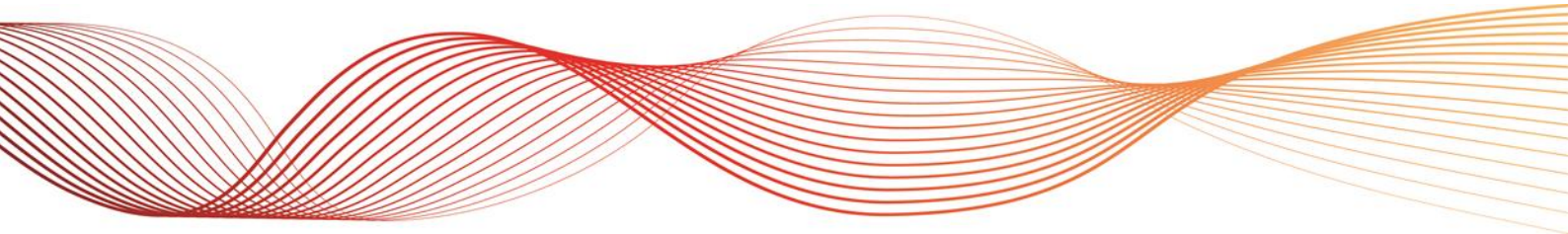




GUIDE TO ANCILLARY SERVICES IN THE NATIONAL ELECTRICITY MARKET

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IMPORTANT NOTICE

Purpose

AEMO has prepared this document to provide information about Ancillary Services in the National Electricity Market, as at the date of publication.

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1. INTRODUCTION

This document provides a broad explanation of ancillary services and outlines the arrangements that apply for frequency control ancillary services in the National Electricity Market (NEM). This explanation is provided in a non-technical manner and is aimed at readers that 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. In order to fulfil this obligation AEMO controls key technical characteristics of the power system such as frequency and voltage, through Ancillary Services. The Rules provides for AEMO to purchase these services, from market participants, by means of either:

- Market Ancillary Service Arrangements; or
- Ancillary Service Agreements.

1.1 Ancillary Service Categories

All NEM Ancillary Services can be grouped under one of the following three major categories:

- Frequency Control Ancillary Services (FCAS);
- Network Support & Control Ancillary Services (NSCAS); or
- System Restart Ancillary Services (SRAS)

FCAS are used by AEMO to maintain the frequency on the electrical system, at any point in time, close to fifty cycles per second as required by the NEM frequency standards.

NSCAS are primarily used to:

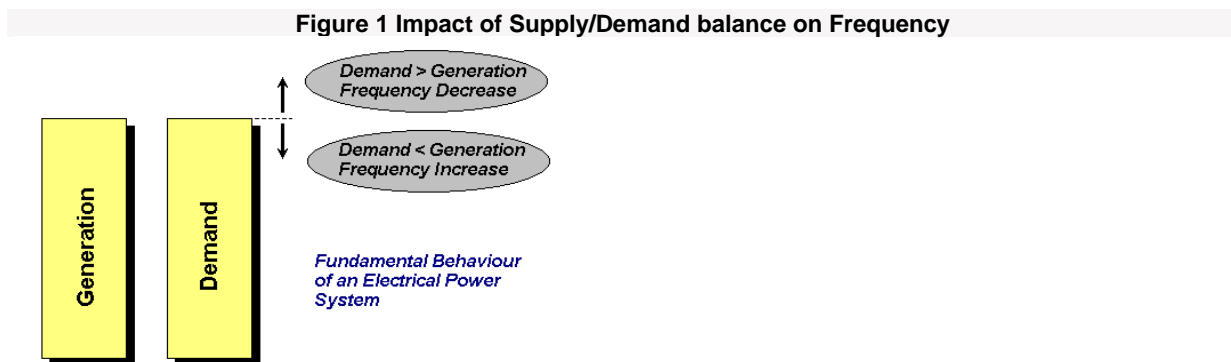
- Control the voltage at different points of the electrical network to within the prescribed standards.
- Control the power flow on network elements to within the physical limitations of those elements.
- Maintain transient and oscillatory stability within the power system following major power system events.

SRAS are reserved for contingency situations in which there has been a complete or partial system blackout and the electrical system must be restarted.

2. FREQUENCY CONTROL

To assist in the understanding of frequency control, analogies can be drawn between a power system and the engine in a car. If a car travelling at a constant velocity is presented with a change in load with no corresponding change to the power input to the engine of the car, then the car will speed up (for decreases in load such as that presented by a downhill) or slow down (for increases in load such as an uphill slope).

