AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Market Ancillary Service Specification Consultation

January 2021

Issues paper

Executive summary

AEMO publishes this Issues Paper with the Notice of First Stage of Consultation to consider proposed amendments to the Market Ancillary Services Specification (MASS)[1].

AEMO has prepared this Issues Paper to consult and seek feedback from Registered Participants and interested parties (Consulted Persons) on proposed amendments to the MASS relating to:

- Changes to measurement requirements for aggregated ancillary service facilities based on learnings from the Virtual Power Plant (VPP) Demonstrations[2], and
- A range of general issues:
  - a simplification and clarification of the document itself;
  - better specification of the expected characteristics and interactions of the different types of frequency control ancillary services (FCAS) and their relationship to the Frequency Operating Standard (FOS); and
  - addressing issues raised in AEMO's Renewable Integration Study (RIS) concerning the balance of frequency responsive and non-frequency responsive FCAS.

The VPP Demonstrations, which commenced in June 2019, were established to provide AEMO with operational visibility to inform consideration of how to integrate VPPs effectively into the NEM. As such, the VPP Demonstrations were designed to inform any necessary changes to operational processes and regulatory frameworks to support a more effective integration of distributed energy resources (DER) within the MASS framework, with the aim of maximising value to consumers while supporting power system security.

AEMO is seeking stakeholder views on whether or not the MASS should be revised in terms of the sampling rate and measurement locations for the delivery of Contingency FCAS from DER. AEMO proposes that these changes, if adopted, would take the form of optional alternative requirements available only for connection points with an import and/or export capacity of less than 1 megawatt (MW). FCAS providers could still opt for the measurement requirements in the current version of the MASS if they are able to meet them.

The scope of the MASS changes to be considered in this consultation is limited to those canvassed in this Issues Paper. Broader framework changes are not being considered as part of this consultation, although AEMO welcomes feedback on additional identified matters to inform the scope for potential future MASS consultations.

In considering and determining any changes to the MASS, AEMO will be guided by the National Electricity Objective (NEO).

Consulted Persons are invited to submit written responses on the issues and questions identified in this Issues paper by 5.00 pm National Electricity Market (NEM) time (Australian Eastern Standard Time) on 25 February 2021, in accordance with the Notice of First Stage of Consultation published with this paper.

[1] The existing MASS can be found on the AEMO webpage, at https://www.aemo.com.au/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/market-ancillary-services-specification-and-FCAS-verification-tool.

[2] More information can be found on the AEMO VPP Demonstrations webpage, at https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations.

Contents

Tables

Figures

1. Background

1.1 Context for this consultation

Distributed energy resources (DER) participation in frequency control ancillary services (FCAS) markets

AEMO launched the Virtual Power Plant (VPP) Demonstrations in June 2019 in collaboration with the Australian Renewable Energy Agency (ARENA), the Australian Energy Market Commission (AEMC), the Australian Energy Regulator (AER), and members of the Distributed Energy Integration Program (DEIP) coordinated by ARENA[3].

Of the five stated objectives of the VPP Demonstrations, two are particularly relevant to this Issues Paper:

- To understand whether VPPs can reliably control and coordinate a portfolio of resources to stack value streams relating to FCAS, energy, and possible network support services.
- To assess current regulatory arrangements affecting participation of VPPs in energy and FCAS markets, and inform new or amended arrangements where appropriate[4].

To support the objectives in relation to FCAS, AEMO developed a VPP Demonstrations FCAS Specification[5] that contained alternative measurement requirements to the current Market Ancillary Services Specification (MASS), which allowed more VPPs to participate in the project and enabled AEMO to thoroughly assess VPPs capabilities to deliver Contingency FCAS. This also enabled AEMO to assess whether it is possible to reliably verify Contingency FCAS delivery under the alternative measurement requirements.

The VPP Demonstrations have seven participating VPPs and have gathered a wealth of data and learnings to date. The learnings presented in this Issues Paper only relate to VPP capability to deliver Contingency FCAS and AEMO's ability to reliably verify that delivery.

As the VPP Demonstrations project is scheduled to conclude on 30 June 2021, this Issues Paper presents two options for what happens next in relation to DER participation in FCAS markets, and seeks stakeholder feedback on each option. This paper also outlines the principles that will guide AEMO in its assessment of these options.

AEMO aims to complete this consultation during May 2021, so that any resulting changes to the MASS can be made prior to the conclusion of the VPP Demonstrations, requirements for ongoing participation in the FCAS markets are clear, and any transitional arrangements for participants in the VPP Demonstrations can be set.

General MASS improvements

Given the requirement to consult on changes to the MASS to facilitate participation from a broader range of potential FCAS providers, AEMO is also taking this opportunity to consult on other improvements to the MASS. In particular, AEMO proposes to address longstanding concerns with the readability, accessibility and usefulness of the MASS, as well as a number of important issues that have been identified through previous consultations, operational experience and other processes such as implementation of the Mandatory Primary

[3] More information on the membership and activities of the DEIP is available on the ARENA website, at https://arena.gov.au/knowledge-innovation/distributed-energy-integration-program/.

[4] AEMO, 2019. *NEM VPP Demonstrations Program: Final Design*, at https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations.

[5] AEMO, 2019. *VPP Demonstrations FCAS Specification*, at https://aemo.com.au/en/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations.

Frequency Response (PFR) rule.[6] These issues centre on the need to clarify the configuration of each type of FCAS, and how they should interact with each other.

1.2 National Electricity Rules (NER) requirements

Clause 3.11.2(b) of the NER requires AEMO to 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.

Clause 3.11.2(f) defines the additional monitoring required to provide FCAS, while clause 3.11.2(g) provides for AEMO to develop standards to be met in installing and maintaining the monitoring equipment required by clause 3.11.2(f). These standards are also specified in the MASS for convenience.

The current version of the MASS was published on 1 June 2020. AEMO may amend the MASS at any time under clause 3.11.2(c) and (d) of the NER, in accordance with the rules consultation procedures (see rule 8.9).

1.3 Structure of this Issues Paper

The next two chapters will present the issues under consideration:

- Chapter 2: DER participation in FCAS markets.
- Chapter 3: General MASS issues.

Chapter 4 will set out the process and expectations on how to respond to this Issues Paper.

[6] National Electricity Amendment (Mandatory primary frequency response) Rule 2020, available on the AEMC's website at https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response.

2. DER participation in FCAS markets

2.1 MASS clauses superseded for the VPP Demonstrations

For the participants of the VPP Demonstrations, the following clauses of the MASS were superseded by the measurement requirements in the VPP Demonstrations FCAS Specification:

- Under Clause 3.6(a)(iii), measurements of power flow and local frequency must be made at intervals of 50 milliseconds (ms) or less when participating in the Fast Contingency FCAS markets.
  - High-speed data would need to be captured for each National Metering Identifier (NMI) if FCAS providers with DER were to comply.
- Under Clause 2.4(i), the power flow representing the amount of generation or load of each relevant plant of the aggregated ancillary service facility must be measured at or close to each of the relevant connection points and summed to calculate the aggregated generation amount or aggregated load amount. Where a relevant plant that forms part of an aggregated ancillary service facility shares a connection point with a variable load or generating unit, it is the gross power flow to or from the relevant plant that forms the aggregated response and must be directly measured.
  - The verification of FCAS delivery would need to be completed using the measurements of the net flow from, or to, the grid if FCAS providers with DER were to comply.

2.1.1 Measurement resolution requirements in VPP Demonstrations

To avoid the need to install a high-speed meter for every DER National Metering Identifier (NMI), AEMO developed a method to verify the delivery of Fast Contingency FCAS using the aggregated measurements of power flow and average Local Frequency captured with a resolution of 1 second across all the NMIs for a VPP. The delivery was compared against the minimum required FCAS response and the ancillary service capacity configured to respond.

The minimum required FCAS response is the expected change in active power for the VPP to remain compliant with the ancillary service capacity configured to respond and is calculated as follows:

- For a proportional/variable FCAS controller, local frequency measurements and the assigned droop setting are used; and
- For a switching controller, the frequency deviation trigger settings and local frequency measurements are used.

The ancillary service capacity configured to respond was either:

- The maximum FCAS capacity that the VPP was looking to register in the FCAS market; or
- The actual capacity dispatched by the NEMDE (NEM dispatch engine), if the VPP is registered in the FCAS markets.

2.1.2 FCAS measurement location in VPP Demonstrations

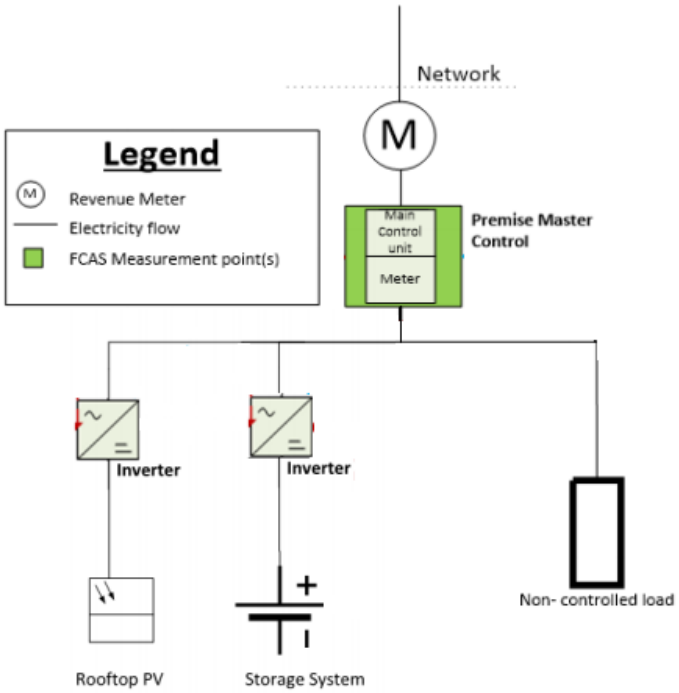
If a VPP consists of only one type of controllable device (such as a battery system or hot water system), the flow from, or to, the grid may be more or less than the minimum required FCAS response, depending on whether the distributed photovoltaic (PV) output or non-controlled load varies during a frequency disturbance. In this scenario, the change in active power from the controllable device could be in line with the

quantity of ancillary services enabled for the aggregated ancillary service facility, however the power flow from or to the grid could show that the VPP under-delivered.

As Section 2 of the FCAS verification tool user guide[7] indicates, power measurements taken before the time at which a Frequency Disturbance occurs are used to calculate a baseline. The change in active power following a frequency disturbance is then subtracted from the baseline to determine the FCAS response. If the FCAS response is measured using the net flow from, or to, the grid, it is the net flow that must be controllable. During the VPP Demonstrations, however, the FCAS response was measured using the flow from, or to, the battery systems only, as they were the only equipment behind the connection point responding to frequency disturbances to deliver FCAS. To ensure the delivery of ancillary services can be accurately compared to the minimum required FCAS response, the measurements of power from, or to, the controllable device must be used.

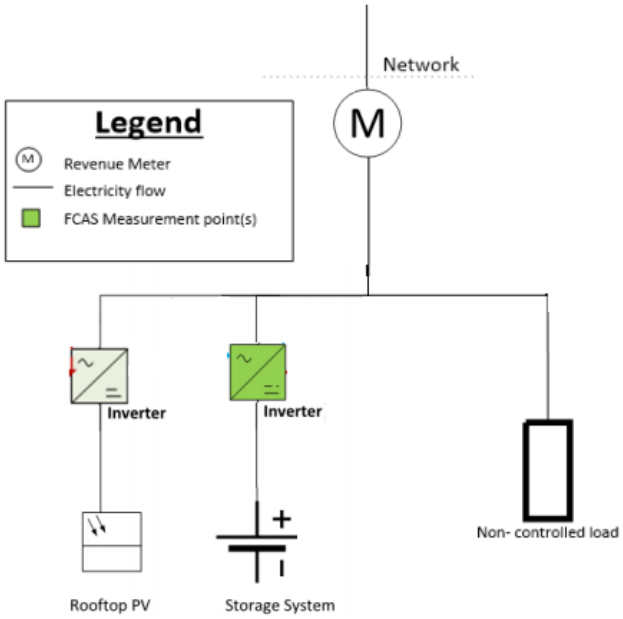
Figure 1 shows the measurement point if the net flow from, or to, the grid is used to verify the delivery of ancillary services, and Figure 2 shows the location of the FCAS meter if the measurements of power from, or to, the controllable device are used to verify the FCAS response. The FCAS measurement point in the VPP Demonstrations could also have been at the hybrid inverter level, depending on whether there was only one inverter on site (refer to Figure 3 in the VPP Demonstrations FCAS Specification). When the flow from, or to, the grid can be controlled, the location of the FCAS measurement point remains as shown in Figure 1 below.

Figure 1 FCAS measurement point as per the MASS



[7] The FCAS verification tool user guide can be found on the AEMO webpage, at https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/2020/FCAS-verification-tool-user-guide---jun-2020.pdf?la=en&hash=1140A71A9DE7D5520B92628DB43DB945.

Figure 2 FCAS measurement point as per VPP Demonstrations



2.2 VPP Demonstrations learnings

The VPP Demonstrations project has provided learnings on a number of topics that are discussed in a series of knowledge sharing reports[8] published by AEMO. The learnings specifically related to the measurement requirements discussed in this Issues Paper are outlined below.

2.2.1 Learnings on the measurement resolution requirements

AEMO has demonstrated that the delivery of Contingency FCAS can be effectively verified using the alternative measurement resolution, as shown in Figure 3 and Figure 4 below.

Figure 3 (from the AEMO VPP Demonstrations knowledge sharing report stage 2) and Figure 4 (to be included in the AEMO VPP Demonstrations knowledge sharing report stage 3, due in February 2021) show a comparison between the minimum required FCAS response from VPPs comprising different battery systems and different types of FCAS controllers, against the actual FCAS response.

An under-delivery could be identified whenever the calculated minimum required FCAS response was more than the actual amount of FCAS delivered.

[8] Information about and reports from the VPP Demonstrations are on AEMO's website, at https://aemo.com.au/initiatives/major-programs/nem-distributed-energy-resources-der-program/der-demonstrations/virtual-power-plant-vpp-demonstrations.

