCAS co-ordination has been modified slightly based on feedback to the first Draft Determination, as detailed in section 5.4 of this report.

## 6. PROPOSED UPDATES TO VERIFICATION METHODOLOGY

This section sets out the proposed updates to the Verification Tool and User Guide that are intended to accompany the Final Determination. While the key changes relate to the measurement issues contemplated in this Second Draft Determination, AEMO intends to use this opportunity to update some other known limitations and issues with the Verification Tool.

The following key changes are proposed:

- The methodology will be updated from Right Riemann to trapezoidal to ensure that the 'area under the curve' is captured more accurately. The 'area under the curve' reflects the change in active power over time and is an integral component of the verification tool to calculate the FCAS capacity delivered.
- The FDT will be identified using the ROCOF method as suggested by UoM. Different approaches were suggested in some formal submissions, but the analysis from UoM has demonstrated that the ROCOF method is more accurate across a range of frequency disturbances.

The complete list of proposed updates to the FCAS Verification Tool to implement the accepted recommendations of this MASS consultation is below. AEMO will provide a sample version of the proposed implementations in the FCAS Verification Tool for comment. AEMO may continue to amend these changes and will consider feedback provided through submissions on the proposed updates. The current FCAS Verification Tool v4.0 and User Guide v3.0 remain in effect until replaced on AEMO's website[150].

1. As discussed in section 4.1.2 above, the trapezoidal method will be implemented as follows in the FCAS Verification Tool to improve the accuracy of FCAS assessments:

$$Time\ Average = \frac{2\sum_0^n CBR - CBR_0\ - CBR_n}{count(CBR) - 1}$$

$$where\ CBR = Compensated\ Basic\ Response\ \&\ CBR_0\ is\ CBR\ at\ t = 0$$

[149] Available at https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2020/interim-pfrr.pdf?la=en.

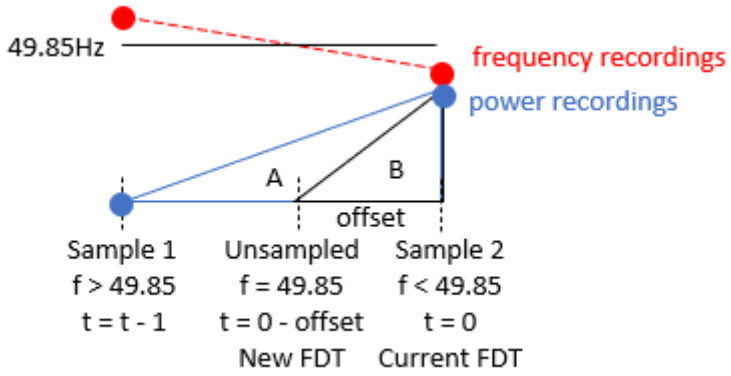
[150] Available at: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/market-ancillary-services-specification-and-fcas-verification-tool

This implementation requires the measurement at t=0 to be included in the calculation of the time average, rather than beginning the calculation of time average from the first measurement after t = 0 as currently implemented.

Where: *RaiseFast*, *RaiseFast4s*, *RaiseSlow*, *RaiseDelayed* *LowerFast*, *LowerFast4s*, *LowerSlow* *LowerDelayed* tabs

2. The FDT will be determined by the ROCOF method, which provides greater certainty as to when frequency crossed the NOFB boundary between measurements, as discussed in section 4.1.2 above. The implementation subtracts area 'A' below from area 'A+B' in the first measurement of the assessment window to calculate time average as shown in Figure 2. Note: area 'A+B' was previously excluded from the calculation of time average but is now incorporated due to the trapezoidal method.

**Figure 2 ROCOF method**




Where: *RaiseFast*, *RaiseFast4s*, *RaiseSlow*, *RaiseDelayed* *LowerFast*, *LowerFast4s*, *LowerSlow* *LowerDelayed* tabs

3. The Contingency Event Time (CET), introduced as part of an earlier MASS consultation in 2020, may result in reduced FCAS assessments in some cases, such as for providers with switching controllers. AEMO will allow FCAS providers to apply a CET offset value of 0 if that results in a higher FCAS assessment and recommends all switching controller assessments to use 0 (i.e., a 'no disadvantage' test will apply to CET).

Where: *RaiseInformation*, *Lower Information* tabs

4. The Frequency Dead-band Limit is a reference to the FCAS unit frequency controller dead-band. The default value of 50 Hz will be updated to 49.85 Hz and 50.15 Hz to reduce potential for confusion.

Where: *RaiseInformation*, *Lower Information* tabs

5. The time reference in G15 on *LowerFast* tab, which incorrectly referred to the *RaiseInformation* tab, has been corrected.

Where: *LowerFast* tab

6. The calculation of reference trajectory for the Fast service has been corrected, as it was incorrectly interpolating the reference trajectory for the first five minutes of a frequency event.

Where: *RaiseFast*, *RaiseFast4s*, *LowerFast*, *LowerFast4s* tabs

7. The frequency smoothing in the *RaiseFast4s and LowerFast4s* has been corrected from using an offset by nine time intervals, because at 4 s resolution this offset represents 36 s. This logic was copied from the *RaiseFast* and *LowerFast* tabs but not changed for the lower time resolution.

   Note: *RaiseFast4s* and *LowerFast4s* tabs are not used in FCAS assessment but are provided to help where high speed data is not available.

   Where: RaiseFast4s, LowerFast4s tabs

8. The FCAS Verification Tool User Guide has been corrected to clarify the implemented logic of frequency smoothing in the FCAS Verification Tool, as detailed below.