In a similar manner, if the load is varied on a power system without a corresponding variation in the generation feeding that power system, the frequency (speed) will deviate.



In order to maintain the frequency within the NEM frequency standards, FCAS have been developed to alter the generation or demand to maintain the generation / demand balance.

Frequency control can be divided into two:

- Regulation
- Contingency

Regulation frequency control can be described as the correction of the generation / demand balance in response to minor deviations in load or generation. Contingency frequency control refers to the correction of the generation / demand balance following a major contingency event such as the loss of a generating unit/major industrial load, or a large transmission element.

Regulation versus Contingency

Regulation services are continually used to correct for minor changes in the demand / supply balance. However, contingency services, while always enabled to cover contingency events, are only occasionally used.

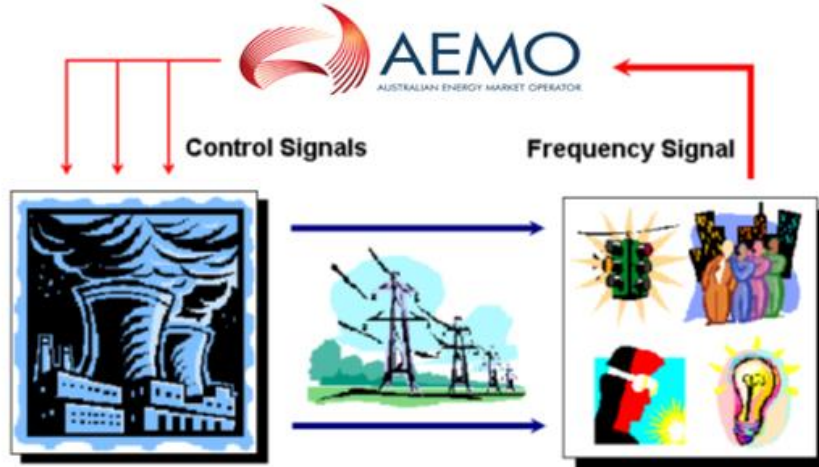
Regulation services are controlled centrally from one of AEMO's two control centres. Contingency services are controlled locally and are triggered by the frequency deviation that follows a contingency event.

2.1 Regulation and Contingency Frequency Control

2.1.1 Regulation Frequency Control

The regulation frequency control services are provided by generators on Automatic Generation Control (AGC). The AGC system allows AEMO to continually monitor the system frequency and to send control signals out to generators providing regulation in such a manner that the frequency is maintained within the normal operating band of 49.85Hz to 50.15Hz.

Figure 2 Regulation frequency control using AGC

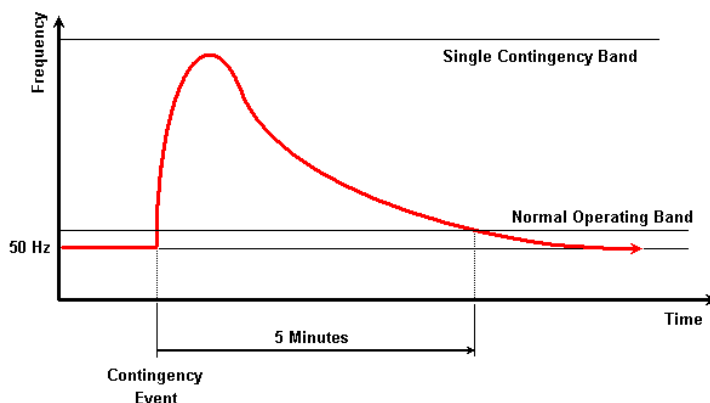


These control signals alter the megawatt (MW) output of the generators in such a manner that corrects the demand / generation imbalance.

2.1.2 Contingency Frequency Control

Under the NEM frequency standards AEMO must ensure that, following a credible contingency event, the frequency deviation remains within the contingency band and is returned to the normal operating band within five minutes.

Figure 3 Contingency frequency control using Contingency services



Contingency services are provided by technologies that can locally detect the frequency deviation and respond in a manner that corrects the frequency. Some examples of these technologies include:



- **Generator Governor Response:** where the generator governor reacts to the frequency deviation by opening or closing the turbine steam valve and altering the MW output of the set accordingly.
- **Load shedding:** where a load can be quickly disconnected from the electrical system (can act to correct a low frequency only).
- **Rapid Generation:** where a frequency relay will detect a low frequency and correspondingly start a fast generator (can act to correct a low frequency only).
- **Rapid Unit Unloading:** where a frequency relay will detect a high frequency and correspondingly reduce a generator output (can act to correct a high frequency only).