Figure 3 Response to low grid frequency, Energy Locals VPP, 2 March 2020

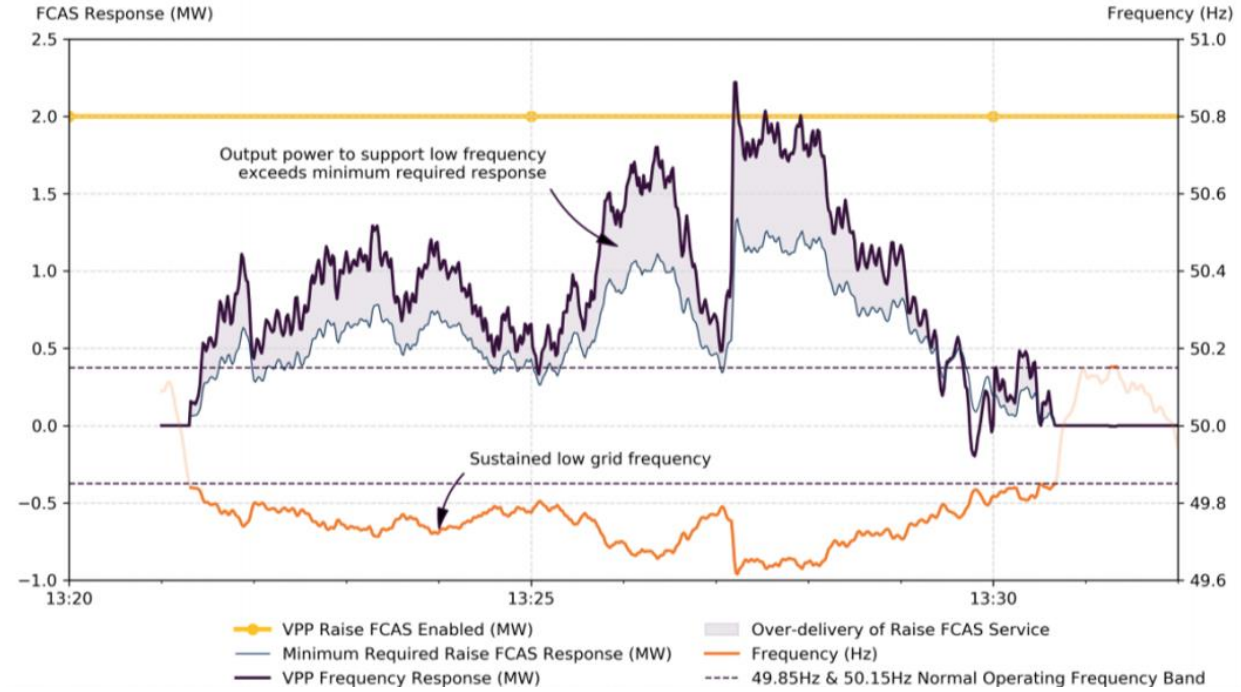
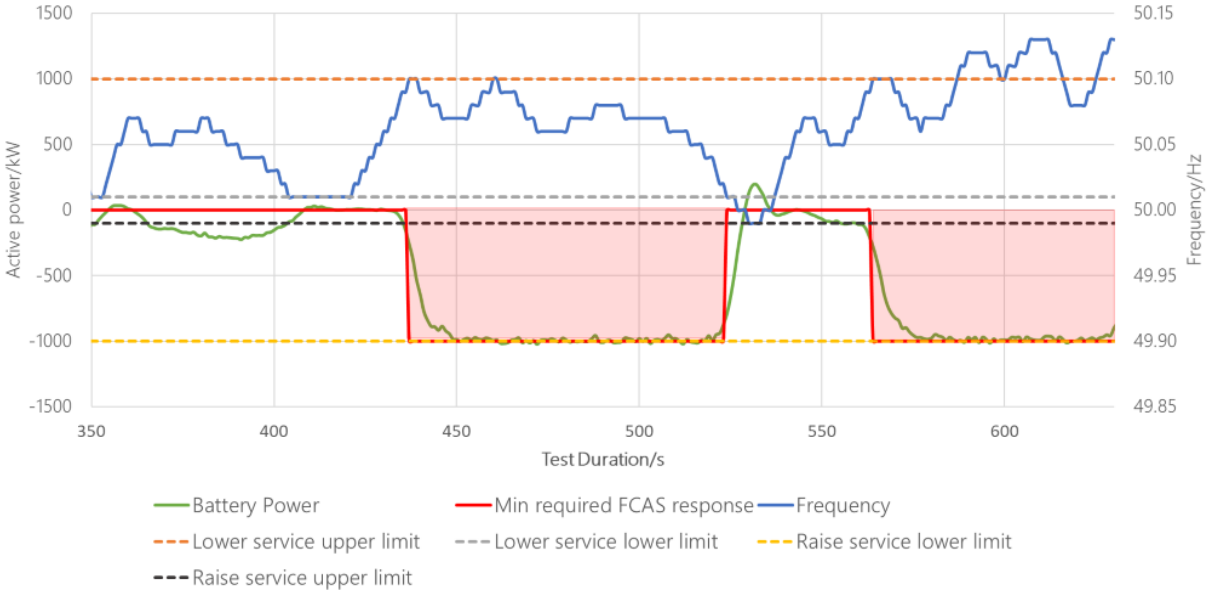


Figure 4 Switching FCAS controller VPP-wide test results



2.2.2 Learnings on the measurement location requirements

AEMO used the power measurements from the frequency responsive device to verify the FCAS delivery during the VPP Demonstrations. This verification method allowed AEMO to identify under-delivery of FCAS when the response from the battery systems/controllable devices was not in line with the agreed droop setting or frequency deviation trigger setting, and ancillary service capacity dispatched by NEMDE.

As an example, Figure 5 (from the AEMO VPP Demonstrations knowledge sharing report stage 1) and Figure 6 (from knowledge sharing report 2) show how AEMO identified the under-delivery of Contingency FCAS from a VPP following power system incidents using power measurements from the battery systems.

Figure 5 Lower Contingency FCAS response on 16 November 2019

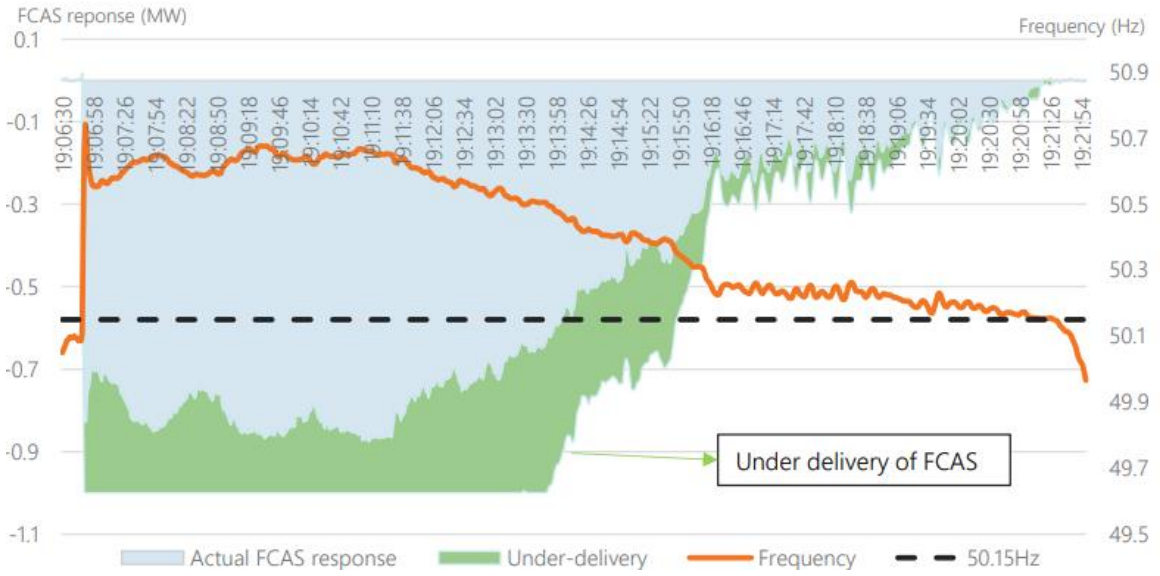
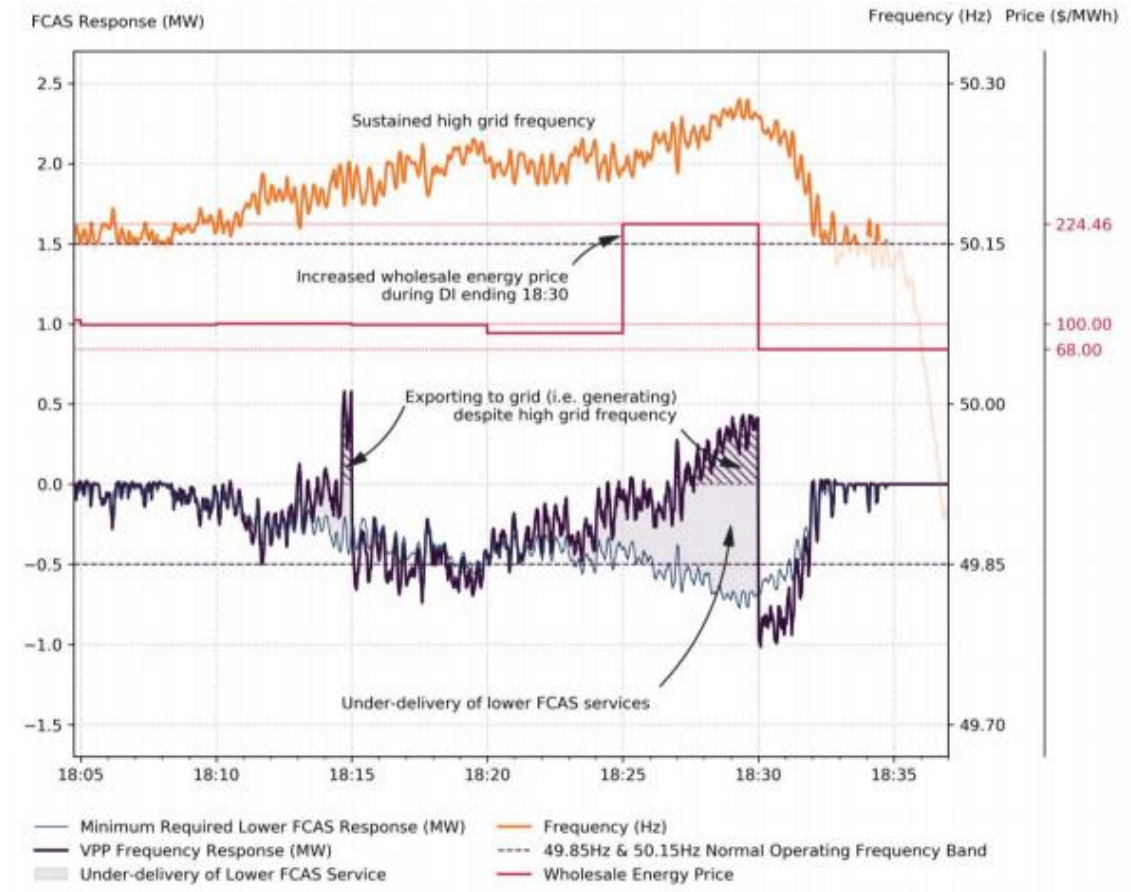


Figure 6 Lower Contingency FCAS response on 28 January 2020



2.3 Options for ongoing FCAS measurement requirements for DER

As the VPP Demonstrations are scheduled to end on 30 June 2021, AEMO is seeking stakeholder feedback on what the ongoing measurement requirements for DER participation in FCAS markets should be.

At a high level, the two options are:

- 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 ongoing MASS.

These options are outlined in more detail below.

2.3.1 Option 1: Leave current measurement requirements unchanged

If the current measurement requirement in the MASS remained unchanged, then any VPP seeking to participate in Fast Contingency FCAS markets must be capable of measuring power flow and local frequency at intervals of 50 ms or less at every site (NMI).

In addition to the above data resolution requirement, FCAS providers with DER must be able to control the grid flow as the delivery of Contingency FCAS will be verified using the power measurements from, or to, the grid.

2.3.2 Option 2: Embed measurement requirements tested in the VPP Demonstrations

If the measurement requirements tested in the VPP Demonstrations were to be embedded in the ongoing MASS, the relevant revisions for consultation are outlined below.

Measurement resolution for Fast Contingency services

Chapter 3 of the MASS would be updated to allow DER to meet the measurement requirements by capturing power flow and local frequency with a resolution of less than or equal to 1 second across all NMIs.

The following additional conditions would also need to be met if an FCAS provider chooses to capture data with a resolution of less than or equal to 1 second, rather than less than or equal to 50 ms, when participating in the Fast Contingency FCAS markets:

- Frequency injection test on every different type of controllable device that responds to a frequency excursion is to be provided, with results in line with the agreed droop setting or frequency deviation trigger setting.
  - The measurements of power and frequency for this test must be captured at intervals of 50 ms or less, and also meet the tolerance level allowed under Clause 3.6(a)(v) and Clause 3.6(a)(vi) of the current MASS.
  - In the VPP Demonstrations, a frequency injection test was required on every different type of battery system in a VPP. The measurements of power and frequency were in line with Section 3.6(a) of the MASS and the MASS FCAS verification tool was used to calculate the maximum ancillary service capacity of the battery system.
- All controllable units within the same VPP operate with the same type of FCAS controller (that is, proportional/variable or switched).
- For every 5 megawatts (MW) of aggregated ancillary service capacity per region, a high-speed meter capturing measurements of power flow and frequency with a resolution of less than or equal to 50 ms on a common time scale must be installed.
  - The high-speed measurements will be used to confirm whether the response from the controllable system was initiated at the right time and, in the case of switching controllers, whether the local frequency went below or above the assigned Raise and Lower frequency deviation trigger settings. At AEMO's discretion, the minimum number of high-speed meters may be reviewed depending on the number of controllable systems and the types of systems used to deliver ancillary services under the same aggregated ancillary service facility.