   - **Page 10 of 31 – Clarified labelling of variables and their relationships**

     (iv) add to each adjusted power measurement an amount of:

     $IR_i = 4\ p^2\ I\ f_{local,i}\ df/dt_i$

     where $IR_i$ is the *inertial response* at time $t_i$,

     I is the effective moment of inertia of the *ancillary service generating unit* or *ancillary service load* as agreed between *AEMO* and the relevant *Market Participant*,

     $f_{local,i}$ is the measurement of *local frequency* at time $t_i$ corresponding to the power measurement at time $t_i$,

     and

     $df/dt_i$ is the rate of change of offset smoothed *local frequency* at $t_i$ given by

     $$df/dt_i = \frac{2\times f_{i+2}^{offset-smoothed} + f_{i+1}^{offset-smoothed} - f_{i-1}^{offset-smoothed} - 2\times f_{i-2}^{offset-smoothed}}{5\times t_{i+1} - 5\times t_{i-1}},$$

     $f_i^{offset\text{-}smoothed}$ is the offset smoothed *local frequency* at time $t_i$ given by

     $f_i^{offset\text{-}smoothed} = f_{i+9}^{smoothed}$, and

     $f_{i+9}^{smoothed}$ is the smoothed *local frequency* at time $t_{i+9}$ given by

     $f_{i+9}^{smoothed} = 0.9^* f_{i+8}^{smoothed} + 0.1^* f_{local,i+9}$

   - **Page 11 of 31 – Local frequency, not smoothed frequency, to be used in proportional compensation calculation in Fast FCAS assessment. (linked to note 11 below on Proportional Compensation Cap change)**

     where $f_{local}$ is the *local frequency* measurement coincident with the basic response measurement being compensated,

     ~~$f_{local}$ is smoothed using the following process~~

     ~~$f_{local,i-10} = f_{local\text{-}offset,i} = 0.9^* f_{local\text{-}offset,i-1} + 0.1^* f_{metered\text{-}offset,i}$~~

     ~~where $f_{metered\text{-}offset,i}$ is the measurement of *local frequency* at time $t_i$~~

     ~~$f_{local\text{-}offset,i}$ is the offset smoothed *local frequency* at time $t_i$,~~

~~$f_{local,i}$ is the smoothed *local frequency* at time $t_i$.~~

- **Page 14 of 31 – Local Frequency, not Smoothed Frequency is used in Slow service assessment**

  where $f_{local}$ is the *local frequency* measurement coincident with the basic response measurement being compensated.

  ~~$f_{local}$ is smoothed using the following process~~

  ~~$f_{local,i-10} = f_{local-offset,i} = 0.9 * f_{local-offset,i-1} + 0.1 * f_{metered-offset,i}$~~

  ~~were $f_{metered-offset,i}$ is the measurement of *local frequency* at time $t_i$~~

  ~~$f_{local-offset,i}$ is the offset smoothed *local frequency* at time $t_i$,~~

  ~~$f_{local,i}$ is the smoothed *local frequency* at time $t_i$.~~

9. Recorded power values (MW) of zero (0) can propagate a DIV#0 error and prevent completion of an FCAS assessment in the FCAS Verification Tool. This error is now handled as per below.

   Was: = S15*(B15/D15)

   Now: =IF(D15=0,S15,S15*(B15/D15))

   Where: *RaiseFast*, *RaiseFast4s*, *RaiseSlow*, *LowerFast*, *LowerFast4s*, *LowerSlow* tabs

10. Assessment of each FCAS service is based on calculating the minimum time average value of two time windows, as per min(Window 1, Window 2). If frequency recovery occurs prior to the beginning of the second time window, the FCAS Verification Tool defaults to a zero assessment as min(Window 1, zero) is zero. The tool has been updated to ignore the second window in this scenario.

    Where: *RaiseFast*, *RaiseFast4s*, *RaiseSlow*, *RaiseDelayed* *LowerFast*, *LowerFast4s*, *LowerSlow* *LowerDelayed* tabs

11. Proportional compensation currently uses a cap of 3x. This cap can produce inaccurate FCAS assessments for proportional controllers, particularly when frequency is between 49.72Hz and 49.85Hz. AEMO has reviewed and is proposing the following implementation to address this issue.

    Was:

$$MIN\left(MAX\left(1,\frac{ABS\left(f_{raise\ DB}-f_{resp-rate}\right)}{ABS\left(f_{raise\ DB}-f_{local}\right)}\right),3\right)\times G$$

if $f_{local}$ less than 50 Hz

Now:

$$MIN\left(MAX\left(1,\frac{ABS\left(f_{raise\ DB}-f_{resp-rate}\right)}{ABS\left(f_{raise\ DB}-f_{local}\right)}\right),\left(f_{raise\ DB}-f_{resp-rate}\right)\times 1000\right)\times G$$

if $f_{local}$ less than 50 Hz

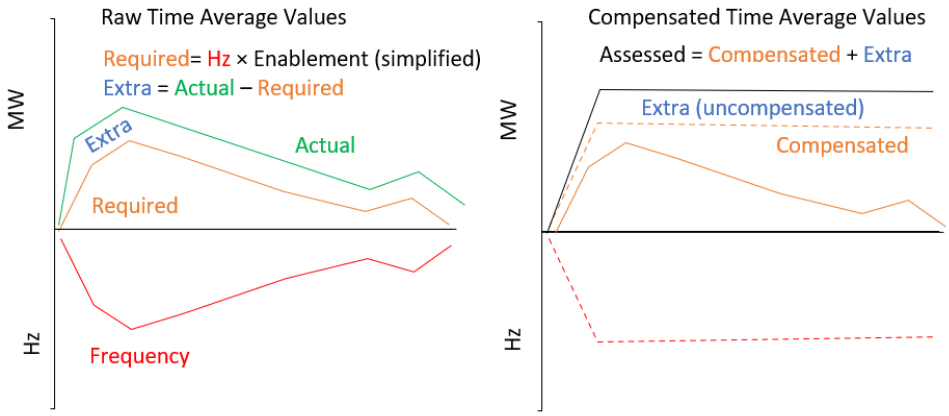
For a typical FCAS generator with dead-band ±0.15Hz, the effective cap is now:

$$(49.85 - 49.5) \times 1000 = 350$$

The multiplier of 1000 has been selected to compensate to a granularity of 0.001 Hz, or to 49.849 Hz in the case of a raise service with dead-band ±0.15 Hz.

This proportional compensation is applied to the enabled FCAS response. Any FCAS response beyond the required enabled FCAS is included in the time average response but is uncompensated, or in other words is compensated at 1x, as shown in Figure 3 below.

**Figure 3 Compensation factor application**




12. This implementation does not affect any unit registrations as all compensation is 1x in registration. For FCAS assessments where frequency behaviour is very different to the standard frequency reference ramp rate, this implementation should deliver a more accurate and consistent estimate of FCAS delivery.

    A new graph has been added to the FCAS Verification Tool to assist interpretation.

