Battery Energy Storage System guide to Contingency FCAS registration

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Important notice

Purpose

AEMO has prepared this document to provide general guidance about requirements for battery energy storage systems to participate in the ancillary services markets for contingency raise and lower services, as at the date of publication.

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Current version release details

Version	Effective date	Summary of changes
4.0	28/06/2024	• Clarification of BESS testing requirements for DC-coupled systems • Minor editorial changes

Note: There is a full version history at the end of this document.

1. Introduction

1.1. Purpose

A Battery Energy Storage System (BESS) is capable of providing a contingency FCAS response using one of two methods:

(a) Via a variable controller, where it varies its active power when the local frequency exceeds either the lower or upper limit of the *normal operating frequency band* (NOFB), or its frequency control deadband (whichever is narrower); or

(b) Via a switching controller, where a step change in active power is triggered when the local frequency exceeds the Frequency Setting allocated to the switching controller of the FCAS Facility.

The purpose of this document is to assist market participants in registering a BESS in the contingency FCAS markets. The testing requirements for the FCAS assessment completed during the registration process are described. In addition, information on the applicable settings for the FCAS controller and the resulting impact on the registered maximum FCAS capacity is provided.

A fact sheet[1] for registering utility-scale battery system in the NEM has been published by AEMO for industry, describing the options for integrating battery systems into the NEM.

Broader information on the participant category classification of a battery system can be found in the *Guide to Generator Exemptions and Classification of Generating Units* document[2].

1.2. Definitions and interpretation

1.2.1. Glossary

Terms defined in the National Electricity Rules (NER) have the same meanings in this document unless otherwise specified. These terms are intended to be identified in this document by italicising them, but failure to italicise a defined term does not affect its meaning. In addition, the words, phrases and abbreviations in the table below have the meanings set out opposite them when used in this document.

Table 1 Definitions

Term	Definition
BESS	Battery energy storage system
FCAS	Frequency control ancillary services
Frequency deadband	The range of local frequency through which a variable controller will not operate.

[1] See https://aemo.com.au/-/media/files/electricity/nem/participant_information/new-participants/registering-a-battery-system-in-the-nem.pdf?la=en.

[2] See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/New-Participants/Generator-Exemption-and-Classification-Guide.docx.

Term	Definition
Frequency Deviation Setting	The setting allocated to an Ancillary Service Facility by AEMO within the range shown in Table 5 for the Mainland and Table 6 for the Tasmania region.
FOS	*Frequency operating standard* published by the AEMC Reliability Panel.
Local frequency	The frequency measured by an FCAS Provider at the connection point of the FCAS Provider's Ancillary Service Facility or at each connection point in an Aggregated Ancillary Service Facility, in Hz.
MASS	*Market ancillary service specification*
NOFB	The relevant *normal operating frequency band* corresponding to 'normal' conditions, specified in Column 2 of Table A.1 in the FOS (that is, between 49.85 Hz and 50.15 Hz).
OFTB	The relevant *operational frequency tolerance band* corresponding to 'normal' conditions, specified in Column 2 of Table A.1 in the FOS (that is, 49 Hz to 51 Hz in the mainland, and 48 Hz to 52 Hz in Tasmania).
PFR	*Primary frequency response*
Raise Reference Frequency	The lower value in the 'containment band' for Generation Events and Load Events, as specified in Table A.3 of the FOS for the Mainland and Table A.6 for Tasmania. The raise reference frequency used for the FCAS assessment is 49.5 Hz for the mainland and 48.0 Hz for Tasmania.
Lower Reference Frequency	The upper value in the 'containment band' for Generation Events and Load Events, as specified in Table A.3 of the FOS for the Mainland and Table A.6 for Tasmania. The lower reference frequency used for the FCAS assessment is 50.5 Hz for mainland and 52.0 Hz for Tasmania

2. Contingency FCAS registration requirements for BESS

A BESS operator seeking to provide contingency FCAS will need to consider the following:

(a) A piecewise linear type droop response is expected from variable FCAS controllers delivering an increase or decrease in active power in response to changes in frequency. If the battery system is also providing PFR, AEMO will determine the FCAS capacity based on the applicable fixed droop settings and frequency deadbands for PFR and FCAS.

