AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Guide to Ancillary Services in the National Electricity Market

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Current version release details

Version	Effective date	Summary of changes
2.0	9 October 2023	Updated to include Very Fast Contingency FCAS. New template. Minor edits.

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

1. Introduction

1.1. Purpose and scope

This document provides a broad explanation of ancillary services 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. The Rules provide for AEMO to purchase these services from Market Participants by means of either:

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

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.

Terms defined in the Rules are intended to be identified in this guide 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 guide.

Term	Definition
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 enablement 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
MW	Megawatt
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

Term	Definition
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
SRAS	System Restart Ancillary Services
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

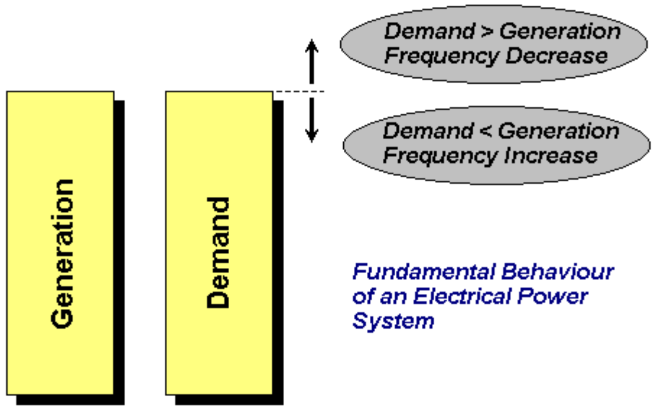
Title	Location
FCAS Model in NEMDE	https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/dispatch/policy_and_process/fcas-model-in-nemde.pdf?la=en
Frequency Contributions Factor Procedure	https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/frequency-contribution-factors-procedure/final-documents/final-frequency-contribution-factors-procedure.pdf?la=en
Frequency Operating Standard	Frequency operating standard - in effect 9 October 2023 (aemc.gov.au)
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
NSCAS Description and Quantity Procedure	https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2020/ncas/2021-nscas-description-and-quantity-procedure.pdf?la=en
SO_OP_3708 Non-Market Ancillary Services	https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/power_system_ops/procedures/so_op_3708-non-market-ancillary-services.pdf?la=en
SRAS Guideline	https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/sras/sras-guideline-2021.pdf?la=en

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

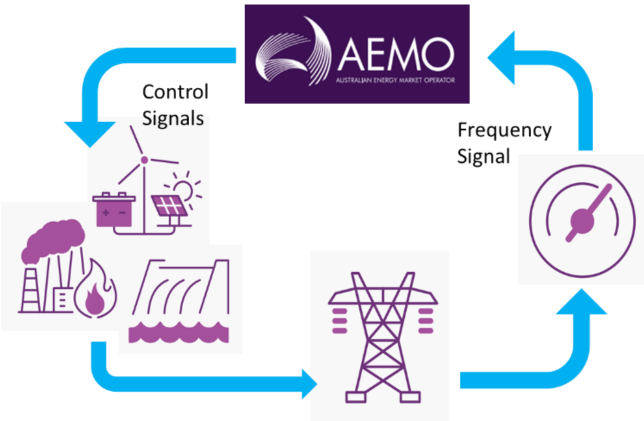
To maintain frequency within the NEM frequency standards, frequency control ancillary services (FCAS) have been developed to alter generation or demand so the generation/demand balance is always maintained. These services can be either regulation or contingency services.

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 generators providing regulation 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

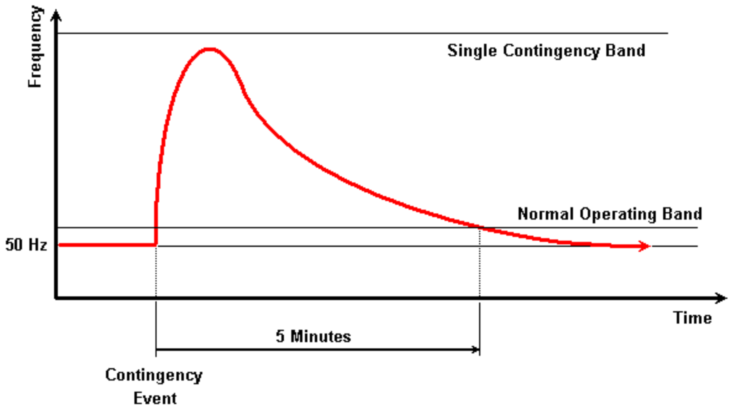


2.1.2. Contingency frequency control

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.

Under the NEM frequency standards, AEMO must ensure that after 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 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 megawatt 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 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 Market Management Systems.