3. FCAS MARKETS

There are eight markets in the NEM for procuring sufficient FCAS at any given time. These are listed below under the two types of frequency control.

Regulation

- Regulation Raise: Regulation service used to correct a minor drop in frequency.
- Regulation Lower: Regulation service used to correct a minor rise in frequency.

Contingency

- 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.

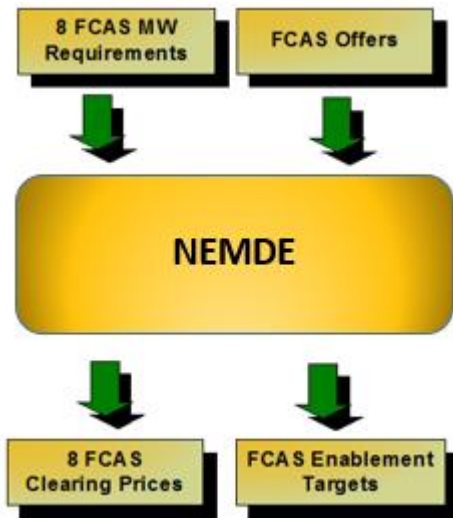
Participants must register with AEMO to participate in each distinct FCAS market. Once registered, a service provider can participate in an FCAS market by submitting an appropriate FCAS offer or bid for that service, via AEMO's Market Management Systems.

An FCAS offer or bid submitted for a raise service represents the amount of MWs that a participant can add to the system, in the given time frame, in order to **raise** the frequency.

An FCAS offer or bid submitted for a lower service represents the amount of MWs that a participant can take from the system, in the given time frame, in order to **lower** the frequency.

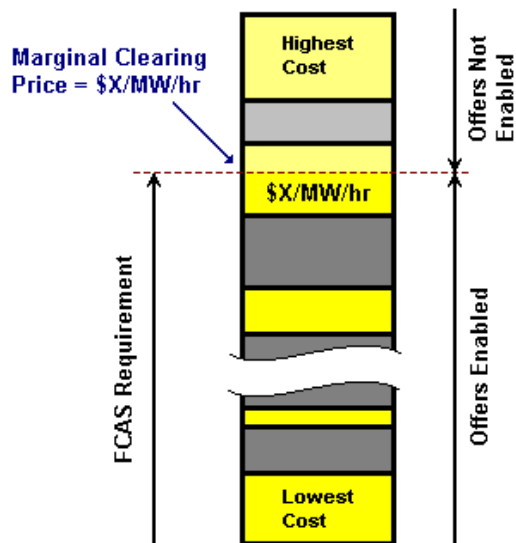
During each and every trading interval of the market, National Electricity Market Dispatch Engine (NEMDE) must enable a sufficient amount of each of the eight FCAS products, from the FCAS bids submitted, to meet the FCAS MW requirement.

Figure 4 NEMDE and FCAS Prices, Targets



NEMDE will enable MW FCAS offers in merit order of cost. The highest cost offer to be enabled will set the marginal price for the FCAS category.

Figure 5 Marginal clearing price for FCAS



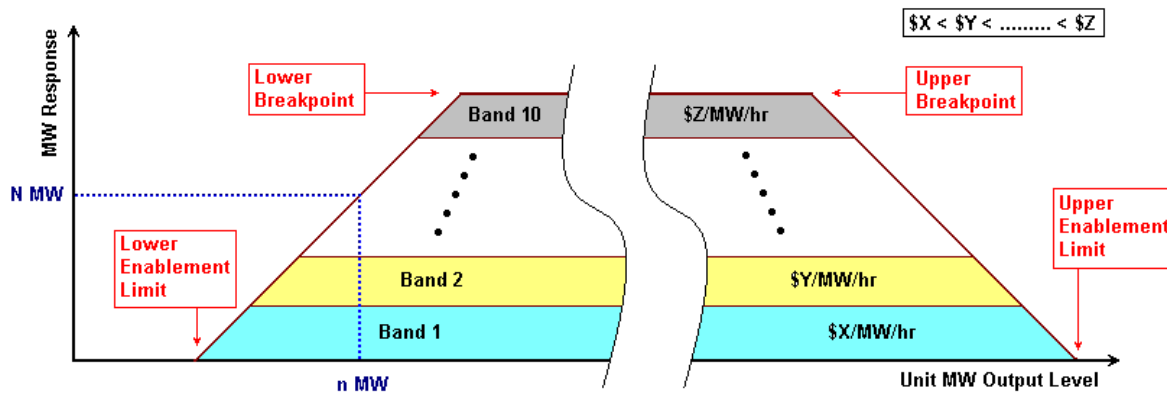
During periods of high or low demand, it may be necessary for NEMDE to move the energy target of a scheduled or semi-scheduled generating unit, wholesale demand response unit¹, or scheduled load in order to minimise the total cost (of energy plus FCAS) to the market. This process is named **co-optimisation** and is inherent in the dispatch algorithm.

