

BATTERY ENERGY STORAGE SYSTEM GUIDE FOR CONTINGENCY FCAS REGISTRATION

PREPARED BY: AEMO Operations Department – Systems Performance
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Approved for distribution and use by:

APPROVED BY: James Lindley
TITLE: Group Manager System Capability - Operations

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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 National Electricity Market ancillary service markets for contingency raise and lower services, as at the date of publication.

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Note: There is a 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 by varying its active power when the local frequency exceeds the narrower of the lower or upper limit of the *normal operating frequency band* (NOFB) and its frequency control dead-band. The purpose of this document is to assist market participants in the National Electricity Market (NEM) looking to register a battery energy storage system to provide contingency FCAS.

Information on the type of frequency controllers to be used and the allowable droop settings when delivering FCAS is also provided to help participants determine the maximum ancillary service capacity that can be registered, subject to a successful FCAS assessment by AEMO.

A guidance document¹ on utility-scale battery technology has been published by AEMO for industry, describing interim arrangements to apply in a number of key areas including: registration, metering, SCADA, negotiation of generator performance standards (GPS) and engagement with NSPs. Further information regarding battery registration can be found in the *Guide to Generator Exemptions and Classification of Generating Units* document².

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.

Term	Definition
BESS	Battery energy storage system. The information in this document applies for utility scale batteries.
FCAS	Frequency control ancillary services
Frequency Deadband	The range of Local Frequency through which a Variable Controller will not operate.
Frequency Deviation Setting	The setting allocated to an Ancillary Service Facility by AEMO within the range shown in Table 5 for the Mainland and Table 6 for the Tasmania region.
FOS	<i>Frequency operating standard</i> 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	<i>Market ancillary service specification</i>

¹ See [https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant Information/New-Participants/Interim-arrangements-for-utility-scale-battery-technology.docx](https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant%20Information/New-Participants/Interim-arrangements-for-utility-scale-battery-technology.docx)

² See [https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant Information/New-Participants/Generator-Exemption-and-Classification-Guide.docx](https://www.aemo.com.au/-/media/Files/Electricity/NEM/Participant%20Information/New-Participants/Generator-Exemption-and-Classification-Guide.docx)

Term	Definition
NOFB	<i>Normal operating frequency band</i> as specified in the FOS (refers to system frequency between 49.85 Hz to 50.15 Hz, when not operating in an island or during supply scarcity).
OFTB	<i>Operational frequency tolerance band</i> as specified in the FOS (refers to the frequency between 49.0 Hz to 51.0 Hz in mainland when not operating during supply scarcity and 48.0 Hz to 52.0 Hz in Tasmania).
PFR	Primary frequency response
Raise Reference Frequency	means the containment frequency below 50 Hz for Generation Events, as specified in the relevant FOS. The raise reference frequency used for the FCAS assessment is 49.5 Hz for mainland and 48.0 Hz for Tasmania
Lower Reference Frequency	means the containment frequency above 50 Hz for Load Events, as specified in the applicable FOS. 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 account for the following:

- (a) A single droop setting is to be chosen if the control system to provide FCAS is a proportional/variable controller. A piecewise linear type droop response is expected from contingency FCAS providers 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 droop settings and frequency dead-bands 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 constrain the amount of switched FCAS enabled 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 dead-band that will be implemented on site before the desktop simulation or the on-site testing.
- (g) Using a sufficiently accurate model on PSCAD, PSSE or Simulink, simulate a frequency disturbance 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 details are below:

