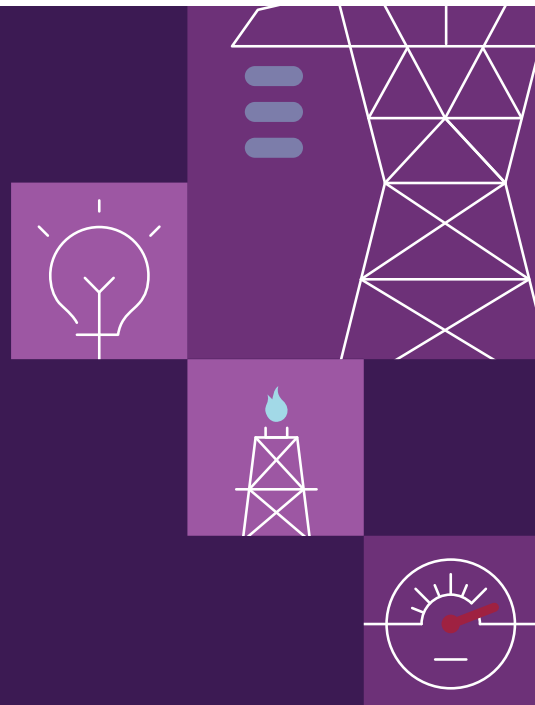


Guide to Frequency Control Ancillary Services



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Current version release details

Version	Summary of changes
4.0	Renamed and revised to focus on Frequency Control Ancillary Services only.

1. Introduction

1.1. Purpose and scope

This document provides a broad explanation of frequency control ancillary services (FCAS) in the National Electricity Market (NEM). This explanation is provided in a non-technical manner and is aimed at readers who have had little or no previous exposure to ancillary services.

AEMO is responsible under the National Electricity Rules (Rules) for ensuring that the power system is operated in a safe, secure and reliable manner. To fulfil this obligation, AEMO controls key technical characteristics of the power system, such as frequency and voltage, through ancillary services.

Power system frequency is controlled using FCAS, which are purchased through the spot market. For this reason they are known in the Rules as *market ancillary services*. Other ancillary services are purchased using contracts.

1.2. Definitions and interpretation

1.2.1. Glossary

Terms defined in the National Electricity Law and the Rules have the same meanings in this guide unless otherwise specified in this clause.

In addition, the words, phrases and abbreviations in the table below have the meanings set out opposite them when used in this guide.

Term	Definition
AEMO	Australian Energy Market Operator
ACE	Adjusted consumed energy
AGC	Automatic Generation Control
ASOE	Adjusted sent out energy
BDU	Bidirectional unit
CF	Contribution Factor, a factor calculated in respect of, and applied to, an eligible unit with appropriate metering
Co-optimisation	The process of trading off between energy dispatch and FCAS enablement to achieve the lowest total cost
CRMP	Cost Recovery Market Participant
Delayed Raise and Lower	Contingency frequency control services required to return the frequency to the normal operating band within five minutes of a contingency
DUID	Dispatchable Unit Identifier
EMMS	Electricity Market Management System
Fast Raise and Lower	Contingency frequency control services required to arrest a frequency deviation within six seconds following a contingency
FCAS	frequency control ancillary services
FPP	Frequency Performance Payment
MW	megawatt/s

Term	Definition
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
Regulation Raise and Lower	Frequency control services required to maintain the frequency within the normal operating band
Rules	National Electricity Rules
SCADA	Supervisory Control and Data Acquisition equipment
Slow Raise and Lower	Contingency frequency control services required to maintain the frequency within the single contingency band over the sixty seconds following a contingency
Trading Interval	Five minute market period for which the dispatch engine is run
Very Fast Raise and Lower	Contingency frequency control services required to arrest a frequency deviation within one second following a contingency