Measurement location

Chapter 2 of the MASS would be updated to allow verification of FCAS delivery to be completed using power measurements captured at the inverter or controllable device level rather than at the connection point, provided the following additional conditions are met:

- Power flow measurements from the controllable device and generating units behind the connection point, and the grid flow must also be captured.
- AEMO must be able to determine the non-controlled load using the data provided by the FCAS provider for compliance purposes, to ensure that the delivery of ancillary services is not being negated on purpose by changes in load during frequency disturbances.
- The high-speed meter installed for every 5 MW of aggregated ancillary service capacity must capture the power flow measurements from the controllable devices, generating units behind the connection point, grid flow, and local frequency.

Thresholds at which to apply alternative measurement requirements

The VPP Demonstrations comprised primarily residential battery systems responding to frequency disturbances. The capacity from a single ancillary service load (ASL) did not exceed 1 MW at the NMI, and AEMO does not consider it would be appropriate to vary the current measurement requirements for ASLs greater than 1 MW.

Larger facilities have more capability to impact the power system, and an ASL with a capacity of more than 1 MW at the NMI will have a significantly larger change in active power per hertz than residential battery systems. For these larger connections, high-speed measurements of power must be captured to verify compliance with the MASS. An ASL with a capacity of more than 1 MW may also be registered with its own Dispatchable Unit Identifier (DUID) in the FCAS markets.

AEMO therefore proposes that, if included in the MASS, the options to verify FCAS delivery using power flow measurements from the inverter or device level, and the less stringent data resolution requirement of less than or equal to 1 second, would be limited to Fast Contingency FCAS from ASLs rated at less than or equal to 1 MW. An FCAS provider could not choose to apply the varied measurement requirements if the aggregated ancillary service facility includes any ASL with an import or export capacity greater than 1 MW.

2.4 Principles to guide AEMO's assessment of these options

AEMO will be guided by the National Electricity Objective (NEO) when assessing these options and the submissions received to this Issues Paper. The NEO 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:

- price, quality, safety and reliability and security of supply of electricity
- the reliability, safety and security of the national electricity system.

In this context, AEMO will prioritise the following key principles in its assessment:

- Ensuring that the delivery of FCAS from DER can be reliably verified to identify non-compliances and minimise potential for gaming.
- Efficient operation and use of FCAS – by avoiding unnecessary costs in the provision of FCAS.
- Promoting competition – by minimising barriers to entry so that more FCAS providers can compete in the market, without putting any other key principles at risk, such as AEMO's ability to reliably verify FCAS delivery and maintain power system security.

2.5 Consultation questions for DER participation

AEMO encourages stakeholders to submit their perspectives by answering the questions below. All views will be considered and AEMO will explain its positions on various matters transparently throughout this consultation.

1. Which option for the ongoing measurement requirements for DER described in Section 2.3 do you want AEMO to implement and why? Should any other options be considered?
2. Which option do you think is more consistent with the NEO, and why?
3. Should AEMO consider any principles other than those described in Section 2.4 to guide its assessment?
4. What is the difference in implementation costs, such as updating the communication links or installing additional equipment, for capturing data at a resolution of either 50 ms or 1 second for every NMI for different VPP facility types? Do you consider the cost difference to be prohibitive for participating in the Contingency FCAS markets? Please provide examples or analysis if possible.
5. Do you think that either of the options presented will result in more or less competition in the Contingency FCAS markets?
6. Are there any technical risks that you envisage if the Option 2 measurement requirements are allowed? How material do you consider those risks and how could they be efficiently mitigated?
7. Does the sampling rate of one second rather than 50 ms for Fast Contingency FCAS under Option 2 and the determination of the FCAS delivery at the inverter/controllable device level create market distortion or negatively impact the FCAS markets?
8. If Option 2 was adopted, should the changes to the measurement requirements of the MASS be limited to small-scale DER (under 1 MW per NMI), or should a different threshold apply, such as 5 MW? For example, what do you see as the risks and benefits of expanding these measurement requirements to other FCAS providers and in what circumstances might that be appropriate?

3. General MASS issues

In this consultation, AEMO also intends to address longstanding concerns with the readability, accessibility and usefulness of the MASS, and to consult on a number of important issues that have been identified through previous consultations, operational experience and implementation of the Mandatory Primary Frequency Response (PFR) rule. These issues are focused on clarification of how different types of FCAS should be configured, and how they should interact with each other.

AEMO also invites views on how to address the increasingly significant matter of managing the relative mix of frequency response types (switched or triggered block response, compared with continuous control) as highlighted in AEMO's Renewable Integration Study (RIS) Stage 1 report[9] and, subject to rule change outcomes, how FCAS timing requirements and associated specifications should be revised to incorporate fast frequency response (FFR) as a separate service.

AEMO appreciates that consultation on these matters may attract a wide range of input that could be challenging to reconcile and channel into a clear reform path for the MASS. Given the time constraints necessary to achieve a clear path to continued participation of DER in FCAS markets well before the VPP Demonstrations end on 30 June 2021, and dependencies on other work and processes, this part of the consultation is not expected to resolve all of the issues canvassed in this Issues Paper. The likely result will be incremental rather than radical changes to the MASS.

At this initial stage of consultation, and subject to submissions, AEMO expects that the MASS could incorporate amendments to address (fully or partly):

- Improvements to MASS readability and usability (discussed in Section 3.1).
- Clarification of Frequency Operating Standard (FOS) references in the MASS (discussed in Section 3.2).
- Adjustments to response ranges to improve utilisation of FCAS from frequency responsive and non-frequency responsive controllers (discussed in Section 3.3).
- Clarification and enhancement of requirements to improve the co-ordination of local (Contingency FCAS and PFR) controls with remote (Regulation FCAS/AGC) controls (discussed in Section 3.4).
- Clarification of the characteristics and requirements for the provision of Regulation FCAS (discussed in Section 3.53.4).
- Clarification of the requirements of Delayed FCAS (discussed in Section 3.6)

Due to frequency control rule change processes currently underway, AEMO considers that it would not be appropriate to undertake detailed amendments for incorporating FFR as a separate service and assessing impacts on current specifications (discussed in Section 3.7). Following the conclusion of the rule change AEMO will likely be required to undertake a major review of the MASS to accommodate any changes in frequency control frameworks.

There are several issues associated with FCAS quantities and registration that are not specified in the MASS that AEMO will address through separate consultation processes. These include:

- Overall limits on the participation of non-frequency responsive FCAS (discussed in Section 3.3 and 3.7).
- Maximum frequency response rates (such as droop rate limitations)
- Area based limits for FCAS enablement

On matters where no clear path forward emerges, the submissions from this consultation will be used to determine the scope of future MASS change proposals.

[9] Published April 2020, available at https://aemo.com.au/-/media/files/major-publications/ris/2020/renewable-integration-study-stage-1.pdf?la=en&hash=BEF358122FD1FAD93C9511F1DD8A15F2.

3.1 MASS readability and usability

Based on consistent feedback from participants, AEMO proposes a structural overhaul of the MASS to improve its readability and transparency, where this is feasible without changing its substantive meaning. AEMO particularly notes the following issues with the document:

- There is considerable unnecessary repetition, particularly where aspects of each service are repeated.
- The language could benefit from more consistency, with careful attention to identifying MASS, FOS, and NER terms.
- Services are largely described by the procedures used to verify their delivery, rather than in terms of what each FCAS is intended to achieve and what kind of control arrangements should be implemented to deliver it.
- The MASS references terms that are defined in other documents (such as the normal operating frequency band (NOFB) in the FOS), to determine how controls are intended to be configured. This leads to complexity, ambiguity and the potential for error that could be resolved by using specific numbers in the MASS. However, specifying values carries the risk of misalignment with the FOS. This issue is discussed in more detail in Section 3.2.
- The utility of the MASS could be significantly improved with examples of compliant FCAS delivery of each FCAS. It could also describe how typical control arrangements are specified as FCAS quantities, for example, how a standard droop controller with typical parameters would see its response translated into Fast FCAS, Slow FCAS and Delayed FCAS quantities.

AEMO has prepared a restructured version of the MASS (refer to Attachment 1). It does not add new material, only contains clarifications and removes repetition; AEMO proposes to build on this version through this consultation to address the matters highlighted in this Issues Paper.

AEMO invites submissions on the proposed new form of the MASS, the drafting issues and proposals identified in this section, and any other suggestions for improving the readability and accessibility of the MASS.

3.2 Clarification of FOS references

One of the issues noted in the section above is the way the MASS references terms in the FOS that may have ambiguous values. A key example of this is in the many references in the MASS to the NOFB. The FOS defines a number of different bands that constitute the 'NOFB', depending on the region and system conditions at the time.

AEMO intends to clarify in the MASS that the FOS terms that have different potential values always refer to the values listed in Table A.1 of the FOS ('NEM Mainland Frequency Operating Standards – interconnected system') for the mainland, and Table A.2.1 for Tasmania unless explicitly stated otherwise. For the absence of doubt, this means that as per the current FOS:

- All MASS references to the frequency range NOFB would refer to the band between 49.85 hertz (Hz) and 50.15 Hz.
- All references to 'containment frequency' in the MASS (for example, as used in the definition of Raise Reference Frequency and Lower Reference Frequency) would refer to the values 49.5 Hz and 50.5 Hz respectively in the case of the mainland, or 48 Hz and 52 Hz for Tasmania.

AEMO invites submissions on this proposal, and in particular if there are any other similar ambiguities that should be considered.

3.3 Frequency responsiveness of FCAS

The RIS Stage 1 report examined a range of issues associated with the 'frequency responsiveness' of FCAS, and highlighted a particular issue (see its sections B4.7 and B4.8[10]) that requires attention in the MASS and related guidelines and procedures. This issue concerns the amount of 'frequency responsive' FCAS in the power system. The term 'frequency responsive', as used in the RIS Stage 1 report and here, refers to whether a facility continually adjusts its response to measured frequency. As an example, a typical proportional controller (a droop-style response) would be considered to be frequency responsive, while a typical switched or triggered controller is not considered to be frequency responsive.

There are two aspects to managing the amount of frequency responsive Contingency FCAS:

- Ensuring that a satisfactory mix of frequency responsive and non-frequency responsive FCAS is dispatched.
- Ensuring that the amount of non-frequency responsive FCAS delivered adequately corresponds to the amount dispatched.

The first matter is, in AEMO's view, not a matter for the MASS, but rather the dispatch of FCAS, and is discussed in Section 3.7.

The second matter can be addressed in the MASS, as it concerns the requirements placed on providers of non-frequency responsive FCAS.

Currently, the controls at many non-frequency responsive facilities are not directly linked to market outcomes. This means that they will typically trigger if the right frequency conditions are met, regardless of market outcomes (that is, whether or not they are 'dispatched' or 'enabled' for FCAS).

Generally, under normal system conditions, there is no issue with facilities providing frequency response when not selected by the FCAS markets, but there are conditions where this becomes problematic. In particular, the possibility of frequency rebound and overshoot exists under adverse system conditions and especially during islanded conditions, where the triggering of large amounts of switched services could be highly detrimental to power system security.

Hence, AEMO is proposing to introduce additional requirements on non-frequency responsive facilities to manage this possibility. The requirements under consideration are:

- Requiring that non-frequency responsive facilities deliver response only when 'enabled' (that is, receive a non-zero dispatch for the relevant FCAS).
- Requiring that non-frequency responsive facilities not deliver significantly more than their enablement (for example, more than 50% additional response over their enablement amount).

AEMO appreciates that these requirements might introduce complexity into the control processes of affected FCAS providers, and invites submissions on this approach and whether alternative approaches are feasible for managing this issue.

Revision of switching controller trigger range

Tables 3 and 4 in the current MASS set out the frequency trigger ranges that may be assigned to switching controllers. AEMO is proposing to amend these ranges to bring them closer to the edge of the NOFB, because:

- Frequency performance improved markedly during late 2020, meaning excursions outside the NOFB are becoming rare and are tending to be associated with contingency events, rather than a general lack of control inside the NOFB.
- There is, therefore, an increasing disparity between the work (number of response events or total supplied FCAS) expected of a proportional controller and a switching controller, which appears unjustified.

[10] Appendix B, Frequency Control, at https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

The following tables show the current and proposed frequency ranges for Switching Controllers. Current settings are in strikeout text where new values are proposed.

Table 1 Frequency settings for regions other than Tasmania

Level	Raise service Frequency Deviation Setting (Hz)	Lower service Frequency Deviation Setting (Hz)	Frequency Rate of Change Multiplier (seconds)
Frequency Deviation Setting range	~~49.80 Hz to 49.60 Hz~~ 49.85 Hz to 49.70 Hz	~~50.20 Hz to 50.4 Hz~~ 50.15 Hz to 50.3 Hz	0.4
Default Frequency Deviation Setting	~~49.65 Hz~~ 49.80 Hz	~~50.35 Hz~~ 50.20 Hz	0.4

Table 2 Frequency settings for the Tasmania region

Level	Raise service Frequency Deviation Setting (Hz)	Lower service Frequency Deviation Setting (Hz)	Frequency Rate of Change Multiplier (seconds)
Frequency Deviation Setting range	~~49.50 Hz to 48.75 Hz~~ 49.60 Hz to 49.00 Hz	~~50.50 Hz to 51.25 Hz~~ 50.40 Hz to 51.00 Hz	0.875
Default Frequency Deviation Setting	~~49.125 Hz~~ 49.30 Hz	~~50.825 Hz~~ 50.70 Hz	0.875

Revision of proportional controller response range

The current MASS allows (and arguably encourages) Contingency FCAS providers using proportional controllers to apply effective frequency response deadbands at the edge of the system normal NOFB – that is, at ±0.15 Hz. The MASS also indicates that frequency response should be maintained (or at least not withdrawn) until frequency recovery, defined as ±0.1 Hz, inside the NOFB.

The FOS states that AEMO should restore frequency to be within the NOFB, not its edge. AEMO has noted many frequency events where frequency struggles to recover to be within the NOFB, as Contingency FCAS response may be very weak or withdrawn entirely as frequency approaches the edge of the NOFB.