(b) Unless agreed by AEMO, the delivery of active power must be configured to be in proportion to the local frequency.

(c) The minimum allowable droop setting of any BESS with a nameplate rating of 5 MW or above is 1.7%.

(d) Upon request by the participant and at AEMO's sole discretion, alternative settings such as a narrower frequency deadband, a more aggressive droop setting than 1.7% or a switching FCAS controller may be considered for any BESS with a nameplate capacity less than 5 MW only.

Note: AEMO may limit the amount of FCAS enabled for switching controllers in any given trading interval if AEMO considers it is reasonably necessary to manage or maintain power system security.

(e) The maximum registered FCAS capacity for any of the contingency services will be capped at the nameplate capacity of the BESS.

(f) AEMO must be informed of the deadband that will be implemented on site before the desktop simulation or the on-site testing.

(g) Using a sufficiently accurate model (PSCAD, PSSE, Simulink, or other approved by AEMO), the provider must simulate a frequency ramp and provide data to demonstrate the active power response. The simulation test results must have been reviewed by AEMO before the on-site testing. The desktop simulation requirements are described under clause 2(j).

(h) The provider should demonstrate the active power response to frequency during the onsite testing. The data captured from tests described under clause 2(j) will be used to finalise the maximum ancillary service capacity of the BESS. An example of the expected FCAS delivery of a BESS and the required tests to be carried out is provided under Section 3.

(i) The metering facilities must comply with the MASS requirements specified under Table 5 of the MASS[3]. The data provided following the tests during the commissioning process will be used to confirm whether the facility complies with the MASS.

(j) The following test cases are to be verified via simulation and on-site testing, and results in both simulation and on-site testing must be consistent:

- 3 starting points for raise FCAS tests
    1. Maximum charge when providing FCAS to Idle
    2. Idle to maximum discharge when providing FCAS
    3. Cycle from partial charge to partial discharge
- 3 starting points for lower FCAS tests.
    1. Maximum discharge when providing FCAS to Idle
    2. Idle to maximum charge when providing FCAS
    3. Cycle from partial discharge to partial charge
- Frequency is held at 50 Hz (+/- 0.01 Hz) for 20 seconds before the frequency ramp.
- After 20 seconds, frequency is to be ramped to the reference frequency shown in Table 2 at the specified ramp rate for each ancillary service. Other considerations are:
    1. If the participant is registering for Very Fast FCAS, only the faster ramp rate (1 Hz/s) is required in these tests.
    2. If necessary, progressive step changes in frequency may be used to approximate the relevant frequency ramp.

[3] The measurement requirements are specified under Table 5 of MASS Version 8.2.

Table 2 Applicable reference frequency and ramp rate

FCAS	Mainland		Tasmania	
	Reference frequency (Hz)	Ramp rate (Hz/s)	Reference frequency (Hz)	Ramp rate (Hz/s)
Very Fast Raise	49.5	1	48	1
Fast Raise, Slow Raise, Delayed Raise	49.5	0.125	48	0.4
Very Fast Lower	50.5	1	52	1
Fast Lower, Slow Lower, Delayed Lower	50.5	0.125	52	0.4

- For Very Fast or Fast FCAS, provide at least 5 seconds of high speed data recording, as defined by the MASS, before disturbance and at least 60 seconds after disturbance.
- For all contingency FCAS, provide at least 20 seconds of appropriate data recording (at least 4s resolution as defined by the MASS) before disturbance and at least 10 minutes after disturbance.
- Measurements of power and frequency must be captured on a common time scale.
- High speed data and low speed data must be provided to AEMO in clearly labelled spreadsheet tabs or files.

