Market Ancillary Service Specification Consultation

May 2022

Issues paper

Important notice

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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 inform and seek feedback on amendments to the MASS required by the *National Electricity Amendment (Fast frequency response market ancillary service) Rule 2021 No. 8* [2] to implement a new frequency control ancillary services (FCAS) market for very fast market ancillary services (**Very Fast FCAS**). AEMO is required to publish the amended MASS by 19 December 2022.

After considering the information available to AEMO at this stage, including the higher incidence of increased rates of change of frequency following contingencies on the power system, as well as technical input from industry representatives, AEMO proposes to specify a Very Fast FCAS with the following attributes:

- 1-second response time.
- 6-second total timeframe.
- Raise/Lower reference frequency at ±0.5 Hz for the Mainland and ±2 Hz for Tasmania, in line with other Contingency FCAS.
- An assumed frequency ramp rate of 1 Hz/s.

The above parameters of Very Fast FCAS are key matters to be decided by way of this consultation. This Issues Paper also explains how AEMO proposes to address matters arising from the introduction of Very Fast FCAS, such as the interaction with (and impact on) other FCAS, inertia and primary frequency response, and the requirements for appropriate measurement and verification. AEMO seeks feedback on its consideration of these matters, including responses to the questions posed at the end of each section using the template response provided with this Issues Paper. AEMO has commissioned detailed analysis to inform the selection of suitable measurement requirements and expects to report on this prior to closure of submissions on the Issues Paper.

Although not a matter for the MASS, it is also important for potential providers of Very Fast FCAS to be aware of the probability that the proportion of switched response enabled in the FCAS mix will need to be managed in future to ensure sufficient variable control facilities are available to meet the NEM power system security needs. While these considerations affect FCAS of all types, they will be exacerbated with Very Fast FCAS.

Due to the mandated timeframe for completion of the MASS changes required for the introduction of Very Fast FCAS, the focus of this consultation is limited to matters that are strongly related to these new services. A number of other potential MASS reforms were identified in 2021, and these will be progressed outside the current consultation.

AEMO invites submissions on its proposed MASS amendments, including any unintended adverse consequences, and potential alternatives that interested parties consider might better achieve the objectives of this consultation (including the National Electricity Objective[3]).

[1] The MASS is available at http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Market-ancillary-services-specifications-and-FCAS-verification.

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

[3] See section 7 of the National Electricity Law.

Submissions on the MASS Issues Paper should be forwarded to mass.consultation@aemo.com.au by 5.00 pm (AEDT) on Tuesday 14 June 2022.

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1 Background

1.1 Context for this consultation

In July 2021, the Australian Energy Market Commission (**AEMC**) published the *National Electricity Amendment (Fast frequency response market ancillary service) Rule 2021 No. 8*[4] (**Amending Rule**), which introduces two new market ancillary services (**FCAS**) to help control power system frequency and keep the power system secure. These new services are the very fast lower service and very fast raise service, referred to collectively in this Paper as **Very Fast FCAS**.

The Amending Rule requires AEMO to amend and publish the market ancillary service specification (**MASS**) by 19 December 2022, with the amended MASS to take effect on 9 October 2023.

As for all existing FCAS, the MASS needs to incorporate:

- A detailed description of Very Fast FCAS in accordance with clause 3.11.2(b)(1) of the Amending Rule.
- The performance parameters and requirements for a service to qualify as Very Fast FCAS, and to be met when Very Fast FCAS is delivered, each in accordance with clause 3.11.2(b)(2) of the National Electricity Rules (**NER**).

1.2 Other NER requirements

Clause 3.11.2(f) defines the additional monitoring required to provide FCAS while clause 3.11.2(g) requires AEMO to develop standards that must be met when installing and maintaining the required equipment.

Further background on the MASS and its relationship with other instruments and governance institutions in the National Electricity Market (**NEM**) can be found in section 5.5.2 of AEMO's (first) Draft Determination in its 2021 consultation on amendments to the MASS[5].

When amending the MASS, AEMO must comply with the Rules consultation procedures[6]. The release of this Issues Paper and the Notice of First Stage of Consultation commences the first stage of consultation under those procedures. AEMO invites feedback on the issues and proposals discussed in this Paper from NEM registered participants and other interested parties (**Consulted Persons**).

1.3 Recent MASS consultation

Following a lengthy consultation to amend the MASS to address the measurement arrangements for the provision of FCAS by aggregated ancillary service facilities and the restructure of the MASS that concluded on 22 December 2021, Version 7 of the MASS took effect on 1 February 2022.

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

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

[6] See rule 8.9 of the NER.

1.3.1 Deferred issues

During the 2021 MASS consultation, AEMO deferred consideration of potential amendments to address the following matters, pending the outcomes of ongoing regulatory processes:

- Fast Frequency Response (**FFR**) - deferred pending finalisation of the Amending Rule.
- Refining and clarifying proportional controller activation ranges and service termination settings – deferred pending finalisation of the primary frequency response (**PFR**) incentive arrangements rule[7].
- Clarifying how Delayed FCAS should support the return of frequency to its nominal value of 50 Hz, rather than to the edge of the normal operating frequency band (**NOFB**), including how pure proportional controllers should be valued – also pending finalisation of the PFR incentive arrangements rule.

This consultation will only address the first of these issues. The second and third will require further consultation after the AEMC makes its final rule on PFR incentive arrangements.

1.3.2 Consultative Forum

In June 2021[8], AEMO outlined a proposal to establish a Consultative Forum as a vehicle for collaboration between AEMO and interested stakeholders to raise, prioritise, and progress issues relating to the development of FCAS, in particular, concerns with distributed energy resource (**DER**) inverter behaviour. The Consultative Forum would establish issue-specific working groups tasked with progressing issues and providing advice to the Consultative Forum for consideration and action. Stakeholders were invited to register an expression of interest to participate.

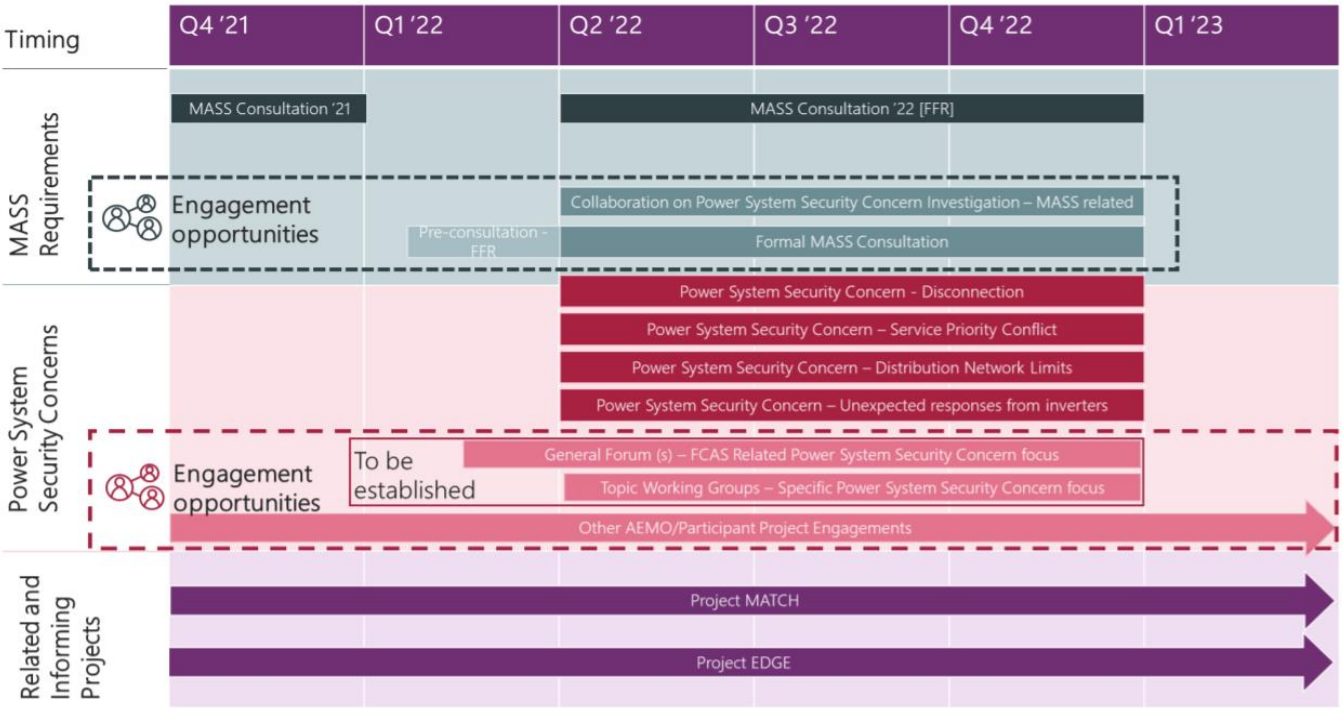
In October 2021[9], AEMO published an indicative roadmap, reproduced in Figure 1, showing all the work AEMO is engaged in that has a direct impact on the FCAS markets.

[7] See the documents available at https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements.

[8] (First) Draft Report and Determination, available at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/second-stage/mass-draft-determination-2021.pdf?la=en.

[9] Second Draft Report and Determination, available at https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2021/mass/third-stage/amendment-of-the-mass-der-general-consultation-second-draft-determination.pdf?la=en.

Figure 1 Indicative Roadmap from AEMO's 2021 second draft determination



Support from industry for the establishment of the Consultative Forum and the contents of the indicative roadmap was extensive. Some stakeholders suggested that AEMO integrate the Consultative Forum with other industry working groups.

At the conclusion of the 2021 MASS consultation, the potential issues suggested for further examination by the Consultative Forum include those listed in Table 1, which separates them into issues related exclusively to DER, and general issues.

Table 1 Issues identified during the 2021 MASS consultation as requiring further work

ISSUES	
DER	
1	Power system security concerns associated with DER providing FCAS, including whether a variety of frequency set-points and different DUIDs for small customers would help to alleviate system security concerns.
2	DER inverter behaviour, especially uncontrolled oscillations in response to grid disturbances.
3	Measures to mitigate the risk of exceeding the limits of secure distribution network operation limits during the provision of FCAS by DER.
4	Whether greater alignment with specifications in other standards is warranted, in particular the application of AS/NZS4777 2:2020.
5	Formalise AEMO's and DER provider/virtual power plant (VPP) data-sharing arrangements.
6	Possibility of using separate DUIDs and minimum bid levels to support a lower cost and more flexible future residential DER regime.
7	Whether adjustment of minimum bid and other market settings might facilitate greater DER market innovation and participation.
8	How the technical envelopes and operating conditions of distribution networks can be adjusted to facilitate greater DER penetration.
9	What appropriate compliance mechanisms should be for response and measurement, particularly given that the MASS was originally implicitly written for specialist power quality measurement instrumentation – typically being calibrated in a traceable manner– and cost-effective DER necessitates inherently lower-cost approaches.

ISSUES	
GENERAL	
1	Transparency around testing protocols for inverters.
2	Publication of a list of all meters approved by AEMO for Fast FCAS.
3	How Very Fast FCAS is best incorporated within the MASS.
4	Development of trials to facilitate specification of Very Fast FCAS.
5	Comprehensive redesign of FCAS that ensure local as well as global grid security requirements are addressed.
6	Whether to separate frequency controllers and FCAS metering requirements.
7	Guidance on limits and management of non-frequency responsive FCAS.
8	How Delayed FCAS could better support frequency outcomes.
9	Continued development of Regulation FCAS specification.

These and similar issues (see also section 6) sit on a broad spectrum of matters associated with industry change, including the growing role of DER in the NEM. As such, a number of these matters are outside the scope of the MASS but are still related to FCAS provision. AEMO notes that the intention behind the proposed Consultative Forum is to focus on the development of market ancillary services, including related concerns around DER inverter behaviour. As several industry participants have noted, there are existing working groups or other forums which can be used to address these issues.

AEMO notes that the Consultative Forum concept is similar in purpose to the currently dormant Ancillary Services Technical Advisory Group (ASTAG). AEMO proposes to provide a forum by re-instating the ASTAG.

The ASTAG can:

- Note and monitor the issues already being addressed in existing forums
- Discuss and determine general directions for FCAS-related issues not currently being addressed elsewhere.

AEMO will aim to schedule the first (re-instated) ASTAG to be held by 1 June.

The DER-specific issues will not be addressed during this consultation, either because they involve matters outside the scope of the MASS or because it is not feasible to resolve them within the prescribed timeframes to complete the MASS amendments for Very Fast FCAS. It would be appropriate for these issues to be considered by the ASTAG.

In relation to the 'General' issues in Table 1, this consultation will address items 3 and 4 and touch on aspects of item 7. The remaining 'General' matters require more time and resources than are available for completing the Very Fast FCAS specification within the time allowed by the NER for this consultation, and are not so urgent that they must be addressed in the very short term. AEMO intends that they will be considered:

- If within the scope of the MASS, in a future consultation with input from the ASTAG on priorities as appropriate.
- Otherwise, through the ASTAG or as part of other suitable reform workstreams. .

1.4 Industry advice

In preparing for this consultation, AEMO assembled a representative technical working group with a range of specialists from industry. This technical working group provided expertise that assisted AEMO in developing this

Issues Paper with the intent of providing a better foundation for the consultation. AEMO is grateful for the contribution of all working group members.

Questions

1. Are there any further issues for investigation by the Consultative Forum that are **relevant** to the specification of Very Fast FCAS?

2 Overview of the Contingency FCAS markets

2.1 Current state

There are eight types of FCAS, each of which is procured by AEMO through a spot market. Each type provides a different service and, collectively, they assist AEMO's management of power system frequency within the limits prescribed by the frequency operating standard (**FOS**).

Because Very Fast FCAS is defined in the Amending Rule as a new type of Contingency FCAS, this Paper will focus on Contingency FCAS, of which there are currently six.

For completeness, the eight FCAS are shown in Figure 2.

Figure 2 FCAS types and inter-relationships

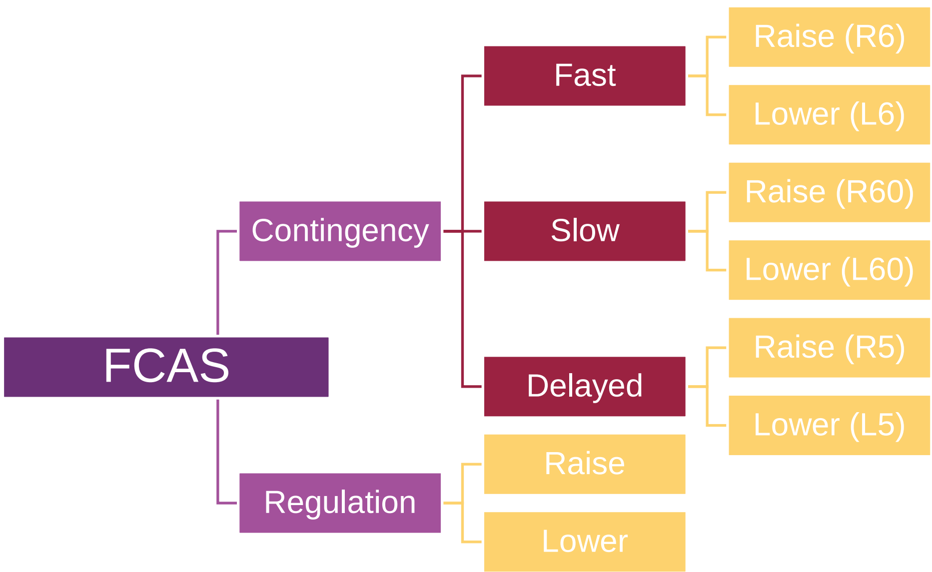


Table 2 shows the registered capacity in MW for each of the Contingency FCAS markets, which has increased significantly since AEMO published a similar table in AEMO's 2021 technical advice to the AEMC on FFR implementation options[10].

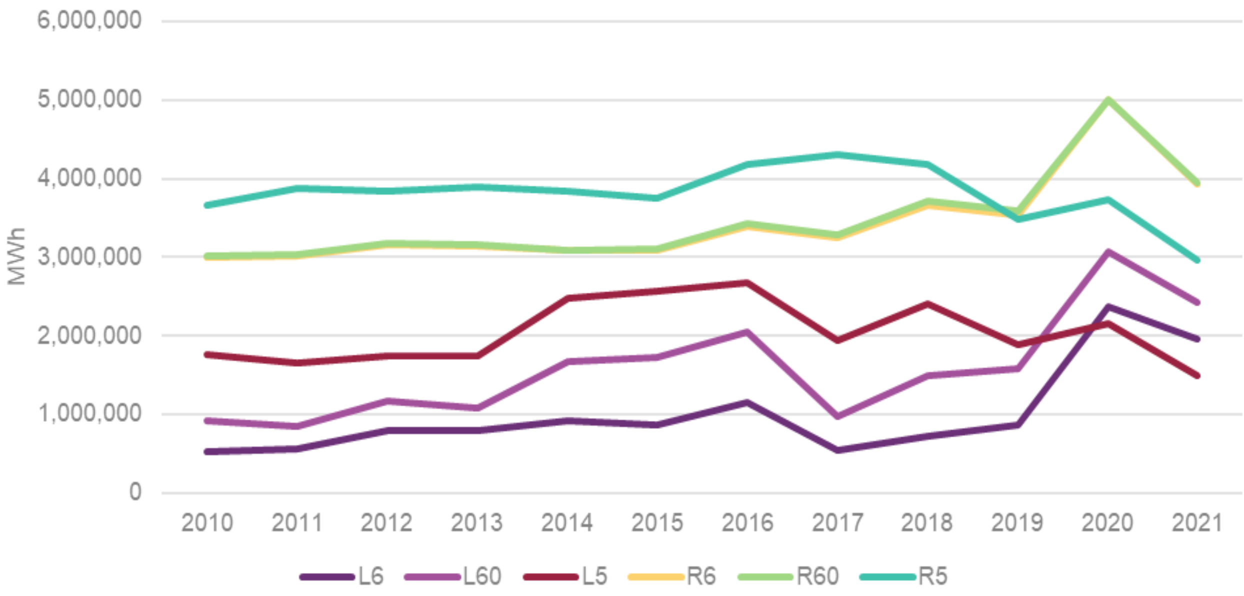
[10] Available at https://www.aemc.gov.au/sites/default/files/2021-04/FFR%20Implementation%20options%20-%20FINAL.pdf, at page 48.