- The simulation must show that the BESS can cycle (charge to discharge and vice versa) to deliver FCAS.
 - The frequency must ramp to at least the raise and lower reference frequency as shown in Figure 2 and Figure 3 of the *market ancillary service specification*³ (MASS)
 - The frequency ramp rate to be applied in the desktop simulation is specified under Table 1 of the MASS. If step changes are applied, the difference between 2 consecutive step changes must be in line with the standard frequency ramp rate.
- (h) Demonstrate the active power response to a frequency disturbance during the commissioning stage. The data captured from the on-site testing 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 4 of the MASS. 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 parameters must be consistent in both simulation and on-site testing.
- 3 starting points for raise FCAS tests
 1. Full charge to Idle
 2. Idle to full discharge
 3. Cycle from partial charge to partial discharge
 - 3 starting points for lower FCAS tests.
 1. Full discharge to Idle
 2. Idle to full charge
 3. Cycle from partial discharge to partial charge
 - Frequency at 50 Hz for 20 seconds before frequency disturbance.
 - After 20 seconds, frequency ramps down to 49 Hz at 0.125 Hz/s to test raise FCAS capability and frequency ramps up to 51 Hz at 0.125 Hz/s to test lower FCAS capability.
 - Provide 5 seconds of high speed data at the measurement time resolution for Fast FCAS specified in the MASS before disturbance and 60 seconds after disturbance.
 - Provide 20 seconds of ≤ 4 second data before disturbance and 10 minutes after disturbance.
 - Measurements of power and frequency to be captured on a common time scale.
 - High speed data and low speed data to be provided in clearly labelled spreadsheet tabs or files.
- (k) If a frequency injection test cannot be completed on-site for technical reasons, the dead-band or Frequency Deviation Setting can be narrowed to demonstrate the FCAS response of the BESS based on local frequency measurements. The on-site testing is to be completed in three stages at the following setpoints for 1 hour each:
- Half charge
 - Idle

³ See https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/primary-freq-resp-norm-op-conditions/market-ancillary-services-specification-v70.pdf?la=en

- Half discharge

The measurements of power and frequency must be captured at the same time resolution specified under clause 2(h).

3. BESS CONTINGENCY FCAS REGISTRATION EXAMPLE

The section below provides more information on the expected response of a BESS when delivering FCAS. In this example, the capacity of the BESS is assumed to be 50 MW and is registered by AEMO as a scheduled generator and a scheduled load.

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:

$$\begin{aligned}
 \% \text{ Droop} &= 100 * \frac{(FB-D)}{50} * \frac{C}{SP} \\
 &= 100 * \frac{(1-0.15)}{50} * \frac{50}{50} \\
 &= 1.7 \%
 \end{aligned}$$

Where

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

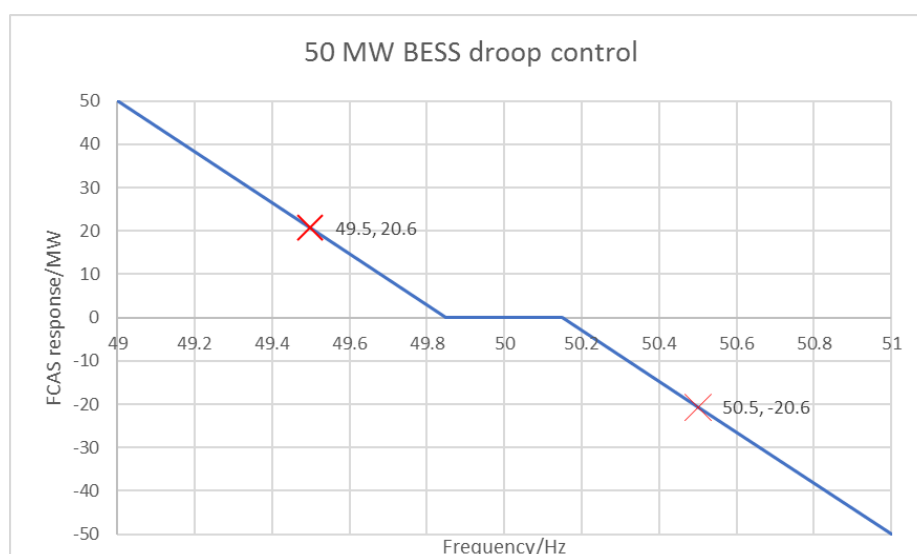
D is the frequency controller dead band, which has a value of +/-0.15 Hz in this example.

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 the FCAS capacity

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 maximum ancillary service capacity is calculated using the formula below:

$$\begin{aligned} \text{Contingency FCAS capacity} &= 100 * \frac{1}{\% \text{Droop}} * \frac{(\min(FB, FR) - D)}{50} * C \\ &= 100 * \frac{1}{1.7} * \frac{(\min(1, 0.5) - 0.15)}{50} * 50 \\ &= 20.6 \text{ MW} \end{aligned}$$

Where

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

The calculated maximum FCAS capacity is rounded down to the closest integer and is therefore equal to 20 MW.