A key reason for this is the historical application of frequency response deadbands at the edge of the NOFB; Figure 7 shows how, with a typical proportional Contingency FCAS controller, frequency response diminishes to zero as frequency approaches the NOFB. It also shows how, with a narrower deadband (i.e. ±0.1 Hz), the response is maintained while non-Contingency FCAS controls can take over.

The pattern of poor frequency recovery has lessened considerably since the large-scale rollout of the Mandatory PFR rule began in late September 2020. The rule requires Affected Generators to apply frequency response deadbands in line with the Interim Primary Frequency Response Requirements (IPFRR). These deadbands are well within the NOFB (±0.015 Hz is the default requirement). The Mandatory PFR Rule does not affect all FCAS providers, however, and it does not seem appropriate to rely on a non-market arrangement such as PFR to address a sub-optimal specification of Contingency FCAS, especially since the Mandatory PFR rule does not require that any headroom (or footroom) is maintained for Affected Generators to respond.

Figure 7 Contingency FCAS response deadband impact for providers not affected by Mandatory PFR rule

Therefore, AEMO proposes that the MASS require proportional FCAS controllers not affected by the IPFRR to have frequency response deadbands no wider than ±0.1 Hz. This will encourage significantly better co-ordination between Contingency FCAS and Regulation FCAS, which help ensure the frequency recovery requirements set out in the FOS are met. It will also lessen arguably unjustified reliance on PFR to address this gap.

AEMO acknowledges potential concerns that this may result in increased duty on Contingency FCAS controls. However, the recent marked improvement in frequency performance indicates that controllers might be triggered less frequently at a ±0.1 Hz deadband than they would have previously at ±0.15 Hz.

For example, this would be the case based on power system frequency performance during November and December 2020, as compared with the preceding months; there were 1,308 instances where frequency went below 49.85 Hz in September 2020, but only 115 events during December 2020 where it went below 49.9 Hz. A summary is provided in Table 3.

Table 3 Frequency events crossing various frequency thresholds either side of 50 Hz

	Number of frequency events exceeding threshold frequency			
Month	**> 0.15 Hz**	**> 0.1 Hz**	**< 0.15Hz**	**< 0.1Hz**
Jun 2020	141	7,185	552	6,650
Jul 2020	138	5,567	449	4,855
Aug 2020	137	7,561	787	7,085
Sep 2020	281	11,569	1,308	10,370
Oct 2020	14	1,918	270	2,912
Nov 2020	0	25	37	199
Dec 2020	0	5	18	115

AEMO also notes potential concerns that narrowing response deadbands (for those not already narrowed due to the Mandatory PFR Rule) could result in under-delivery of FCAS. This was a concern raised by participants affected by the Mandatory PFR rule.

AEMO consulted on this matter during MASS Consultation[11] in 2019, and concluded that all genuine frequency response should be counted towards a provider's Contingency FCAS obligations. Changes were made to the MASS to ensure that under the widest possible set of circumstances, all frequency response would be measured as contributing to Contingency FCAS. AEMO invites submissions on any remaining concerns around this question.

As the Mandatory PFR rule change request made clear, a general deadband specification of ±0.15 Hz or ±0.1 Hz for proportional controllers is not suitable for managing frequency satisfactorily. However, the ±0.1 Hz setting is proposed as a default maximum setting for ancillary service facilities that do not have settings derived from other mechanisms including the Mandatory PFR rule. This could include VPPs, loads and other non-scheduled facilities implementing a proportional controller.

3.4 Co-ordination of FCAS and PFR

The current MASS focuses on the specification of each type of FCAS, and does not provide a great deal of information regarding how each FCAS should be co-ordinated. Also, as highlighted by the rollout of the Mandatory PFR rule, the MASS provides no guidance on how PFR controls should be co-ordinated with Automatic Generation Control (AGC), including Regulation FCAS, which is implemented through the use of AGC. AEMO is seeking to address these matters in this consultation.

AEMO considers that the following should be addressed, and invites submissions on whether there are other co-ordination matters that ought to be considered:

- How a facility's Contingency FCAS controls interact with Regulation FCAS (AGC) controls.
- How PFR controls interact with Contingency FCAS controls.
- How PFR controls interact with AGC controls.
- How switched and proportional controls interact where a facility is using them to supply different types of FCAS simultaneously.

As an example, section 6.9 of the current MASS states that the provision of Contingency FCAS should be prioritised over Regulation FCAS when power system frequency is outside the NOFB, but this is problematic,

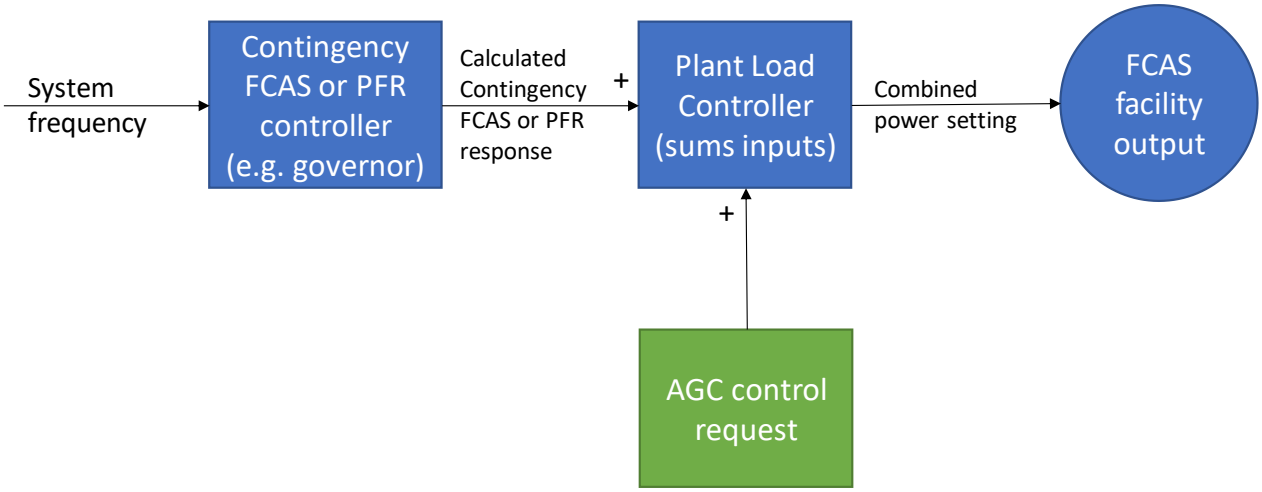
[11] See https://aemo.com.au/en/consultations/current-and-closed-consultations/primary-frequency-response-under-normal-operating-conditions.

especially in light of the implementation of narrow deadband PFR controls. Furthermore, there are genuine reasons why, despite the need to manage frequency, a facility might need to be ramped in a direction counter to frequency, for example to comply with a constraint equation.

To address this, AEMO is proposing to introduce considerably more detail on the preferred approach to co-ordinating local controls (Contingency FCAS and PFR) controls with remote controls (Regulation FCAS/AGC). Proposed points of clarification include:

- All facilities implementing PFR (including PFR and Contingency FCAS) should add that local calculated control to the AGC-issued setpoint control or MW equivalent of the accumulated AGC-issued raise/lower controls (that is, a net sum). There are no normal conditions where the AGC-issued controls should be blocked, paused or ignored[12]. This could be shown diagrammatically in the MASS with a simplified control diagram, such as shown in Figure 8.
- AGC-issued raise/lower controls that use the facility output MW as the closed loop feedback value are adjusted by AGC (by AEMO) for frequency coordinated control; that is, the controls have considered PFR action using either a calculated estimate or telemetered actual value if available[13].
- AGC-issued raise/lower controls that use the control request feedback as the closed loop feedback value are NOT adjusted by AGC for frequency coordinated control.
- When using the facility output MW, that value will include PFR action. Therefore, the raise/lower control needs to be adjusted accordingly.
- AGC-issued setpoint control is not adjusted for frequency coordination. The frequency coordination for these facilities will be implemented at the local plant.

Figure 8 Proposed diagrammatic representation of frequency-coordinated control design



3.5 Requirements for Regulation FCAS

The MASS presently provides only limited guidance on the requirements for Regulation FCAS, in section 6.5 of the MASS. Currently, this simply states that providers must act on AEMO's AGC signals in an 'accurate and timely manner'. The determination of what constitutes accurate and timely action is effectively left to AEMO's discretion.

[12] It would be up to AEMO to implement appropriate AGC controls – for example, that could potentially pause AGC ramping where they conflict with frequency. In AEMO's view, this is highly preferable to an approach where providers may need to make (potentially arbitrary) decisions about when and if to follow AGC commands.

[13] When using the resource output MW, that value would include any local PFR, and therefore the raise/lower control needs to be adjusted accordingly by AEMO using a model of the facility's primary controls. This is a feature of the existing AGC product, but requires careful tuning.

This means there is no transparent and objective guidance on how to design or optimise controls, or for AEMO to measure performance against. This lack of guidance has been noted by participants in the past, particularly when FCAS assessments are undertaken. AEMO has seen an increasing divergence between different FCAS providers in terms of the accuracy and timeliness of following Regulation FCAS instructions via AGC, which might be due to this lack of guidance.

AEMO proposes to expand this part of the MASS to provide better guidance as to the characteristics and requirements expected of Regulation FCAS providers. Guiding principles for these proposed requirements are that each should be:

- **Relevant** – there should be a genuine reason for the characteristic or requirement.
- **Testable** – it must be possible to test and measure each characteristic or requirement.

On this basis, and on advice from independent AGC experts, AEMO has developed a set of proposed requirements that could be set out clearly in the MASS. AEMO recognises that any new requirements for Regulation FCAS would require a suitable transition period for existing providers, and seeks submissions on this.

AEMO's proposed Regulation FCAS requirements are as follows:

- **Telemetered data rate** – data from each regulating facility must be updated at least every 4 seconds with no more than 8 seconds data latency. The section following this list sets out the data proposed to be sent to AEMO through AGC/SCADA.
- **AGC controllable** – the regulating 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). It must be possible to observe the change in output over and above any noise and oscillation in the telemetered output. For setpoint controlled facilities, the minimum change of the control request (setpoint change deadband) must be no larger than half the facility's allowed minimum bid size.
- **Minimum bid size** – for facilities with very clean output measurements (noise and oscillation on output is less than 3 MW), such as batteries or other inverter-based resources, this value is proposed to be 2 MW. For other facilities, such as large thermal generating units, the observability requirements might necessitate this value being 5 MW, or even 10 MW.
- **Maximum control response delay (CRD)** – at a high level, CRD refers to the time a facility takes to materially implement a step change in AGC's control request[14]. It is a material input to each of the generating unit controls in AGC. It is assigned during AGC tuning by measuring actual response to a series of step control requests. Since NEMDE can select different facilities for Regulation FCAS duty every 5 minutes, the acceptable CRD must be significantly lower than 5 minutes. AEMO proposes allowing a maximum value of 150 seconds (half the length of a dispatch interval), which independent advice from AGC specialists has suggested is readily achievable by all types of regulating facilities. Those resources which currently have CRD values set higher than 150 seconds will be contacted by AEMO and AGC tuning conducted to revise CRD, wherever possible.
- **Minimum ramp rate** – AEMO proposes that the telemetered value for the facility's ramp rate should be large enough that the market cleared Regulation FCAS capacity can be fully deployed in **3 minutes** without exceeding the telemetered ramp rate. The reason for proposing 3 minutes is that frequency events may occur at any point, and there are a variety of delays involved in AGC controls, so a value of approximately 3 minutes is required to reliably deliver the full bid Regulation Raise or Lower amounts within a 5-minute dispatch interval. Note that Regulation FCAS bid ramp rates would also need to meet this requirement to be accepted for dispatch.

[14] Materially, in the case of AEMO's AGC platform, it is 63.2%. This value is essentially 'built into' the AGC software and is based on the time constant in an exponential lead/lag filter. The actual value is not especially important, rather it is important that it is used consistently when assessing all resources so the relative CRDs are reflected in the unit control logic.

Required measurements – participating facility to AGC

AEMO proposes that facilities providing Regulation FCAS should provide an agreed set of real-time measurements to AEMO through SCADA, and that these be set out in the MASS. Most facilities already provide some or all of these values.

For each of these measurements, the value could be for each individual facility or for the sum of all facilities in an aggregated facility. Each of the measurements should have an update rate of no longer than 4 seconds and with no more than 8 seconds data latency.

- **Facility output (MW)** – this is the output MW value; typically, it is the gross value as measured at the facility terminals.
- **Control request feedback (MW)** – this is the latest AGC-issued control request as known by the facility. This value excludes any change in output from PFR action. For setpoint controlled facilities, this is simply an echo back of the control request. For raise/lower controlled facilities, this is the MW value of the stream of raise/lower controls as accumulated internal to the plant controller or equivalent.
- **Ramp rate (MW/minute)** – the rate of change the facilities are prepared to move in response to AGC issued control requests. Providers would be expected to ensure that the telemetered ramp rate can cover changes in energy dispatch plus any Regulation capacity cleared in NEMDE.
- **Maximum AGC control limit (MW)** – the maximum available MW capacity for AGC-issued control requests. This recognises that a facility might have additional capacity that is not currently available to AGC control but is available to the plant operator (e.g. overload capability).
- **Minimum AGC control limit (MW)** – the minimum available net MW capacity for AGC-issued control requests. As for maximum AGC control limit, this recognises the plant operator may have additional capability to reduce output that is not available to AGC.
- **Online/offline status** – indicates that the facility is connected to the grid and ready to produce power.
- **Remote/local status** – indicates the source of output requests as seen by the local plant controller. Remote indicates the local plant controller or equivalent for aggregated facilities is ready to receive AGC-issued control requests.
- **Local PFR (MW)** – represents the current MW equivalent of any local PFR as extracted from the local plant controller or equivalent.

AEMO also proposes that battery-based facilities provide the following:

- **Maximum limit duration (seconds**) – the duration the Maximum AGC control limit (see definition in above list) can be sustained for the current state of battery charge.
- **Minimum limit duration (seconds)** – the duration the Minimum AGC control limit (see definition in above list) can be sustained for the current state of battery charge.

Testing cycle for Regulation FCAS

There is currently no scheduled program of testing to ensure facilities are operating appropriately when providing Regulation FCAS.