Table 2 Current state of Contingency FCAS markets

	R6	R60	R5	L6	L60	L5
MW registered[11]	5,273.5	9,458.4	8,619.9	3,863	8,113	9,329
Number of Facilities[12]	120	133	125	108	122	113
Number of Providers[13]	28	22	30	22	26	24

The size of the Contingency FCAS markets has not grown greatly over the last 10 years in volume, other than during 2020, when the assumed contribution of load relief was reduced, leading to higher Contingency FCAS volumes. However, there are significant differences in the size of the market revenues in each market, with R6 showing the highest growth, as shown in Figure 3 and Figure 4[14].

Figure 3 Total enabled volume of Contingency FCAS in the last 11 years



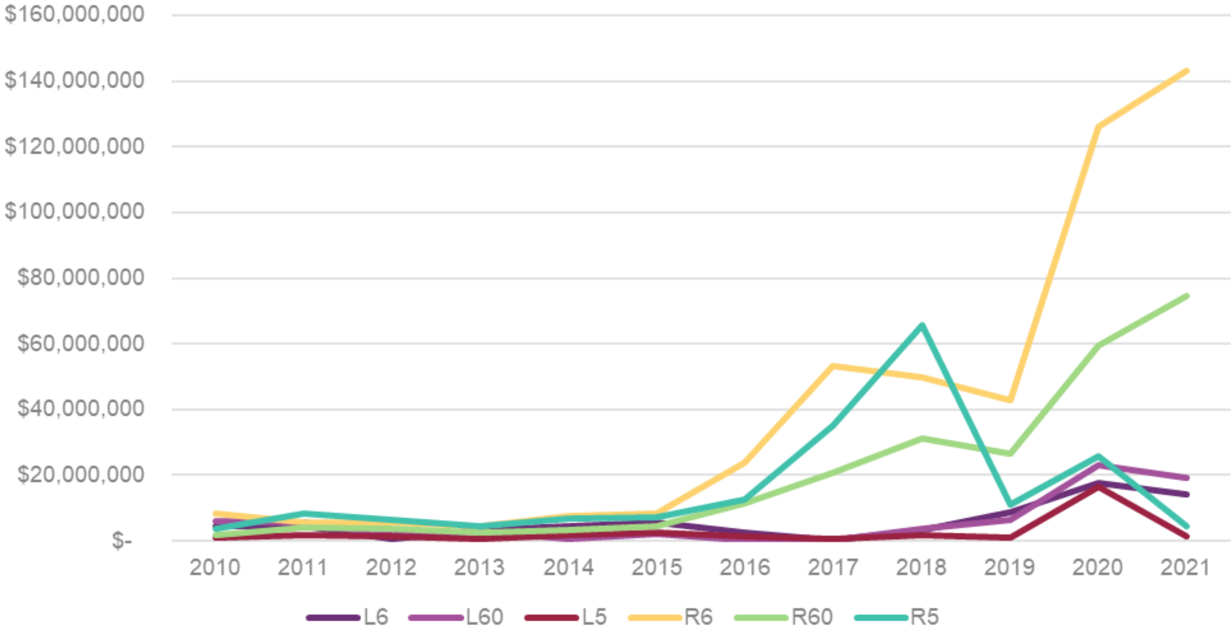
[11] Figures current as at 12 April 2022.

[12] By *generating unit*, not *power station*.

[13] FCAS Providers that are related, or subsidiary, entities are counted as one.

[14] Noting that R6 figures are up to October 2021.

Figure 4 Total Contingency FCAS market revenue in the last 11 years



2.2 Sources of Contingency FCAS

By capacity, plant classified to provide Contingency FCAS is dominated by coal and hydro generation plant, as can be seen from Figure 5. Figure 5 indicates that by capacity, the Fast FCAS markets have the smallest pool of *facilities* and at present are still dominated by black coal and hydro technologies. For comparison, Figure 6 shows the enabled amount of Contingency FCAS over the last decade by fuel type, which shows that hydro and coal's enablement share has been ceding to battery storage, loads and aggregated facilities over the last few years, a trend that is expected to continue.

Figure 5 Registered Contingency FCAS capacity by fuel type

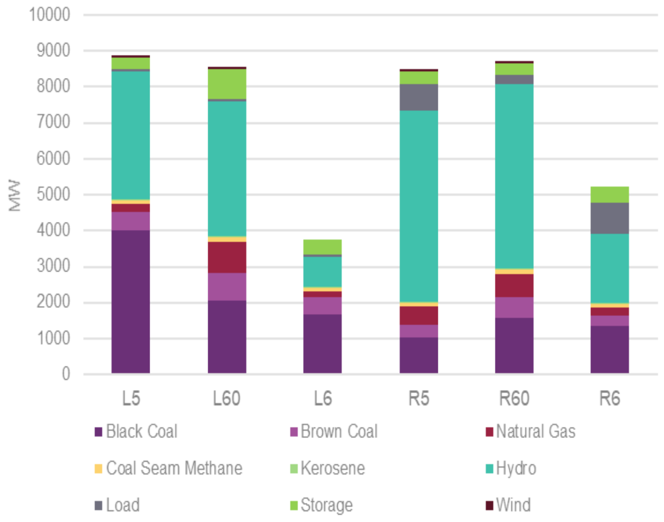
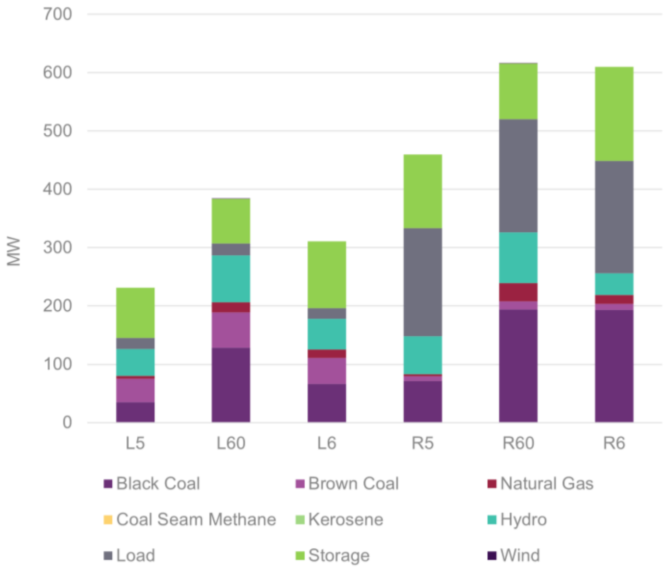


Figure 6 Enabled Contingency FCAS capacity by fuel type



In determining the feasibility of a given specification for Very Fast FCAS, AEMO will be guided by these observations and the technology considerations in Section 1.

3 Capability of different technologies to deliver Very Fast FCAS

CIGRE recently published Technical Brochure C2/C4[15] (**CIGRE Brochure**), on the Impact of High Penetration of Inverter-Based Generation on System Inertia of Networks.

The CIGRE Brochure includes a comparison of the FFR response times of different types of technologies. Table 3 is an extract of Table 5.5 from the CIGRE Brochure, detailing pertinent data for this consultation.

Table 3 Summary of potential FFR capabilities of various technologies

Technology	Time to full response	Sustained response
Synchronous Generation (including pumped hydro and compressed air storage)	2 seconds	Yes
Load	0.25 – 0.5 second	Yes
Wind Turbine	0.5 – 1 second[16]	Few seconds with recovery. Ineffective at low wind speed.
Solar PV	0.5 – 1 second	Yes, depending on the sun.
Battery Storage	0.2 – 1 second	Yes, depending on state of charge.
Supercapacitor	<0.2 second	Only a few seconds. Depends on size.
Flywheel	<0.01 second	<15 minutes
HVDC Voltage Source Converter	0.2 – 1 second	No. Depends on available energy.

For another discussion of different technology FFR capabilities, see the North American Electric Reliability Corporation (**NERC**) White Paper titled "Fast Frequency Response Concepts and Bulk Power System Reliability Needs NERC Inverter-Based Resource Performance Task Force"[17], which also details specific plant capabilities by manufacturer. This White Paper exhibits reasonable agreement with the FFR capabilities outlined in the CIGRE Brochure.

In 2017, AEMO published a working paper as part of its Future Power System Security Program titled Fast Frequency Response in the NEM[18], which also explored the capabilities of different technologies. Table 2 in that paper highlighted some examples of inverter-connected technologies that could deliver FFR. It also identified which technologies could provide a sustained response, where sustained means the potential for maintaining the response for tens of seconds or longer. Those technologies included:

- Wind farms that use wind pitch control to rotate the blades to precisely follow a set point below the total available power.
- Solar PV farms that use controls to precisely follow a set point below the total available power.

[15] Available at https://e-cigre.org/publication/851-impact-of-high-penetration-of-inverter-based-generation-on-system-inertia-of-networks.

[16] AEMO understands that there is potential to tailor this for faster response times, but manufacturers advised in 2017 that there are likely to be tower stress constraints that will limit the speed of response. See page 19 of AEMO's submission to the AEMC's System Security Market Frameworks Review Directions Paper, dated 26 April 2017, available at https://www.aemc.gov.au/sites/default/files/content/917b38b1-2f61-4601-a72e-f084cba0e2ce/MarketReview-Submission-EPR0053-AEMO-170426.pdf.

[17] Available at https://www.nerc.com/comm/PC/InverterBased%20Resource%20Performance%20Task%20Force%20IRPT/Fast_Frequency_Response_Concepts_and_BPS_Reliability_Needs_White_Paper.pdf.

[18] Available at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/reports/2017/ffr-working-paper.pdf.

- Batteries that can very rapidly adjust active power supply or demand in response to a range of types of control signals.
- Demand-side response can rapidly reduce consumption, providing Raise FCAS without the need to reserve headroom.
- Aggregators can deliver changes in active power supply or demand from loads, distributed storage, and DER.

At present, there are no wind farms or solar farms registered to provide Fast FCAS, yet there is 5,825 MW of solar generation and 9,346 MW of wind generation in the NEM[19]. Global-Roam & Greenview Strategic Consulting noted recently that solar and wind power purchase agreements hinder the desire to constrain output so as to be able to provide FCAS[20].

Questions

2. Do you agree with the capabilities expressed in Table 3? If not, please advise which of these you do not agree with and provide evidence to support alternative capabilities.
3. Are there any technologies not mentioned in Table 3 that could potentially provide Very Fast FCAS? If so, what characteristics (including response time) could be expected of them? Please provide evidence to support their capabilities.
4. How could wind farm and solar farm operators be incentivised to participate in the Very Fast FCAS markets? What are the technical barriers impeding participation? For example, this may be a conflict of voltage disturbance controls with frequency response controls.
5. Are there any other issues relevant to the capability to provide Very Fast FCAS by different technologies that AEMO should consider?

[19] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

[20] Page 13, Deep Dive 08 – Frequency Performance, GenInsights21, Global-Roam and Greenview Strategic Consulting, December 2021.

4 Proposed design of Very Fast FCAS markets

4.1 Guidance from the AEMC

In its final report on the Amending Rule[21], the AEMC discussed the rationale for prescribing new services, rather than reconfiguring Contingency FCAS to accommodate Very Fast FCAS. The Amending Rule, in effect, requires that Very Fast FCAS have some overlap with Fast FCAS, as seen in Figure 7, which is extracted from the AEMC's final report. The nature of the overlap was left for AEMO to specify in the MASS and is therefore a key issue to be resolved during this consultation.

Figure 7 Very Fast FCAS (Fast Frequency Response) against full suite of Contingency FCAS

4.2 Guidance from other FFR markets

The CIGRE Brochure considers several other existing markets for the procurement of FFR, and AEMO is actively sharing information on FFR design issues with a number of other market operators. Table 4 lists the key performance requirements of each FFR market included in the CIGRE Brochure.

[21] AEMC, Fast Frequency Response Market Ancillary Service, Final report, 15 July 2021. Available at https://www.aemc.gov.au/rule-changes/fast-frequency-response-market-ancillary-service.

Table 4 Key performance requirements in other FFR markets[22]

Parameter	CEN[23]	EirGrid[24]	ERCOT[25]	ONS[26]	National Grid[27,28]	Nordic TSOs
Time to Respond	1 second	<2 seconds	0.5 second[29] 0.25 second	<1 second	1 second	0.7 second – 1.3 second
Sustain Time	>5 minutes	>8 seconds	1 hour 15 minutes	5 seconds	15 minutes	>5 seconds[30]

It must be appreciated that each power system has its own unique challenges, and the design of any FFR market addresses the needs of that power system. Nonetheless, it can be seen that there is not much variation between markets in specifying a response time around the 1-second mark. More variation can be seen with the sustain time, but the choice of this parameter is arguably more a result of the design of the other frequency control arrangements in those markets.

Questions

6. Are there any specific useful lessons to be learned from other FFR markets around the world?

4.3 Proposed design of Very Fast FCAS markets

In designing the proposed Very Fast FCAS markets for the NEM, AEMO will be guided by the following principles:

- Power system security considerations are paramount.
- Very Fast FCAS should be utilised to fulfil a need that Fast FCAS cannot.
- If possible, the markets should be simple.
- If possible, the markets should maintain consistency with the existing Contingency FCAS markets.
- Unless there is a clear power system need to adjust the requirements for registration, the registration of existing Fast FCAS Providers should remain unaffected.

[22] Information extracted from the CIGRE Brochure, available at https://e-cigre.org/publication/851-impact-of-high-penetration-of-inverter-based-generation-on-system-inertia-of-networks, NERC Industry Webinar – White Paper: Fast Frequency response Concepts and Bulk Power System Reliablity Needs, available at https://www.nerc.com/comm/PC/IRPTF_Webinars_DL/2020-04_Webinar-FFR_White_Paper.pd - 16 April 2020, and CIGRE - JWG C2/C4.41: Impact of High Penetration of Inverter-Based Generation on System Inertia of Networks – 10 December, 2020, available at http://cigre.ru/research_commitets/ik_rus/c2_rus/materials/library/WBN022%20-%20C2.C4.41%20-%20Dec20.pdf.

[23] Coordinator Electrico Nacional (Chile).

[24] The state-owned electric power transmission operator in Ireland.

[25] Electric Reliability Council of Texas.

[26] Operator Nacional do Sistema Electrico (Brazil).

[27] National Grid ESO is the electricity system operator for Great Britain.

[28] National Grid information has been assessed against the new relatively new “Dynamic Containment” and “Dynamic Moderation” markets and remains appropriate.

[29] ERCOT has two FFR products.

[30] If the power deactivation rate is no more than 20% of the FFR capacity per second. If the deactivation rate is higher, the minimum duration of activation is 30 seconds. See https://www.fingrid.fi/en/electricity-market/reserves_and_balancing/fast-frequency-reserve/#technical-requirements.

- If possible, existing FCAS Providers who wish to provide Very Fast FCAS should be able to integrate their provision of Very Fast FCAS with the provision of other types of Contingency FCAS and use the same measurement equipment.
- If practicable, the design should be technology neutral.

4.3.1 Principles underpinning Very Fast FCAS market design

AEMO proposes to adopt a Very Fast FCAS design with the following properties:

- Very Fast FCAS will be 'overlapped' with Fast FCAS consistent with the manner that the existing Fast FCAS overlaps with Slow FCAS.
- Inertia will not be treated as Very Fast FCAS, as per existing Contingency FCAS arrangements.
- The design is independent of, but compatible with, the Primary Frequency Response (PFR) requirements.
- Concepts such as assumed frequency ramp rates, reference frequencies, etc. will be utilised in Very Fast FCAS as they are in other Contingency FCAS.

While not part of the scope of this Consultation, AEMO expects that Very Fast FCAS will also ultimately have these properties:

- Procurement will be inertia-aware: that is, the procurement volumes for Very Fast FCAS will take into account the level of system inertia.
- Procurement may need to take into account geographic limitations, for example, at a regional level.
- The level of proportional and pure-switched response comprising Very Fast FCAS will need to be managed.