(k) If a frequency injection test cannot be completed on-site for technical reasons, the deadband or Frequency Deviation Setting may be narrowed to a value agreed with AEMO in order to demonstrate the FCAS response of the BESS based on actual local frequency measurements, as an alternative testing arrangement. The on-site testing is to be completed in three stages at the following setpoints for 1 hour each:

- Half charge
- Idle
- Half discharge

The measurements of power and frequency must be captured at the same time resolution specified under Table 5 of the MASS.

(l) If the BESS is participating in the FCAS markets under an Aggregated FCAS Facility, an individual site test will not be required if the nameplate capacity of the BESS is less than 1 MW. In such cases, the following requirements apply:

- A single suite of frequency injection tests as specified in clause 2(j) is required for every distinct type of controllable device in the Aggregated FCAS Facility. These tests can be completed off-site.
- A site-wide test of the new DUID, or of the additional FCAS Facilities being added to an existing DUID, is required to demonstrate the capability of the Aggregated FCAS Facility to respond to frequency deviations. This test can be either the suite of frequency injection tests as per clause 2(j) or the monitoring test with agreed narrow deadband settings as per clause 2(k).

(m) If providing FCAS from an Aggregated FCAS facility such as a Virtual Power Plant (VPP), the participant may be required to demonstrate compliance by providing aggregated measurements across all connections points for net flow, PV output and BESS power.

(n) If providing FCAS from within an embedded network, measurements of power are required from both:

- The child connection point with the FCAS facility, to verify the FCAS delivery, and
- The parent connection point, to demonstrate there is no direct interaction between other elements in the embedded network and the FCAS Facility.

(o) If providing FCAS from facility with DC-coupled energy storage system, measurements of power are required from:

- A MASS-compliant FCAS meter installed on the AC side of the inverter, to verify the FCAS delivery, and
- PV output and BESS power, measured by the inverter or metered on the DC side.
- Additional testing may be required to demonstrate the ability to ensure adequate headroom or footroom is being reserved to deliver the raise or lower services. Detailed test plans must have been reviewed by AEMO before the on-site testing.

3. BESS contingency FCAS registration example

In this section, the example BESS is assumed to have a 50 MW charge and discharge capacity, and is registered by AEMO as a scheduled generator and a scheduled load pair. It employs a Variable FCAS controller.

3.1. Calculation of the droop percentage

As per clause 6.2.2(b)(i) of the MASS for a variable controller, the Raise Response or Lower Response is an amount which commensurate with the difference between Local Frequency and Frequency Deadband where the Local Frequency is between the Frequency Deadband and the lower limit (for a Raise Response) of the *operational frequency tolerance band* (OFTB) or upper limit (for a Lower Response) of the OFTB in accordance with the Ancillary Service Facility's proportional response function (droop function or droop curve).

The droop of the BESS is calculated using the formula below:

$$\% \text{ Droop} = 100 * \frac{(FB-D)}{50} * \frac{C}{SP}$$

$$= 100 * \frac{(1-0.15)}{50} * \frac{50}{50}$$

$$= 1.7\ \%$$

Where

FB is the frequency deviation at which the maximum charge or discharge of the BESS is provided.

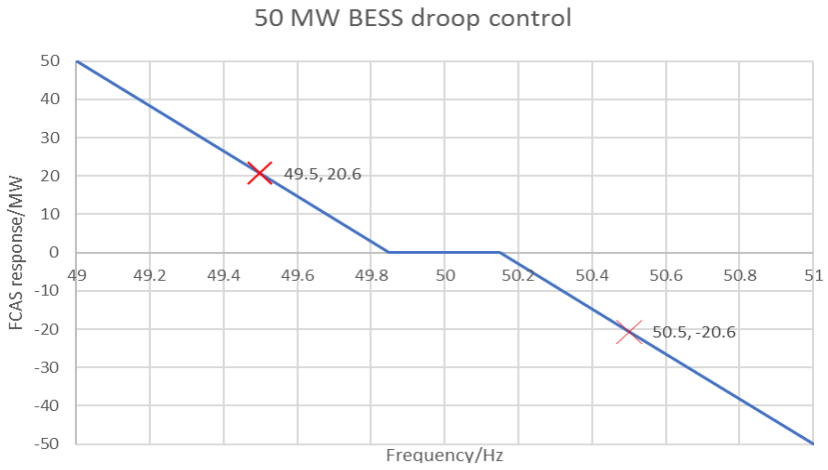
D is the frequency controller deadband, which has a value of +/-0.15 Hz in this example[4].