AEMO proposes the introduction of a Regulation FCAS testing cycle.

AEMO suggests that a two-year testing cycle might be appropriate, and invites submissions on this, and how it could be best co-ordinated with affected plant. The tests would be set out in the MASS based on existing processes currently employed for testing and tuning AGC controls, and would involve checking that:

- Each of the Regulation FCAS requirements (as determined following consultation and set out in the future MASS) were met.
- A small set of ramp up and ramp down tests were ensuring controls had been implemented at the facility as expected and the required CRD characteristics had been achieved.

3.6 Clarification of requirements for Delayed FCAS

Currently, the MASS does not provide clear guidance on the design of Delayed Raise and Lower FCAS controls. In particular, it does not distinguish whether Delayed FCAS controls should be implemented via switched or proportional control. Over time, participants have been registered using various control designs to deliver these services.

The purpose of Delayed FCAS, as stated in section 5.1 of the MASS, is "*to return System Frequency to 50 Hz within the first five minutes of a Frequency Disturbance that resulted in System Frequency being outside the normal operating frequency band*".

Two aspects of this definition are particularly notable:

- That it is to **return frequency to 50 Hz** (nominal frequency), not to within the NOFB; and
- It is to do this **within five minutes** of the Frequency Disturbance.

Frequency restoration to nominal frequency cannot be achieved by a proportional controller, which relies on a frequency deviation to compute response. It especially cannot be achieved with the application of a wide deadband frequency response, such as a deadband at ±0.15 Hz.

Instead, it needs to be achieved with a suitable 'switched' response which triggers a specific shift in base power output when the trigger conditions are met. Alternatively, it could be done via a signal from AEMO, such as via AGC.

For example, some Delayed service providers rapidly drive their active power setpoint away from its dispatch point so as to achieve an increase or decrease in output separate to, or in addition to, droop type proportional response.

While it seems apparent that the specification of Delayed FCAS control requirements could be improved by providing clearer and more specific guidance on acceptable control arrangements, there are a range of potential issues it may be valuable to address before implementing such a change. These may include:

- The potential lead time required to implement changes.
- Concerns around impacts on Delayed FCAS registration quantities.
- The frequency-sensitivity of the controls (see Section 3.3); for example, the extent to which the controls should take into account the magnitude of the frequency deviation in determining a shift in power output.
- Whether AGC controls should ideally be aware of the Delayed FCAS controls at a plant, and how this could be co-ordinated (including co-ordination with PFR and other Contingency FCAS controls).

AEMO therefore suggests that it may be too early to alter the MASS requirements for Delayed FCAS within the constraints of this review, but invites submissions on how this could be implemented and what other potential issues exist, so a subsequent piece of work could progress this in the MASS.

3.7 Issues associated with pending rule changes and matters for separate consultation

AEMO's Frequency Control Workplan[15] identified a task to examine whether the definition of Fast Contingency FCAS could be changed to accommodate FFR (see Task ID 7). The matter of considering different FCAS timeframes, particularly for Fast Contingency FCAS, was also identified in the AEMC's Frequency Control Frameworks Review[16].

AEMO notes that the AEMC is currently evaluating a rule change request to introduce FFR (ERC0296). The AEMC is considering the arguments for establishing FFR, specification of such services, and the potential

[15] At https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/frequency-control-work-plan.

[16] At https://www.aemc.gov.au/markets-reviews-advice/frequency-control-frameworks-review.

procurement mechanisms for acquiring them. AEMO will be providing technical advice to the AEMC on FFR, which is expected to be published on the AEMC's rule change page in due course.

It is apparent that the outcome of that rule change request would be a significant consideration for future specifications of the various FCAS. AEMO also notes that any redefinition of FCAS timing specifications would have major implications for FCAS providers and FCAS markets, which should be considered by the AEMC in the rule change process.

In the current context of the MASS Review, AEMO invites submissions on any high-level issues that might need to be considered in, or could be excluded from, any MASS review after conclusion of the AEMC rule change process.

Managing frequency responsiveness of FCAS reserve in aggregate

As stated in Section 3.3, to maintain adequate control of frequency, it is necessary for some significant proportion of the facilities contributing to be frequency responsive. The RIS Stage 1 report investigated the issue, stating (in Section B4.7):

> *Removing frequency responsiveness from output completely, by forcing a generator to track a static profile, would have a detrimental impact on system behaviour if adopted widely. Historically, droop control has been applied to governor response so that all generators share the response to a frequency disturbance. By facilitating this sharing, droop control prevents generators responding too aggressively creating adverse interactions between each other. It also prevents over provision in the case of small imbalances.*

AEMO already has constraint equations invoked in Tasmania that ensure an appropriate level of FCAS in Tasmania comes from frequency responsive facilities. In light of an increasing quantity of non-frequency responsive FCAS providers on the mainland, similar measures are likely to be needed for the rest of the NEM.

As with Tasmania, the most practical approach AEMO is aware of would be to manage this through an appropriate set of FCAS constraint equations. The form of FCAS constraint equations is set out in the Constraint Formulation Guidelines[17], and a consultation on that document would be needed to advance such changes. AEMO highlights the matter here given its relevance for the expected MASS review audience, and invites submissions on progressing this initiative.

Maximum frequency response rate

Currently AEMO limits that the maximum frequency response rate for proportional controllers, setting an effective limit of 1.7% droop. Following recent improvements in frequency control and the associated increase in robustness in power system resilience, AEMO will be considering if the maximum allowable frequency response rate can be increased. This may need to be managed in tandem with area based limitations on FCAS, as discussed below, in particular to ensure stable operation in adverse system conditions.

Area based limitations on FCAS

AEMO is required to ensure that the delivery of FCAS will not compromise power system security. The increased installation of frequency responsive plant that may be able to provide a large proportion of the total FCAS requirement on its own, presents a potential concern that FCAS from concentrated sources may cause power system security issues. To address this AEMO may need to limit the amount of FCAS sourced in any one area. Please note that AEMO will engage with the industry prior to any changes in the way FCAS services are procured or constrained.

[17] At https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Congestion-Information/2016/Constraint-Implementation-Guidelines.pdf.

3.8 Consultation questions for general MASS issues

9. Does the proposed reformat of the MASS (see Attachment 1) make for improved readability and understanding? What other improvements in the form and drafting of the MASS could be beneficial? If you consider the reformatted MASS may have materially changed the substantive meaning of the MASS v6.0, please also bring this to our attention.
10. Clarification of FOS references – please provide any feedback on the proposal to clarify that FOS terms relate to Table A.1 of the FOS, and any other terms that have ambiguous values.
11. Frequency responsiveness of FCAS:
    a. What would be involved in ensuring that non-frequency responsive facilities:
        i. Respond only when enabled in the relevant FCAS market(s)?
        ii. Do not deliver significantly more than market enablement (for example, >50%)?

        Do any alternative options exist to manage over-delivery?
    b. Please provide feedback on the proposed revised trigger ranges for switching controllers set out in Table 1 and Table 2 of section 3.3.
    c. Please provide feedback on the proposal in section 3.3 to require proportional controllers to set deadbands no wider than ±0.1 Hz.
12. Co-ordination of different FCAS and PFR:
    a. Referencing the list of co-ordination matters in section 3.4, are there other co-ordination matters AEMO should seek to address in the MASS?
    b. Does the list of clarifications on co-ordination of Contingency FCAS/PFR controls with AGC controls in Section 3.4 provide a reasonable balance between guidance and flexibility for plant control design?
13. Regulation FCAS requirements:
    a. Are the requirements and proposed settings listed in section 3.5 adequate and achievable? In particular, can PFR (separate to other plant targets) be determined readily and communicated to AEMO?
    b. Would a 1-year phase-in period for existing Regulation FCAS providers be satisfactory?
    c. Do Consulted Persons believe that a 2-year Regulation FCAS testing cycle strike the right balance of stringency and reasonableness?
    a. Clarification of requirements for Delayed FCAS – please consider the implications from your perspective of clarifying that Delayed FCAS controls may be of a switched type only (rather than also proportional), and, whether other factors in addition to those outlined in section 3.6 need to be considered.
14. Regarding issues associated with the pending FFR rule change canvassed in section 3.7 and any other rule changes of concern, AEMO wishes to hear from Consulted Persons on the following issues, which would be used to help scope future changes to the MASS:
    a. What MASS issues they consider should be addressed in subsequent reviews, including if possible, provide reasoning as to why these issues are important.
    b. How any other desirable changes to the MASS could be managed in the context of ongoing rule changes.

4. Response expectations

4.1 Process matters

All written submissions in response to this Issues Paper must be provided digitally by email to mass.consultation@aemo.com.au.

Submissions may be provided as follows:

- Only for the DER MASS review component.
- Only for the General MASS review component.
- Combined, clearly indicating which component is being addressed.

Submissions must be received by AEMO by **5:00pm NEM time (AEST) on Thursday, 25 February 2021.**

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.

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

Public submissions will be published approximately one week after the submission close date. Any confidential submissions must be clearly marked, or any confidential information within a submission should be clearly marked, to make this clear to AEMO so confidentiality can be maintained.

In your submission, you may request a meeting with AEMO to discuss the matter under consultation, stating why you consider a meeting is necessary or desirable. If appropriate, meetings may be held jointly with other Consulted Persons. Subject to confidentiality restrictions, AEMO will generally make details of matters discussed at a meeting available to other Consulted Persons, and may publish them.

4.2 Excluded matters

Exclusions from the scope of this consultation include:

- Co-optimisation of energy and FCAS.
- The definition of load amount in the MASS will not be updated pending the outcome of potential NER changes to recognise bi-directional flow from ancillary service loads to deliver FCAS.
  - The interim arrangements for the provision of FCAS by providers using DER can continue to be applied after the VPP Demonstrations conclude. The AEMC is considering whether clarifications are required to the NER to recognise ancillary service facilities with bi-directional flows, as part of its consultation on AEMO's Integrating Energy Storage Systems into the NEM (ESS) rule change request. AEMO will consider further updates to the MASS at the conclusion of that rule change process.
- Ancillary services generating units with bi-directional flows.
  - Only facilities classified as ASLs have participated in the VPP Demonstrations, which allowed ASLs to export for FCAS purposes. AEMO has not trialled whether ancillary service generating units can import for FCAS purposes and does not know what impact this may have on the power system. Under the current framework, an ancillary service generating unit can only increase export to provide Raise FCAS or reduce export to provide Lower FCAS.
  - It is expected that the ESS rule change request will address bi-directional facilities and, depending on the outcome of that rule change process, the MASS will need to be updated to address any resulting simplification of the current terms and definitions relating to ancillary services load and generation.

- Operational forecasting data.
  - VPP Demonstrations participants were asked to provide forecast data for operational visibility to enrol in the VPP Demonstrations. This data is not required for FCAS participation and AEMO is exploring alternative options to document the requirements for continued provision of this data after the VPP Demonstrations end.
- Changes to broader policy, for example, participation models, GPS.
- Required updates to registration and classification to incorporate interim arrangements for VPP Demonstrations participant enrolments.

Glossary

In this Issues paper, terms defined in the NER have the same meaning. Other frequently used technical terms and acronyms are as defined below.

Term or acronym	Meaning
AEMC	Australian Energy Market Commission.
Affected Generator	As defined in the IPFRR.
AGC	Automated generation control.
ASL	Ancillary service load.
Contingency FCAS	Any of the following (terms defined in the NER): • Fast Raise service; • Fast Lower service; • Slow Raise service; • Slow Lower service; • Delayed Raise service; and • Delayed Lower service.
Consulted Persons	Registered Participants and interested parties.
CRD	Control response delay.
Deadband	Deadband is used to refer to the frequency band within which an Ancillary Service Facility will not provide frequency response in accordance with the applicable Contingency FCAS requirements and/or PFR requirements
DER	Distributed energy resources.
Fast [Contingency FCAS]	Fast Raise service and Fast Lower service.
Slow [Contingency FCAS]	Slow Raise service and Slow Lower service.
Delayed [Contingency FCAS]	Delayed Raise service and Delayed Lower service.
ESS Rule Change Request	Proposed National Electricity Amendment (integrating energy storage systems into the NEM) Rule 2021.
FFR	Fast frequency response.
FCAS	Frequency control ancillary services; referred to as market ancillary services in the NER. Effectively, Contingency FCAS and Regulation FCAS.
Frequency Disturbance	An occasion when the power system frequency moves outside the NOFB.
FOS	Frequency operating standard.
IPFRR	Interim Primary Frequency Response Requirements.
Local Frequency	The frequency of the electricity delivered by an ancillary service generating unit or consumed by an ancillary service load, measured in Hz.

Term or acronym	Meaning
Lower FCAS	Any of the following (terms defined in the NER): • Fast Lower service; • Slow Lower service; and • Delayed Lower service.
Mandatory PFR Rule	National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5
MASS	The market ancillary service specification contemplated by clause 3.11.2(b) of the NER.
MASS Verification Tool	The FCAS verification tool is an Excel spreadsheet that has been made available to NEM participants to calculate FCAS delivered by their plant.
MW	Megawatt.
NEMDE	NEM dispatch engine.
NEO	The objective specified in section 7 of the National Electricity Law, which is to: *... promote efficient investment in, and efficient operation and use of, electricity services for the long term interests of consumers of electricity with respect to—* *(a) price, quality, safety, reliability and security of supply of electricity; and* *(b) the reliability, safety and security of the national electricity system.*
NER	National Electricity Rules.
NMI	National metering identifier.
NOFB	Normal Operating Frequency Band.
PFR	Primary frequency response
Raise FCAS	Any of the following (terms defined in the NER): • Fast Raise service; • Slow Raise service; and • Delayed Raise service.
Regulation FCAS	Any of the following (terms defined in the NER): • Regulating Raise service; and • Regulating Lower service.
SCADA	Supervisory control and data acquisition.
VPP	Virtual power plant
VPP Demonstrations	Program of work designed to inform changes to regulatory frameworks and operational processes so Distributed Energy Resources (DER) can be effectively integrated into the National Electricity Market (NEM), maximising value to consumers while also supporting power system security.