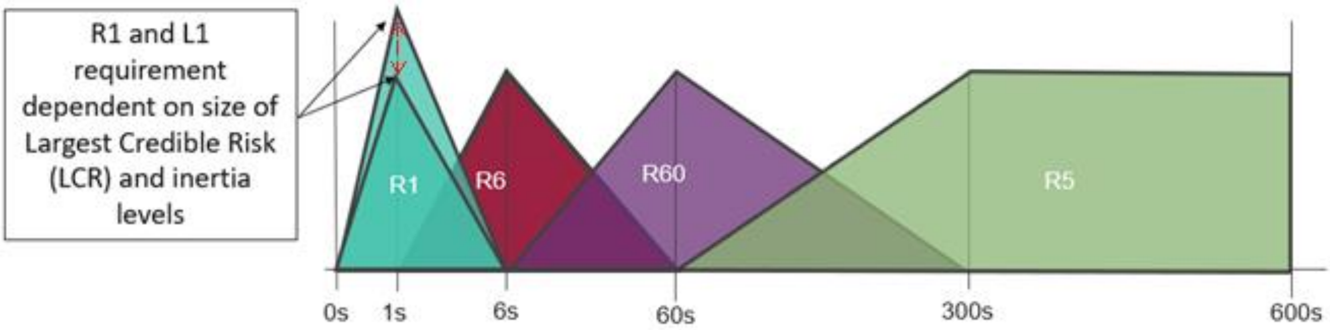
4.3.2 AEMO's proposed high level market design

As stated in Section 4.3.1, AEMO proposes that Very Fast FCAS be specified a manner that reflects the existing relationship between Fast and Slow FCAS. That is, the 'ramp up time'[31] of Very Fast FCAS would coincide with the commencement of Fast FCAS, mirroring how Fast FCAS peaks at the time Slow FCAS commences (i.e. the 6-second mark). An implication of this is that the Fast FCAS measurement window must be shifted to accommodate Very Fast FCAS. Assuming a Very Fast FCAS designed with a 1-second ramp up time, this leads to the design shown in Figure 8.

Figure 8 also shows how it is expected that Very Fast FCAS would be inertia-aware: an estimate of system inertia would be a factor in the constraint equations governing procurement volumes. While the procurement methodologies for Very Fast FCAS are not addressed in the MASS, an illustration of anticipated procurement arrangements is useful in describing the context for Very Fast FCAS markets.

[31] That is, the critical time no later than which the FCAS should achieve its maximum response. For example, this would be the 6-second mark for Fast FCAS or 60-second mark for Slow FCAS.

Figure 8 Very Fast FCAS requirement based on largest credible risk (LCR) and inertia levels



Questions

7. Are there any issues with the concept of shifting Fast FCAS to accommodate a similar, but faster, Very Fast FCAS? Is there a better alternative that is compatible with the Amending Rule?
8. Are there any other issues relevant to market design that AEMO should consider?

4.3.3 Impact of inertia

In the NEM, inertia is not currently a market ancillary service. The AEMC is considering the provision of inertia and related services through the Synchronous Services Markets and Capacity Commitment Mechanism rule change requests[32].

Hence, at this stage, inertia is not within the scope of this consultation other than as referred to in section Figure 1.

Nevertheless, it should be noted that:

- FFR, or something like FFR, is capable of forming the basis of an inertia support activity under the NER framework for maintaining secure levels of inertia in each NEM inertia sub-network (currently the regions)[33].
- The availability of inertia support activities can reduce the level of inertia requirements in a region, and hence reduce or eliminate an inertia shortfall that would otherwise arise.
- Very Fast FCAS is designed to be provided under system intact conditions, whereas an inertia support activity is likely to be required where a region is, or is likely to be, operating under islanded conditions.
- To date, AEMO has declared inertia shortfalls in South Australia, Tasmania and Queensland[34].

On the relationship between inertia and FFR, AEMO advised the AEMC in 2017[35] that:

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[32] See the AEMC's list of rule change projects at https://www.aemc.gov.au/our-work/changing-energy-rules/rule-changes.

[33] AEMO's Inertia Requirements Methodology, available at https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-security-market-frameworks-review/2018/inertia_requirements_methodology_published.pdf?la=en.

[34] AEMO's latest System Strength Security Reports are available at: https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/planning-for-operability

[35] See page 19-20 of AEMO's submission to the AEMC's System Security Market Frameworks Review Directions Paper, dated 26 April 2017, available at https://www.aemc.gov.au/sites/default/files/content/917b38b1-2f61-4601-a72e-f084cba0e2ce/MarketReview-Submission-EPR0053-AEMO-170426.pdf.

- The need for inertia is related to surviving non-credible, protected events such as separation of a region, which are associated with very extreme rate of change of frequency (**RoCoF**) levels (2-3Hz/s).
- This means that for FFR to effectively "substitute" for inertia in managing these events, it would need to act very rapidly to arrest the frequency decline. For example:
  - A RoCoF of 2Hz/s would require a full FFR response in less than 500ms (to avoid UFLS).
  - A RoCoF of 3Hz/s would require a full FFR response in less than 330ms.

Inertia from synchronous generation or synthetic inertia from other technology will not be included as Very Fast FCAS for the following reasons:

- Consistency with the specification of other types of FCAS.
- FCAS and inertia are not directly interchangeable.
- If Very Fast FCAS is to be sustained for 6 seconds as shown in Figure 8, inertia cannot be sustained within this timeframe.
- The Amending Rule indicates that inertia is a separate service and likely best procured through other mechanisms.
- Subsequently, in December 2021, the AEMC received a rule change request[36] from the Australian Energy Council (**AEC**) relating to the efficient provision of inertia.

Questions

9. Are there any other issues relevant to the impact of inertia that AEMO should consider?

4.3.4 Primary Frequency Response

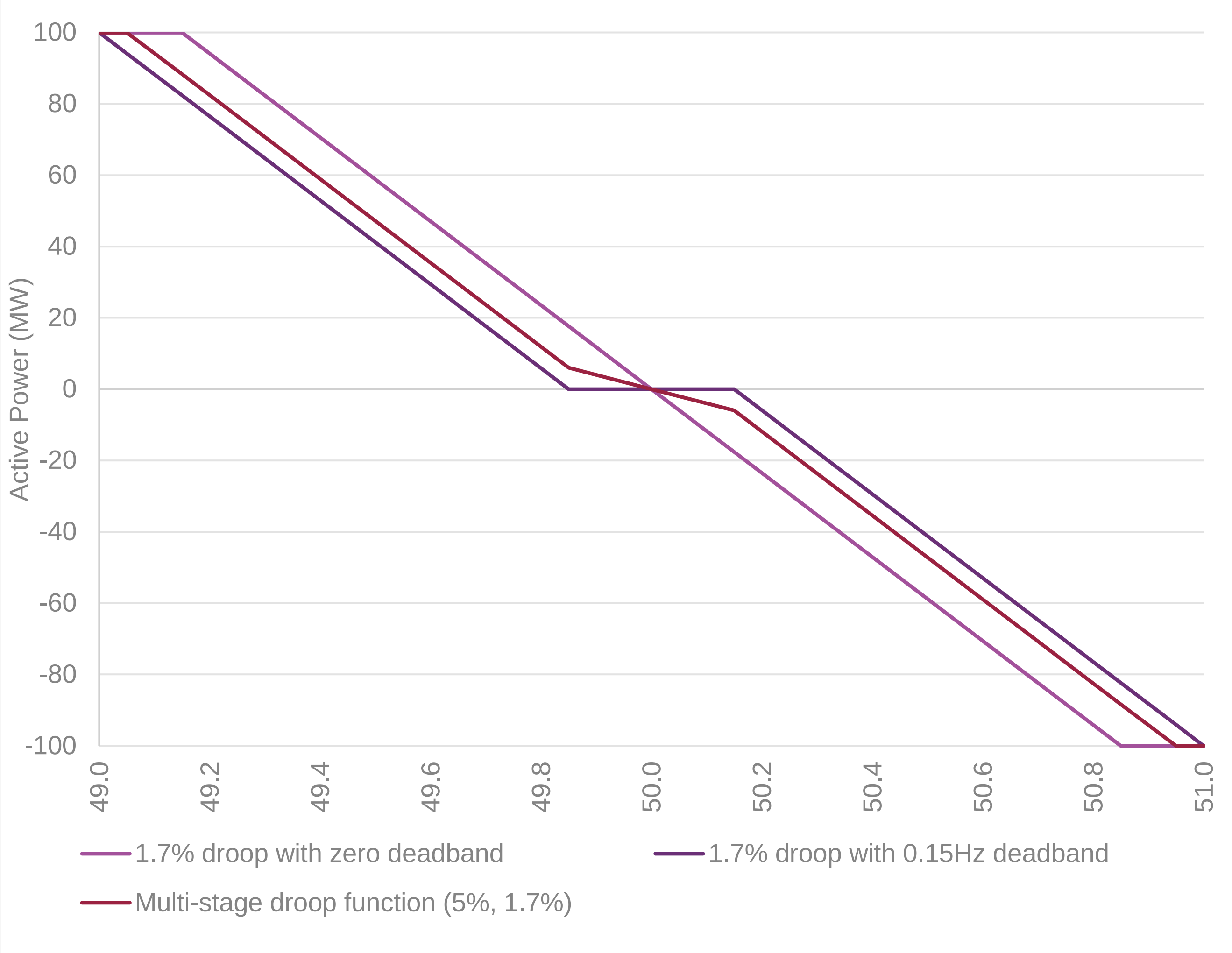
AEMO considers that the proposed design of Very Fast FCAS is compatible with the provision of PFR in the NEM. AEMO proposes to treat Very Fast FCAS in the same manner as Fast FCAS when considering its interaction with PFR: if provided in the relevant timeframes and otherwise consistent with the requirements of the relevant Contingency FCAS, PFR will be treated as Contingency FCAS.

AEMO's previous two MASS consultations emphasised the principle that all 'genuine' frequency response should count towards Contingency FCAS, regardless of whether it is delivered by a PFR mechanism, or whether it is inside or outside of the NOFB. This approach will continue for Very Fast FCAS.

AEMO notes that FCAS Providers can also take steps to manage the interaction between PFR and FCAS controls by applying variable droop settings to reduce plant sensitivity to small frequency changes. For example, all three examples of frequency response functions shown in Figure 9 are compatible with both PFR and Contingency FCAS obligations:

[36] Available at https://www.aemc.gov.au/sites/default/files/2021-12/ERC0339%20Rule%20change%20request%20pending.pdf.

Figure 9 Example frequency response functions compatible with PFR and Contingency FCAS obligations



Questions

10. Are there any other issues relevant to the interaction between Very Fast FCAS and PFR that AEMO should consider?

4.4 Existing capability to deliver Very Fast FCAS

As this Paper describes, there are several potential sources of Contingency FCAS. As shown in Table 3 in Section 1, however, the specification of a service needed to deliver FFR is unlikely to be met by all types of technology that currently provide existing Contingency FCAS.

AEMO recognises that the specification for Very Fast FCAS will affect the availability of facilities that can meet it. For example, if the critical response time AEMO specifies is 1 second, this could mean that a significant portion of coal, gas and hydro generation would be unable to offer material quantities. If we consider the current technology mix in the Fast FCAS markets in Figure 10 and as a hypothetical exercise, remove these technologies, Contingency FCAS availability would look like Figure 11.

Figure 10 Current technology mix in Fast FCAS markets

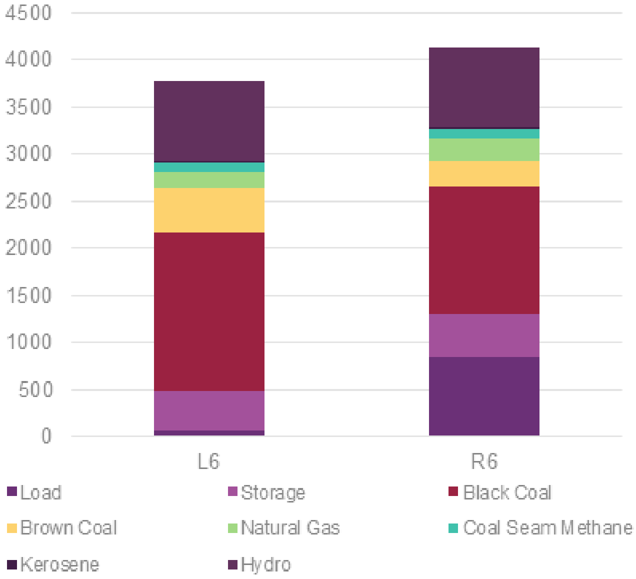
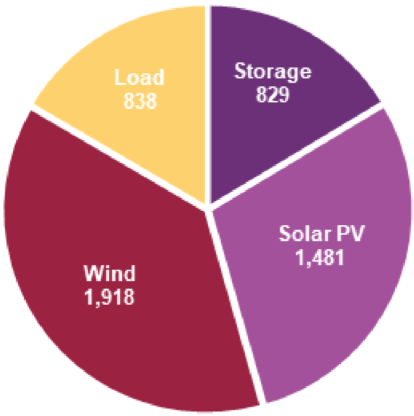


Figure 11 Technology mix in Fast FCAS markets without combustion and hydro

This discussion would, however, be incomplete without considering the total resource pool in the NEM, because only a subset of the available resources is currently providing FCAS. If one considers all storage, wind, solar and load that is classified as market generation or scheduled loads (as applicable) with AGC capability, there is a pool of around 5,000 MW of resources that could very likely meet a 1-second response time specification, as shown in Figure 12, and around 800 MW awaiting registration, not to mention the additional 4,355 MW of committed generation[37] that could also meet this specification.

[37] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/nem-forecasting-and-planning/forecasting-and-planning-data/generation-information.

Figure 12 Existing resources that would likely meet a 1-second response time specification (by MW)



AEMO recognises that not all of these resources could or would be applied to the provision of FCAS, for which registration is voluntary. Indeed, the current lack of participation by wind farm operators in the FCAS markets, especially Fast FCAS, indicates a possible reluctance to participate, noting there are also technical challenges. AEMO understands that wind inertia-based FFR could typically provide around 10% of its maximum operating level when operating at higher levels, however, AEMO also understands that this capability is only available for some wind farm technologies, and other technical impediments to using this capability exist.

Of the existing registered Fast FCAS Ancillary Service Facilities, AEMO considers that at least 25 (across 16 owners) are likely to meet the proposed Very Fast FCAS specification outlined in this Paper, subject to yet-to-be-defined metering requirements.

Questions

11. Does a 1-second response time specification automatically exclude certain technologies from being able to participate in the Very Fast FCAS markets? Which ones and why?
12. Is there anything else AEMO should consider in maximising the pool of potential Very Fast FCAS?

5 Specification of Very Fast FCAS and other changes to the MASS

5.1 Need for Very Fast FCAS

5.1.1 Mainland

Experience demonstrates that Fast FCAS is adequate for maintaining power system frequency during credible contingency events. Specifically, AEMO does not have present concerns regarding maintaining frequency within the containment bands specified in the FOS for ‘generation events’ and ‘load events’ in Table A.3 for the Mainland and Table A.6 for Tasmania following a single credible contingency under system intact conditions.

In the short term, as inertia levels decline, under actual or potential island conditions or lower inertia conditions, Very Fast FCAS would be helpful in dealing with the faster RoCoF observed on the power system and to avoid exceeding the containment bands in some cases. It would also help with managing the impact of non-credible contingency events, but the FCAS framework is designed for managing power system frequency following credible contingency events.

In the medium term, Very Fast FCAS is expected to be essential for meeting these requirements. While the level of inertia under actual or potential island conditions is already low, it is very likely that due to the forecast inertia under system intact conditions in the future, a faster FCAS response would be required to maintain power system frequency within the containment bands.

Therefore, AEMO considers that the capacity of Very Fast FCAS enabled must not only depend on the largest credible risk (**LCR**) but also on the amount of inertia available at the time. This means that the amount of Very Fast FCAS required could be zero, or small, when the power system is interconnected and significant inertia is available.

The design considerations for Very Fast FCAS were developed after reviewing near-term issues related to low inertia in South Australia (SA) and Queensland (QLD) islands and then assessing against longer term NEM projections. It is reasonable to expect that Very Fast FCAS will likely be effective at managing system intact scenarios if the specification has been designed to help manage potential, or actual, islanding scenarios.

5.1.2 Tasmania

The reference frequency levels and the standard ramp rate for Tasmania in the MASS are different to the Mainland, owing to the different FOS requirements and physical realities of the Tasmanian power system, which is not synchronously connected to the Mainland. The existing FCAS arrangements perform adequately in Tasmania, however, it already features additional measures not used in the Mainland to reliably do so. For example, local FCAS constraints maintain minimum levels of proportional FCAS and are inertia-aware. Similar to the Mainland, Fast FCAS is currently adequate for arresting frequency within the containment bands specified in the FOS for a generator event or a load event in Tasmania when the Tasmanian power system is intact, however, Very Fast FCAS may be required in the future to manage higher RoCoF events.

The lower inertia in Tasmania leads to a faster RoCoF following a credible event, and AEMO examined the maximum RoCoF observed on a monthly basis before determining whether the Very Fast FCAS specifications for Tasmania would need to be different than the Mainland.

As mentioned above, the nature of the Tasmanian *region* suggests it should be given special consideration in developing the right settings for Very Fast FCAS. To this end, AEMO intends to engage with the relevant TNSP and other directly affected bodies following the publication of this Issues Paper to discuss specific arrangements for Tasmania.

5.1.3 Study to determine Very Fast FCAS parameters

To assist AEMO's exploration of the utility of different Very Fast FCAS response times, AEMO developed a simple modelling tool based on solving the swing equation. This tool allows AEMO to assess the peak RoCoF and frequency nadir for different contingency event scenarios. Analysis was conducted on projected minimum inertia levels from AEMO's 2022 Draft ISP modelling. Cases were run for both potential island and system intact scenarios. This has enabled AEMO to assess the required Very Fast FCAS response time that would ensure:

- FOS frequency containment obligations are met (± 0.5 Hz for an intact system, and ±1 Hz in an island).
- A threshold RoCoF value of 1 Hz/s was not breached[38].