1.3. Related documents

Title	Location
Guide to Analysing Constraint Outcomes for FCAS Cost Recovery	https://aemo.com.au/-/media/files/initiatives/frequency-performance-payments-project/aemo-guide-to-constraint-outcomes-for-fcas-cost-recovery.pdf?la=en
FCAS Model in NEMDE	https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/fcas-model-in-nemde.pdf?la=en
Frequency Contributions Factor Procedure	https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/frequency-contribution-factors-procedure/final-documents/final-frequency-contribution-factors-procedure.pdf?la=en
Frequency Operating Standard	Electricity guidelines, standards and schedules AEMC
Frequency Performance Payments (FPP) – Factor Calculation Guide	https://aemo.com.au/-/media/files/initiatives/frequency-performance-payments-project/aemo-nem-fpp-factor-calculation-guide.pdf?la=en
Market Ancillary Services Specification	https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2023/primary-freq-resp-norm-op-conditions/market-ancillary-services-specification-v81.pdf?la=en
Settlements Guide to Ancillary Services and Frequency Performance Payments	https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/ancillary-services-data/ancillary-services-payments-and-recovery

2. Frequency control

To help understand frequency control, think about the engine in a car. If a car travelling at a constant velocity is presented with a change in demand for power, with no corresponding change to the power input to the engine, then the car will speed up (for decreases in load such as a downhill slope) or slow down (for increases in load such as an uphill slope).

In a similar way, if the load (demand) is varied on a power system without a corresponding variation in the generation feeding that power system, the frequency will go up or down.

Figure 1 Impact of supply/demand balance on frequency

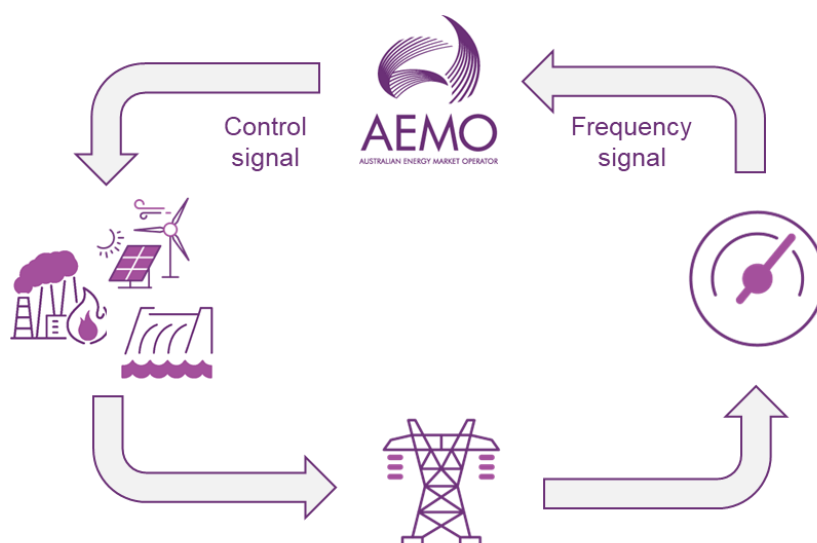
2.1. Regulation and contingency frequency control ancillary services

To maintain frequency within the NEM frequency standards, FCAS have been developed to alter generation or demand so the generation/demand balance is always maintained. These services can be either regulation or contingency services.

2.1.1. Regulation frequency control

Regulation frequency control corrects the supply/demand balance in response to minor deviations in load or generation. These services are continually used to correct for minor changes in the supply/demand balance, and are controlled centrally from one of AEMO's two control rooms.

The regulation frequency control services are provided by generators on Automatic Generation Control (AGC). The AGC system allows AEMO to continually monitor system frequency. If there is a minor imbalance between supply and demand, the system sends control signals out to Ancillary Service Providers providing regulation FCAS services, to alter their megawatt (MW) output to restore the supply/demand balance so frequency is maintained within the normal operating band of 49.85 hertz (Hz) to 50.15 Hz.