    Where: *RaiseFast*, *RaiseFast4s*, *RaiseSlow*, *LowerFast*, *LowerFast4s*, *LowerSlow* tabs

# 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 |
| ACF | Australian Conservation Foundation |
| AEC | Australian Energy Council |
| AEMC | Australian Energy Market Commission |
| AER | Australian Energy Regulator |
| AGC | Automatic generation control system |
| Ancillary Service Facility | As defined in the MASS |
| API | Application programming interface |
| ARENA | Australian Renewable Energy Agency |
| BAU | Business-as-usual |
| BESS | Battery energy storage system |
| BTM | Behind the meter |
| C&I | Commercial and industrial |
| CBP | Cape Byron Power |
| CEC | Clean Energy Council |
| Contingency FCAS | Any of the following:<br>• fast raise service;<br>• fast lower service;<br>• slow raise service;<br>• slow lower service;<br>• delayed raise service; and<br>• delayed lower service |
| Contingency Event Time | The time at which a contingency event occurred, which is determined as follows: (a) Where the initial frequency change that led to a Frequency Disturbance is clear, there was a single rapid and significant change in frequency, the Contingency Event Time is the starting point of that frequency change. (b) If there was a series of step changes in frequency or a slow ramp in frequency, the Contingency Event Time will be at the start of the greatest rate of change of frequency, as measured by AEMO. (c) If neither paragraph (a), nor (b), applies, AEMO will take into account the circumstances of the contingency event and select a time that, in AEMO's opinion, represents the start time of the frequency disturbance, against which the FCAS response to it can reasonably be measured. |
| 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 |

| Term or acronym | Meaning |
|---|---|
| DEIP | ARENA's Distributed Energy Integration Program |
| Delayed FCAS | Delayed raise service and delayed lower service |
| DELWP-V | Victorian Government Department of Environment, Land, Water and Planning |
| 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 |
| DUID | Dispatchable Unit Identifier |
| EA | Energy Australia |
| ECA | Energy Consumers Australia |
| ENA | Energy Networks Australia |
| ESB | Energy Security Board |
| ESS | Energy storage system |
| Fast FCAS | Fast raise service and fast lower service |
| FCAS | Frequency control ancillary services, referred to as market ancillary services in the NER – effectively, Contingency FCAS and Regulation FCAS |
| FCAS Provider | A Market Participant in one or more FCAS markets |
| FCAS Verification Tool | An Excel spreadsheet published by AEMO[151] to assist market participants to calculate FCAS delivered by their plant |
| FFR | Fast frequency response |
| FIT-D | Frequency Injection Test – Device |
| FOS | Frequency operating standard |
| Frequency Disturbance | An occasion when the power system frequency moves outside the NOFB |
| Frequency Disturbance Time (FDT) | As defined in the MASS |
| Frequency Settings | As defined in the MASS |
| HSM | High speed meter/metering |
| Hz | Hertz |
| IPFRR | Interim primary frequency response requirements. |

[151] Available 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

| Term or acronym | Meaning |
|---|---|
| Issues Paper | AEMO's Issues Paper titled: Market Ancillary Service Specification Consultation – January 2021[152] |
| Local Frequency | The frequency of the electricity delivered by an ancillary service generating unit or consumed by an ancillary service load, measured in Hz |
| Lower FCAS | Any of the following (terms defined in the NER):<br>• fast lower service;<br>• slow lower service; and<br>• delayed lower service |
| MASP | Market Ancillary Service Provider |
| MASS | Market ancillary service specification |
| ms | millisecond |
| MW | megawatt |
| NEM | National Electricity Market |
| NEM2025 | The ESB's Post 2025 Electricity Market Design |
| NEMDE | The NEM dispatch engine |
| NEO | The objective specified in section 7 of the National Electricity Law,<br>which is to:<br>… promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to—<br>(a) price, quality, safety, reliability and security of supply of electricity; and<br>(b) the reliability, safety and security of the national electricity system. |
| NER | National Electricity Rules |
| NOFB | Normal operating frequency band |
| NSP | Network Service Provider |
| OEM | Original equipment manufacturer |
| Option 1 | See the description in section 2.2 |
| Option 2 | See the description in section 2.2 |
| PFR | Primary frequency response |
| PIAC | Public Interest Advocacy Centre |
| Quinbrook | Quinbrook Infrastructure Partners |
| Mandatory PFR Rule | National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5 |
| Raise FCAS | Any of the following:<br>• fast raise service;<br>• slow raise service; and<br>• delayed raise service |
| Redback | Redback Technologies |

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

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| Term or acronym | Meaning |
|---|---|
| Regulation FCAS | Any of the following:<br>• regulating raise service; and<br>• regulating lower service |
| Reposit | Reposit Power |
| Rheem & CET | Rheem Australia & Combined Energy Technologies |
| RIS | AEMO's Renewable Integration Study |
| RoCoF | Rate of change of frequency |
| RTU | Remote terminal unit |
| s | second |
| SA | South Australia |
| SAPN | SA 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 |
| Tesla | Tesla Motors Australia |
| TNSP | Transmission Network Service Provider |
| Trial Participant | A participant in the VPP Demonstrations |
| UNSW | University of New South Wales |
| UoM | University of Melbourne |
| VDRT | Voltage disturbance ride-through |
| 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 |

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# APPENDIX B. SUMMARY OF SUBMISSIONS AND AEMO RESPONSES

| NO. | CONSULTED PERSON | ISSUE | AEMO RESPONSE |
|---|---|---|---|
| 1. | Various | Measurement Time Resolution for FCAS provided by DER<br>See section 4.1.1. | See sections 4.1.2 and 4.1.3. |
| 2. | Various | Location of Measurement Point for FCAS provided by DER<br>See section 4.2.1. | See sections 4.2.2 and 4.2.3. |
| 3. | Various | Trial Participant Transitional Issues<br>See section 4.3.1. | See sections 4.3.2 and 4.3.3. |
| 4. | Various | Consultative Forum on the provision of FCAS by DER<br>See section 4.4.1. | See sections 4.4.2 and 4.4.3. |
| 5. | Various | Application of the NEO to the provision of FCAS by DER<br>See section 4.5.1. | See sections 4.5.2 and 4.5.3. |
| 6. | Various | Importance of VPP Demonstrations<br>See section 4.6.1. | See sections 4.6.2 and 4.6.3. |
| 7. | Various | Relevance of other Market Experience<br>See section 4.7.1. | See sections 4.7.2 and 4.7.3. |
| 8. | Various | MASS Readability and Usability<br>See section 5.1.1. | See sections 5.1.2 and 5.1.3. |
| 9. | Various | Clarification of References to the Frequency Operating Standard<br>See section 5.2.1. | See sections 5.2.2 and 5.2.3. |
| 10. | Various | Requirements for Non-Frequency Responsive Facilities<br>See section 5.3.1. | See sections 5.3.2 and .5.3.3 |
| 11. | Various | Co-ordination between different FCAS and PFR<br>See section 5.4.1. | See sections 5.4.2 and 5.4.3. |
| 12. | Various | Relationship between MASS and other Instruments or Institutions<br>See section 5.5. | See section 5.5. |
| 13. | Various | Requirements for Regulation FCAS<br>See section 5.6.1. | See sections 5.6.2 and 5.6.3. |