Key assumptions of study

- The frequency response from FCAS Providers has been modelled to align with the minimum FCAS measurement approach set out in the MASS; that is, the FCAS response shapes consistent with the triangle shapes shown in Figure 8. This approach provides conservative results in that it identifies a frequency response that if met, will meet or exceed the FOS requirements, and is also objective in that it does not assume anything not directly covered by the MASS measurement methodology. The actual expected response of any given Ancillary Service Facility depends on the technology type, droop setting, deadband or frequency deviation trigger setting.
- PFR has not been modelled as it is not a type of FCAS and, therefore, does not require headroom/footroom or stored energy. An objective here is that FCAS ensures the relevant FOS outcomes are met, with no reliance on PFR.
- Contingency event size has been set at the LCR. Note that for the studies of the SA island, it is assumed that some PV generation in SA is curtailed to reduce the size of the LCR in case PV systems disconnect due to a voltage disturbance caused by the trip of a generating unit.
- The volume of Very Fast FCAS in each scenario has been set equal to the LCR and is assumed to be always available (i.e. the model does not attempt to estimate actual Very Fast FCAS availability).
- Only Raise FCAS was modelled: the results for Lower FCAS would be mathematically identical.
- Studies for 2022 are based on minimum 2021-22 projected inertia in the Draft 2022 ISP. For example, for South Australia, the figures are extracted from the A7.4.6 South Australia inertia outlook chart.
- Studies for 2026 are based on the minimum inertia observed in the Draft 2022 ISP 'Progressive Change' scenario, using a linear interpolation between the published years.

[38] The case for RoCoF limits in the FOS may be examined in the upcoming FOS Review.

Results

A comparison was conducted of the frequency traces with, and without, Very Fast FCAS for a contingency size similar to the LCR for an SA island, QLD island and the Mainland, based on the assumed minimum inertia levels for 2022 and 2026. A summary of the results of the study is available in Table 5. The R6 results reflect the expected RoCoF and frequency nadir if Fast FCAS was delivered but no Very Fast FCAS was available. The R2, R1, and R0.5 results reflect the availability of existing Fast FCAS and one of the Very Fast FCAS considered based on the respective response time of 2 seconds, 1 second and 0.5 second. Further detail can be found in Appendix A – Frequency traces, including frequency traces and the required FCAS 'triangles' to ensure adequate response to contain power system frequency within the relevant containment bands.

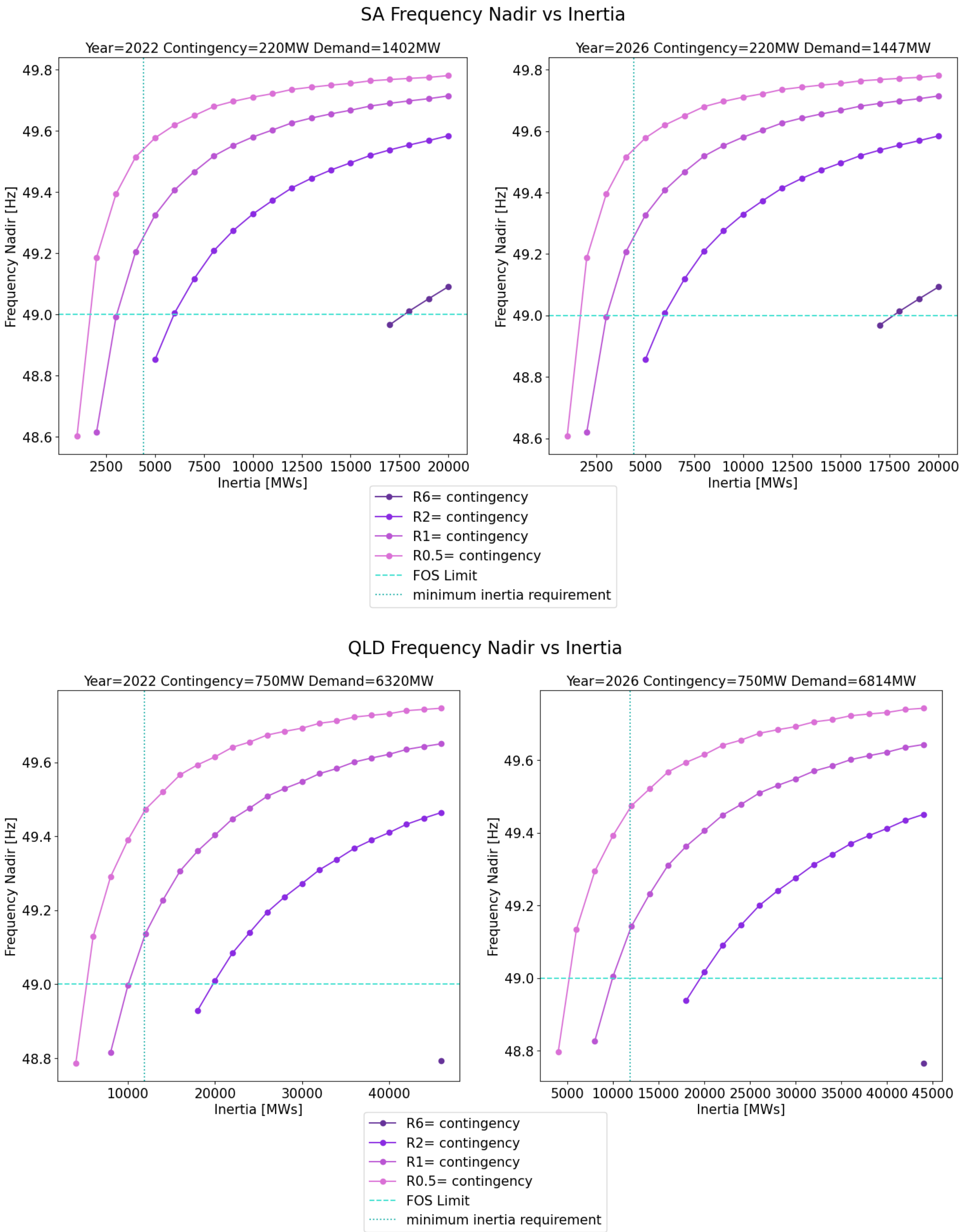
Table 5 Comparison of RoCoF and frequency nadir for varying Very Fast FCAS response times

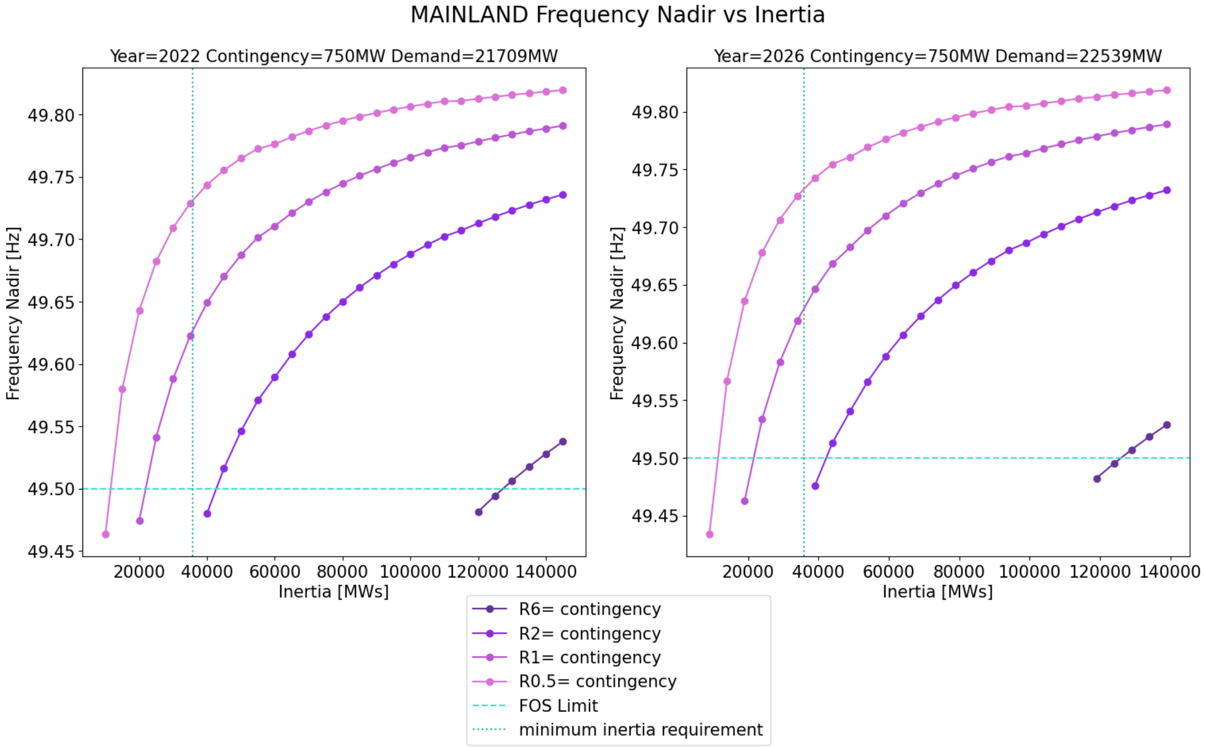
			RoCoF (Hz/s)	Frequency Nadir (Hz)
R6	2022	SA	-0.9	47.6
		QLD	-1.0	47.5
		MAINLAND	-0.3	49.2
	2026	SA	-1.1	47.3
		QLD	-1.1	47.5
		MAINLAND	-0.4	49.1
R2	2022	SA	-0.9	49.0
		QLD	-1.0	48.9
		MAINLAND	-0.3	49.6
	2026	SA	-1.0	48.8
		QLD	-1.0	48.9
		MAINLAND	-0.4	49.6
R1	2022	SA	-0.8	49.4
		QLD	-0.9	49.3
		MAINLAND	-0.3	49.7
	2026	SA	-1.0	49.3
		QLD	-0.9	49.3
		MAINLAND	-0.4	49.7
R0.5	2022	SA	-0.7	49.6
		QLD	-0.8	49.6
		MAINLAND	-0.3	49.8
	2026	SA	-0.8	49.6
		QLD	-0.8	49.6
		MAINLAND	-0.4	49.8

The results in Table 5 indicate the response time is adequate to manage contingency events under these low inertia conditions.

AEMO has also considered how different response times for Very Fast FCAS and varying levels of inertia impact the frequency nadir for a contingency size equivalent to the LCR in an SA island, QLD island and the Mainland. These results are shown in Figure 13.

Figure 13 Comparison of Very Fast FCAS response times and inertia levels on frequency nadir in SA, QLD and the mainland NEM in 2022 and 2026





The graphs in Figure 13 show that a Very Fast FCAS response with either a 0.5-second or 1-second response time (R0.5, R1) would be adequate to contain frequency within the applicable containment band of the FOS for an islanding scenario and an interconnected system. In contrast, a 2-second service (R2) falls short of maintaining frequency over 49 Hz in an SA island and a QLD island, and 49.5 Hz in the Mainland, when considering the minimum threshold level of inertia requirements[39] of 4,400 MWs for SA, 11,900 MWs for QLD and a combined total of 35,800 MWs for the Mainland[40].

5.2 Proposed key parameters for Very Fast FCAS

AEMO proposes that the specification for Very Fast FCAS have the following attributes:

- A 1-second timeframe to reach maximum response.
- A total timeframe of 6 seconds.
- Raise/Lower reference frequency to remain at ±0.5 Hz for the Mainland and ±2 Hz for Tasmania, like other Contingency FCAS.
- Standard fast frequency ramp rate of 1 Hz/s for the Mainland and for Tasmania.

The rationale for proposing these parameters is explored in the following sections.

[39] See AEMO's 2021 System Security Report. available at https://aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/operability/2021/system-security-reports.pdf?la=en.

[40] The sum of the regional minimum threshold level of inertia requirements for SA, QLD, NSW and VIC is 35,800 MWs.

5.2.1 Response time and service timeframe

It is evident from the summary in Table 5 that a faster FCAS response is required to arrest power system frequency within the relevant containment band following a credible contingency equivalent to the size of the LCR for the scenarios considered.

AEMO's study also showed that a 2-second Very Fast FCAS will not be adequate to prevent power system frequency from falling below 49 Hz in a QLD island in 2022, and in an SA and QLD islands in 2026. In contrast, both a 1-second and a 0.5-second response will be effective at maintaining frequency over 49 Hz for the SA and QLD islands. If the specified response time for Very Fast FCAS is less than 0.5 second, however, it is evident from the information in Table 3 that the types of Ancillary Service Facility that could be used to participate in a 0.5 second Very Fast FCAS market would be significantly fewer.

Furthermore, measurements at a higher resolution will be required to participate in a 0.5-second Very Fast FCAS market compared to a 1-second market. It is possible that the additional cost associated with higher speed meters will also result in less participation, particularly from aggregators.

These considerations lead AEMO to propose a 1-second Very Fast FCAS market, however, it is also evident that overall, faster specifications can provide more utility than slower ones, as long as any potential issues with large rapid power injections can be managed. For example, the studies discussed in section 5.1.3 demonstrate how a faster service allows containment of frequency at lower inertia levels. Therefore, AEMO has included questions seeking to determine what the impact could be on potential providers if a faster specification, such as 0.5 seconds, were to be adopted.

The proposed timeframe (i.e. sustain duration) for the Very Fast Raise FCAS and Very Fast Lower FCAS is 6 seconds, to provide for an orderly transition to Fast FCAS. AEMO's study with the frequency response modelled as the 'FCAS triangles' in Figure 8 demonstrated that a Very Fast FCAS response within 1 second and with a timeframe of 6 seconds would be effective at managing both islanding scenarios and the Mainland under low inertia conditions.

Other considerations of response time and duration options

AEMO advised the AEMC in 2017[41] that, for required response times of significantly less than 1 second, a response triggered by local frequency measurement might not be sufficiently robust and reliable, could be prone to false triggering and that a direct event detection approach is likely to be more technically viable. Where the required response time is of 1 second or more, local frequency detection (similar to existing FCAS) would be adequate.

In its consultation on the Amending Rule, the AEMC considered the application of a 2-second response time, but this was illustrative only. The AEMC confirmed[42] that the final specification was for AEMO to determine in the MASS.

[41] See page 19-20 of AEMO's submission to the AEMC's System Security Market Frameworks Review Directions Paper, dated 26 April 2017, available at https://www.aemc.gov.au/sites/default/files/content/917b38b1-2f61-4601-a72e-f084cba0e2ce/MarketReview-Submission-EPR0053-AEMO-170426.pdf.

[42] See, for example, page 35 of the AEMC's Final Report. Available at https://www.aemc.gov.au/sites/default/files/2021-07/Fast%20frequency%20response%20market%20ancillary%20service%20-%20Final%20Determination.pdf.

AEMO advised the AEMC in 2017[43] that, where RoCoF is in the range of 0.2 Hz/s, an FFR response time of 1-2 seconds is adequate and useful.

Questions

13. Will some technology types be locked out of the Very Fast FCAS markets if the maximum response time is specified as 0.5 seconds rather than 1 second?
14. Are there benefits to setting the response time for Very Fast FCAS faster than 1 second that AEMO should consider?
15. Are there any other issues relevant to the proposed response time and timeframe that AEMO should consider?

5.2.2 Market ancillary service offer requirements

As for existing Contingency FCAS, the MASS will need to include provisions governing the 'offer requirements' for Very Fast FCAS. AEMO is proposing the following requirements for the specification of Very Fast FCAS in Market Ancillary Service Offers, picking up the text from sections 7.1, 8.1 and 9.1 of the MASS. Note that this will include the proposed feature of capping the FCAS measurement to the peak active power change observed in the relevant FCAS timeframe, as discussed in Section 5.6.4.

Very Fast Raise FCAS

The amount of very 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 FDT Time and ending 1 second from the FDT, excluding any Inertial Response and capped to the actual peak active power change; and

(b) twice the Time Average of the Raise Response between 1 second and 6 seconds from the FDT, excluding any Inertial Response and capped to the actual peak active power change,

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.

Very Fast Lower FCAS

The amount of very 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 FDT and ending 1 second past the FDT, excluding any Inertial Response and capped to the actual peak active power change; and

(b) twice the Time Average of the Lower Response between 1 second and 6 seconds from the FDT, excluding any Inertial Response and capped to the actual peak active power change,

[43] See page 19-20 of AEMO's submission to the AEMC's System Security Market Frameworks Review Directions Paper, dated 26 April 2017, available at https://www.aemc.gov.au/sites/default/files/content/917b38b1-2f61-4601-a72e-f084cba0e2ce/MarketReview-Submission-EPR0053-AEMO-170426.pdf.

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.

AEMO discusses the rationale for applying a cap to the maximum registered FCAS capacity based on the actual peak active power change in Section 5.6.4.

Questions

16. Are there any other issues relevant to the proposed market ancillary service offer requirements that AEMO should consider?

5.2.3 Reference frequency levels

The maximum capacity at which an Ancillary Service Facility may be classified for participation in the FCAS markets is determined by measuring the change in active power when the frequency ramps from 50 Hz to the limits of the containment bands, as can be seen in Figure 14.