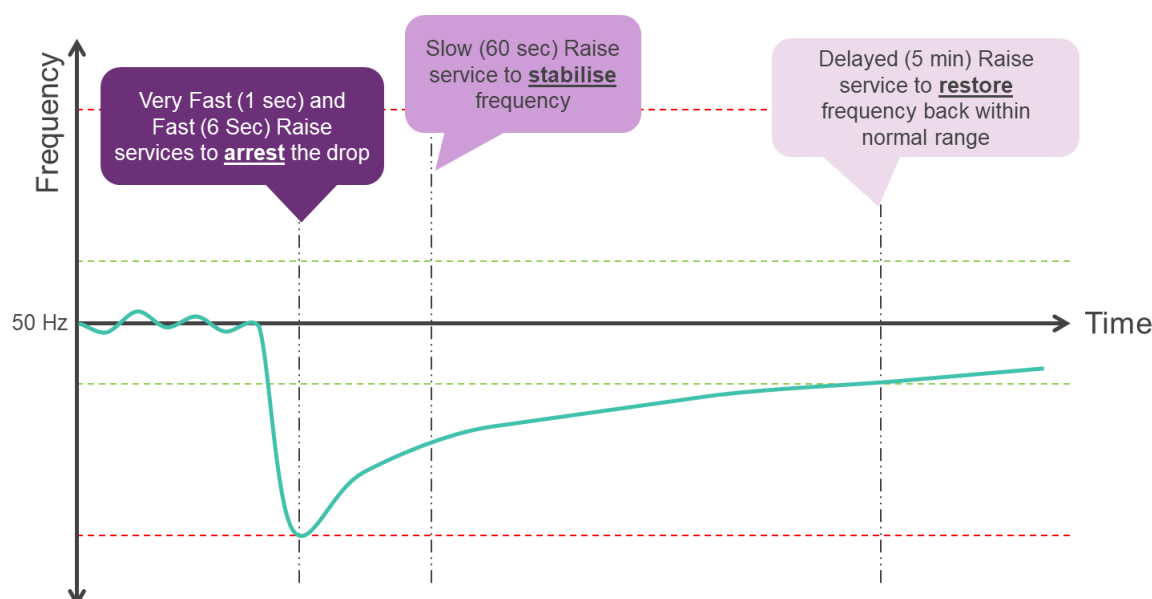
Figure 2 Regulation frequency control using AGC

2.1.2. Contingency frequency control

Contingency frequency control corrects the supply/demand balance following a major contingency event, such as the loss of a generating unit, major industrial load, or large transmission element. While they are always enabled to cover contingency events, contingency services are only occasionally used.

The Frequency Operating Standard for the NEM defines limits on the permissible time that power system frequency may be outside the normal operating frequency band following a credible contingency event.

Figure 3 Contingency frequency control using contingency services



Contingency services are provided locally by technologies that can detect the frequency deviation and respond to correct the frequency, for example:

- Generator governor response – the generator governor reacts to the frequency deviation by opening or closing the turbine steam valve and altering the generator's MW output.
- Load shedding – a load can be quickly disconnected from the electrical system (this can only correct a low frequency).
- Rapid generation – a frequency relay will detect a low frequency and correspondingly start a fast generator (this can only correct a low frequency).
- Rapid unit unloading – a frequency relay will detect a high frequency and correspondingly reduce a generator output (this can only correct a high frequency).

3. FCAS markets

3.1. The 10 FCAS markets in the NEM

There are 10 markets in the NEM for procuring sufficient FCAS at any given time.

Regulation markets

- Regulation raise – used to correct a minor drop in frequency.
- Regulation lower – used to correct a minor rise in frequency.

Contingency markets

- Very fast raise (1 second raise) – 1 second response to arrest a major drop in frequency following a contingency event.
- Very fast lower (1 second lower) – 1 second response to arrest a major rise in frequency following a contingency event.
- Fast raise (6 second raise) – 6 second response to arrest a major drop in frequency following a contingency event.
- Fast lower (6 second lower) – 6 second response to arrest a major rise in frequency following a contingency event.
- Slow raise (60 second raise) – 60 second response to stabilise frequency following a major drop in frequency.
- Slow lower (60 second lower) – 60 second response to stabilise frequency following a major rise in frequency.
- Delayed raise (5 minute raise) – 5 minute response to recover frequency to the normal operating band following a major drop in frequency.
- Delayed lower (5 minute lower) – 5 minute response to recover frequency to the normal operating band following a major rise in frequency.

3.2. Registering for FCAS markets

Participants must register with AEMO to participate in each distinct FCAS market. Once registered, a service provider can participate in an FCAS market by submitting an appropriate FCAS bid for that service, via AEMO's Electricity Market Management Systems (EMMS).

