AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Frequency and Time Error Monitoring – 4th Quarter 2019

March 2020

For the National Electricity Market

PURPOSE

AEMO has prepared this document to provide information about the frequency and time error performance in the National Electricity Market (Mainland and Tasmania) for the period October to December 2019 inclusive.

DISCLAIMER

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Introduction

AEMO must use reasonable endeavours to maintain power system frequency and time error within the limits specified by the Reliability Panel in the Frequency Operating Standards (FOS)[1] for the mainland and Tasmanian areas. This document reports on the frequency and time error performance observed during October, November and December 2019 in all regions of the National Electricity Market (NEM). Queensland, New South Wales, Victoria and South Australia are referred to as the 'mainland' throughout the report.

The *Power System Frequency and Time Deviation Monitoring Report – Reference Guide*[2] outlines the calculation procedure used by AEMO to produce the quarterly Frequency and Time Error Monitoring report.

Analysis of Slow Raise, Slow Lower, Delayed Raise and Delayed Lower Frequency Controlled Ancillary Services (FCAS) presented in this report is based on 4-second SCADA information derived from AEMO's systems. Unless otherwise noted, frequency data for the mainland is sourced from 4-second measurements in New South Wales and frequency data for Tasmania is sourced from 4-second measurements in Tasmania.

[1] https://www.aemc.gov.au/australias-energy-market/market-legislation/electricity-guidelines-and-standards/frequency-0

[2] http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Frequency-and-time-error-monitoring

1. Operation within the Normal Operating Frequency Band

Clause A.1.2(b) of the FOS provides that in the absence of a contingency event and while the entire system is interconnected, AEMO should maintain system frequency within the applicable normal operating frequency excursion band and should not exceed the applicable normal operating frequency band for more than five minutes on any occasion and not for more than 1% of the time over any 30 day period[3].

AEMO calculates the percentage of time spent inside the NOFB on a daily rolling average. The minimum of these 30-day averages observed within each month is reported in Figure 1, which is based upon the normal intact-system requirements. Figure 1 shows statistics both including and excluding data during contingency events.

Frequency performance in the mainland was slightly reduced over Quarter 3, however remained in line with the FOS requirement that frequency should remain within the NOFB 99% of the time over any 30-day period.

Frequency performance in Tasmania improved significantly over Quarter 3 due to the return of Basslink from an outage that separated Tasmania from the rest of the NEM for the period 24 August to 29 September, however Tasmanian frequency performance remains below the levels set out in the FOS.

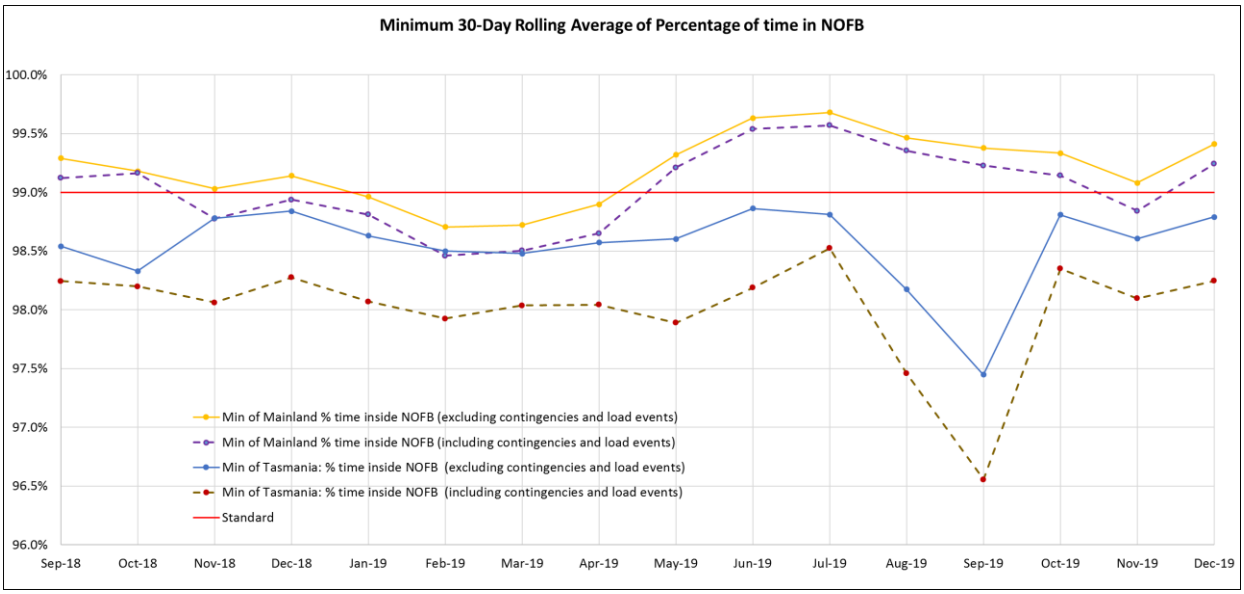

Figure 1 Minimum 30-Day rolling average of percentage of time mainland and Tasmania frequencies remained within NOFB from October 2019 to December 2019

[3] https://www.aemc.gov.au/sites/default/files/content/c2716a96-e099-441d-9e46-8ac05d36f5a7/REL0065-The-Frequency-Operating-Standard-stage-one-final-for-publi.pdf

The frequency distribution over Quarter 4 2019 is shown in Figure 2 and Figure 3.