Figure 14 Comparison of FOS containment band outcomes for interconnected system and intact Tasmania

Table A.3: Summary of mainland system frequency outcomes for an interconnected system

CONDITION	CONTAINMENT BAND (HZ)	STABILISATION BAND (HZ)	RECOVERY BAND (HZ)
No *contingency event* or **load event**	49.75 – 50.25 49.85 – 50.15[1]	49.85 – 50.15 within 5 minutes	
Generation event or **load event**	49.5 – 50.5	49.85 – 50.15 within 5 minutes	

Table A.6: Summary of Tasmania system frequency outcomes where the Tasmanian power system is intact

CONDITION	CONTAINMENT BAND (HZ)	STABILISATION BAND (HZ)	RECOVERY BAND (HZ)
No *contingency event* or **load event**	49.75 – 50.25 49.85 – 50.15[1]	49.85 – 50.15 within 5 minutes	
Generation event, **load event** or **network event**	48.0 – 52.0	49.85 – 50.15 within 10 minutes	

The containment bands under system intact conditions are 49.5 Hz to 50.5 Hz for the Mainland and 48 Hz to 52 Hz for Tasmania.

If an island has been formed within the Mainland, the containment band for a generation event or load event is 49 Hz to 51 Hz, but remains 48 Hz to 52 Hz for an island within Tasmania, as shown in Figure 15.

Figure 15 Comparison of FOS containment band outcomes for an Island within the Mainland and Tasmania

Table A.4: Summary of Mainland system frequency outcomes for an island within the Mainland other than during supply scarcity

CONDITION	CONTAINMENT BAND (HZ)	STABILISATION BAND (HZ)	RECOVERY BAND (HZ)
No *contingency event* or **load event**	49.5 – 50.5	N/A	
Generation event, **load event** or **network event**	49.0 – 51.0	49.5 – 50.5 within 5 minutes	

Table A.7: Summary of Tasmania system frequency outcomes where an island is formed within Tasmania

CONDITION	CONTAINMENT BAND (HZ)	STABILISATION BAND (HZ)	RECOVERY BAND (HZ)
No *contingency event* or **load event**	49.0 – 51.0	N/A	
Load event, **generation event** or **Network event**	48.0 – 52.0	49.0 – 51.0 within 10 minutes	

The market ancillary service offer requirements for mainland units detailed in Section 5.2.2 refer to the 'Raise Reference Frequency' and 'Lower Reference Frequency', both of which are defined in the MASS by reference to the containment bands applicable under system intact conditions.

In contemplating the specification of a Very Fast FCAS, AEMO has considered whether it should change the reference frequency levels for the Mainland to 49 Hz to 51 Hz to reflect the containment band for a generation or load event **for an island** within the Mainland. This could, for example, allow variable controllers to register for a potentially greater amount of FCAS (in the absence of other changes) as registration would then be based on a 1 Hz deviation rather than 0.5 Hz (see section 5.3 for discussion of proposed control options to address this). Adopting a new practice regarding reference frequencies appears to be quite problematic, however, for at least the following reasons:

- There is no obvious case to change the definitions of 'Raise Reference Frequency' and 'Lower Reference Frequency' for an interconnected system, which is by far the situation most commonly served by FCAS. If the FCAS capacity of variable controllers were to be based on the containment bands for a separation event[44], the amount of FCAS enabled for an interconnected system would need to be significantly increased to ensure that the FCAS response from variable controllers is sufficient to maintain frequency within the containment band of 49.5 Hz to 50.5 Hz for a generator or load trip.
- AEMO considered whether a different specification should be applied during island scenarios, i.e., the maximum ancillary service capacity of an Ancillary Service Facility in the Mainland would be based on the change in active power for a ±1 Hz deviation. It was considered, however, that the following implications could have a negative impact on the market:
  - A two-tier registration approach would be required to manage the maximum enablement for variable FCAS controllers when the power system is interconnected and following a separation event. Two FCAS trapezia would need to be registered for each FCAS market and the ability to switch to the relevant trapezium under certain conditions would be essential to avoid under-delivery.
  - For dispatch of energy and FCAS to be internally consistent, the reference frequency level for all Contingency FCAS needs to be consistent. That is, to allow Very Fast FCAS to be based on a ±1 Hz deviation, all other Contingency FCAS would also need to adopt this convention, rather than using ±0.5 Hz. If not, an Ancillary Service Facility dispatched on a ±1 Hz basis for Very Fast FCAS would need to hold the headroom to deliver that amount of capacity and, therefore, could not use it for energy or Regulation FCAS purposes. Additionally, it would seem inefficient to determine the Slow and Delayed FCAS capacity of an Ancillary Service Facility based on a ±1 Hz deviation when frequency should be significantly restored prior to the Slow FCAS response.
  - Following a credible contingency under islanding scenarios, Very Fast FCAS will be adequate to arrest the frequency deviation before it exceeds ±1 Hz. Considering that the key purpose of Very Fast FCAS is to arrest power system frequency for high RoCoF events, it is uncertain whether additional Fast, Slow or Delayed FCAS would need to be enabled as well.

Questions

17. Are there any other issues or concerns relevant to AEMO's proposal to apply the current definitions of 'Raise Reference Frequency' and 'Lower Reference Frequency' to Very Fast FCAS?

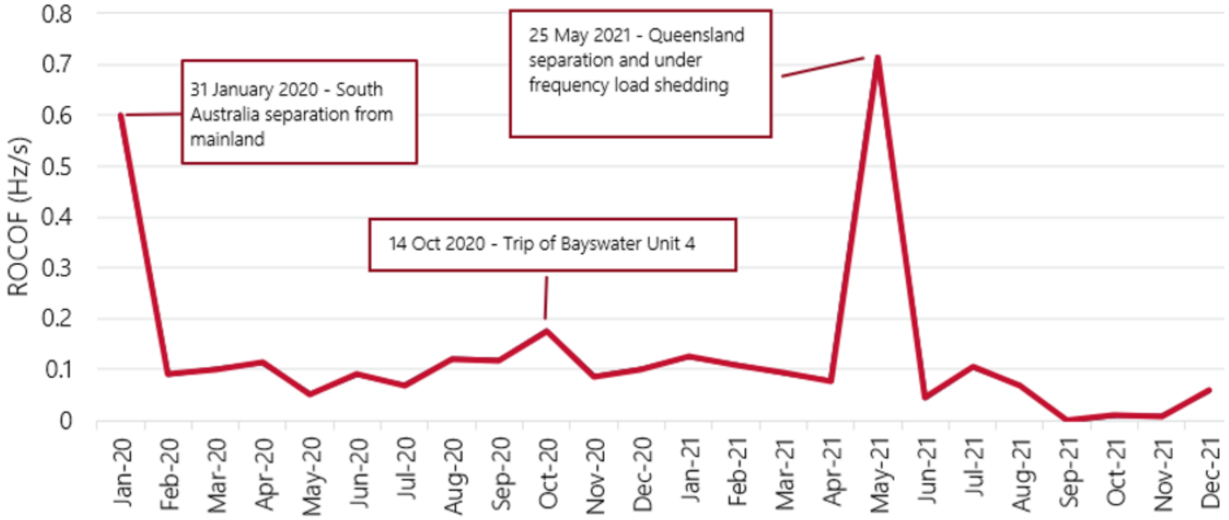
[44] The term 'separation event' is defined in the FOS.

5.2.4 Frequency Ramp Rate

The RoCoF observed following a single credible contingency while the Mainland power system is interconnected is typically within the 0.125 Hz/s specification for Fast FCAS (Standard Frequency Ramp Rate). Experience shows that the existing FCAS arrangements successfully arrest power system frequency excursions within the containment bands for system intact conditions following a generation event or load event.

AEMO reports to the market on the frequency and time error performance of the power system on a quarterly basis. The most recent report includes Figure 16, which charts the monthly maximum RoCoF in Mainland regions during 2020 and 2021[45]. The two highest peaks correspond to RoCoF following non-credible events and are not particularly relevant in assessing the suitability of a RoCoF threshold for credible events. Interestingly, a trip of Bayswater Unit 4 on 14 October 2020 resulted in RoCoF exceeding 0.125 Hz/s, but RoCoF this high has not been observed since during a credible contingency event. This event occurred at a time of low Mainland inertia of approximately 75,000 MWs but also considers there were likely other contributing factors to the 14 October 2020 event that are not easily discoverable.

Figure 16 Monthly maximum RoCoF recorded in Mainland regions during 2020 and 2021

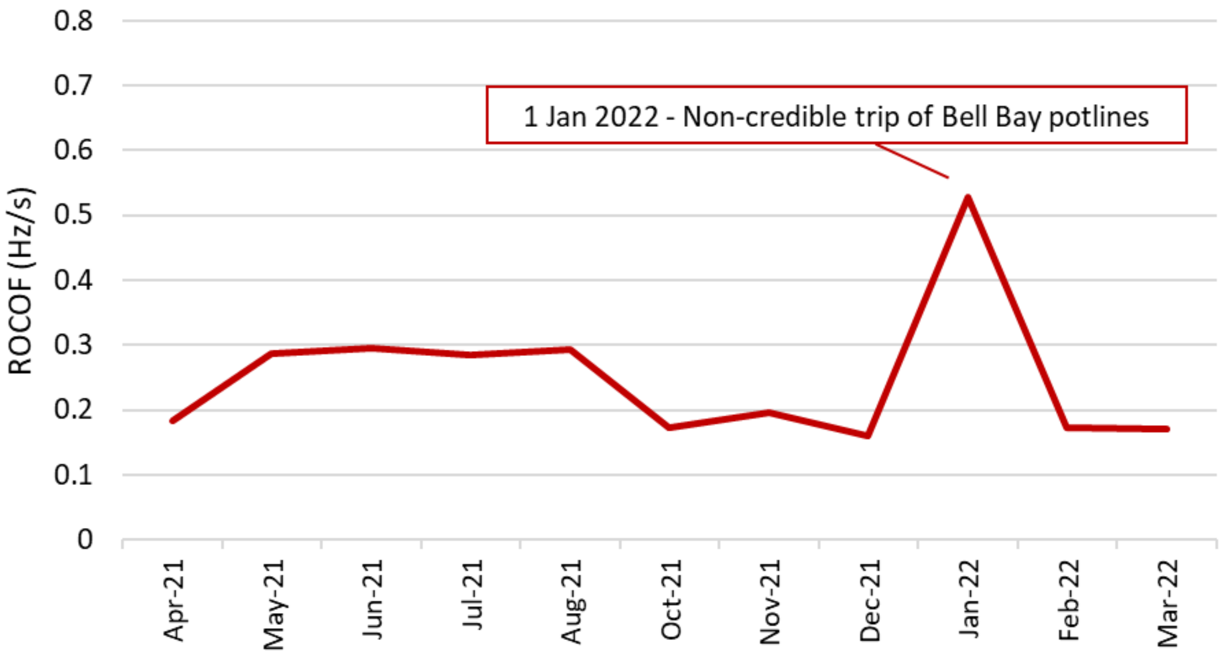


Note: 25 May 2021 ROCOF as measured in Queensland and 31 January 2020 ROCOF as measured in South Australia.

To further validate that the current standard ramp rates specified in the MASS are adequate thresholds for credible contingency events, Figure 17 shows the monthly maximum RoCoF in Tasmania for the last 12 months. Single credible contingencies did not cause RoCoF to go over the standard frequency ramp rate of 0.4 Hz/s for Tasmania, but a non-credible contingency event on 1 January 2022 resulted in RoCoF exceeding 0.4Hz/s.

[45] Frequency and Time Error Monitoring report for Quarter 4 2021. Available at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/frequency-and-time-error-reports/quarterly-reports/2021/frequency-and-time-error-monitoring-4th-quarter-2021.pdf?la=en

Figure 17 Monthly maximum RoCoF recorded in Tasmania during 2021 and 2022



It should be noted, however, that Fast FCAS is not designed to guarantee the arrest of power system frequency within the system intact containment bands specified in the FOS when RoCoF is significantly greater than 0.125 Hz/s in the Mainland and 0.4 Hz/s in Tasmania. Furthermore, the FCAS capacity enabled to contain power system frequency within ±0.5 Hz in the Mainland and ±2 Hz in Tasmania after a single credible contingency event assumes that RoCoF will not exceed the Frequency Ramp Rate under system intact conditions, and the maximum registered ancillary service capacity of all FCAS Providers in the Mainland and Tasmania have been subsequently determined by measuring the change in active power when frequency ramps from 50 Hz to the raise or lower reference frequency level at the Frequency Ramp Rate.

AEMO's 2020 Renewable Integration Study (**RIS**)[46] forecasts indicate that a 1 Hz/s RoCoF could be observed in extreme cases for the LCR on the Mainland by 2025 as shown in Figure 18. AEMO's Draft 2022 Integrated System Plan (**ISP**)[47] suggests that the inertia levels in 2025 could be lower than initially predicted in the RIS 2020 assumptions due to the earlier retirement of some synchronous generation. Absent other major changes in the power system, this would lead to a higher likelihood of these extreme RoCoF levels occurring. However, predicting the outlook for inertia is difficult given the range of possible ways the power system can develop, plus the demands of other power system requirements, for example fault current and synchronising torque, also factor into the role that inertia could play in the coming years.

[46] Available at https://aemo.com.au/energy-systems/major-publications/renewable-integration-study-ris.

[47] See Appendix 7 of the Draft 2022 ISP, available at https://aemo.com.au/consultations/current-and-closed-consultations/2022-draft-isp-consultation

Figure 18 Mainland instantaneous RoCoF duration curves, 2015-19 and forecast for 2025 from RIS 2020

Based on the monthly maximum RoCoF observed in the Mainland and Tasmania since January 2020 and the RoCoF forecasts due to declining inertia, AEMO is proposing to specify a Frequency Ramp Rate of 1 Hz/s for Very Fast FCAS for the Mainland. The current rate of 0.125 Hz/s is too slow and not adequate to determine the Very Fast FCAS capacity of Ancillary Service Facilities, which will be required to respond to high RoCoF events.

AEMO also notes that the up-and-coming FOS Review may provide an avenue for examining potential RoCoF limits for the NEM.

Questions

18.Are there any other issues relevant to RoCoF that AEMO should consider?

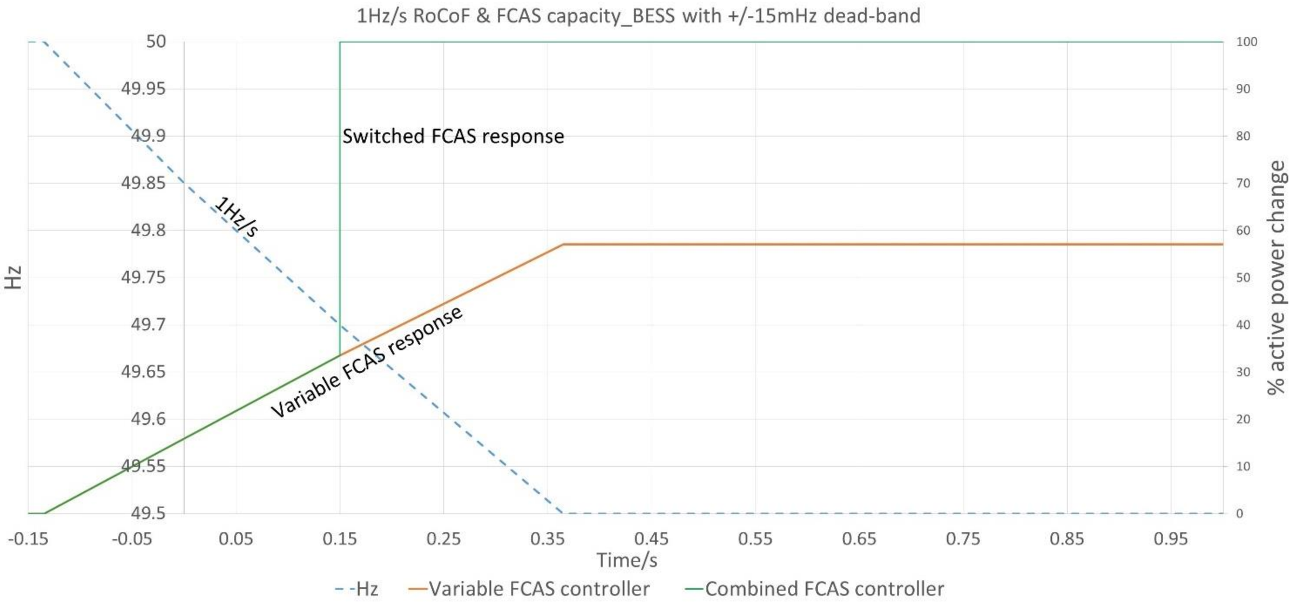
5.3 Control system requirements

The MASS Contingency FCAS requirements allow the use of variable (proportional) and switching controllers. For Very Fast FCAS, AEMO is considering whether the same specifications as for Fast FCAS are appropriate, or whether alternative specifications are warranted. AEMO is also aware that some FCAS Providers would prefer a highly prescriptive MASS insofar as its control requirements are concerned, while others prefer an approach that provides the maximum possible degree of freedom. AEMO considers that a ‘middle-ground’ between these two views might be more feasible.

While Ancillary Service Facilities with variable controllers have generally operated with a single fixed droop setting, AEMO notes that this has some important implications. In particular, with the typical maximum allowed droop limit of 1.7% and a fixed reference frequency of ±0.5 Hz, Ancillary Service Facilities with proportional controllers cannot be registered for their entire capacity for FCAS as this droop function means that a 0.85 Hz change in frequency (plus any deadband) would be required for a 100% change in active power. Various FCAS Providers have advised AEMO that this leads them to prefer a switching controller, which does not have similar restrictions. For Ancillary Service Facilities of 5 MW or more, however, variable controllers are preferred from a power system security perspective where feasible, as this control design is more versatile. AEMO considered the advantages and disadvantages of both types of controls during the 2021 MASS consultation and noted that the proper operation of the power system requires adequate levels of frequency response to be provided by way of variable control.