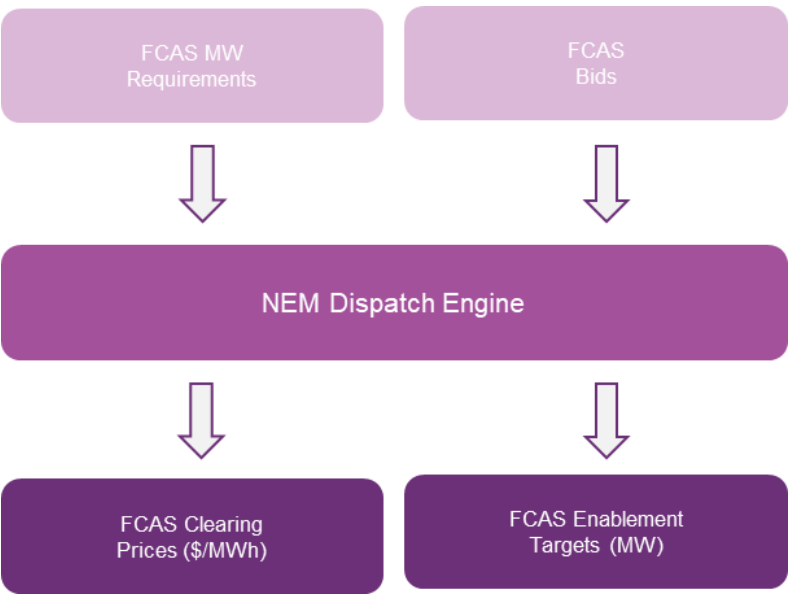
3.3. Bidding in FCAS markets

3.3.1. Background

An FCAS bid submitted for a raise service represents the amount a participant can contribute to increase the frequency in a given timeframe, while an FCAS bid submitted for a lower service represents the amount a participant can contribute to reducing the frequency in a given timeframe.

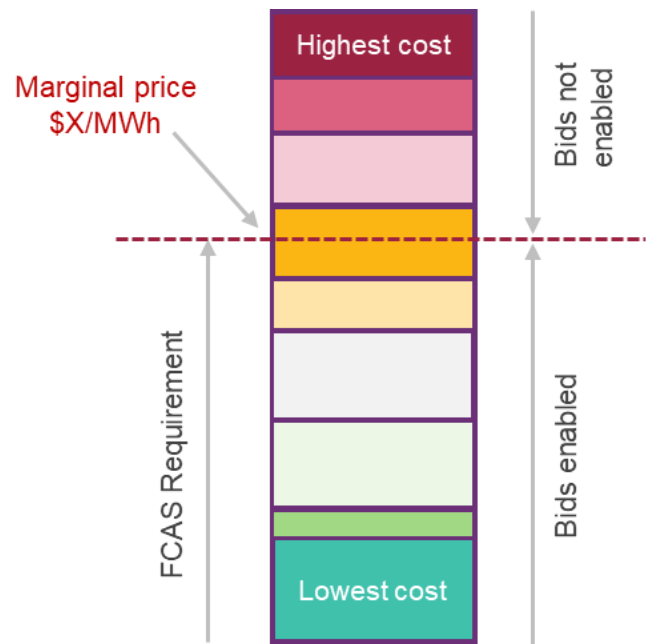
During each trading interval, the National Electricity Market Dispatch Engine (NEMDE) must enable a sufficient amount of each FCAS service, from the FCAS bids submitted, to meet the FCAS MW requirement.

Figure 4 NEMDE and FCAS prices and targets



NEMDE will enable FCAS bids in increasing order of cost. The highest cost bid to be enabled will set the marginal price for the service (Figure 5).

Figure 5 Marginal clearing price for FCAS



During periods of high or low demand, it may be necessary for NEMDE to move the energy target of a scheduled generating unit, scheduled bidirectional unit (BDU), scheduled load, semi-scheduled generating unit, or wholesale demand response unit¹, to minimise the total cost

¹ Only for a wholesale demand response unit that has a single dispatch unit identifier (DUID) allocated for wholesale demand response and FCAS. There is no energy and FCAS co-optimisation by NEMDE if it involves two DUIDs (that is, one DUID for energy [wholesale demand response] and one DUID for FCAS).

of energy plus FCAS to the market. This process is known as co-optimisation and is an intrinsic part of the dispatch algorithm.