3.3. Bidding in FCAS markets

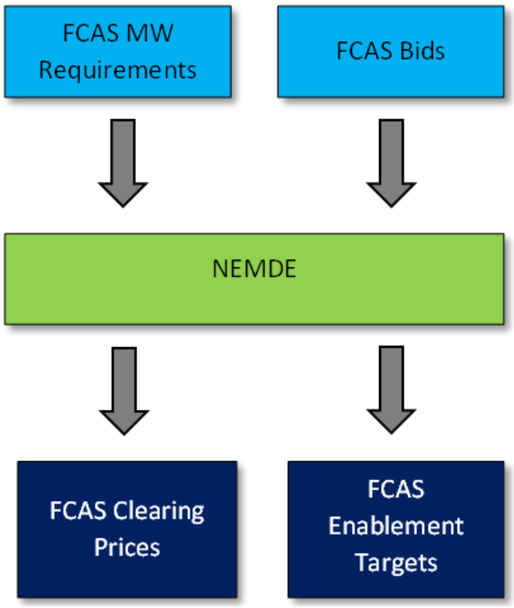
3.3.1. Background

An FCAS bid submitted for a raise service represents the amount of megawatts a participant can add to the system, in the given timeframe, to raise the frequency.

An FCAS bid submitted for a lower service represents the amount of megawatts a participant can take from the system, in the given timeframe, to lower the frequency.

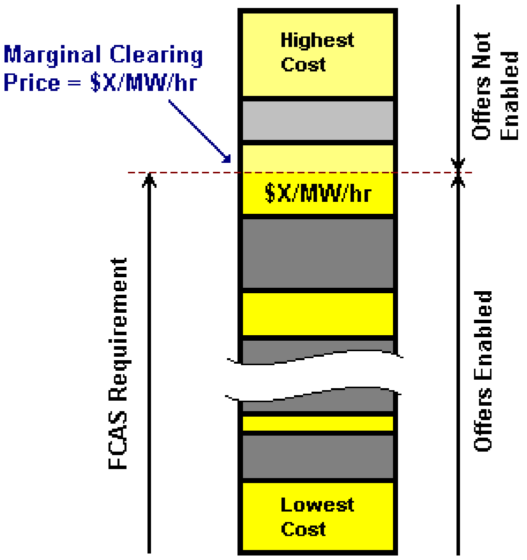
During every trading interval, the National Electricity Market Dispatch Engine (NEMDE) must enable a sufficient amount of each of the 10 FCAS products, from the FCAS bids submitted, to meet the FCAS megawatt requirement.

Figure 4 NEMDE and FCAS prices and targets



NEMDE will enable megawatt FCAS offers in increasing 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



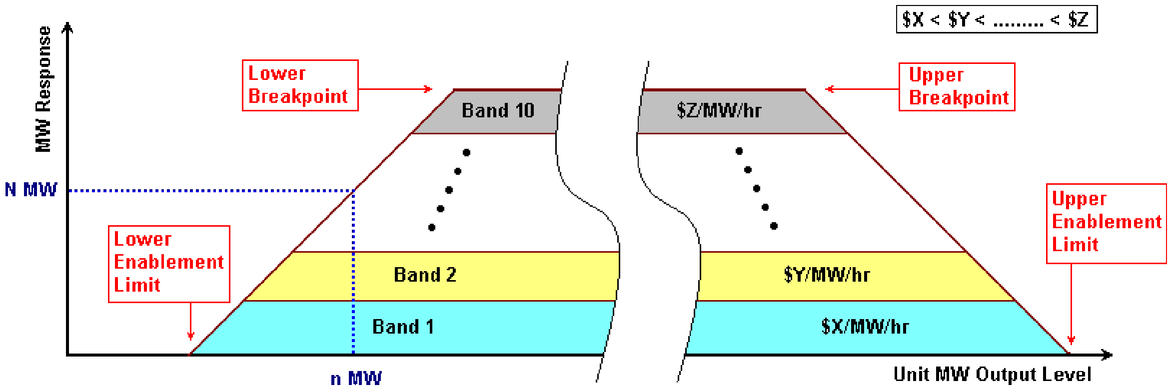
During periods of high or low demand, it may be necessary for NEMDE to move the energy target of a scheduled or semi-scheduled generating unit, wholesale demand response unit[1], or scheduled load to minimise the total cost of energy plus FCAS to the market. This process is known as co-optimisation and 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 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, as shown in Figure 6.

Figure 6 Generic FCAS trapezium



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 availabilities.
- Each band price must be greater than any preceding band price.
- Band prices must be set by 12:30 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.