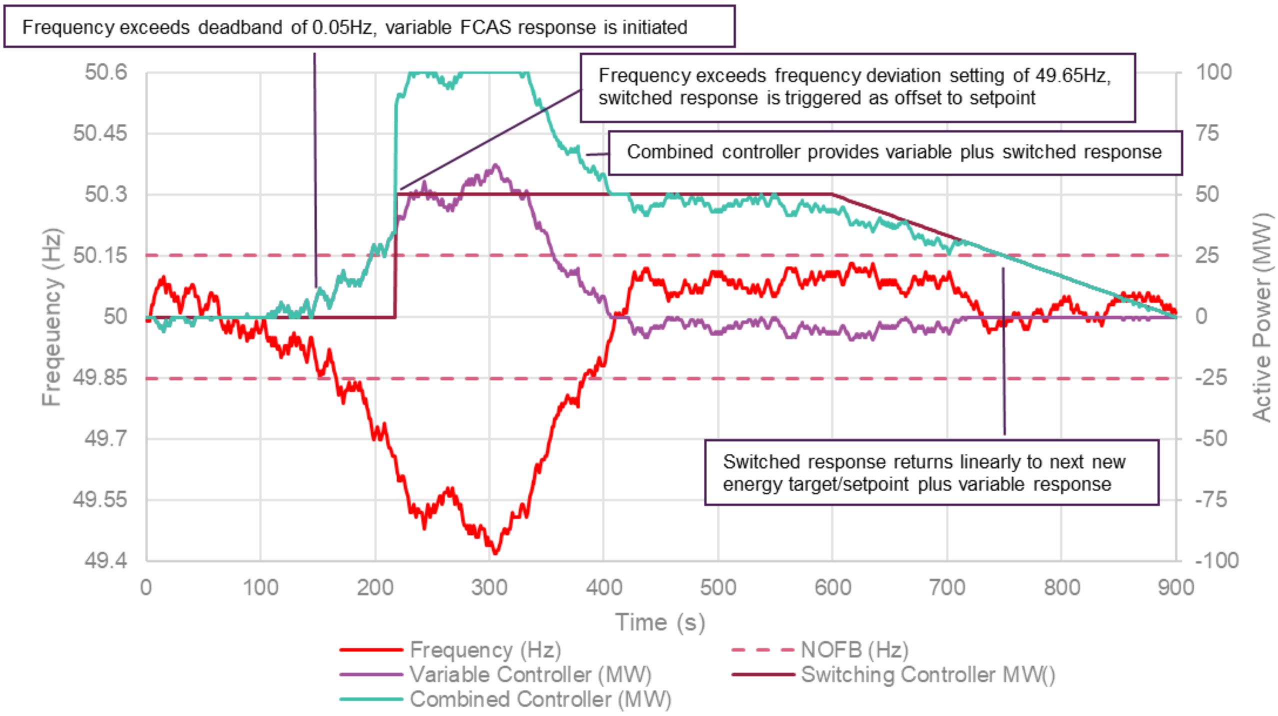
While most existing Contingency FCAS Providers implement either proportional or switched controllers, the MASS also contemplates 'combination' controllers, where an Ancillary Service Facility uses a hybrid of proportional and switched controls. AEMO is considering whether to extend these options for Very Fast FCAS and provide more guidance on this 'combination' option. This would mean that a Very Fast FCAS Provider could potentially register a combined FCAS controller like that shown in Figure 19. In this example, the Ancillary Service Facility has a variable controller component at 1.7% droop, along with a switched component that activates at 49.65 Hz.

Figure 19 Comparison of variable FCAS controller and combined FCAS controller



With a control design of this nature, it might be possible for an Ancillary Service Facility to potentially register a higher FCAS value, even up to 100% (subject to other normal limits). In practice, this design means that when frequency goes outside an assigned frequency setting of the controller, the Ancillary Service Facility deviates from its droop curve to deliver an additional switched response which acts like an offset. It would be important to ensure that Ancillary Service Facilities do not withdraw the switched FCAS response too quickly once frequency starts to recover, which could potentially cause a second frequency disturbance. To manage this, some requirements on how to phase out the switched part of the response would be justified. A possible design is presented in Figure 20 for a hypothetical 100 MW BESS with a frequency response deadband of ±0.5 Hz. In this example, the switched component of the response is gradually withdrawn at the end of the FCAS period, so as to be a zero offset by the next energy target. Throughout the period, the variable component of the response remains active. As previously indicated, it is important for existing and potential FCAS providers to be aware that the proportions of switched and variable controls enabled to provide frequency response at any given time need to be carefully managed and are likely to be subject to future constraints to ensure adequate levels of variable control. In particular, AEMO must manage potential over-delivery of FCAS response, and resultant frequency rebound or over-shoot.

Figure 20 Proposed FCAS response of a combined FCAS controller following frequency recovery



Questions

19. Is AEMO's proposal to permit the use of a 'combination' controller, namely, a hybrid of proportional and switched controls for Very Fast FCAS appropriate? Please provide reasons for your response.
20. Are there any other issues relevant to the proposed control system requirements for a combined FCAS controller that AEMO should consider?
21. Are there other FCAS delivery methods that AEMO should consider allowing for Very Fast FCAS?

5.4 Verification and measurement requirements

As with all other FCAS, the measurement time resolution, allowable error and accuracy must be sufficient for AEMO to assess that Very Fast FCAS has been delivered in accordance with all MASS requirements. The two most important factors in the verification of Contingency FCAS delivery are that:

- The FCAS is delivered within the relevant time parameters; and
- The correct quantity of FCAS (in both energy and capacity terms) is delivered. Generally, this means that at least the enabled quantity has been provided, noting that the expected quantity is also dependent on the size of the frequency deviation.

The following sections examine how these two factors may be satisfied.

5.4.1 Measurement time resolution and discounting

During the 2021 MASS consultation, AEMO examined the appropriate measurement strategy for Fast FCAS, especially where delivered by Aggregated Ancillary Service Facilities. AEMO again intends to complete an analysis to determine the implied verification error for Very Fast FCAS when data is captured at different measurement time resolutions, e.g. from 10 ms to 200 ms.

At the conclusion of the 2021 consultation, AEMO adopted a tiered measurement regime for Fast FCAS, detailed in section 5.4 of the MASS. The MASS now applies a discount factor to Fast FCAS delivered by Aggregated Ancillary Service Facilities made up of DER that meet certain criteria.

AEMO considers that the same approach could be applied to Very Fast FCAS. AEMO has commenced a study to determine the relative error associated with different sampling rates with the assistance of independent advisers. Consulted Persons should note that no changes are proposed to the calculation methodology itself, only its application to Very Fast FCAS.

The application of a discount will mean that additional Very Fast FCAS will not need to be procured to offset the potential verification errors arising from data captured at a lower measurement time resolution. Depending on the findings of the analysis, Very Fast FCAS Providers may either capture data at a higher resolution (thus avoiding the application of a discount), or continue to use their Fast FCAS metering installation to participate in the Very Fast FCAS markets knowing that a discount will apply to their delivered quantities.

The applicable discount must be reasonable. Given the proposed Very Fast FCAS must respond six times faster than Fast FCAS, measurement times with a resolution of 200 ms or even 100 ms might not be adequate for measurement of Very Fast FCAS.

5.4.2 Power measurements

The allowable error and accuracy for power measurements is currently the same for all types of Contingency FCAS, with a margin of error of 2% and resolution of 0.2%.

AEMO's preference is to apply the same margin of error and resolution to Very Fast FCAS. The use of a percentage error rather than a fixed active power value ensures that the same standards will be maintained across all Contingency FCAS.

5.4.3 Frequency measurements

In contrast, existing Contingency FCAS types have different allowable error and accuracy margins for frequency measurement. Slow and Delayed FCAS must have a margin of error of $\leq$0.02 Hz and resolution of $\leq$0.01 Hz; for Fast FCAS, these are set at $\leq$0.01 Hz and $\leq$0.0025 Hz respectively.

While it would be reasonable to expect a smaller margin of error and resolution for Very Fast FCAS, AEMO considers that a balance needs to be reached between sufficient accuracy and the relative cost of compliance.

Questions

22. What is the error margin and resolution for frequency measurements by high-speed metering installed by Fast FCAS Providers that could be retrofitted to existing Ancillary Service Facilities for participation in Very Fast FCAS markets?
23. What is the error margin and resolution for frequency measurements by high-speed metering that is not currently in use in the NEM, but is available for use in the Very Fast FCAS markets?
24. What is the cost of high-speed metering that captures frequency measurements with a margin of error lower than <0.01 Hz?
25. Can metering providers submit the specifications of their high-speed metering currently available, or in use by Fast FCAS providers?
26. Are measurement rates of <100ms feasible for your technology? What is the nature and extent of changes that would need to be made to support rates of <100ms?
27. Are there any other issues relevant to the proposed verification and measurement requirements that AEMO should consider?

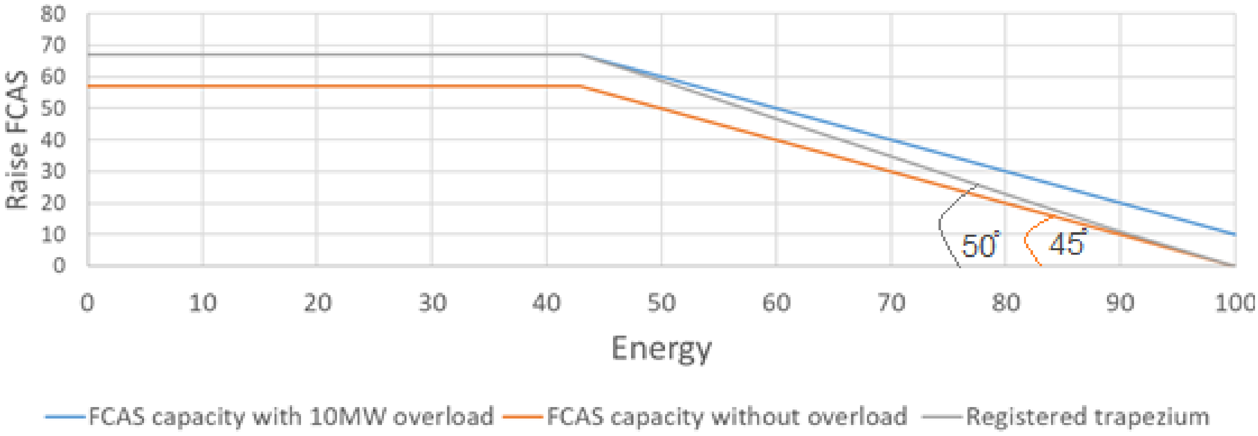
5.5 Overload capacity

AEMO is seeking information to assist its consideration of whether the overload capacity of an Ancillary Service Facility may be counted as Very Fast FCAS. While it might not be possible to recognise such capacity in the initial Very Fast FCAS specification, it could also be considered for a subsequent refinement. This will depend on the physical capabilities of Ancillary Service Facilities, the availability of overload capacity, interactions with other controls and the degree of change needed to AEMO's systems to accommodate it.

To meet the proposed specification for Very Fast FCAS, the overload capacity would need to be able to be maintained for at least 6 seconds.

To accommodate overload capability, a possible approach would be to allow the maximum upper angle of the FCAS trapezium for Very Fast Raise FCAS to be more than 45 degrees as shown in the example in Figure 21, which is for a hypothetical BESS with an export capacity of 100 MW.

Figure 21 FCAS trapezium of a 100 MW BESS with 10 MW overload capacity



The maximum enablement level for scheduled and semi-scheduled generating units could be based on combined energy capacity and overload capacity. Further tests would be required to determine the feasibility of this option.

Questions

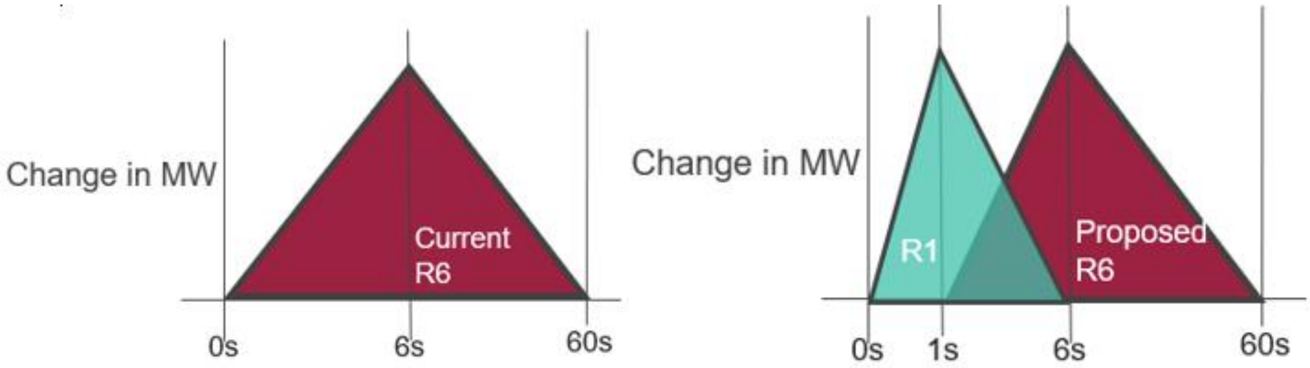
28. How long can overload capacity be sustained?
29. What percentage of a generating unit's nameplate rating is equivalent to the overload capacity?
30. How often can overload capacity be triggered in a 5-minute trading interval?
31. Can overload capacity be delivered proportionally to the frequency deviation, or can it only be delivered by a step change in active power?
32. Is there an energy payback after overload capacity is delivered?
33. What technologies other than BESS have overload capacity that be sustained for at least 6 seconds?
34. Are there any other issues relevant to the potential use of overload capacity for Very Fast FCAS that AEMO should consider?

5.6 Changes to other FCAS

5.6.1 Interaction between Very Fast FCAS and Fast FCAS

As Very Fast FCAS will become the fastest category of Contingency FCAS, its measurement would need to commence from the beginning of the measurement period and Fast FCAS would need to commence later. Specifically, AEMO proposes that measurement of Very Fast FCAS would commence from the Frequency Disturbance Time (**FDT**) and would end 6 seconds from the FDT. This proposal does not consider how the Contingency Event Time would be factored in; Section 0 discusses its potential removal. To accommodate Very Fast FCAS, measurement of Fast FCAS would therefore need to commence at 1 second after the FDT and end 60 seconds after the FDT. In effect, this means that the timeframe for Fast FCAS would be compressed by 1 second, as shown in Figure 22.

Figure 22 Comparison between current and proposed Fast FCAS timeframes



Changing the timeframe for delivery of Fast FCAS has the potential to impact the maximum ancillary service capacity of Fast FCAS Providers. Recognising that this could effectively require providers to re-register their Fast FCAS, AEMO investigated the materiality and flow-on effects of such a change, assuming that no Ancillary Service Facility provides Very Fast FCAS, at least in the very near future.

Assuming the same control configuration is maintained by a Fast FCAS Provider, it would be expected that the time average of the change in active power over the first 6 seconds of a disturbance would be lower than the time average of the change in active power between 1 to 6 seconds of the disturbance. Consequently, the Fast FCAS capacity of Ancillary Service Facilities is anticipated to be the same or higher under the new proposed timeframe in most cases. In Table 6, AEMO has calculated the Fast FCAS capacity of some representative Ancillary Service Facilities if the timeframe of Fast FCAS were compressed as proposed. In all these example cases, AEMO has calculated a small increase in the Fast FCAS quantity. Note that these calculations are based on the existing time average methodology: the proposed revision of the FCAS methodology to recognise the capacity provided by FCAS (rather than just energy) is discussed in section 5.6.4.

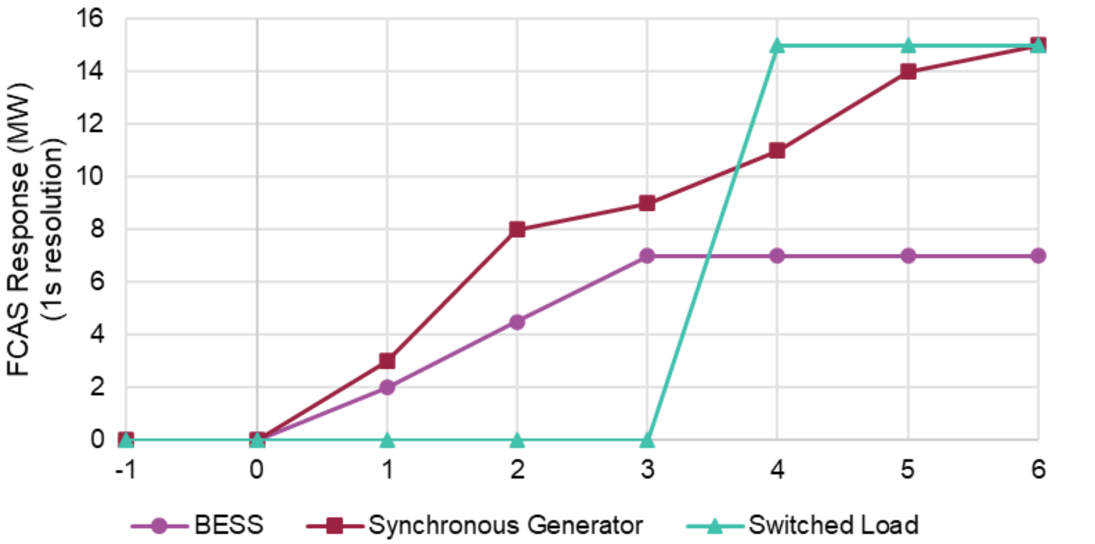
In light of these examples, a re-assessment of Ancillary Service Facilities delivering Fast FCAS should not be needed if AEMO's proposal is adopted unless Fast FCAS Providers wish to use the same Ancillary Service Facilities to delivery Very Fast FCAS, in which case the relevant testing and assessment processes would need to be undertaken regardless. AEMO notes that other changes proposed to FCAS measurement in section 5.6.4 could, however, result in the need to re-assess a limited number of Ancillary Service Facilities.