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| NO. | CONSULTED PERSON | ISSUE | AEMO RESPONSE |
|---|---|---|---|
| 14. | Various | Clarification of Requirements for Delayed FCAS<br>See section 5.7.1. | See sections 5.7.2 and 5.7.3. |
| 15. | Various | Issues Associated with Pending Rule Changes and Matters for Separate Consultation<br>See section 5.8.1. | See sections 5.8.2 and 5.8.3. |
| 16. | Tesla | Conditional logging<br>Tesla also notes that logging of 100ms on a conditional basis only is critical to the scalability of VPPs. Under this approach, Tesla proposes to commence logging at 100ms as soon as frequency exits the normal operating frequency band (NOFB) and for 60sec thereafter. Data will be logged on a 1 second basis for all other times of the year.<br>This approach significantly reduces the data housing costs for an aggregated fleet. (for context a fleet of 3500 systems would log and store 1.1 trillion datapoints per year per signal if logging occurs at 100ms resolution on a permanent basis). Noting that most of this data does not provide value to AEMO for the purpose of verifying FCAS delivery, and that it does not improve performance at all, this approach will reduce the overall costs of entry for aggregated fleets of DER, whilst maintaining data integrity requirements. It is a critical step in enabling the scalability of VPPs. | AEMO agrees with Tesla that measurements of power and frequency at high resolution are not required to be captured permanently from every NMI, as high-speed data is required to verify the performance of Fast FCAS providers following a frequency excursion. However, AEMO notes that as per Table 4 of the draft MASS, data from Fast FCAS providers is only required to be captured for a minimum of 5 seconds before the Frequency Disturbance Time and a minimum of 60 seconds after. A DER FCAS provider is not required to record 200 ms data at all times. Recent major improvements in frequency performance mean Frequency Disturbances are now much less frequent. |
| 17. | CEC | **Fee for Service**<br>We strongly support the work that AEMO has undertaken in its VPP trials and the support for enhanced DER participation in markets. DER policy is lacking a framework or agreement on which services should be provided through market mechanisms and which should be provided using regulations and standards. As a general principle, provision of system services and network services should always be paid for and should not be mandated as a condition of grid connection. This should include support for FCAS markets and voltage management on distribution networks. The only exception to reliance on market mechanisms should be genuine, well-defined emergency situations. | Noted. |
| 18. | CEC & SolarEdge | **Registration Fees**<br>Fees for de-registering and registering NMIs are applicable. Under the proposed rules, VPPs would incur normal market registration fees ($2,800) each time they need to amend their portfolio. Fees for adjusting registration should only be applicable when the DUID changes, not for individual NMIs – and then the cost should reflect the administrative time required rather than the standard registration fee.<br>The approach needs to consider DER assets potentially in the tens of thousands were end users may move house or decide to upgrade or replace a system. They could also move internet provider or retailer, therefore the registering/de-registering fees NMIs for VPP's need to be carefully considered so that participation barriers or disincentivizing to participate becomes the predominant factor. | AEMO's fees are determined periodically in accordance with clause 2.11 of the NER. The latest fee determination was published by AEMO following consultation on 26 March 2021 and the structure of fees commenced on 1 July 2021 and will end on 30 June 2026.<br>The structure of fees reflects the effort involved in assessing the suitability of loads as ancillary services loads, which it is required to do under the NER. |

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| NO. | CONSULTED PERSON | ISSUE | AEMO RESPONSE |
|---|---|---|---|
| | | SolarEdge sees a pragmatic approach here with allowing VPP aggregators or operators to be contracted at committed levels and enabled to manage the pool of resources that respond to this contractual commitment. This can remove the need for registration at the site level and remove an administrative burden that could quickly absorb any of the FCAS value pool available. This would also enable flexibility in consumer choice to shift VPP contracts, reflecting the freedoms of choice consumers have in Retail Electricity markets<br>**7. Recommendations**<br>…<br>11. Fees for adjusting registration should only be applicable when the DUID changes, not for individual NMIs, the cost should reflect the administrative time required only. | |
| | Simply Energy | Simply Energy is concerned that AEMO's proposed fee structure for adjusting registrations could become a financial burden. If fees are payable to AEMO each time a NMI (or a group of NMI's) rolls in or rolls out, rather than only when the MW registration of the DUID changes, then this could become a further barrier to entry. Simply Energy urges AEMO to re-evaluate the underlying processes and fee structure to ensure that it presents the most economic approach for both Trial Participants and the market operator. | |
| | SwitchDin | Currently normal market registration fees are incurred by VPPs every time amendment of the portfolio is required (for example for de-registering and re-registering NMIs), with the published market registration fee set at $2,800. While multiple NMIs can be added and removed at a time, this is a significant cost to VPP operators who have little control over customer churn. In addition, this results in less accurate registration information over time as the fee structure encourages operators to batch process any changes.<br>We suggest that registration fees should only be incurred for a change to a DUID (for example, for an increase in the registered capacity) and not for changes to individual NMIs. The fees should also be cost reflective taking into account the administrative costs required to implement the change rather than charging a standard fee. | |
| | Discover Energy | **4b. Transfer of operational control of a NMI (site) between MASP/DRSPs**<br>In line with the philosophy of Power of Choice and the concept of one MASP/DRSP for one NMI, the process for the transfer of a NMI (and its associated, BTM assets) should be streamlined and adjusted to reflect the administrative costs of transferring the registration of one NMI from one DUID to another. If AMEO still envisions that the administrative labour of such a transfer is still in the order of $2,800 as it is according to the current fee structure, then AEMO is obliged to consider changes to its administrative processes to expedite the process and reduce this cost.<br>Discover Energy understands that the concepts that it has put forward are highly innovative and is more than willing to assist AEMO in assessing their suitability, confident that, as they have been implemented extensively in other jurisdictions, they will be able to satisfy AEMO's provision of system security. | |
| 19. | Discover Energy | **4. MASP Registration Processes** | The registration process and ongoing compliance are matters that are not within the scope of the MASS. They need to be |