3.3.2. Bidding

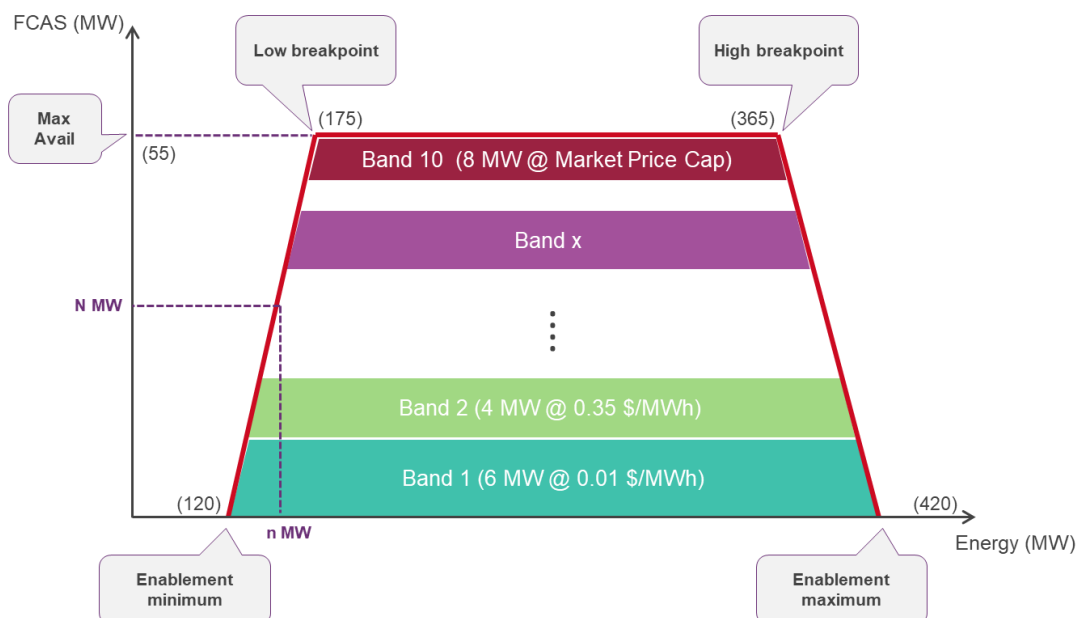
Bids for FCAS take the form of the generic FCAS trapezium defined by enablement limits and breakpoints. The trapezium indicates the maximum amount of FCAS that can be provided (y-axis) for a given MW in either power generation, consumption, or load reduction in the energy market (x-axis)².

For example, a generator or load dispatched in the energy market at “n” MW could be enabled by NEMDE to provide up to “N” MW of the relevant FCAS, as shown in Figure 6.

FCAS bids must comply with bidding rules, similar to those that apply to the energy market:

- Bids can consist of up to 10 bands with non-zero MW availabilities³.
- Band prices must be greater than or equal to zero and less than or equal to the Market Price Cap.
- Each band price must be greater than any preceding band price.
- Band prices must be set by 12:30 AEST on the day prior to the trading day for which the bid applies.
- Band availabilities, enablement limits and breakpoints can be rebid under rules similar to those applying to the energy market.

Figure 6 Generic FCAS trapezium



² Power generation for scheduled and semi-scheduled generating units, power consumption for scheduled loads, and load reduction for wholesale demand response units. For bidirectional units it may be power generation or power consumption.

³ Regulation FCAS bids for scheduled BDU units may consist of one bid from the generation side (all enablement limits and breakpoints are non-negative) or one bid for the load side (all enablement limits and breakpoints are non-positive) or bids for both generation and load sides which are optimised individually within NEMDE.

Ancillary service plant dispatched between an enablement limit and a corresponding breakpoint can be moved in the energy market to obtain more FCAS. For example, if a generator was dispatched between the upper enablement limit and the upper breakpoint, NEMDE may “constrain” the unit in the energy market to obtain more FCAS, provided this led to the lowest overall cost. This is another way of describing “co-optimisation”.