Attachment 1 – new proposed form of current MASS

AEMO has published a reformatted draft version of the MASS as a separate document with this Issues Paper. The draft has been substantially reworked from v6.0 in the interest of readability and usability, but does not address any of the substantive issues or amendments canvassed in this issues paper. AEMO will publish drafting to address those matters at the draft report and determination stage, after considering feedback on this Issues Paper.

MARKET ANCILLARY SERVICE SPECIFICATION

PREPARED BY: AEMO Systems Performance and Commercial
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DATE:

VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
1.0	Sep 2001	Initial document issued at the commencement of the market ancillary services
1.5	27 Feb 2004	Revised to include the Tasmania region
2.0	5 May 2009	Revised to align with the revised Tasmania frequency operating standards
3.0	1 Jul 2010	Revised after consultation
4.0	30 Mar 2012	Revised after consultation
5.0	30 Jun 2017	Revised after consultation
6.0	1 Jun 2020	• Revised following consultation on relationship with the draft Primary Frequency Response rule change (ERC0274). • Minor drafting updates, corrections and clarifications.
6.1		Draft for consultation following a restructure of the document to remove unnecessary duplication and improve readability.

CONTENTS

TABLES

FIGURES

1. INTRODUCTION

1.1. Purpose and scope

This is the *market ancillary service specification* (**MASS**) made under clause 3.11.2(b) of the National Electricity Rules (**NER**). It includes the monitoring and recording standards referred to in clause 3.11.2(g).

The MASS has effect only for the purposes set out in the NER. The NER and the *National Electricity Law* prevail over the MASS to the extent of any inconsistency.

1.2. Definitions and interpretation

1.2.1. Glossary

Terms defined in the *National Electricity Law* or the NER have the same meanings in the MASS unless otherwise specified in this section 1.2.1. NER defined terms are intended to be identified in the MASS by italicising them, but failure to italicise a defined term does not affect its meaning.

The words, phrases and abbreviations in Table 1 have the meanings set out opposite them when used in the MASS.

Table 1 Definitions

Term	Definition
Aggregated Ancillary Service Facility	The *ancillary service generating units* or *ancillary service loads* aggregated by an FCAS Provider under clause 3.8.3 of the NER for the purpose of providing FCAS.
Aggregated Generation Amount	The amount of *active power* flow through one or more *connection points* of an Aggregated Ancillary Service Facility comprised of *ancillary service generating units*, in MW.
Aggregated Load Amount	The amount of *active power* flow through one or more *connection points* of an Aggregated Ancillary Service Facility comprised of *ancillary service loads*, in MW.
Ancillary Service Facility	An *ancillary service generating unit* or *ancillary service load* used to deliver FCAS.
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.
Contingency FCAS	A term used to refer to *fast raise service*, *fast lower service*, *slow raise service*, *slow lower service*, *delayed raise service* and *delayed lower service* collectively.
Controlled Quantity	A quantity of *generation* or *load* that is: (a) controlled by Raise Signals and Lower Signals; and (b) measured at the relevant *connection point*.

Term	Definition
Delayed FCAS	*delayed raise services* and *delayed lower services*.
Fast FCAS	*fast raise services* and *fast lower services*.
FCAS	*market ancillary services*, commonly referred to as "frequency control ancillary services".
FCAS Provider	A *Market Ancillary Service Provider* or *Ancillary Service Provider*, as applicable.
FCASVT	Frequency Control Ancillary Service Ancillary Service Verification Tool: An Excel spreadsheet used to verify the delivery of Contingency FCAS.
FOS	*frequency operating standard*.
Frequency Deadband	The range of Local Frequency through which a Variable Controller will not operate.
Frequency Deviation Setting	The setting allocated to an Ancillary Service Facility by AEMO within the range shown in Table 5 for the Mainland and Table 6 for the Tasmania *region*.
Frequency Disturbance	An occasion when System Frequency is outside the NOFB.
Frequency Disturbance Time[1]	The time[2] when Local Frequency is outside the NOFB following a Frequency Disturbance, as determined by AEMO.
Frequency Ramp Rate	0.125 Hz/s for the Mainland or 0.4 Hz/s for Tasmania.
Frequency Rate of Change Multiplier	See Table 5 for the Mainland, and Table 6 for Tasmania.
Frequency Recovery	The first change in Local Frequency to occur after a Frequency Disturbance from above 50.15 Hz to below 50.1 Hz, or below 49.85 Hz to above 49.9 Hz.
Frequency Setting	The level of *frequency* or a combined level of *frequency* and *frequency* rate of change determined by AEMO in accordance with section 6 for use by an Ancillary Service Facility's Switching Controller.
Generation Amount	The amount of *active power* flow through the *connection point* of an *ancillary service generating unit*, in MW, with flow from the ancillary service generating unit being positive.
Generation Event	As defined in the FOS.
Inertial Response	The change in Generation Amount or Load Amount due to the impact of an Ancillary Service Facility's *inertia*.
Initial Value	The Generation Amount or Load Amount immediately prior to a Contingency Event Time.
Load Amount	The amount of *active power* flow through the *connection point* of an *ancillary service load*, in MW, with flow towards the *ancillary service load* being negative.
Load Event	As defined in the FOS.
Local Frequency	The *frequency* measured by an FCAS Provider at the *connection point* of the FCAS Provider's Ancillary Service Facility or Aggregated Ancillary Service Facility, in Hz.
Lower Control Limit	The lowest level to which a Controlled Quantity can be controlled in response to Lower Signals.
Lower Rate Limit	The highest rate at which a Controlled Quantity can be controlled in response to Lower Signals.

[1] Referred to as occurring at t=0 in the equations used in the MASS.
[2] *Australian Eastern Standard Time.*

Term	Definition
Lower Reference Frequency	The upper value in the 'containment band' for Load Events, as specified in Section A.1 of the FOS (A.2.1 for Tasmania).
Lower Response	The decrease in Generation Amount or increase in Load Amount as compared with its Initial Value.
Lower Signal	An *AGC* control signal sent by or on behalf of AEMO to request delivery of a Regulating Lower Response.
Mainland	All *regions* other than Tasmania.
MASS	This document, namely, the *market ancillary service specification*.
NER	National Electricity Rules.
NOFB	*normal operating frequency band*.
OFTB	*operational frequency tolerance band*.
Raise Control Limit	The highest level to which a Controlled Quantity can be controlled in response to Raise Signals.
Raise Rate Limit	The highest rate at which a Controlled Quantity can be controlled in response to Raise Signals.
Raise Reference Frequency	The lower value in the 'containment band' for Generation and Load Events, as specified in Section A.1 of the FOS (A.2.1 for Tasmania).
Raise Response	The increase in Generation Amount or decrease in Load Amount as compared with its Initial Value.
Raise Signal	An *AGC* control signal sent by or on behalf of AEMO to request the delivery of a Regulating Raise Response.
Regulating Lower Response	The decrease in Generation Amount or increase in Load Amount delivered in response to one or more Lower Signals.
Regulating Raise Response	The increase in Generation Amount or decrease in Load Amount delivered in response to one or more Raise Signals.
SCADA	Supervisory control and data acquisition system.
Slow FCAS	*Slow raise services* and *slow lower services*.
Standard Frequency Ramp	A linear change in Local Frequency from one level to another at the applicable Frequency Ramp Rate and then sustained, as shown in Appendix A.
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.
System Frequency	The *frequency* of the *power system*, as measured by AEMO.
Time Average	For a Raise Response or Lower Response and a time interval, the average value of that Raise Response or Lower Response over that time interval, determined as the integral of the Raise Response or Lower Response over the time interval divided by the duration of the time interval.
Trigger Range	The *frequency* range for which an Ancillary Services Facility with one or more switching controllers must record and store data regarding its performance, commencing 0.2 Hz either side of 50 Hz for the Mainland, and 0.8 Hz for Tasmania.
Trigger Rate	0.05 Hz/s for the Mainland and 0.15 Hz/s for Tasmania.
Variable Controller	A *control system* that delivers FCAS upon the commencement of a Frequency Disturbance corresponding to the size of the *frequency* excursion outside the NOFB.

1.2.2. Interpretation

The following principles of interpretation apply to the MASS unless otherwise expressly indicated:

(a) The MASS is subject to the principles of interpretation set out in Schedule 2 of the *National Electricity Law*.

(a) Units of measurement are in accordance with the International System of Units.

1.3. Related documents

Table 2 Title and location of related documents

Title	Location
Application for Registration as a Customer in the NEM	http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Application-forms-and-supporting-documentation
Application for Registration as a Generator in the NEM	http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Application-forms-and-supporting-documentation
Application for Registration as a Market Ancillary Service Provider and Classification of Load	http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Application-forms-and-supporting-documentation
Dispatch Procedure SO_OP_3705	http://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3705---Dispatch.pdf
FCAS Verification Tool User Guide	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification
Generator Exemption and Classification Guide	http://aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/New-Participants/Generator-Exemption-and-Classification-Guide.pdf
Generator Registration Guide	http://aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/Application-forms-and-supporting-documentation/NEM_GENERATOR_REGISTRATION_GUIDE.pdf
Guide to Ancillary Services in the National Electricity Market	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services
MASS 4.0 FCAS Verification Tool_v2.08	http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification
NEM Market Ancillary Service Provider and Classification of Load Registration Guide	http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Participant-information/New-participants/Application-forms-and-supporting-documentation
Pre-Dispatch Procedure SO_OP_3704	http://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3704---Predispatch.pdf
Interim Primary Frequency Response Requirements	https://aemo.com.au/-/media/files/initiatives/primary-frequency-response/2020/interim-pfrr.pdf

2. MASS PRINCIPLES

2.1. Open Access

When specifying the requirements for participation, the MASS is designed to permit open access to the FCAS *spot markets*.

2.2. Priority of Contingency FCAS over Regulation FCAS

If a *contingency event* occurs while an Ancillary Service Facility is *enabled* to deliver both Regulation FCAS and Contingency FCAS, until Local Frequency has returned to be within the NOFB, the Ancillary Service Facility must deliver Contingency FCAS only.

If a *contingency event* occurs while an Ancillary Service Facility is *enabled* to deliver both Regulation FCAS and Contingency FCAS, the Ancillary Service Facility should give priority to providing the Contingency Services and not respond to AGC instructions while responding to Contingency Service actions until such time as the Local Frequency has returned to the NOFB.

Commented [A1]: Replaces current 6.9.

2.3. Contracting

Nothing prevents an FCAS Provider from procuring a third party to provide equipment or a monitoring or recording service to the FCAS Provider under contract, or perform any other action required or contemplated by the MASS on behalf of that FCAS Provider.

The FCAS Provider remains responsible for compliance with its NER obligations regardless of whether it provides *market ancillary services* itself or outsources part or all of their delivery.

Commented [A2]: Replaces current 2.2 though this section is a candidate for removal.

2.4. Inertia

FCAS does not include the impact of *inertia*.[3]

Commented [A3]: Reflects current 2.1.1.

2.5. Delivery of FCAS by Ancillary Service Facilities

An Ancillary Service Facility can be *enabled* to deliver any combination of FCAS it is capable of delivering.

3. DESCRIPTION OF EACH TYPE OF FCAS

Commented [A4]: Replaces current 2.1.

FCAS are essential to the management of *power system security*, facilitation of orderly trading in electricity, and ensuring that electricity supplies are of acceptable quality. They are procured through the FCAS *spot markets* operated by AEMO and the *central dispatch* process in accordance with clause 3.8.1 of the NER.

AEMO procures FCAS to manage System Frequency during normal operating conditions and following *contingency events*. FCAS usually takes the form of an increase or decrease in *active power* output or consumption by an Ancillary Service Facility to address the impact of supply/demand imbalances on System Frequency. Each type of FCAS is delivered to different specifications to address different needs.

Clause 3.11.2(a) of the NER specifies that there are eight different types of FCAS. Table 3 details these, provides their common names, differentiates between Contingency FCAS and Regulation FCAS, and provides a brief description of how they are usually provided.

[3] See also the definition of Frequency Disturbance Time.

Table 3 Description of each FCAS

Commented [A5]: Contents reflect existing 3.1, 3.2, 4.1, 4.2, 5.1 & 5.2.

Type	NER Term	Commonly Referred to as…	Group	Description	Purpose	Usually Facilitated by…
Contingency FCAS	*Fast raise service*	6-Second Raise FCAS	Fast FCAS	A rapid increase in *generation* or a decrease in *load* in response to decreases in Local Frequency.	To arrest a change in System Frequency following a *contingency event* that takes it outside the NOFB within the first 6 s of a Frequency Disturbance and then provide an orderly transition to a Slow FCAS.	• Governor or governor-like *control systems* • Frequency relay detecting System. Frequency below NOFB and starting a fast *generating unit* or *disconnecting load.* • Rapid change in charging or discharging from batteries.
	Fast lower service	6-Second Lower FCAS		A rapid decrease in *generation* or an increase in *load* in response to increases in Local Frequency.		• Governor or governor-like *control systems.* • *Frequency* relay detecting System Frequency above NOFB and reducing a *generating unit's* output or reducing *load.*
	Slow raise service	60-Second Raise FCAS	Slow FCAS	An increase in *generation* or a decrease in *load* in response to decreases in Local Frequency.	To stabilise System Frequency following a *contingency event* within the first 60 s of a Frequency Disturbance, and then provide an orderly transition to a Delayed FCAS.	• Governor or governor-like control systems • *Frequency* relay detecting a frequency deviation and reducing *load*.
	Slow lower service	60-Second Lower FCAS		A decrease in *generation* or an increase *load* in response to increases in Local Frequency.		Governor systems on *generating units.*
	Delayed raise service	5-Minute Raise FCAS	Delayed FCAS	An increase in *generation* or a decrease in *load* in response to decreases in Local Frequency.	To return System Frequency to 50 Hz within the first 5 min of a Frequency Disturbance, and to sustain that response until *central dispatch* can re-schedule *generation* and *load* to balance the *power system*.	*Frequency* relay detecting a *frequency* deviation starting up *generating units* or reducing *load.*
	Delayed lower service	5-Minute Lower FCAS		A decrease in *generation* or an increase in *load* in response to increases in Local Frequency.		*Frequency* relay detecting a *frequency* deviation and reducing *generating unit* output or increasing *loads*.
Regulation FCAS	*Regulating raise service*	Raise Regulation FCAS	Regulation FCAS	Increasing *generation* or decreasing *load* in response to Raise Signals to increase System Frequency.	To support the control of System Frequency within the NOFB and time error in response to variations of demand and *generation* within a *dispatch interval.*	Setpoint controllers on *generating units*.
	Regulating lower service	Lower Regulation FCAS		Decreasing *generation* or increasing *load* in response to Lower Signals to reduce System Frequency.		