| NO. | CONSULTED PERSON | ISSUE | AEMO RESPONSE |
|---|---|---|---|
| | Tesla | Given that the MASS determines the requirements for registration, including fees for new registrations and transfers and underscores the testing process to prove capability for ancillary services, said testing processes should be standardized and as such included or directly linked to the MASS.<br><br>**6.4 Updates to MASS based on recommendations above and VPP Demonstrations**<br>Based on Tesla's assessment of both the outcomes of the VPP Demonstrations, and our recommendations on the positioning put forward by AEMO in the Draft Determination, Tesla believes that AEMO should develop a guideline that articulates the registration and compliance obligations of VPPs on a BAU basis.<br>Tesla has articulated our views of this approach, as a general piece of industry guidance, in Attachment A. There has been significant work done to date by AEMO and industry in developing a scalable, sustainable model for VPP market integration, and it is critical that these insights are adopted by AEMO to maintain industry growth in line with AEMO projections. | addressed outside of this consultation and the result could be that the Registration Guide is updated, instead.<br>AEMO will consider whether this needs to be addressed following the additional work to be carried out in respect of the participation of DER inverters in the FCAS markets. |
| 20. | Intellihub | **Guidance on FCAS Aggregation for VPPs**<br>We note that section 4.1 of the MASS allows FCAS providers to apply to AEMO to aggregate their ancillary services generating units or loads, however, does not specifically reference VPPs of small-scale DER.<br>For clarity, we ask that AEMO consider providing guidance on the eligibility of VPPs of small-scale DER to provide contingences (sic) FCAS. | The terms 'ancillary service generating unit' and 'ancillary service load' are classification categories under Section 2.2.6 and 2.3.5 of the NER. The MASS must reflect the terms used in the NER, and VPP or DER are not registration or classification categories.<br><br>For clarity, a person operating a VPP and registered as a:<br>• Demand Response Service Provider and/or a Market Customer (retailer) can classify market load connection points (NMIs), which connect small-scale DER (exempt generating units), as ancillary services loads and aggregate them together to provide contingency FCAS.<br>• Small Generation Aggregator is not able to classify their small-scale DER (market generating units) as market ancillary services generating units and therefore cannot not provide contingency FCAS from these connection points (NMI). |
| 21. | Empower Energy | **Check metering**<br>We are satisfied with AEMO's intention to not pursue market approaches requiring check metering per unique DER type. Aside from some questionable reliability in characterising DER unit response with this approach, the potential for this approach to limit market access to market-dominant solution vendors and favoured DER integration topologies is anti-competitive and, accordingly, inconsistent with the NEO. | Noted. |

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| 22. | Intellihub | **Standards to Assure Measurement Accuracy**<br>While the MASS does specify measurement requirements in Table 4, these do not reference any Australian or International standard, nor is a testing or certification process required. When in the context of large generating units participating in the NEM, this carries little risk as large generating units will typically be using high-end power quality meters as a matter of course. The cost of these meters is immaterial with respect to the generating unit itself.<br>However, in the context of small-scale DER operating as part of a VPP, the number of individual measurement devices across a single VPP may number in the tens-of-thousands or more. The cost of the meter to each individual site becomes a material factor and each installation is under cost pressure.<br>In the absence of a test or certification process for these measurement devices, there is a risk that these devices may not in reality deliver the level of accuracy claimed by the OEM or VPP operator. This may distort the FCAS markets and erode industry trust. Requiring that each model of measurement device is tested and certified to a common standard will remove this risk.<br>We ask that AEMO consider requiring that each model of measurement device is tested and certified to a common standard. This will provide industry and public assurance of data accuracy and ensure a level playing field for VPP operators. One such standard that may be appropriate is IEC 61557-12:2018 which covers accuracy requirements for power metering and monitoring devices. | All devices capturing measurements of power flow and frequency for an FCAS Provider must meet the metering requirements of the MASS (refer to Table 4 of the draft MASS).<br>As part of applying for registration as an FCAS Provider, a series of tests on the proposed Ancillary Service Facility are required.<br>DER FCAS Providers with controllable devices are required to complete a benchmarking test and the assessment also includes on-site testing to demonstrate the aggregated FCAS response across the FCAS Provider's fleet. AEMO's compliance process after registration requires verification of the compliance of FCAS provided by DER following large frequency excursions.<br>AEMO can clawback the payments from FCAS Providers, or even limit the FCAS enablement through constraints if they fail to meet their requirements. |
| 23. | sonnen<br><br>Empower Energy | **Uncertainty in delivery**<br>sonnen is concerned by the mixed messages delivered by AEMO during the second stage of this consultation with AEMO advising via a Fact Sheet that "Accuracy of measurement is not within the scope of the current MASS consultation" while AEMO is seeking responses from industry participants and interested parties on achievable measurement technical capabilities and projected costs.<br><br>There are limits. The current MASS review has established that 1Hz metering is not sufficient for adequately-accurate characterisation of frequency response. The advent of AS/NZS 4777.2:2020 – implementing a 10Hz standard (albeit at lesser total accuracy than the MASS, were the MASS reduced to 10Hz sampling rate) allows a more rigorous minimum condition for participation – at negligible marginal cost – that is worthy of evaluation in future MASS reviews. As mentioned in our original submission, these developments are consistent with development and market directions for frequency response market participation from significant classes of DER in overseas markets, which will ultimately impact the availability and prevalence of such solutions in the Australian market. | The error associated with slower sampling rate must not be conflated with the metering accuracy of power flow measurements.<br>The focus of this consultation is on the error introduced when measurements of power are captured at a lower measurement time resolution, whereas the metering accuracy specified in the MASS refers to how close those measurements or data samples are to the true value.<br>Lowering the accuracy requirements of FCAS measurements would introduce an error in the verification process and AEMO must be able to reliably confirm the amount of FCAS delivered by a provider.<br>This consultation has only afforded a cursory examination of the measurement accuracy issue, and further work would be necessary to fully assess the impacts of such a change.<br>UoM's analysis has demonstrated that a substantial error would be introduced in the FCAS verification process if the metering accuracy was lowered from 2% to 4% for an |