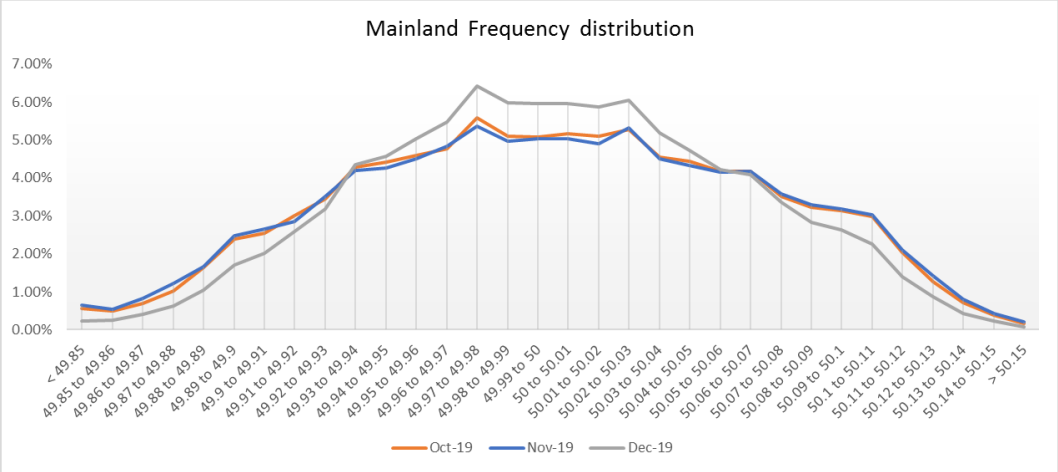

Figure 2 Mainland frequency distribution

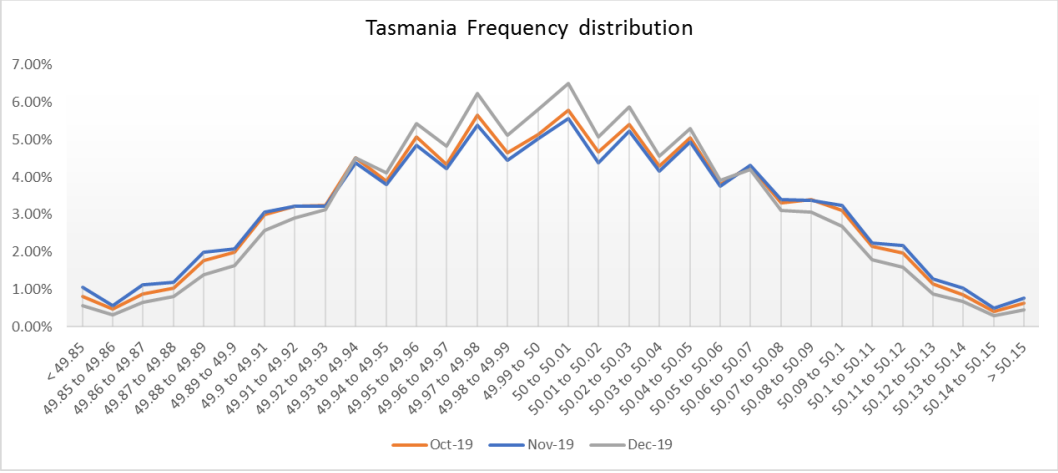

Figure 3 Tasmania frequency distribution

Figure 4 shows that when the frequency is within the NOFB in the mainland, the percentage of the time that frequency is close to the boundaries of the NOFB has decreased further from Quarter 3.