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

3.1 FCAS Markets – Offers and Bids

Offers and bids for the FCAS services 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 output level for a generating unit, or given MW load reduction level for a wholesale demand response unit, or given MW consumption level for a scheduled load (x axis). 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.

Figure 6 Generic FCAS Trapezium



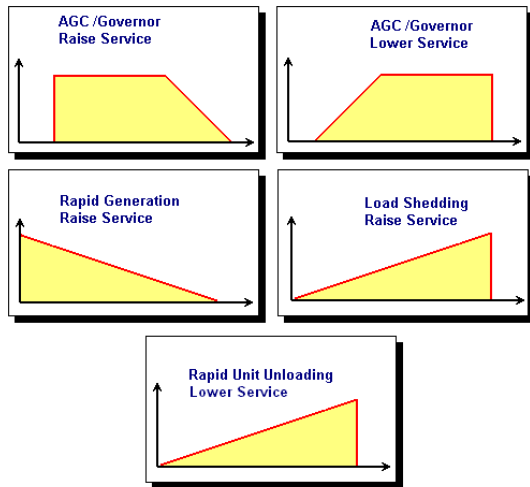
The FCAS offers and bids must comply with similar bidding rules that apply to the energy market:

- Offers / Bids can consist of up to 10 bands with non-zero MW availabilities;
- Band prices must be monotonically increasing;
- Band prices must be set by 12:30 on the day prior to the trading day for which the offer/bid applies;
- Band availabilities, enablement limits and breakpoints can be rebid under rules similar to those applying to the energy market.

Ancillary service plant dispatched between an enablement limit and a corresponding breakpoint can be moved in the energy market in order 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 in order to obtain more FCAS, provided this led to the lowest overall cost.

The generic trapezium shown above is altered to suit the various technologies that provide FCAS. For example, a load shedding service would be fully available when the load is dispatched fully in the energy market, and the availability would reduce linearly to zero as the energy dispatch point moved 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.

Figure 7 FCAS Trapeziums for different services (Raise, Lower)



3.2 FCAS Markets – Settlements

3.2.1 Payments

For each trading interval of the market, NEMDE determines a clearing price for each of the eight FCAS markets. This price is then used by settlements to determine payments to each of the FCAS providers, for each of the eight FCAS, under the following formula:

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

where:

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

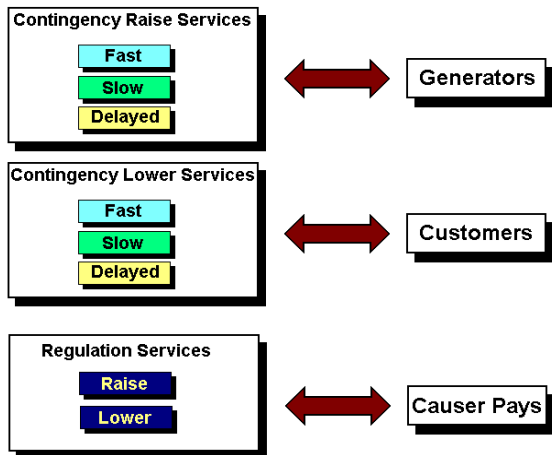
CP is the clearing price for the service in that trading interval.

(Note that as the bids / offers and, hence, the clearing price is defined as dollars per MW per hour, dividing the result by twelve brings the payment back in line with the five minute trading interval.)

3.2.2 Recovery

All payments to frequency control ancillary service providers are recovered from market participants according to the recovery rules.

Figure 8 FCAS Cost Recovery



As contingency raise requirements are set to manage the loss of the largest generator on the system, all payments for these three services are recovered from generators.

On the other hand, as contingency lower requirements are set to manage the loss of the largest load / transmission element on the system, all payments for these three services are recovered from customers.

Recovery for contingency services is pro-rated over participants based on the energy generation or consumption in the trading interval.

The recovery of payments for the regulation services is based upon the “**Causer Pays**” methodology. Under this methodology the response of measured generators and loads², to frequency deviations, is monitored and used to determine a series of causer pays factors.

Participants whose measured entities operate in a manner that assists in the correction of frequency deviations would be assigned a low causer pays factor while those whose measured entities operate in a manner that cause the frequency to deviate would be assigned a high factor.