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| | | | ancillary service facility participating in the energy markets or providing other services than FCAS.<br>There is also no clear evidence that a metering accuracy of 2% is a barrier to entry as it was not brought up as a key issue by most consulted persons in their formal submissions. All DER FCAS providers including VPP Demonstrations participants are required to comply with the accuracy requirement of the MASS.<br>For the reasons mentioned above, AEMO will not be lowering the metering accuracy. |
| 24. | New Energy Ventures | **Other matters – Request for clarification around acceptable frequency response rates (droop settings)**<br>One area that the Draft Determination has not addressed in sufficient detail is acceptable frequency response rates or droop settings. Many respondents raised this issue. AEMO stated that "Further work on allowable frequency response rates will be undertaken outside of this MASS Review". We acknowledge this, but see this as an urgent item of attention for AEMO. NEV also suggests that AEMO consider whether it is appropriate to have items such as frequency response rates addressed in separate documentation to the MASS.<br>Throughout the VPP Demonstrations, assets under 1MW in size were permitted to participate with a droop setting as low as 0.7, in effect allowing the complete capacity of a battery to be bid into Contingency FCAS markets. In discussions with AEMO, NEV understands that the following is acceptable to AEMO:<br>• For BESS greater than 2.5MW in size, AEMO allows for a minimum droop setting of 1.7% corresponding to a frequency band of ±1Hz. With a standard ramp of 6s, this corresponds to 41% of the total capacity of the battery. For example, if a participant wishes to participate with a 10MW BESS, only 4MW can be bid into the Contingency FCAS markets.<br>• For BESS less than 2.5MW in size, AEMO will allow a droop setting as low as 0.7% corresponding to a frequency band of ±0.5Hz. This allows for up to 100% of the batteries capacity to be bid into the Contingency FCAS market. AEMO will only lower the droop setting as much as is required to meet the 1MW bid threshold. For example, if a MASP proposes to bid a 1.5MW battery into the 6s raise market, AEMO will allow for a droop setting of 1.0% corresponding to 66% of the battery capacity and 1MW.<br>• BESS less than 1MW in size may be aggregated and controlled together and be bid into the FCAS market as long as the minimum bid is 1MW. In this case, the droop setting for the individual BESS units can be a low as 0.7%. | AEMO's Battery Energy Storage Systems Requirements for Contingency FCAS Registration document[153] will be updated by the end of the year and cross-referenced in the Registration Guide.<br>AEMO recognises that this document needs to provide more clarification on the allocation of droop settings but notes that the default droop setting for a grid-scale BESS is 1.7%, and FCAS Providers must not assume that a more aggressive droop setting or a switching controller will be allowed without AEMO's approval. |

[153] Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Battery-Energy-Storage-System-requirements-for-contingency-FCAS-registration.pdf

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| | | The above is not documented clearly in the MASS or supporting documents such as BESS requirements for Contingency FCAS registration guide. NEV suggests that AEMO confirm the information, making it clearer for proponents to participate in the Contingency FCAS markets. | |
| 25. | Reposit | **4 Trials of new technologies**<br>Reposit flagged changes to AEMO's "Trials of New Technologies" in section 6.3 of its first stage submission to the Issues Paper.<br>Repost reasserts that the formulation of trials under the MASS has a significant impact on future investments in FCAS providing technology.<br>Reposit recommends that Chapter 8 NER Regulatory Sandbox Processes are implemented for all FCAS trials to make them consistent with other NEM electricity services innovation processes.<br>**4.1 Redefinition in proposed MASS**<br>The Proposed MASS changes to the "Trials of New Technologies" section removes all constraints on AEMO when executing a trial under the MASS. In MASS v6 this section reads:<br>**7.3. Trials of new technologies**<br>*AEMO*, at its absolute discretion, may allow an Ancillary Service Facility to participate in a trial to test the performance of new technologies.<br>It is envisaged that any trial will:<br>• Be for a limited period,<br>• Be for a limited measurable quantity of the service, and<br>• Be subject to the conditions that the party conducting the trial:<br>– Withdraw from the market if directed by *AEMO*.<br>– Use best endeavours to meet the full requirements of the MASS.<br>– Meet any other requirements AEMO, at its discretion, requests.<br>In the Proposed MASS, this section reads:<br>**11. TRIALS OF NEW TECHNOLOGIES**<br>**11.1. AEMO's Requirements**<br>From time to time, a trial to demonstrate the capability of new technologies in the delivery of FCAS may be authorised. Where this occurs, AEMO may specify the capabilities, measurements, verification and other requirements and conditions of the trial in its absolute discretion.<br>**11.2. Report to AEMO**<br>AEMO may specify the contents of a report and supporting data that trial participants must submit to AEMO upon the conclusion of a trial to enable AEMO to assess the efficacy of reviewing the MASS to address any issues that the trial has raised as to the performance of the new technologies in the delivery of FCAS or the operation of the *spot markets* for FCAS.<br>While MASS v6 only "envisaged" that an AEMO trial formulator would apply constraints on time period, measurable quantity and conditions, the Proposed MASS applies no constraints | AEMO considers that its response in the Draft Determination does not require modification, except for the addition of 'duration' under AEMO's requirements when specifying the conditions for a trial.<br>A statement that something is "'envisage(d)" does not impose any constraint on AEMO in its formulation of any trial conditions.<br>AEMO will consider further changes to section 11 if the Regulatory Sandbox is likely to become part of the NER. |

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| | | whatsoever. This is clearly a lessening of structure and regulation applicable to trials of new FCAS - albeit from a low base.<br>Reposit considers this inappropriate given the very clear market distortion and resulting inefficiencies created by the VPP Demonstrations executed under the "tighter" trial conditions in MASS v6.<br>Reposit asserts that the market can learn from the outcomes of the VPP Demonstrations to make the trialling of FCAS innovations more efficient.<br>Reposit flagged the changes to AEMO. AEMO's response to Reposit was as follows[154]:<br>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 specified in the MASS and this is not an efficient way to carry out this work.<br>AEMO agrees with Reposit Power that a trial is not a backdoor 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.<br>Reposit disagrees that the more liberal phrasing of the Proposed MASS's trial section makes it more restrictive. Reposit suggests that it gives AEMO more discretion and FCAS investors, Participants and Consumers even less certainty on the conduct and governance of any future trial.<br>Reposit does agree that requiring a MASS Consultation to vary trial conditions is inefficient. A middle ground is required. This middle ground should balance the risks of running in-market trials against the benefits of in-market evaluation of new technologies. NEM market bodies have been working on exactly this sort of<br>middle ground. The Regulatory Sandboxes rule change specifically addresses in-market trialling of innovations in the NEM.<br>**4.2 MASS application of Regulatory Sandbox processes**<br>The Regulatory Sandboxes rule change process has been running since November 2019. Its objective is to implement[155]:<br>a framework within which participants can test innovative concepts in the market under relaxed regulatory requirements at a smaller scale, on a time-limited basis and with appropriate safeguards in place.<br>It was recommended by the Finkel review which resulted in the COAG Energy Council requesting advice on "how to best facilitate coordination of proof-of-concept trials and the need for formal regulatory sandbox arrangements"[156]. | |