C is the registered capacity of the BESS which is 50 MW (not the full cycle capacity of 100 MW).

SP is the capacity of the BESS used to provide an FCAS response.

Figure 1 shows the droop curve of a 50 MW BESS participating in the FCAS markets.

Figure 1 Droop curve of a 50 MW BESS



3.2. Calculation of peak active power change

As per clauses 7.1, 7.2, 8.1, 8.2, 9.1 and 9.2 of the MASS, and using the principles and settings described in Section 3.1, the peak active power change when delivering FCAS is calculated using the formula below:

$$\text{Peak active power change} = 100 * \frac{1}{\%Droop} * \frac{(\min(FB, FR) - D)}{50} * C$$

$$= 100 * \frac{1}{1.7} * \frac{(\min(1, 0.5) - 0.15)}{50} * 50$$

$$= 20.6\ MW$$

where

FR is the absolute value of the difference between 50 Hz and the raise or lower reference frequency.

The maximum registered FCAS capacity is determined by the MASS FCAS verification tool using the results of the on-site tests. For reference, the maximum registered FCAS capacity of battery systems can be found in the NEM Registration and Exemption list[5].

Version 8[6] of the MASS, which will be effective on 9 October 2023, caps the registered FCAS capacity for all FCAS providers to peak active power change.

[4] A 50 MW BESS is required to provide PFR and this example does not consider the implementation of a narrow deadband.

[5] See https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant_Information/NEM-Registration-and-Exemption-List.xls.

[6] See section 6.3(b) https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/amendment-of-the-mass/final-determination/market-ancillary-services-specification---v80-effective-9-oct-2023.pdf?la=en.

3.3. Expected simulation and commissioning FCAS test results

For a 50 MW BESS providing FCAS by charging or discharging in the mainland, the test results shown in the figures below are expected in order to confirm the FCAS capability of the BESS.

Figure 2 Increase in active power from 0 MW to +20 MW following a 0.5 Hz frequency deviation to the raise reference frequency

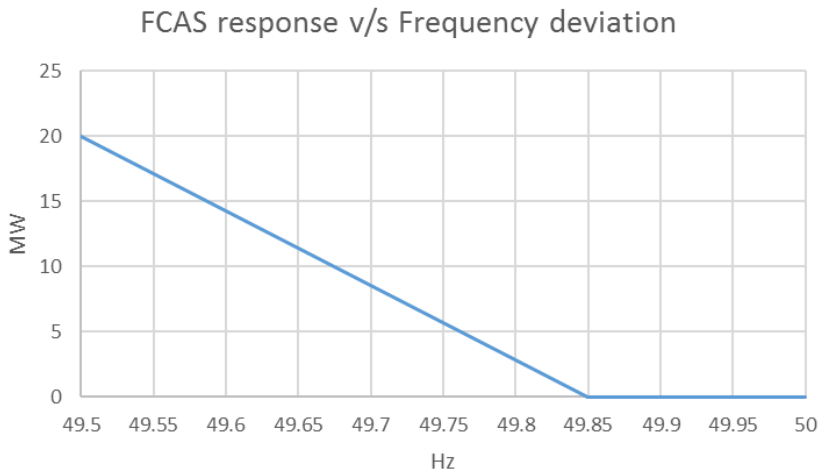


Figure 3 Increase in active power from -20 MW to 0 MW following a 0.5 Hz frequency deviation to the raise reference frequency