All non-measured entities (customers without SCADA) are assigned causer pays factors based upon the remainder (causers not accounted for by measured entities) and based upon their energy consumption in the trading interval being settled.

For each trading interval of the market, total regulation payments are recovered from participants on the basis of these causer pays factors.

For the purpose of FCAS payments and recovery, the market is treated globally. Hence, for the purpose of recovery, participants are treated equally, regardless of region.

² Generators and loads that have their generation or consumption levels monitored at the AEMO control centre via SCADA.

4. NETWORK CONTROL AND SYSTEM RESTART ANCILLARY SERVICES

4.1 Network Support and Control Ancillary Service (NSCAS)

Network control ancillary services can be subdivided into two distinct categories:

- Voltage Control Ancillary Service (VCAS)
- Network Loading Control Ancillary Service (NLCAS)
- Transient and Oscillatory Stability Ancillary Service (TOSAS)

4.1.1 Voltage Control Ancillary Service

Under standards set by the reliability panel, AEMO must control the voltage on the electrical network to within specified tolerances. One method of controlling voltages on the system is through the dispatch of voltage control ancillary services. Under these ancillary services, generators absorb or generate reactive power from or onto the electricity grid and control the local voltage accordingly.

The voltage control ancillary services can be further categorised as follows:

- Synchronous Condenser: A generating unit that can generate or absorb reactive power while not generating energy in the market;
- Static Reactive Plant: Equipment such as capacitors or reactors that can supply or absorb reactive power.

4.1.2 Network Loading Control Ancillary Service

Network loading ancillary services are used, by AEMO, to control the flow on inter-connectors to within short term limits.

For example, if the flow on an inter-connector from region A to region B exceeds the short term limit, AEMO could reduce the flow by increasing the generation levels of generators in region B, or by shedding load in region B.

Hence, flow on network elements can be controlled through the use of Automatic Generation Control (the same technology that is used for regulation frequency control) or Load Shedding.

4.1.3 Transient and Oscillatory Stability Ancillary Service (TOSAS)

When faults such as short circuits or malfunctioning equipment occur, a sharp transient "spike" in power flows can result. This can cause damage to equipment throughout the network.

Transient and Oscillatory Stability Ancillary Services (TOSAS) control and fast-regulate the network voltage, increase the inertia of rotating mass connected to the power system or rapidly increase/reduce load connected to the power system.

Some examples of TOSAS services are: Power System Stabilisers (PSS), Fast regulating voltage services (synchronous condensers, SVCs, generators), Inertia support services etc.

4.2 System Restart Ancillary Services (SRAS)

System restart ancillary services are required to enable the power system to be restarted following a complete or partial black-out. This can be provided by two separate technologies:

- General Restart Source: a generator that can start and supply energy to the transmission grid without any external source of supply.
- Trip to House Load: a generator that can, on sensing a system failure, fold back onto its own internal load and continue to generate until AEMO is able to use it to restart the system.

4.3 Payments and Cost Recovery

4.3.1 Payments

Both NSCAS and SRAS are provided to the market under long term ancillary service contracts negotiated between AEMO (on behalf of the market) and the participant providing the service. These services are paid for through a mixture of:

- Enablement Payments – made only when the service is specifically enabled
- Availability Payments – made for every trading interval that the service is available.
- Testing Payments – made for costs incurred for annual testing of service.
- Usage Payments – made for every trading interval when the service is used.

Table below summarise the payment types for Voltage Control Ancillary Service (VCAS) and System Restart Ancillary Services (SRAS).

Table 1 Payments for VCAS and SRAS

Service	Payment
Voltage Control Ancillary Service (VCAS)	
Synchronous Condensor	Enablement + Testing
Static Reactive Plant	Availability
System Restart Ancillary Service (SRAS)	
Generator Restart, Trip to House Load	Availability + Testing + Usage

4.3.2 Cost Recovery

NSCAS payments are recovered fully from market customers while SRAS payments are recovered from both customers and generators on a 50 / 50 basis.

GLOSSARY

Term	Description
AEMO	Australian Energy Market Operator
AGC	Automatic Generation Control
Causer Pays	The process by which Regulation FCAS is recovered on the basis of participant response to frequency deviations
Co-optimisation	The process of trading off between energy dispatch and FCAS dispatch to achieve the lowest total cost
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
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
NCAS	Network Control Ancillary Services
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 require to maintain the frequency within the single contingency band over the sixty seconds following a contingency
SRAS	System Restart Ancillary Services
Trading Interval	Five minute market period for which the dispatch engine is run