Table 6 Calculation of time average for Fast Raise FCAS for 0-6s and 1-6s timeframes

Time	Frequency	BESS	Synchronous Generator	Switched Load
-1	50.000	0.0	0.0	0.0
0	49.875	0.0	0.0	0.0
1	49.750	2.0	3.0	0.0
2	49.625	4.5	8.0	0.0
3	49.500	7.0	9.0	0.0
4	49.500	7.0	11.0	15.0
5	49.500	7.0	14.0	15.0
6	49.500	7.0	15.0	15.0
	Time Avg 0-6s	4.9	8.6	6.4
	Time Avg 1-6s	5.8	10.0	7.5
	Delta	+0.8	+1.4	+1.1

The three Fast FCAS profiles considered in the comparison of the time average in Table 6 are shown in Figure 23. Note that these examples come from real (anonymised) FCAS Provider data.

Figure 23 Fast FCAS profiles for calculation of time average for 0-6s and 1-6s timeframes



Questions

35. Can Consulted Persons identify any case where a decrease in Fast FCAS capability could be observed?

36. Are there any other issues relevant to the interaction between Very Fast FCAS and Fast FCAS that AEMO should consider?

5.6.2 Interaction between Very Fast FCAS and Slow FCAS and Delayed FCAS

AEMO has considered potential interactions between Very Fast FCAS and Slow and Delayed FCAS and has not identified any issues that require consideration during this consultation.

Questions

37. Are there any issues relevant to the interaction between Very Fast FCAS and Slow FCAS and Delayed FCAS that AEMO should consider?

5.6.3 Interaction between Very Fast FCAS and Regulation FCAS

AEMO has considered potential interactions between Very Fast FCAS and Regulation FCAS and has not identified any issues that require consideration during this consultation.

Questions

38. Are there any issues relevant to the interaction between Regulation FCAS and Very Fast FCAS that AEMO should consider?

5.6.4 Revision to FCAS measurement

AEMO has previously identified emerging issues with the legacy FCAS measurement approach based solely on a time average of energy. With the appearance of highly responsive Ancillary Service Facilities, this measurement approach raises the possibility that measured FCAS volumes (in both registration and verification following delivery) can exceed the actual capacity provided to the power system. As a simple example, consider a 30 MW switched load Ancillary Service Facility operating at full capability (i.e. switches from 30 MW to 0 MW) at one second from FDT. The existing Fast FCAS methodology will value this as 2 x AVG (0,30,30,30,30,30) = 50 MW. The Ancillary Service Facility, therefore, is permitted to be registered at 167% of its capacity as FCAS. AEMO refers to this as the FCAS 'multiplier effect'.

It is imperative that the replacement capacity (i.e. the FCAS quantity injected) equals the lost capacity (i.e. the lost generation or load). While accelerated FCAS responses are useful, and the total injected energy is important (and especially energy injected prior to the frequency nadir), it does not avoid the fact that the power system must be balanced for frequency to be arrested. If a significant portion of the FCAS procured is not actual capacity but comes from this 'multiplier effect', this can adversely impact power system security.

While this problem exists for all Contingency FCAS, Very Fast FCAS makes it even more important to address the issue. In the conditions where Very Fast FCAS is needed, the power system will be under higher stress and any deficit in actual FCAS delivery is emphasised.

AEMO is, therefore, proposing to modify the FCAS assessment and registration process as follows:

- A cap will be applied to the maximum registered ancillary service capacity for all FCAS markets based on the actual peak active power change.

  Very Fast FCAS offers AEMO an opportunity to recognise and value the accelerated response from highly capable Ancillary Service Facilities through the application of a cap to reflect more accurately the physical capacity delivered and to ensure that the added capacity is at least equal to the lost capacity (notwithstanding effects of load relief). AEMO appreciates that this cap will have an impact on some FCAS Providers currently benefitting from the existing treatment of Fast FCAS, however, notes the following mitigating factors:

  – The Very Fast FCAS market will see this accelerated response properly valued and paid for.

  - AEMO is working on methods to allow the most affected FCAS Providers (those whose Ancillary Service Facilities used fast proportional control) to register and deliver greater quantities of FCAS (see section 5.3).

- A new requirement that the relevant Contingency FCAS must be initiated no later than half-way through the relevant ramp-up period. For example, this would be by 3 seconds after FDT for Fast FCAS.
- FCAS Providers seeking to participate in the Very Fast FCAS markets would be required to update their registration in the Fast, Slow and Delayed FCAS markets

  For the reasons mentioned in Section 5.2.4, the Frequency Ramp Rate applied to determine the Very Fast FCAS capacity delivered by an Ancillary Service Facility is proposed to be 1 Hz/s. Therefore, FCAS Providers who are already providing, or seeking to provide, other types of Contingency FCAS in addition to Very Fast FCAS will undergo a new assessment using a 1Hz/s Frequency Ramp Rate to meet the new specification.

  This is because the same Frequency Ramp Rate must be applied across all Contingency FCAS due to the interaction of the different FCAS. The proposed treatment is illustrated in Table 7.

Table 7 Frequency Ramp Rates

Ancillary Service Facilities providing...	Frequency Ramp Rate	
	Mainland	Tasmania
One or more of types of Fast FCAS, Slow FCAS and Delayed FCAS	0.125 Hz/s*	0.4 Hz/s*
Very Fast FCAS only	1 Hz/s	1 Hz/s
Very Fast FCAS and one or more types of Fast FCAS, Slow FCAS and Delayed FCAS	1 Hz/s	1 Hz/s

* The Frequency Ramp Rates in the first row are the existing values specified in the MASS.

Questions

39. Are there alternatives to capping the registered Very Fast FCAS capacity to the actual peak active power change to minimise the discrepancy between the amount of FCAS enabled and the actual contingency size?

40. Are there any other issues relevant to the proposed market ancillary service offer requirements that AEMO should consider?

5.7 Proposed handling of Contingency Event Time

Contingency Event Time was introduced in version 6 of the MASS. Its primary purpose was to address concerns raised by the (at the time) proposed introduction of the National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5[48] (**Mandatory PFR Rule**). Specifically, its purpose was to count PFR delivered inside the NOFB towards an Ancillary Service Facility's Contingency FCAS obligations.

Now that the Mandatory PFR rule has been implemented to a significant degree, and with the benefit of experience and a marked change in power system frequency performance, it appears that using the Contingency Event Time complicates the assessment of FCAS delivery, especially for FCAS Providers who cannot easily

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

determine the Contingency Event Time independently of AEMO. Handling of Contingency Event Time becomes especially important for Very Fast FCAS given that the timeframe of this service is much shorter.

AEMO therefore proposes to remove the Contingency Event Time offset and revert to using the Frequency Disturbance Time as the starting point for FCAS measurement.

To compensate for Ancillary Service Facilities being significantly away from their true baseline due to frequency response action, AEMO is proposing to adopt a compensating approach to employ a simple method to adjust the pre-disturbance baseline by the Ancillary Service Facility's known frequency response function. Owing to recent frequency performance, AEMO suggests the usage of this compensation should be relatively rare, and if required, generally minor. Figure 24 and Figure 25 show illustrations of the current and proposed methodology respectively.

Figure 24 Current methodology for calculating Fast FCAS quantity

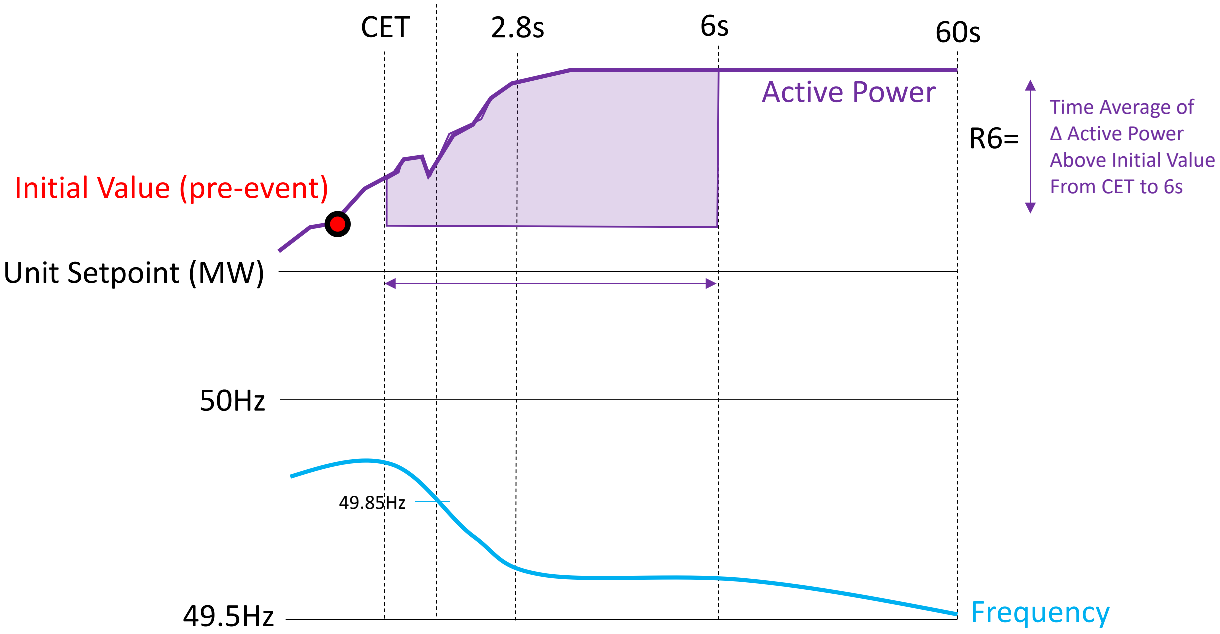
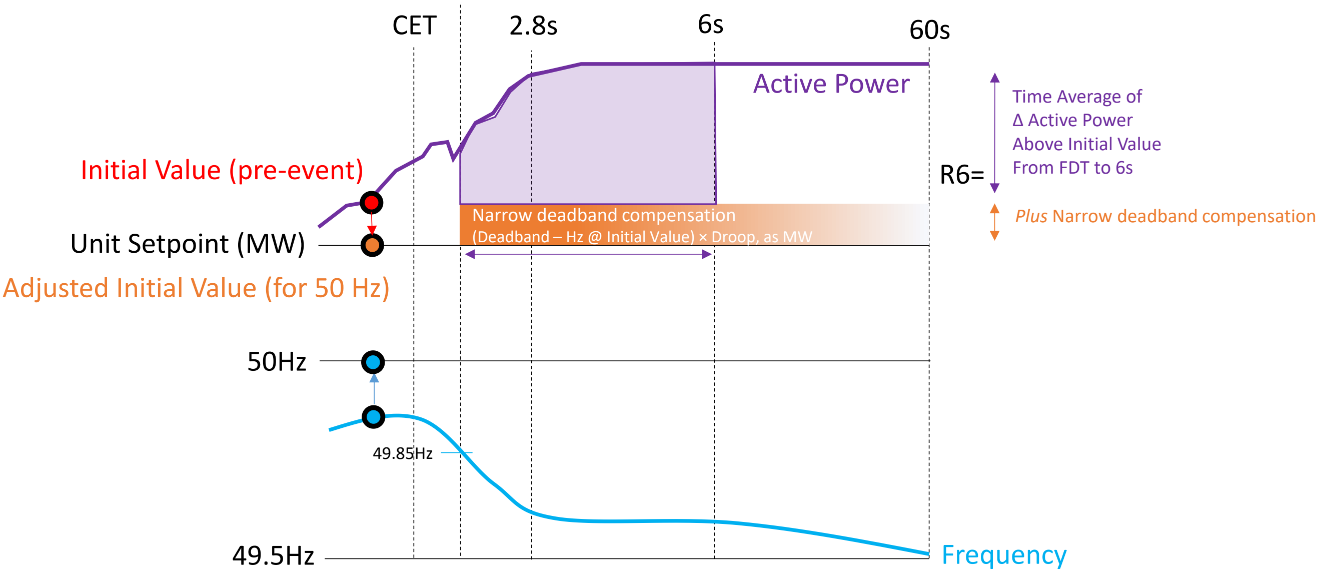


Figure 25 Proposed method for calculating Fast FCAS quantity



Questions

41. Are there any other issues relevant to the proposed removal of Contingency Event Time that AEMO should consider?

42. In there a better alternative to the baseline compensation approach than the one proposed by AEMO? Please provide reasons for your response.

6 Issues not under consultation

Further to the residual issues identified in the 2021 Consultation (Table 1), this section notes some potential reforms related to FCAS development or implementation that have been previously identified or recommended. These matters are not included in this 2022 MASS consultation, but may be included in future consultations or appropriate reform workstreams.

6.1 AEMO suggested MASS inclusions

AEMO notes that there are further matters that could require changes to the MASS but these are secondary to the primary focus of this consultation. Given the resource constraints of both AEMO and Consulted Persons, these are noted in Table 8 but may require consideration during future consultations. It is intended that consideration of these matters will be prioritised based on advice from the ASTAG in conjunction with other items in Table 1.

Table 8 Matters for potential future inclusion in the MASS

MATTERS	
1	Formalising droop limits and preference for variable controllers
2	Guidance on termination of Very Fast FCAS, to avoid problems that could arise from abrupt withdrawal
3	Guidance on FCAS behaviour over trading interval boundaries

6.2 Urgency for Very Fast FCAS

AEMO has advised the AEMC that the procurement of Very Fast FCAS is not urgently required[49]. This means there is an opportunity to integrate the Very Fast FCAS markets with the existing NEM Contingency FCAS markets gradually to facilitate a smooth transition.

AEMO also notes some feedback during the AEMC's rule change consultation that Very Fast FCAS should be introduced in *regions* where it is most needed first[50]. This issue is discussed in the context of geographical diversity in section 6.4.

6.3 Calculation of procurement quantity

The calculation of the procurement quantity is not a matter for the MASS.

AEMO notes that the Final Rule amends clause 4.8.16(b) to require that AEMO include the following in its quarterly Frequency and Time Error Monitoring Reports[51]:

[49] See page ii and 33 of the AEMC's Final Report. Available at https://www.aemc.gov.au/sites/default/files/2021-07/Fast%20frequency%20response%20market%20ancillary%20service%20-%20Final%20Determination.pdf. See also page 18 of AEMO's submission to the AEMC's System Security Market Frameworks Review Directions Paper, dated 26 April 2017, available at https://www.aemc.gov.au/sites/default/files/content/917b38b1-2f61-4601-a72e-f084cba0e2ce/MarketReview-Submission-EPR0053-AEMO-170426.pdf.

[50] See page 34 of the AEMC's Final Report, available at https://www.aemc.gov.au/sites/default/files/2021-07/Fast%20frequency%20response%20market%20ancillary%20service%20-%20Final%20Determination.pdf.

[51] Available at https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/frequency-and-time-deviation-monitoring.

(1A) the basis on which *AEMO* determined the quantity and type of any *market ancillary service* or combination of *market ancillary services*, procured by *AEMO* in order to improve *power system frequency* control outcomes, including, to the extent that is relevant, the relationship between the volume of the *market ancillary services* procured and the levels of *inertia* in the *power system*.

This provision does not commence until 9 October 2023, however, AEMO expects that the Frequency and Time Error Monitoring Reports will be amended to accommodate these matters before that date, to inform the market of the proposed procurement quantities to facilitate an orderly commencement of the Very Fast FCAS markets. These changes could be a good subject for consideration by the ASTAG or in another appropriate forum.

6.4 Geographic diversity

AEMO's technical advice to the AEMC[52] referred to international experience suggesting that locational concentrations of Very Fast FCAS should be avoided as they could affect angular separation between *regions* and increase the risk of separation between *regions*.

AEMO considers it would be prudent to put some limits on the *regional* allocation of Very Fast FCAS from the outset. While it is extremely difficult to develop exact limitations, especially without the benefit of operational experience, a reasonable starting point could be to restrict FCAS from any *region* from being *dispatched* for more than 50% of the total requirement.

As geographical distribution of Very Fast FCAS is a matter for FCAS procurement, this is outside of the scope of the MASS. Nonetheless, AEMO is interested in any views from Consulted Persons on how this might be implemented.

Questions

43. Are there any other issues relevant to geographic diversity that AEMO should consider?

6.5 Inertia network services and inertia support activities

The general matter of inertia and its relationship with Very Fast FCAS is discussed in Section 4.3.3.

The NER uses the terms *inertia network services* and *inertia support activities,* which are quite different to Very Fast FCAS. The manner in which inertia could affect Very Fast FCAS procurement volumes is not within the scope of the MASS.