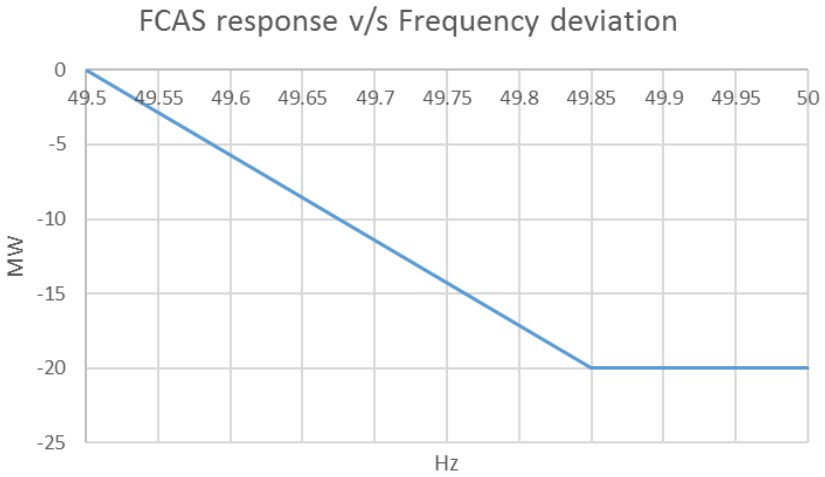


Figure 4 Increase in active power from -10 MW (charging) to +10 MW following a 0.5 Hz frequency deviation to the raise reference frequency

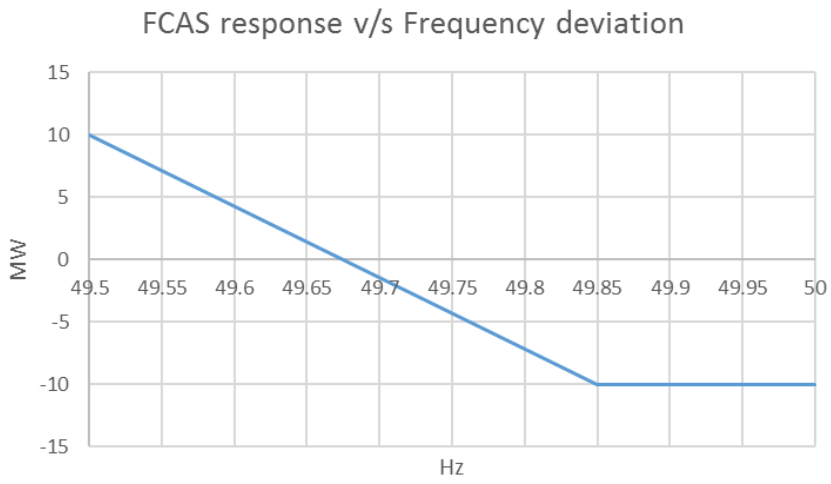


Figure 5 Decrease in active power from +20 MW to 0 MW following a 0.5 Hz frequency deviation to the lower reference frequency

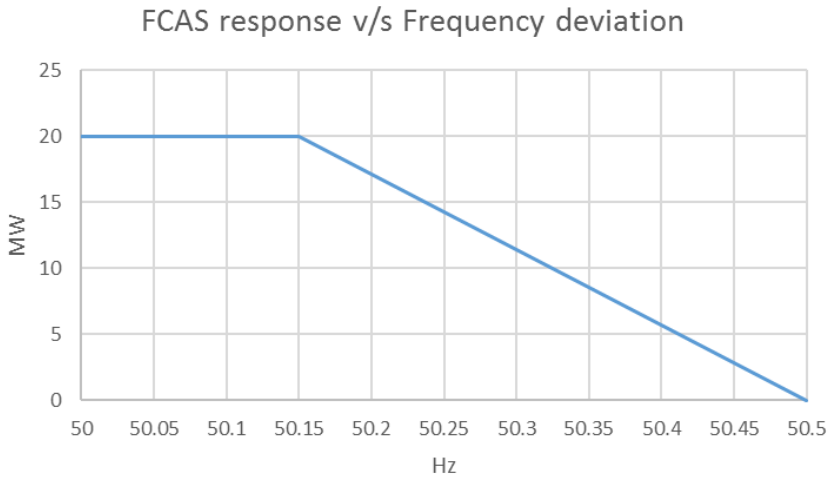


Figure 6 Decrease in active power from 0 MW to -20 MW following a 0.5Hz frequency deviation to the lower reference frequency