[154] AMENDMENT OF THE MARKET ANCILLARY SERVICE SPECIFICATION – DER AND GENERAL CONSULTATION DRAFT REPORT AND DETERMINATION - 14 June 2021 - p. 182

[155] https://www.aemc.gov.au/market-reviews-advice/regulatory-sandboxes

[156] FINAL REPORT - REGULATORY SANDBOXES - ADVICE TO COAG ENERGY COUNCIL ON RULE DRAFTING - 26 MARCH 2020 - Section 1.2

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| | | The sandbox works to modulate the NER, NERR and NGR such that innovative concepts can be tested in the market. It's development has been contributed to by at least eighteen parties - including AEMO.<br>Its formulation is complete and will result in a section J being added to Chapter 8 of the NER, various changes being made to the NERR, and some small changes being made to energy laws.<br>It provides the mechanism for the efficient operation of innovation trials, ensures that existing consumer protections are maintained, and facilitates the gathering of information required to support innovation accommodating changes to regulations.<br>Reposit asserts that the Regulatory Sandbox mechanism is absolutely applicable to FCAS and should be adopted by AEMO for trials of new technologies in the MASS.<br>Reposit suggests that there is no reason why FCAS innovation is different to wholesale energy, network or metering services innovation - all of which will be enabled by the Regulatory Sandbox mechanism. Reposit suggests that doing otherwise may be counter to the achievement of the NEO.<br>As a result, Reposit suggests that Section 11 of the Proposed MASS should formally adopt the Regulatory Sandbox mechanism for trials of new technologies in FCAS. | |
| 26. | Delta Electricity | **Comment on Dispatch Automation**<br>On perhaps an unrelated final note, Delta Electricity considers that Contingency FCAS Dispatch could be enhanced by AEMO requiring additional signalling not considered in AEMOs 2021 MASS review. In a similar way to Regulation FCAS and the automated deselection of Units that automatically drop out of Remote Control, Delta Electricity considers AEMO systems could, in receipt of certain controller activation signals, disengage Contingency FCAS enablements in the event that enabled Units automatically runback from coordinated modes where DCS based FCAS controls are activated. | Noted – AEMO will consider how this could be tested/trialled in a strictly limited manner. |
| 27. | Enphase Energy | **Cyber Security**<br>The change from the traditional centralised distributed electricity system towards a decentralised system brings new challenges and risks from cyber security that need urgent attention.<br>AEMO is encouraged to support the accelerated adoption of new standards to ensure all connected DER, metering and control systems maintain a high level of security.<br>There are several IEC standards series published (or in TR draft) that have been developed by IEC SC/TC-8, TC-57 and ISA 99 workgroups that can be AS/NZS harmonised. Standards relevant to the energy industry in Australia include;<br>• IEC 61850 series (+ 2020 amendments) provides guidance for power utility automation systems and defines the communication between intelligent electronic devices in such a system<br>• IEC 62351:2021 provides guidance on different security objectives including authentication of data transfer through digital signatures, ensuring only authenticated access, prevention of eavesdropping, prevention of playback and spoofing, and intrusion detection.<br>• ISA/IEC 62443 series provide a flexible framework to address and mitigate current and future security vulnerabilities in industrial automation and control systems (IACSs). | Noted. |

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| | | Standards Australia's EL-064 committee for decentralised electrical energy and grid integration of renewable energy systems is currently working through IEC SC/TC8 on a range of standards currently under development that will also be applicable. | |
| | Tesla | The final stated goal was to provide more insights into cyber security risks associated with market participation from DER. To enable this, AEMO established a questionnaire for all Trial Participants to complete which outlined cyber security protection procedures that they needed to comply with. This cyber security questionnaire has since been adopted by the Victorian Government through their recent "Aggregated battery EOI" process.<br>This was one of the few areas that AEMO still rates as a "red" traffic light. Tesla is supportive of more work being done in this space (either directly by AEMO, or as planned through the Maturity Plan process), but it appears to be a topic that applies to DER more broadly, than just to VPPs. As such further development of cyber security protocols has not been considered in the Draft Determination at all, and should not be a barrier to the finalization of the MASS. | |
| 28. | Viotas | 2. Frequency event "t=0" times:<br>As highlighted by VIOTAS in its recent FFR rule change (ERC0296) consultation submission, the determination of "time zero" from which performance is measured is a critical parameter for a frequency event. Currently, the MASS defines this relative to the Contingency Event Time (time of the initial event that led to the frequency leaving the NOFB, determined retrospectively by AEMO) and the FDT (time at which local frequency falls outside the NOFB). VIOTAS believes this is an area where the current MASS is deficient, and that at least for Switched Controllers all performance assessment should be relative to the time at which the local frequency falls below a switching controller's assigned frequency deviation trigger.<br>Currently under the MASS the time interval between the frequency departing the NOFB and crossing the Switched Controller's assigned frequency setting, penalises the calculated volume delivered by the load, despite the Switched Controller having behaved exactly as expected and as agreed with AEMO. VIOTAS recommends this is reviewed and addressed by AEMO in future consultations. | AEMO notes this issue and has proposed measures to address it in Section 6 – Updates to Verification Methodology. |

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# APPENDIX C. ATTACHMENT 1 – DRAFT MASS

The revised draft MASS is published as a separate document on AEMO's website with this Second Draft Determination and it is marked up showing changes against Version 6.1 of the MASS, as published alongside the MASS Issues Paper[157]. For convenience, this Appendix provides a summary of the sections amended between the first and second Draft Determinations, and between the Issues Paper and the first Draft Determination.

### Summary of changes between first and second Draft Determination

The key changes between MASS draft versions 6.2 and 6.3 are as follows:

(On the DER Review)

- Section 5.3.2 in Table 4 and following text: a measurement time resolution of 200 ms or higher is allowed for Fast FCAS providers with an aggregated ancillary service facility and no inertial response. A 5% discount will apply if the number of sites aggregated is less than 200.
- Section 11.3.2: the discount applicable to Fast FCAS providers participating in the VPP Demonstrations has been revised from 20% to 5% if the measurement time resolution is greater than 200 ms but less than or equal to 1 s. No discount will be applied for the VPP Demonstration participants if the measurement time resolution is amended to 200 ms or higher. Arrangements for transitioning VPP facilities to fully MASS-compliant measurement requirements are also made clearer.