3.3. Expected simulation and commissioning FCAS test results

For a 50 MW BESS providing FCAS by charging or discharging in the mainland, the following 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

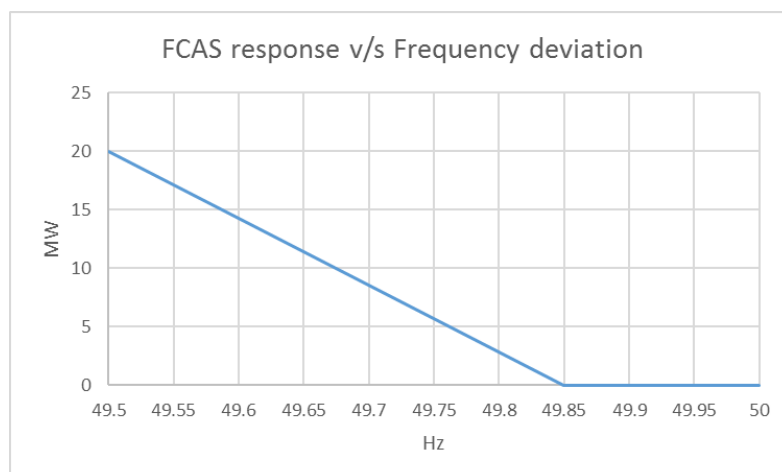


Figure 3 Increase in active power from -20 MW to 0 MW following a 0.5 Hz frequency deviation to the raise reference frequency

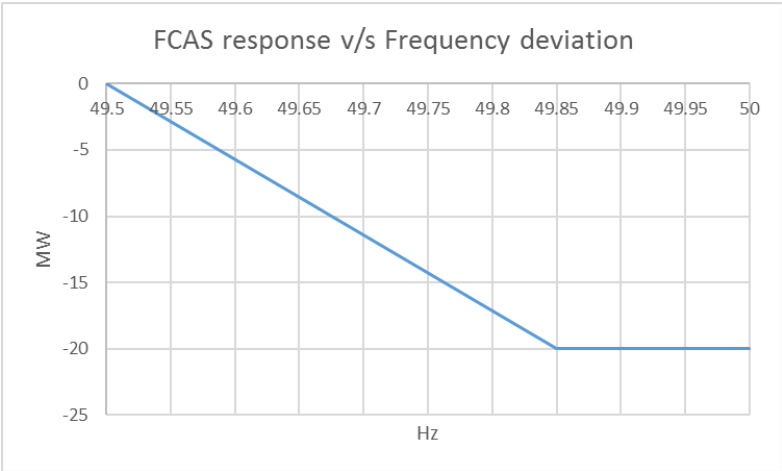


Figure 4 Increase in active power from -10 MW (charging) to +10 MW following a 0.5 Hz frequency deviation to the raise reference frequency

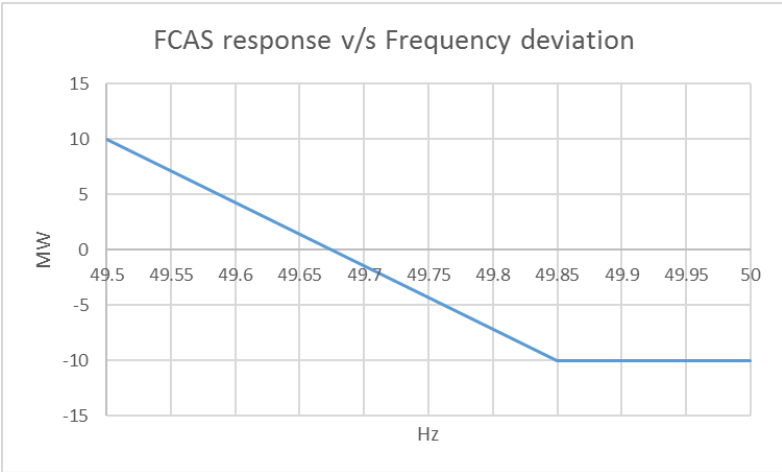


Figure 5 Decrease in active power from +20 MW to 0 MW following a 0.5Hz frequency deviation to the lower reference frequency