6.6 Communication standards review

During the 2021 MASS Consultation, AEMO introduced a number of communications and data requirements for Ancillary Service Facilities providing FCAS, such as those in section 10.4 of the MASS. It is not intended that these requirements be revisited during this consultation. AEMO is currently conducting a separate review of the Data Communications Standard, which sets out standards with which data communication providers must comply

[52] AEMO, Fast frequency response implementation options — Technical advice on the development of FFR arrangements in the NEM, April 2021, page 33. Available at https://www.aemc.gov.au/sites/default/files/2021-04/FFR%20Implementation%20options%20-%20FINAL.pdf.

when transmitting data to and from AEMO[53]. The MASS will continue to identify specific requirements for FCAS Providers. Where different parameters may exist in the MASS and the Data Communications Standard, providers must meet the more onerous requirement. Notwithstanding this, AEMO welcomes feedback on any requirements that appear incompatible.

[53] https://aemo.com.au/consultations/current-and-closed-consultations/review-of-power-system-data-communication-standard

Appendix A – Frequency traces

Figure 26 FCAS power response including R1 and frequency trace for Mainland in 2022

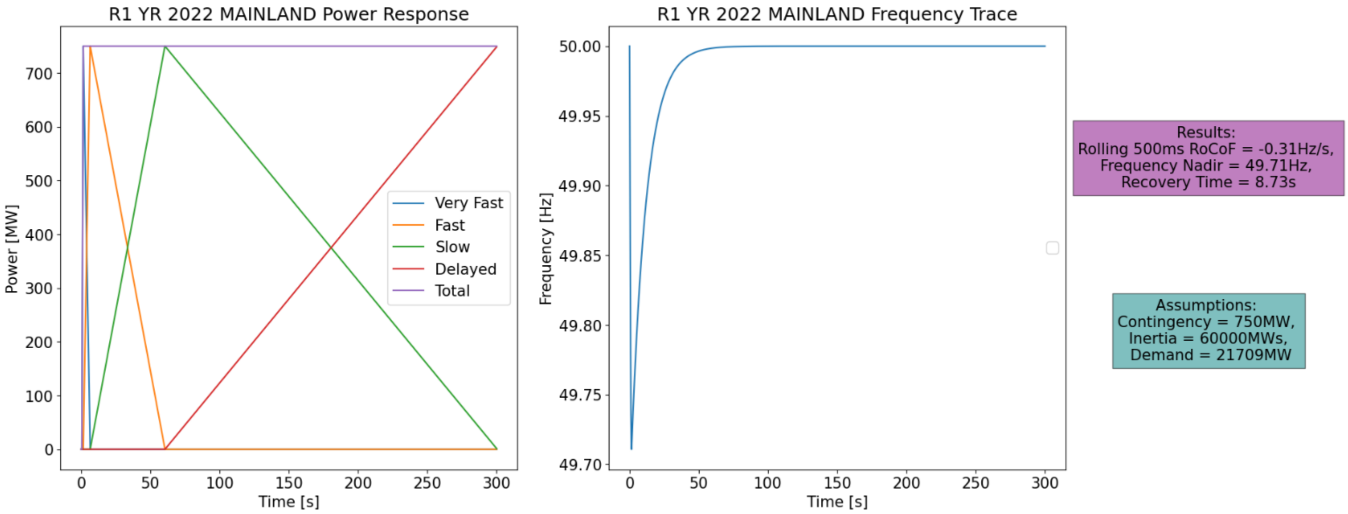


Figure 27 FCAS power response including R1 and frequency trace for Queensland in 2022

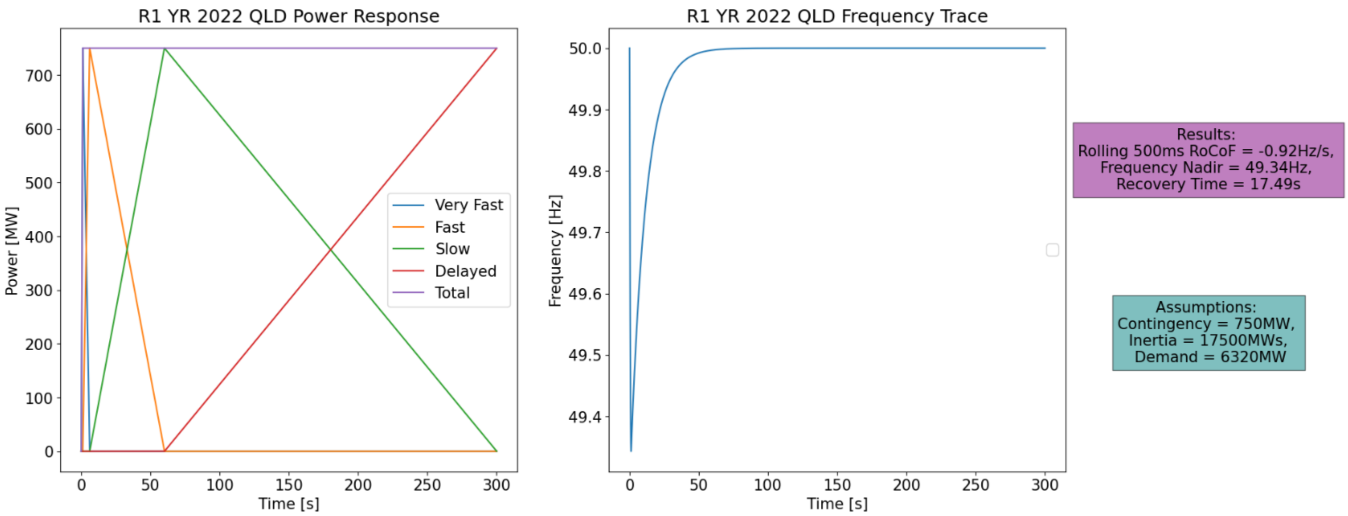


Figure 28 FCAS power response including R1 and frequency trace for South Australia in 2022

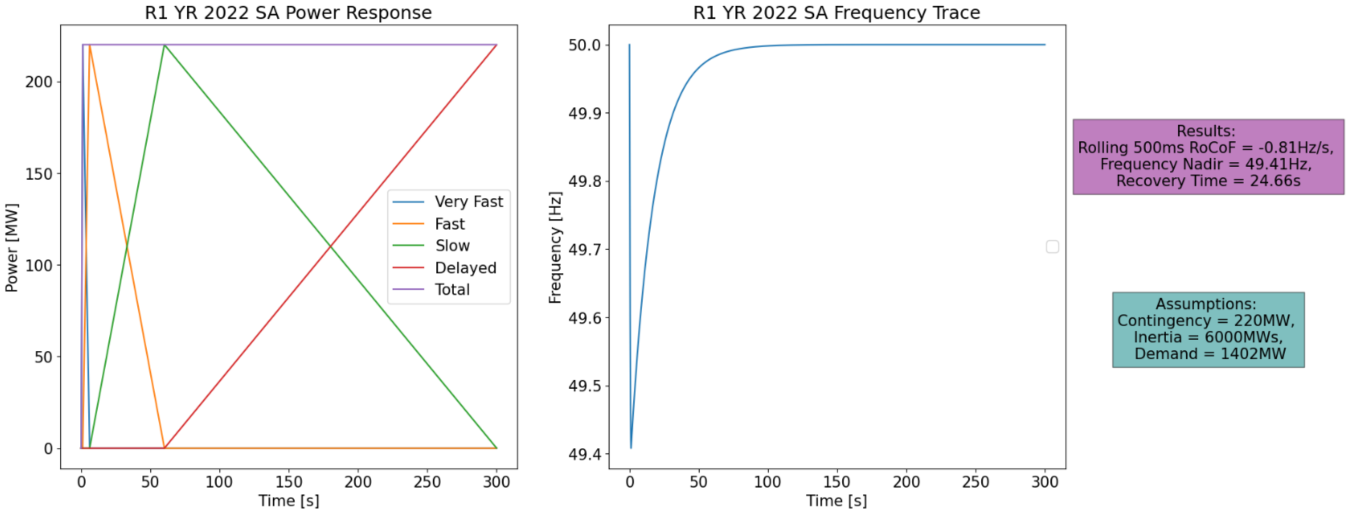


Figure 29 FCAS power response including R1 and frequency trace for Mainland in 2026

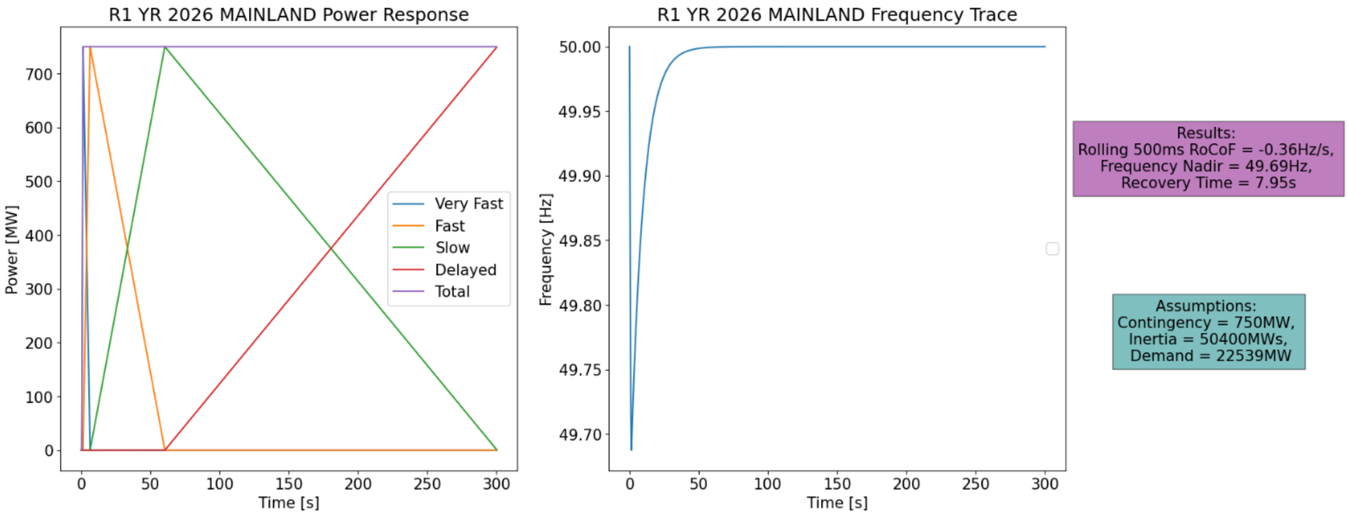


Figure 30 FCAS power response including R1 and frequency trace for Queensland in 2026

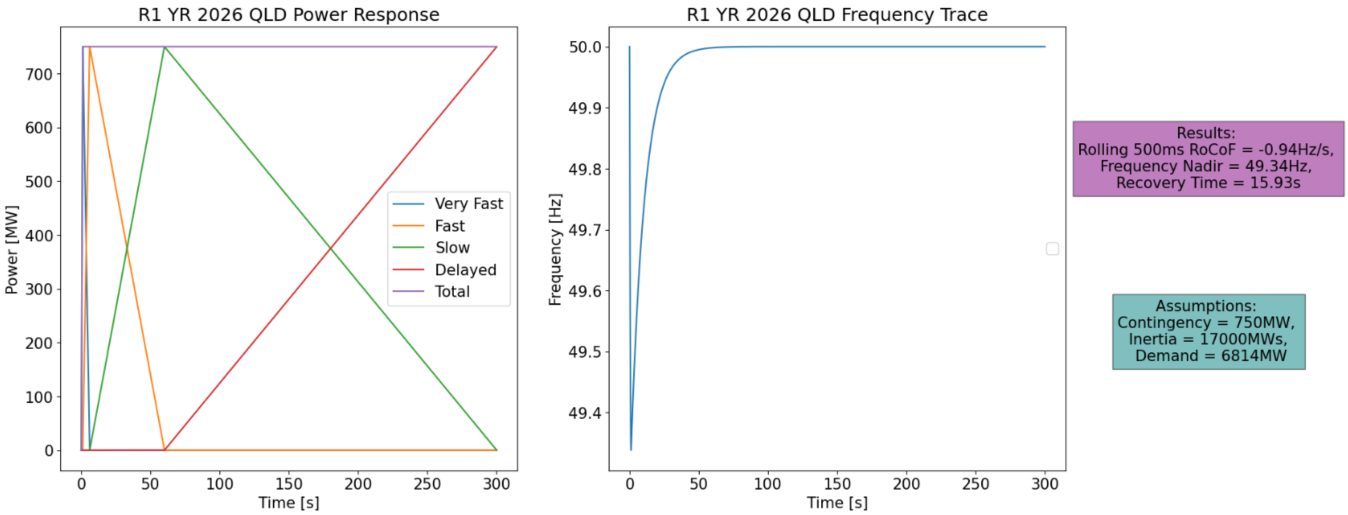
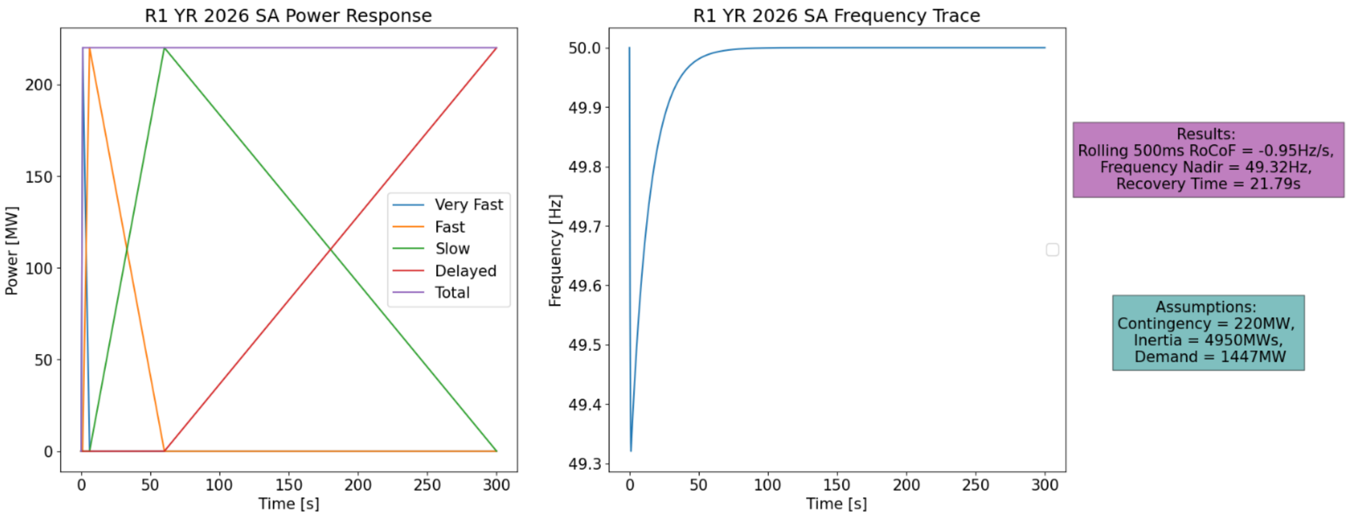


Figure 31 FCAS power response including R1 and frequency trace for South Australia in 2026



Glossary

Terms defined in the NER have the same meaning when used in this Issues Paper. Other acronyms and terms are defined in the table below.

Term or acronym	Meaning
AEMC	Australian Energy Market Commission
AGC	As defined in the MASS.
Aggregated Ancillary Service Facility	As defined in the MASS.
Amending Rule	*National Electricity Amendment (Fast frequency response market ancillary service) Rule 2021 No. 8*.
Ancillary Service Facility	As defined in the MASS.
CIGRE Brochure	CIGRE Technical Brochure C2/C4 dated October 2021 entitled: Impact of High Penetration of Inverter-based Generation on System Inertia of Networks[54].
Contingency Event Time	As defined in the MASS.
Contingency FCAS	Any or all of the following: • fast raise service; • fast lower service; • slow raise service; • slow lower service; • delayed raise service; and • delayed lower service.
Delayed FCAS	Delayed raise service and delayed lower service.
DER	Distributed energy resources.
Fast FCAS	Fast raise service and fast lower service.
FFR	Fast frequency response, a generic term used in the electricity industry that encompasses Very Fast FCAS.
FCAS	frequency control ancillary services
FCAS Provider	A person who provides FCAS.
Frequency Disturbance	As defined in the MASS.
Frequency Disturbance Time or FDT	As defined in the MASS.
Frequency Ramp Rate	As defined in the MASS.
FOS	frequency operating standard[55].

[54] Available at https://e-cigre.org/publication/851-impact-of-high-penetration-of-inverter-based-generation-on-system-inertia-of-networks.

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

Term or acronym	Meaning
ISP	Integrated System Plan.
LCR	Largest credible risk.
Local Frequency	As defined in the MASS.
Mainland	As defined in the MASS.
Mandatory PFR Rule	National Electricity Amendment (Mandatory primary frequency response) Rule 2020 No. 5[56]
MASS	The market ancillary service specification contemplated by clause 3.11.2(b) of the NER.
NEM	National Electricity Market.
NER	National Electricity Rules.
Regulation FCAS	Regulating raise service and regulating lower service.
RIS	Renewable Integration Study.
Slow FCAS	Slow raise service and slow lower service.
Very Fast FCAS	Very fast lower service and very fast raise service.
VPP	Virtual power plant.

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