The generic trapezium shown in Figure 6 is altered to suit the various technologies that provide FCAS⁴. For example, a load reduction service would be fully available when the load is fully dispatched in the energy market, and the availability might reduce linearly to zero as the energy dispatch moves towards the origin. This bid shape would be achieved by setting the lower enablement limit at zero, and both breakpoints and the upper enablement limit equal to the maximum energy capacity of the load.

For a more comprehensive breakdown of FCAS trapeziums, refer to AEMO’s FCAS Model in NEMDE document⁵.

3.4. Settlements in FCAS markets

3.4.1. Payments

NEMDE determines a clearing price for each of the FCAS markets in each region for each trading interval. This price is then used by AEMO Settlements to determine payments to each of the FCAS providers, for each of the FCAS, under the following formula:

$$\text{Payment} = \text{MWE} \times \text{CP} / 12$$

where:

MWE is the amount of MW enabled by NEMDE for the service being settled; and

CP is the regional clearing price for the service in that trading interval.

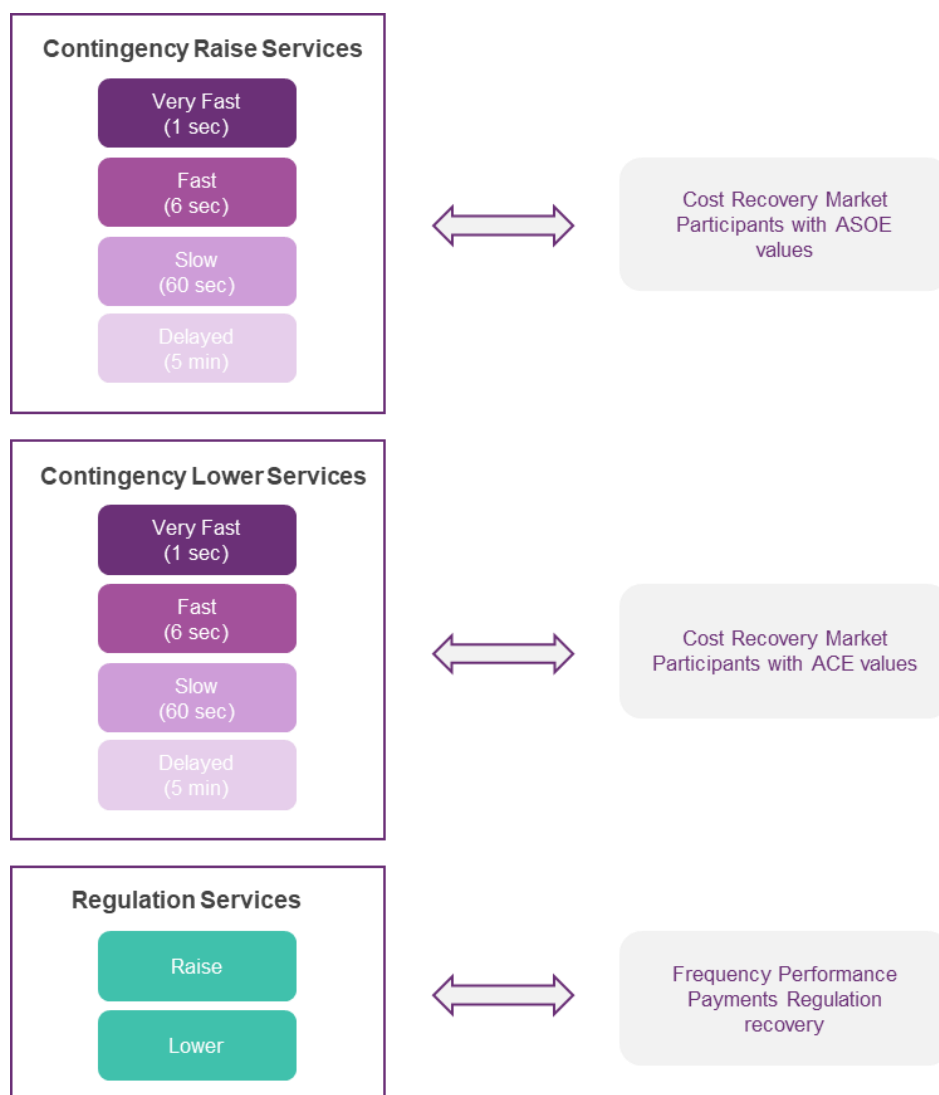
(Note that as the bids and clearing price are defined as dollars per MW per hour, dividing the result by 12 brings the payment back in line with the five-minute trading interval.)