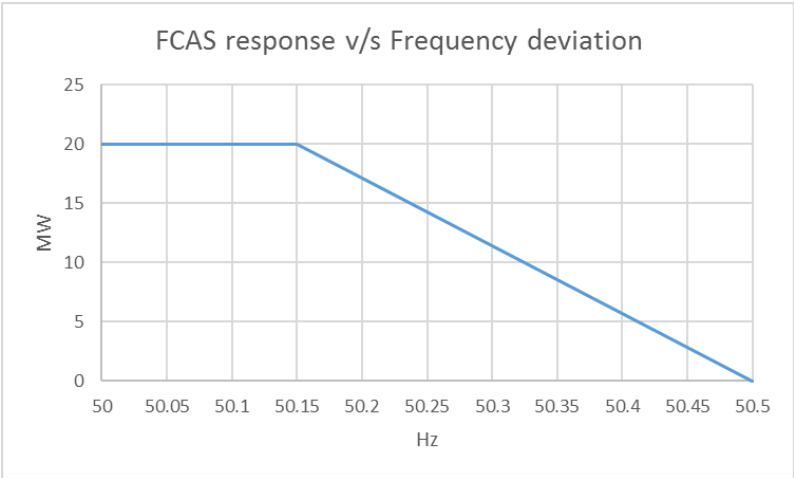


Figure 6 Decrease in active power from 0 MW to -20 MW following a 0.5Hz frequency deviation to the lower reference frequency

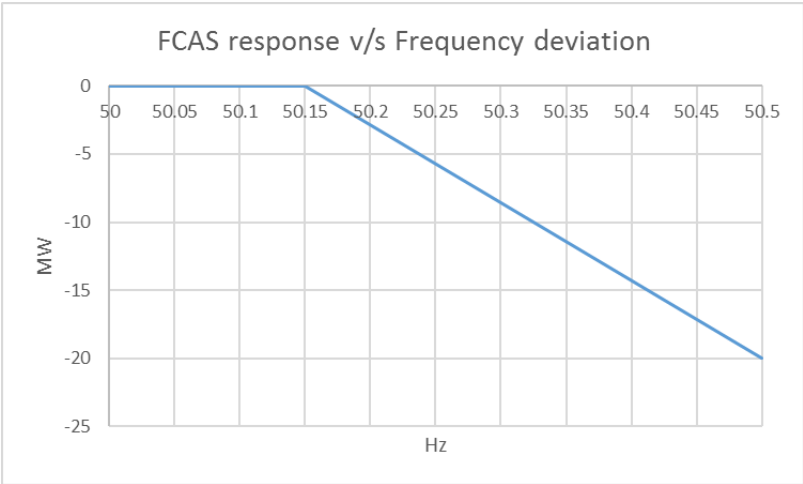
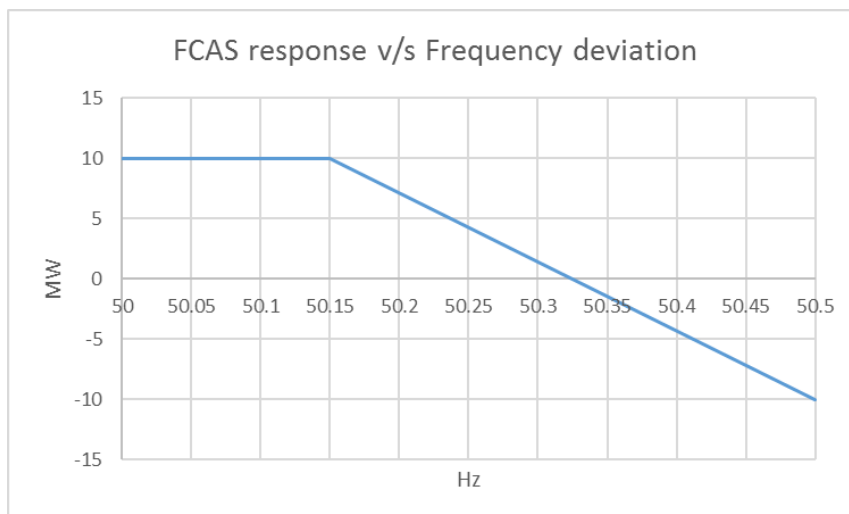


Figure 7 Decrease in active power from +10 MW to -10 MW following a 0.5Hz frequency deviation to the lower reference frequency



3.4. FCAS delivery verification

The MASS FCAS verification tool⁴ (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.

⁴ See https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/2022/external-fcas-verification-tool-v501-for-mass-v7.xlsx?la=en

VERSION RELEASE HISTORY

Version	Effective Date	Summary of Changes
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