3.1. Contingency FCAS

Contingency FCAS manages Frequency Recovery after an under-*frequency* or over-*frequency* event to arrest a fall or rise in System Frequency (as applicable), so that System Frequency can recover as required by the FOS. This means that, while always *enabled* for delivery following a *contingency event*, Contingency FCAS are only delivered if a *contingency event* occurs.

Contingency FCAS are provided by technologies that can detect a System Frequency deviation and respond in a manner that corrects System Frequency following a *contingency event*.

Ancillary Service Facilities need not provide Contingency FCAS once Local Frequency has recovered. For example:

- If Local Frequency recovers above 49.9 Hz within 6 s from the Frequency Disturbance Time, the Ancillary Service Facility is not required to deliver any 60-Second Raise FCAS or 5-minute Raise FCAS.
- If Local Frequency recovers below 50.1 Hz within 6 s from the Frequency Disturbance Time, the Ancillary Service Facility is not required to deliver any 60-Second Lower FCAS or 5-minute Lower FCAS.
- If Local Frequency recovers above 49.9 Hz between 6 s and 60 s from the Frequency Disturbance time, the Ancillary Service Facility is not required to deliver any 5-minute Raise FCAS.
- If Local Frequency recovers below 50.1 Hz between 6 s and 60 s from the Frequency Disturbance Time, the Ancillary Service Facility is not required to deliver any 5-minute Lower FCAS.

3.2. Regulation FCAS

Regulation FCAS are centrally controlled by *AGC*, which allows AEMO to monitor System Frequency and time error at all times. *AGC* also sends control signals through SCADA to Ancillary Service Facilities *enabled* to deliver Regulation FCAS to alter the MW output of *generating units* or electricity consumption of *loads* to assist with correcting the demand/supply imbalance and return System Frequency within the NOFB.

Regulation FCAS are normally delivered during each *dispatch interval*.

4. AGGREGATION OF ANCILLARY SERVICE FACILITIES

4.1. Requests for Aggregation

4.1.1. Generally

FCAS Providers may apply to AEMO under clause 3.8.3 of the NER to aggregate their *ancillary service generating units* or *ancillary service loads* for the purposes of *central dispatch*. Where aggregation has been approved, *market ancillary service offers* must only be made in respect of the Aggregated Ancillary Service Facility.

4.1.2. Regulation FCAS

With Regulation FCAS, AEMO will approve aggregation if an FCAS Provider's *AGC* can support the aggregated *dispatch* of Regulation FCAS, namely it will respond to a single *AGC* signal from AEMO to deliver the requested Regulation FCAS.

The FCAS Provider must ensure that its Aggregated Ancillary Service Facility provides the requested Regulation FCAS in an accurate and timely manner.

Commented [A6]: Reflects 2.1.1.

Commented [A7]: Reflects current 4.2.

Commented [A8]: Reflects current 5.2.

Commented [A9]: Reflects 2.1.2

Commented [A10]: Reflects current 2.4.

4.2. Requests for Reports on Aggregate Ancillary Service Facilities

4.2.1. Generally

A request from AEMO to an FCAS Provider for a report dealing how an Ancillary Service Facility responded to changes in System Frequency under clause 3.11.2(h) of the NER may also be made in respect of an Aggregated Ancillary Service Facility, in which case the FCAS Provider must detail in its report the response of each *plant* within the Aggregated Ancillary Service Facility.

An FCAS Provider must provide a report promptly but, in any event, no more than 20 *business days* after AEMO's request.

4.2.2. Contingency FCAS

Where the report requested concerns the delivery of Contingency FCAS, this may include the response as determined by the FCASVT, or the FCAS Provider may propose an alternative method of demonstrating the response of the relevant *plant*. AEMO, in its absolute discretion, may accept an FCAS Provider's alternative method.

5. COMMON REQUIREMENTS

5.1. Market Ancillary Service Offers

Commented [A11]: Reflects current 2.3.

FCAS Providers must ensure their *market ancillary service offers* reflect the physical availability and capability of their Ancillary Service Facility or Aggregated Ancillary Service Facility (as applicable) to deliver the relevant FCAS, as required by clause 3.8.7A of the NER.

FCAS Providers must rebid in accordance with clause 3.8.22 to reflect changes to FCAS availability and capability.

5.2. Enablement

Commented [A12]: Reflects current 7.1.

FCAS Providers must operate their equipment in accordance with clause 4.9.3A(c) of the NER to deliver FCAS in response to a *dispatch instruction* immediately following *enablement* by AEMO.

5.3. Measurement

Commented [A13]: Replaces current 2.4, 3.6, 4.6, 5.6 & 6.7.

5.3.1. Connection Point

All measurements of Local Frequency, Generation Amount and Load Amount must be taken at or close to 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.

5.3.2. Measurement Requirements

Ancillary Service Facilities

The equipment required to measure and record the delivery of FCAS, including both the source transducer and data recorder, must have the characteristics detailed in Table 4:

Table 4 Measurement Requirements for FCAS

Requirement	Fast FCAS	Slow FCAS	Delayed FCAS	Regulation FCAS
Frequency of Local Frequency measurements	≤50 ms[4]	≤4 s	≤4 s	NR
Frequency of Generation Amount and Load Amount measurements	≤50 ms	≤4 s	≤4 s	≤4 s
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%			
Settling Time	≤50 ms (to 99% of final value after a step change from zero)			
Local Frequency Measurement Range	At least the range specified in the OFTB, with:			NR
	Margin of error:	Resolution:		
	≤0.01 Hz	≤to 0.02 Hz		
	≤0.0025 Hz	≤0.01 Hz		
Frequency Disturbance Time	< 10 s			NR
Recording Period for Power & Frequency Measurements	≥5 s before the Frequency Disturbance Time and ≥60 s after it	≥20 s before the Frequency Disturbance Time and 5 min after it	≥20 s before the Frequency Disturbance Time and 10 min after it	NR
Trigger for Recording Measurements	At least whenever Local Frequency changes ≥ Trigger Range.			NR

Aggregate Ancillary Service Facilities

Commented [A14]: Reflects parts of current 2.4.

If an Aggregate Ancillary Service Facility is used for the delivery of FCAS, measurements must meet these **additional** requirements:

(a) The Generation Amount or Load Amount must be measured at, or close to, each relevant *connection point* and summed to calculate the Aggregated Generation Amount or Aggregated Load Amount. Where any part of an Aggregated Ancillary Service Facility shares a *connection point* with a variable *load* or *generating unit*, it is the gross *active power* flow to or from the relevant *plant* that forms the aggregated response and must be measured directly.

(b) To correct for any discrepancy in the time measurement by Aggregated Ancillary Service Facility *meter* clocks, FCAS Providers must time-align the data logged by each *meter* to the actual time a Frequency Disturbance was detected.

5.4. Data Retention

Commented [A15]: Replaces current 3.6(xi) & (xii), 4.6(x) & (xi), 5.6 (ix) & (x), 6.7(d) & (e)

Measurement and other data recordings must be digital and stored in a format that is reasonably acceptable to AEMO for analysis using commercial spreadsheet software.

Each FCAS Provider must retain recordings of data measurements for at least 12 months from the Frequency Disturbance Time and provide them to AEMO on request.

[4] If another measurement at ≤50 ms is sufficient to determine the timing of the delivery of the Fast FCAS where a Switching Controller is used, the measurement may be at 4-s intervals. Sufficient information should be provided to AEMO to compare the Local Frequency and power flow data in a common time scale.

6. CONTINGENCY FCAS REQUIREMENTS

Commented [A16]: Reflects current 7.2.

6.1. Frequency Deviation Settings provided by Switching Controllers

6.1.1. Default Frequency Deviation Setting

Until an Ancillary Service Facility that uses a Switching Controller to deliver Contingency FCAS is allocated a Frequency Deviation Setting under section 0, 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.

Table 5 Frequency Settings for the Mainland

Level	Raise FCAS Frequency Deviation Setting (Hz)	Lower FCAS Frequency Deviation Setting (Hz)	Frequency Rate of Change Multiplier
Frequency Deviation Setting range	49.80 Hz to 49.60 Hz	50.20 Hz to 50.4 Hz	0.4
Default Frequency Deviation Setting	49.65 Hz	50.35 Hz	0.4

Table 6 Frequency Settings for Tasmania

Level	Raise FCAS Frequency Deviation Setting (Hz)	Lower FCAS Frequency Deviation Setting (Hz)	Frequency Rate of Change Multiplier
Frequency Deviation Setting range	49.50 Hz to 48.75 Hz	50.50 Hz to 51.25 Hz	0.875
Default Frequency Deviation Setting	49.125 Hz	50.825 Hz	0.875

6.1.2. Allocation of Frequency Settings

When allocating Frequency Settings to Ancillary Service Facilities for each Contingency FCAS, AEMO will take into account the following principles, as appropriate:

(a) Where an Ancillary Service Facility is used to deliver more than one type of Contingency FCAS, it will be allocated the same Frequency Settings for each.

(b) Ancillary Service Facilities with larger switched blocks of *generation* or *load* will be allocated Frequency Settings closer to the NOFB.

(c) Ancillary Service Facilities with higher availability will be allocated Frequency Settings closer to the NOFB.

(d) For Aggregate Ancillary Service Facilities, where possible, AEMO will negotiate with the FCAS Provider to allocate Frequency Settings to simulate the behaviour of Variable Controllers to minimise the potential for over-delivery of Contingency FCAS.

(e) AEMO will consider the physical characteristics of the Ancillary Service Facilities.

(f) A Frequency Setting:

(i) for Fast FCAS may be a Frequency Deviation Setting or a combination of both the Frequency Deviation Setting and Frequency Rate of Change Multiplier shown in Table 5 for the Mainland and Table 6 for Tasmania; and

(ii) for Slow FCAS or Delayed FCAS will be based on the allocated Frequency Deviation Setting alone.

(g) The criteria for a combined Switching Controller to initiate delivery of a *fast raise service* based on a combination of both Frequency Deviation Setting and Frequency Rate of Change Multiplier is to occur if both of the following conditions are satisfied:

(i) Local Frequency < 49.85; and

(ii) Local Frequency < FDS + (FRCM * LFRC).

Where:

FDS is the allocated Frequency Deviation Setting

FRCM is taken from Table 5 for the Mainland and Table 6 for Tasmania

LFRC is the measured rate of change of Local Frequency

(h) The criteria for a combined Switching Controller to initiate delivery of a *fast lower service* based on a combination of both Frequency Deviation Setting and Frequency Rate of Change Multiplier is to occur if both of the following conditions are satisfied:

(i) if Local Frequency > 50.15; and

(ii) Local Frequency > FDS – (FRCM * LFRC)

Where acronyms in the formula bear the same meanings as in paragraph (g).

6.1.3. FCAS Provider request to Change Allocation

An FCAS Provider may request AEMO to change a Frequency Deviation Setting if there is a technical reason preventing an Ancillary Service Facility from delivering Contingency FCAS due to its Frequency Deviation Setting. AEMO may change the Frequency Deviation Setting in its absolute discretion subject to the principles in section 0.

6.1.4. AEMO request to Change Allocation

The only circumstances in which AEMO may request a change to a Frequency Deviation Setting are the following:

(a) the principles in section 0 have been amended;

(b) the classification of an Ancillary Service Facility that uses a Switching Controller to deliver a Contingency FCAS has changed;

(c) at least 6 months have elapsed since the last change of Frequency Deviation Settings and one or more Ancillary Service Facility has changed its maximum *response capability*; or

(d) a Frequency Disturbance that involved loss of *load* or *generation* has occurred and AEMO has determined that the relevant Frequency Deviation Setting was inadequate under those circumstances.

6.2. Control of Contingency FCAS

6.2.1. No Operation within the Normal Operating Frequency Band

A Switching Controller must not operate if Local Frequency is within the NOFB.

6.2.2. Notification of Control System Settings

Each FCAS Provider must inform AEMO of the details of each relevant *control system* as reasonably required by AEMO for the purposes of *central dispatch* or allocating the Frequency Settings.

Commented [A17]: Replaces current 3.5(f).

Commented [A18]: Does this only apply to Fast FCAS?

Commented [A19]: Replaces current 3.5(d), 4.5(d) & 4.5(d).

6.2.3. Control System Requirements

Commented [A20]: Replaces current 3.5, 4.5 & 5.5.

Commented [A21]: Reflects current 3.5.

Whenever Contingency FCAS is *enabled*, the Ancillary Service Facility used to deliver the requested Contingency FCAS must have a *control system* to automatically initiate:

(a) a Raise Response when Local Frequency changes are below the lower limit of the NOFB; and

(b) a Lower Response when Local Frequency changes are above the upper limit of the NOFB.

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:

(a) for a Variable Controller, a variable 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);

(b) for a Switching Controller, one or more step changes if Local Frequency falls below its Frequency Deviation Setting (for a Raise Respone) or exceeds its Frequency Deviation Setting (for a Lower Response); or

(c) for a discrete combination of both, responses in accordance with sub-paragraphs (a) and (b).

Where a Switching Controller is used, it must be capable of adjusting its Frequency Deviation Setting to the Frequency Setting provided by AEMO with an error margin of <0.05 Hz for absolute Frequency Deviation Settings and <0.05 s for Frequency Rate of Change Multiplier.

6.3. Measurement when using a combination of Variable Controller and Switching Controller

In addition to the requirements specified in section 5.3, when proposing to use a combination of a Variable Controller and a Switching Controller, FCAS Providers must agree with AEMO on the process used to determine separate amounts of each Contingency FCAS that will be delivered through each type of controller.

6.4. Verification

Commented [A22]: Replaces current 3.7, 4.7 and 5.7.