3.4.2. Recovery

All payments to FCAS providers are recovered from Cost Recovery Market Participants (CRMPs) according to the recovery rules (see Figure 7).

⁴ Note that FCAS bids from BDU units may be a negative value, given units can both generate and consume power. For example, Enablement Min, Low Breakpoint, High Breakpoint and Enablement Max bids for contingency FCAS may be positive or negative depending where they lie on the energy axis. For more information on FCAS bids from BDU units, refer to Section 2.4 of AEMO’s FCAS Model in NEMDE document, at https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/fcas-model-in-nemde.pdf?la=en.

⁵ At https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/fcas-model-in-nemde.pdf?la=en.

Figure 7 FCAS cost recovery

In general, FCAS costs are recovered from the parties deemed responsible for creating the need for each FCAS.

Contingency raise requirements are set to manage the loss of the largest generator on the system. All payments for these services are recovered from CRMPs with adjusted sent out energy (ASOE) values only in the relevant Requirement region(s).

On the other hand, contingency lower requirements are set to manage the loss of the largest load/transmission element on the system, with all payments for these services recovered from CRMPs with adjusted consumed energy (ACE) values only, in the relevant Requirement region(s).

The recovery of payments for regulation services is based on the Frequency Performance Payments (FPP) process, which is a double-sided system of incentive payments and penalties

based on units' impact on system frequency⁶. Under this methodology, a contribution factor (CF) between -1 and 1 is calculated every five minutes for each eligible unit with appropriate metering, which is used to determine both the FPPs and the cost recovery for regulation FCAS⁷. A negative contribution factor reflects the extent to which the unit contributed to the system frequency in an unhelpful manner while a positive contribution factor reflects the extent to which the unit contributed to the system frequency control in a helpful manner. Participants that have a helpful impact on system frequency will receive payments, while those that have an unhelpful impact will pay penalties.

Under FPP, used and unused regulation FCAS costs will be recovered separately. The costs for regulation services used in a trading interval will be allocated based on negative contribution factors determined for the trading interval. In contrast, the costs for regulation services not used in a trading interval will be allocated based on default contribution factors, which are intended to reflect the longer-term historical performance of a facility.

For more detailed information on FCAS cost recovery for both contingency and regulation services, refer to AEMO's Settlements guide⁸.

⁶ FPP regulation cost recovery process was introduced under the Australian Energy Market Commission's (AEMC's) Primary Frequency Response (PFR) incentive arrangement rule change (see <https://www.aemc.gov.au/rule-changes/primary-frequency-response-incentive-arrangements>) and is effective from 8 June 2025. Previously, recovery of payments for regulation services was based on the 'Causer Pays' methodology.

⁷ A residual contribution factor (RCF) is also calculated for eligible units that do not have appropriate metering.

⁸ Available at <https://aemo.com.au/energy-systems/electricity/national-electricity-market-nem/data-nem/ancillary-services-data/ancillary-services-payments-and-recovery>

Version release history

Version	Effective date	Summary of changes
4.0	17 September	Renamed and revised to focus on Frequency Control Ancillary Services only.
3.0	8 June 2025	Updated to reflect the transition from causer pays to Frequency Performance Payments in National Electricity Amendment (Primary frequency response incentive arrangements) Rule 2022 No.8, along with administrative changes to reflect National Electricity Amendment (Integrating energy storage systems into the NEM) Rule 2021 No.13. Other minor edits.
2.0	9 October 2023	Updated to include Very Fast Contingency FCAS. New template. Minor edits.
1.0	3 November 2021	First issue in updated template.