(On the General Review):

- Appendix B, Figure 4 and Figure 5 show examples of the measurement timeframes for the Fast, Slow and Delayed FCAS service. Figure 6 and 7 show examples of the co-ordinated output for an ancillary service facility given a Regulation FCAS request while responding to a Frequency Disturbance.

Other changes between versions 6.2 and 6.3 are as follows:

- Section 1.2. Table 1 Definitions. Updated / new definitions
- Section 2.2. Minor edit
- Section 3. Table 3. Edits for clarification
- Section 3.2. Header 3.2.1 added
- Section 6.1.2. Additional guidance added
- Section 6.2.2. Requirements clarified
- Sections 10.3. Requirements clarified
- Section 10.4. Requirements clarified
- Section 10.6. Requirements clarified

### Summary of changes between Issues Paper and first Draft Determination

The following sections were amended between version 6.1 and 6.2:

- Section 1.2. Table 1 Definitions. Updated / new definitions
- Section 2. Various edits
- Section 3. Various edits

[157] Available at: https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/first-stage/mass-consultation-issues-paper-and-reformatted-mass.pdf?la=en

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- Section 6.1 Tables 5 and 6 and text. Updates to text and default settings
- Section 6.1.2. Guidance for switched controller providers
- Section 6.2.2. Requirements clarified
- Section 6.4 Table 7. Requirements clarified
- Sections 10.1-10.5. Requirements clarified
- Section 10.6. New section added
- Section 11.3. VPP Transitional arrangements added

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# APPENDIX D. ROADMAP

Following the completion of this MASS Consultation, AEMO in collaboration with stakeholders will seek to address the power system security concerns relating to DER participation in FCAS provision that were raised during the consultation process.

The focus areas for further investigation and resolution include:

- Unexpected disconnection of inverters during power system disturbances.
- Service delivery prioritisation and hierarchy.
- DER participation within distribution network limits.
- Unexpected responses from inverters.

An overview of the intended schedule is given in Figure 4 below. This schedule will enable further investigation and collaboration on the power system security concerns raised, with the intent for preliminary solutions to be developed by late 2022. In early 2022, AEMO intends to seek stakeholder participation and contributions to forums.

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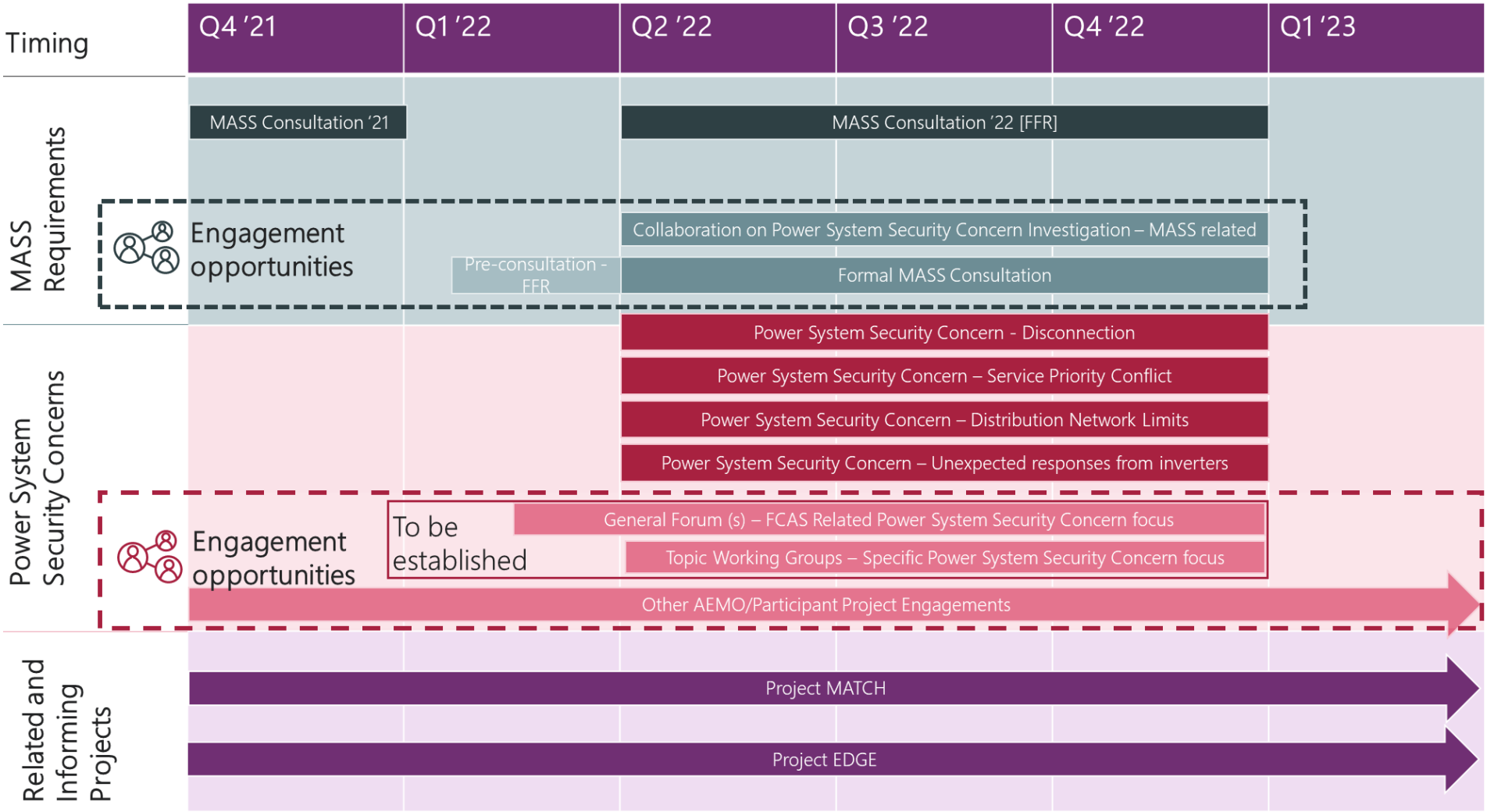
**Figure 4 Indicative roadmap schedule**

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