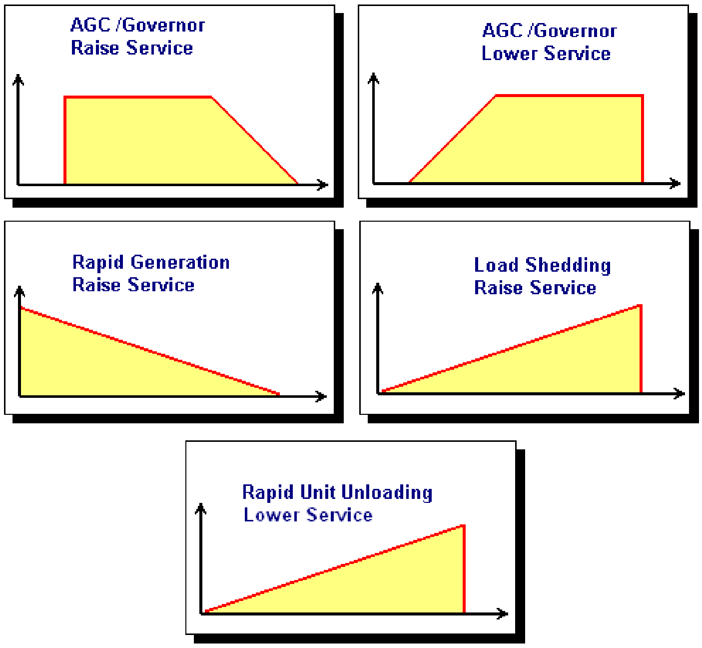
Ancillary service plant dispatched between an enablement limit and a corresponding breakpoint can be moved in the energy market to obtain more FCAS. For example, if a generator was dispatched between the upper enablement limit and the upper breakpoint, NEMDE may “constrain” the unit in the energy market 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 FCAS. 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

[1] `Only for a wholesale demand response unit that has a single dispatch unti 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).

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.

Figure 7 FCAS trapeziums for different services (raise, lower)



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:

Payment = MWE x CP / 12

where:

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

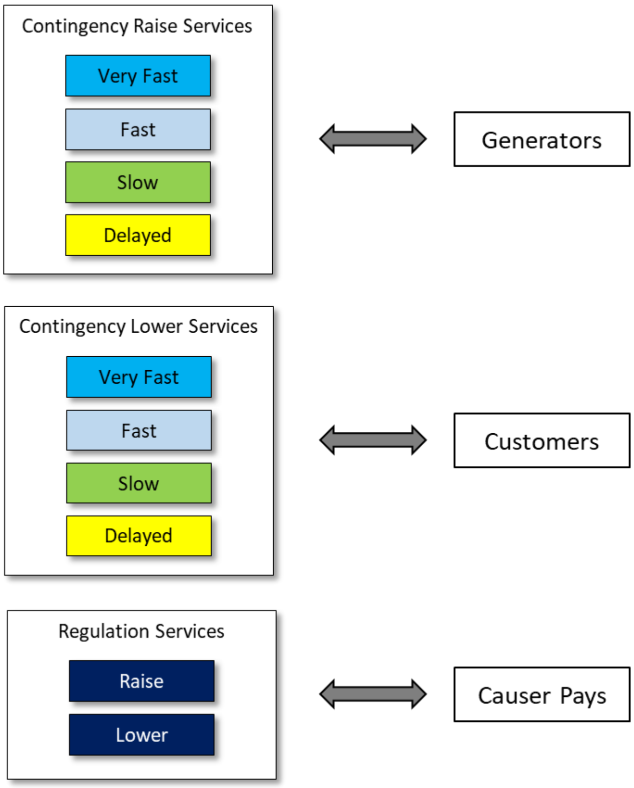
CP is the regional clearing price for the service in that trading interval.

(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 Market Participants according to the recovery rules (see Figure 8).

Figure 8 FCAS cost recovery



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

As contingency raise requirements are set to manage the loss of the largest generator on the system, all payments for these services are recovered from generators, pro-rated based on the energy they generate.

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 services are recovered from wholesale customers, pro-rated based on the energy they consume.

The recovery of payments for regulation services is based on the "Causer Pays" methodology. Under this methodology, the response of measured generators and loads[2] 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 causes the frequency to deviate would be assigned a high factor.

All non-measured entities (customers without SCADA) are assigned causer pays factors based on the remainder (causers not accounted for by measured entities), and based on 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.

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

4. Network support and control and system restart ancillary services

4.1. Network support and control ancillary services (NSCAS)

NSCAS can be subdivided into three categories:

- Voltage control ancillary services (VCAS).
- Network loading control ancillary services (NLCAS).
- Transient and oscillatory stability ancillary services (TOSAS).

4.1.1. Voltage control ancillary services

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 VCAS. Under these ancillary services, generators absorb or generate reactive power from or onto the electricity grid and control the local voltage accordingly.

VCAS can be further categorised as either:

- Synchronous condenser – a generating unit that can generate or absorb reactive power while not generating energy in the market, or
- Static reactive plant – equipment such as capacitors or reactors that can supply or absorb reactive power.

4.1.2. Network loading control ancillary services

NLCAS are used by AEMO to control the flow on interconnectors to within short-term limits.

For example, if the flow on an interconnector 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 (AGC – the same technology used for regulation frequency control) or load shedding.

4.1.3. Transient and oscillatory stability ancillary services (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.

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.

Examples of TOSAS services are power system stabilisers (PSS), fast regulating voltage services (synchronous condensers, static VAR compensators (SVCs), and generators), and inertia support services.

4.2. System restart ancillary services (SRAS)

SRAS are required to restart the power system 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 for NSCAS and SRAS

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 1 below summarises the payment types for VCAS and 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 generators and wholesale customers on a 50/50 basis.

Version release history

Version	Effective date	Summary of changes
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