The verification requirements that must be followed by FCAS Providers are provided in Table 7:

Table 7 Verification Requirements of Contingency FCAS

	Fast FCAS	Slow FCAS	Delayed FCAS
Assessment Period - From the Contingency Event Time to Frequency Recovery up to a maximum of:	60 s	300 s	600 s
Calculation Method	The amount of Contingency FCAS delivered must be compared with the amount of *enabled* Contingency FCAS as follows: (a) If the Ancillary Service Facility is a *scheduled generating unit*, *scheduled load* or *semi-scheduled generating unit*, determine the *generation* or electricity consumption trajectory it would be expected to have followed if the Frequency Disturbance had not occurred. (b) Use this trajectory to adjust the measured Generation Amount and Load Amount to reverse any response in a direction that would hinder Frequency Recovery. (c) Remove the impact of any Inertial Response. (d) The difference between the value calculated following paragraph (c) and a measure of the output of the Ancillary Service Facility just prior to the Frequency Disturbance constitutes the Ancillary Service Facility's 'basic response'. (e) Where a Variable Controller was used, the 'basic response' is compensated to take into account the difference between Local Frequency and the Standard Frequency Ramp. (f) Where a Switching Controller, was used the 'basic response' is compensated to take into account the timing difference for Local Frequency to reach the Frequency Setting, compared to the Standard Frequency Ramp. (g) Where a discrete combination of Switching Controller and Variable Controller was used, the compensated 'basic response' is the sum of the compensated 'basic responses' of each.		
Where more than one Contingency FCAS Enabled	If a Slow FCAS was also *enabled*, the Ancillary Service Facility's response should exceed the required response, such that the Slow FCAS can be delivered.	If a Delayed FCAS was also *enabled*, the Ancillary Service Facility's response should exceed the required response such that the Delayed FCAS can be delivered.	
Specification of Market Ancillary Service Offers	The specifications in sections 7.1 and 7.2 are applied to calculate the Fast FCAS offered.	The specifications in sections 8.1 and 8.2 are applied to calculate the Slow FCAS offered.	The specifications in sections 9.1 and 9.2 are applied to calculate the Delayed FCAS offered
Delivery Requirements	The amount of Fast FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.	The amount of a Slow FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.	The amount of Delayed FCAS delivered in response to a change in Local Frequency must be at least equal to the *dispatched* quantity.

6.5. The FCAS Verification Tool

Commented [A23]: Reflects current 2.5.

The FCASVT[5] is available to help calculate the quantity of any Contingency FCAS delivered by an Ancillary Service Facility. It contains detailed algorithms used by AEMO to verify whether Contingency FCAS has been delivered in accordance with the MASS.

If there is any inconsistency between the FCASVT and the MASS, the MASS will prevail to the extent of that inconsistency.

To avoid doubt, the FCASVT is not part of the MASS.

Commented [A24]: See Glossary

7. FAST FCAS REQUIREMENTS

7.1. Specification of Fast Raise Service in Market Ancillary Service Offer

Commented [A25]: Reflects current 3.3.

The amount of *fast raise service* in a *price band* and all cheaper *price bands* is the **lesser** of:

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

(b) twice the Time Average of the Raise Response between 6 s and 60 s from the Frequency Disturbance Time, excluding any Inertial Response,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Raise Reference Frequency while this *price band* is *enabled*.

7.2. Specification of Fast Lower Service in Market Ancillary Service Offer

Commented [A26]: Reflects current 3.4.

The amount of *fast lower service* in a *price band* and all cheaper *price bands* is the **lesser** of:

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

(b) twice the Time Average of the Lower Response between 6 s and 60 s from the Frequency Disturbance Time, excluding any Inertial Response,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Lower Reference Frequency while this *price band* is *enabled*.

7.3. Dispatch

Commented [A27]: Reflects current 3.2.

AEMO will issue *dispatch instructions* for the delivery of Fast FCAS to *enable* the required quantities based on the *market ancillary service offers* received.

During *enablement*, an Ancillary Service Facility must respond to Local Frequency without further instruction from AEMO.

8. SLOW FCAS REQUIREMENTS

8.1. Specification of Slow Raise Service in Market Ancillary Service Offer

Commented [A28]: Reflects current 4.3.

The amount of *slow raise service* in a *price band* and all cheaper *price bands* is the **lesser** of:

[5] Available at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

(a) twice the Time Average of the Raise Response between 6 s and 60 s from the Frequency Disturbance Time, excluding any *fast raise service* provided; and

(b) twice the Time Average of the Raise Response between 60 s and 5 min from the Frequency Disturbance Time,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Raise Reference Frequency while this *price band* is *enabled*.

8.2. Specification of Slow Lower Service in Market Ancillary Service Offer

Commented [A29]: Reflects current 4.4.

The amount of *slow lower service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Lower Response between 6 s and 60 s from the Frequency Disturbance Time, excluding any *fast lower service* provided; and

(b) twice the Time Average of the Lower Response between 60 s and 5 min from the Frequency Disturbance Time,

that the FCAS Provider making the *market ancillary service* offer expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Lower Reference Frequency while the *slow lower service* in this *price band* is *enabled*.

8.3. Dispatch

Commented [A30]: Reflects current 4.2.

AEMO will issue *dispatch instructions* for the delivery of Slow FCAS to *enable* the required quantities based on the *market ancillary service offers* received.

During *enablement*, an Ancillary Service Facility must respond to Local Frequency without further instruction from AEMO.

9. DELAYED FCAS REQUIREMENTS

9.1. Amount of Delayed Raise Service in Market Ancillary Service Offer

Commented [A31]: Reflects current 5.3.

The amount of *delayed raise service* in a *price band* and all cheaper *price bands* is the **lesser** of:

(a) twice the Time Average of the Raise Response between 1 min and 5 min from the Frequency Disturbance Time and *slow raise service* provided; and

(b) the Time Average of the Raise Response between 5 min and 10 min from the Frequency Disturbance Time,

that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* in response to a Standard Frequency Ramp from 50 Hz to the Raise Reference Frequency while the *delayed raise service* in this *price band* is *enabled*.

9.2. Amount of Delayed Lower Service in Market Ancillary Service Offer

Commented [A32]: Reflects current 5.4.

The amount of *delayed lower service* in a *price band* is the **lesser** of:

(a) twice the Time Average of the Lower Response between 1 min and 5 min from the Frequency Disturbance Time and *slow lower service* provided; and

(b) the Time Average of the Lower Response between 5 min and 10 min from the Frequency Disturbance Time,

that the FCAS Provider making the *market ancillary service* offer expects would be delivered at the relevant *connection point* in addition to the amounts in all cheaper *price bands* in response to a Standard Frequency Ramp from 50 Hz to the Lower Reference Frequency while the *delayed lower service* in this *price band* is *enabled*.

10. REGULATION FCAS

10.1. Specification of Regulating Raise Service in Market Ancillary Service Offer

Commented [A33]: Reflects current 6.3

The amount of *regulating raise service* specified in a *price band* must be the amount of Regulating Raise Response that the FCAS Provider making the *market ancillary service offer* expects would be delivered at the relevant *connection point* progressively over a *dispatch interval* in addition to the amounts in all cheaper *price bands* in response to Raise Signals sent to request the maximum possible Regulating Raise Response while this *price band* is *enabled*.

10.2. Specification of Regulating Lower Service in Market Ancillary Service Offer

Commented [A34]: Reflects current 6.4.

The amount of *regulating lower service* specified in a *price band* must be the amount of Regulating Lower Response that the FCAS Provider making the *market ancillary service* offer expects would be delivered at the relevant *connection point* progressively over a *dispatch interval* in addition to the amounts in all cheaper *price bands* in response to Lower Signals sent to request the maximum possible Regulating Lower Response while this *price band* is *enabled*.

10.3. Compliance Monitoring and Action

Commented [A35]: Reflects current 6.5.

AEMO needs assurance that that an Ancillary Service Facility or Aggregated Ancillary Service Facility (as applicable) *enabled* to deliver Regulation FCAS will respond in an accurate and timely manner.

AEMO will monitor the output of Ancillary Service Facilities and Aggregated Ancillary Service Facilities *enabled* to deliver Regulation FCAS in accordance with Appendix A of the Dispatch Procedure.

AEMO may invoke a fixed *constraint* equation until it is reasonably satisfied that the Ancillary Service Facility or Aggregated Ancillary Service Facility (as applicable) responds as contemplated by the MASS.

10.4. Control System

Commented [A36]: Reflects current 6.6.

The Ancillary Service Facility must have a *control system* to:

(a) transmit the Controlled Quantity, Raise Control Limit, Lower Control Limit, Raise Rate Limit and, if different from the Raise Rate Limit, the Lower Rate Limit every 4 s to AEMO via SCADA;

(b) receive Raise Signals and Lower Signals;

(c) when *enabled* for Regulation FCAS, automatically deliver a Regulating Raise Response or a Regulating Lower Response corresponding to those Raise Signals or Lower Signals; and

(d) not suspend the Regulating Raise Response or Regulating Lower Response (as applicable) for more than 60 s during a Frequency Disturbance, and even then, only if Local Frequency has exceeded the Raise Reference Frequency or Lower Reference Frequency.

An Aggregated Ancillary Service Facility's *control system* for *regulating raise service* or *regulating lower service* must only apply to the whole aggregated *generating unit* or *load*.

10.5. Verification

For the purpose of verifying the amount of *regulating raise service* or *regulating lower service* that can be delivered in response to a Raise Signal or a Lower Signal, the amount of service to be compared with the *enabled price bands* of the relevant *market ancillary service* offer must be determined using the recordings made under section 5.3.2 as follows:

(a) If AEMO or the FCAS Provider wishes to verify delivery of Regulation FCAS, AEMO must transmit no Raise Signals or Lower Signals to the relevant Ancillary Service Facility for at least 60 s and then immediately transmit Raise Signals or Lower Signals to the Ancillary Service Facility that would produce either a Regulating Raise Response or Regulating Lower Response equal to the lesser of the sum of the *enabled price bands* of the relevant *market ancillary services offer* and the corresponding Raise Rate Limit or Lower Rate Limit for at least 5 min such that the Controlled Quantity remains at all times between the Raise Control Limit and the Lower Control Limit.

(b) The following procedure must be used:

(i) fit a linear function of time (of the form P = P1 + R1 * t) to the power measurements made during the sixty seconds to which paragraph (a)(i) refers;

(ii) fit a linear function of time (of the form P = P2 + R2 * t) to the earliest power measurements made over the following five minutes that are all greater than (for Regulating Raise Response) or less than (for Regulating Lower Response) the function to which paragraph (b)(i) refers; and

(iii) determine the Regulating Raise Response or Regulating Lower Response as the slope of the function to which paragraph (b)(ii) refers (in MW/min) multiplied by 5 min.

11. TRIALS OF NEW TECHNOLOGIES

11.1. AEMO's Requirements

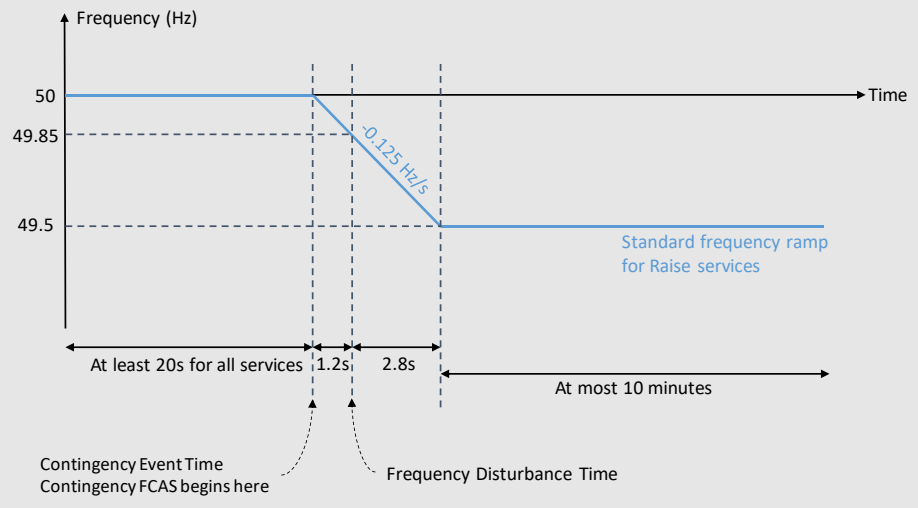
From time to time, a trial to demonstrate the capability of new technologies in the delivery of FCAS may be authorised. Where this occurs, AEMO may specify the capabilities, measurements, verification and other requirements and conditions of the trial in its absolute discretion.

11.2. Report to AEMO

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.

APPENDIX A. STANDARD FREQUENCY RAMP

Figure 1 Standard Frequency Ramp for *regions* other than Tasmania



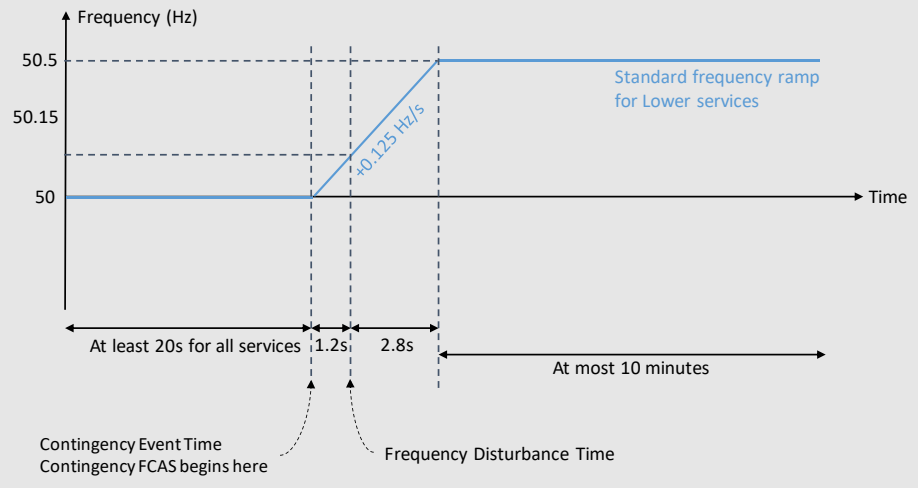


Figure 2 Standard Frequency Ramp for Tasmania