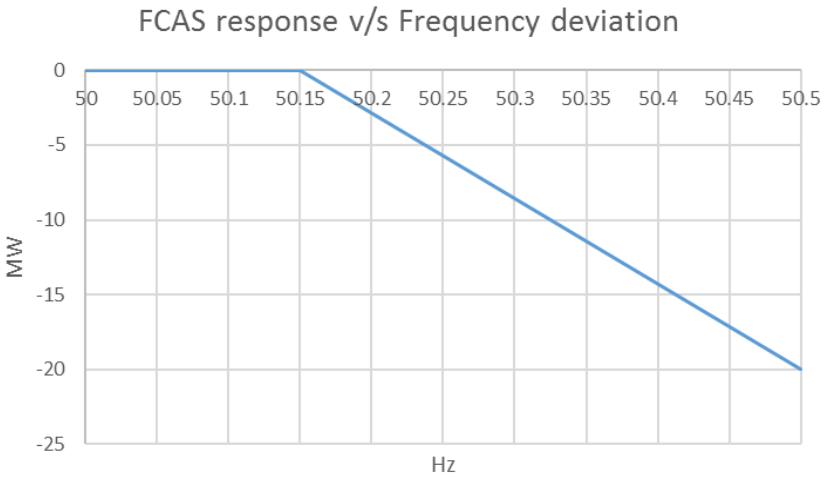
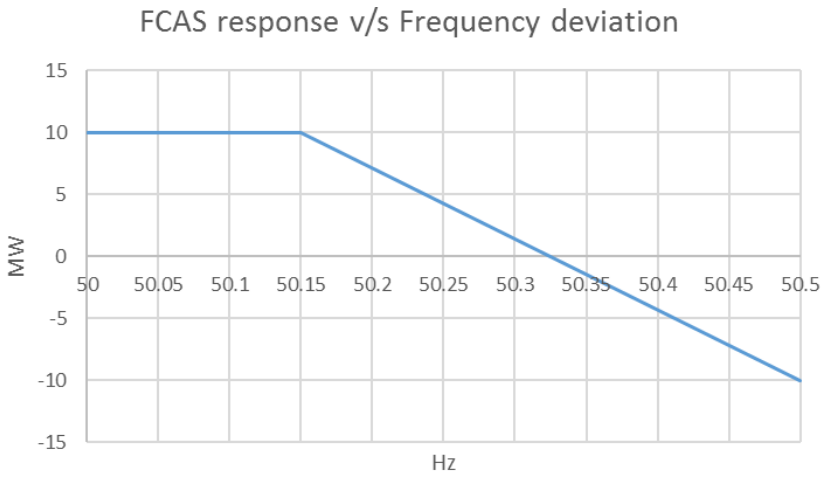


Figure 7 Decrease in active power from +10 MW to -10 MW following a 0.5Hz frequency deviation to the lower reference frequency



3.4. FCAS delivery verification

The MASS FCAS verification tool[7] (FCASVT) is used by AEMO to determine the maximum ancillary service capacity of the BESS. As per section 6.5 of the MASS, if there is any inconsistency between the FCASVT and the MASS, the MASS will prevail to the extent of that inconsistency.

[7] See https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/2024/external-fcas-verification-tool-v62-for-mass-v82.xlsx?la=en.

Version release history

Version	Effective date	Summary of changes
3.0	24 March 2023	• Changes forAddition of testing requirements for Very Fast FCAS. • Clarification of BESS testing requirements for an Aggregated FCAS facility and an embedded network.
2.0	16 February 2022	• Clarification of FCAS registration and testing requirements. • Clarification of AEMO's policy on droop setting and FCAS controller types. • Various edits throughout document.
1.0	14 January 2019	• First issue of the battery energy storage system requirements for contingency FCAS registration.