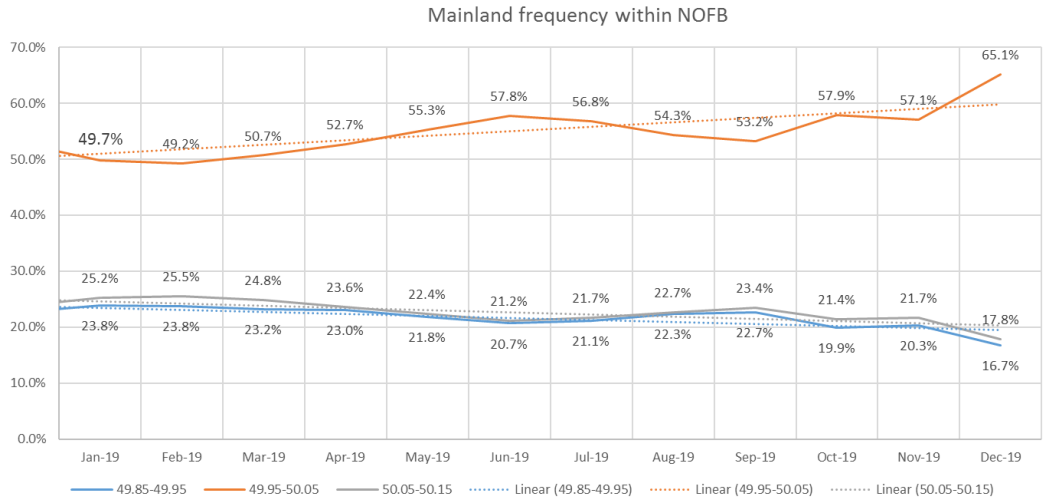

Figure 4 Mainland frequency performance within the NOFB

2. Events outside the Normal Operating Frequency Excursion Band

Table 1 summarises the number of events where there was a frequency excursion outside of the applicable Normal Operating Frequency Excursion Band (NOFEB) [4] that occurred during Quarter 4 in the mainland and Tasmania. For all mainland and Tasmania events listed in Table 1, frequency returned to the NOFB within the times specified in the FOS. Section 3 of this report examines any events that did not meet the requirements of the FOS.

Table 1 Mainland and Tasmania: Frequency excursions outside the NOFEB and returned in FOS timeframes

Event	Low/High/Both Frequency Event	Number of Events	
		Mainland	Tasmania
No contingency or load event noted	LOW	0	14
	HIGH	0	7
	BOTH	0	1
Load Event	LOW	0	70
	HIGH	0	153
	BOTH	0	80
Generation Event	LOW	3	21
	HIGH	0	6
	BOTH	0	2
Network Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0
Separation Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0
Multiple Contingency Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0

[4] Frequency range of 49.75 Hz – 50.25 Hz for an interconnected system and range of 49.0 Hz – 51.0 Hz for an island

2.1 Mainland Events

During this reporting period, there was one notable mainland event which did not breach the requirements of the FOS but will be discussed further below.

Table 2 Frequency event on 9 October 2019

Event	Min Mainland Frequency (Hz)	Duration outside NOFB - 49.85 – 50.15 Hz for min frequency (seconds)
Generation Event	49.61	213

Following the trip of Kogan Creek on 9th October the frequency nadir reached 49.61 Hz and took 213 seconds to return to the NOFB. An assessment of the delivery of enabled raise contingency services following the event was conducted and showed that FCAS was delivered well in aggregate. The delivered quantities of fast raise and slow raise services exceeded the amount enabled by the market, which explicitly acquires a minimum amount projected to contain frequency to the FOS requirements in an event. The raise contingency services enabled and delivered are shown in Table 3.

Table 3 Enabled and Delivered FCAS for 9 October 2019 event for the raise contingency services

Event Date and Time		FCAS enabled in dispatch interval (MW)	
		Fast Raise	Slow Raise
Wednesday 9 October 2019, 0800 hrs	Enabled (MW)	412	412
	Delivered (MW) (% of Enabled)	607 (147%)	764 (185%)

As frequency recovered to within the NOFB within five minutes following the contingency event, accurate quantification of delayed FCAS delivery is not possible. However analysis of delayed FCAS response indicates that enabled providers responded as expected.

3. Events Outside the Frequency Operating Standards

This section analyses the frequency events identified as not having met at least one of the FOS requirements.

3.1 Mainland events

No frequency events were identified in the mainland during this reporting period that did not meet the applicable standards in the FOS.

3.2 Tasmanian Events

No frequency events were identified in Tasmania during this reporting period that did not meet the applicable standards in the FOS.

3.3 No contingency or load event

When there are no associated contingency or load events in an interconnected system, the FOS requires that a frequency disturbance should be contained and stabilised as shown in Table 4.

Table 4 No contingency or load event for an interconnected system

Region	Containment	Stabilisation	Recovery
Mainland	49.75 to 50.25 Hz 49.85 to 50.15 Hz, 99% of the time	49.85 to 50.15 Hz within 5 minutes	
Tasmania	49.75 to 50.25 Hz 49.85 to 50.15 Hz, 99% of the time	49.85 to 50.15 Hz within 5 minutes	

4. Accumulated Time Error

The FOS specifies that the accumulated time error should be maintained within the range ± 15 seconds in the mainland (except in an island or during supply scarcity) and Tasmania (except in an island or following a multiple contingency event). Constraint equations used to assist in controlling mainland accumulated time error by varying the amount of Regulation FCAS enabled are based on measurements taken in Queensland and New South Wales. The ranges of accumulated time error recorded for measurements in the mainland and Tasmania are provided in Table 5.

Table 5 Maximum and Minimum time error measurements for mainland and Tasmania

Value	Mainland	Tasmania
Highest positive time error (seconds)	5.65	5.87
Lowest negative time error (seconds)	-13.29	-14.61

Figure 5 shows the percentage of time where mainland time error was outside the +/- 1.5 second threshold at which accumulated time error begins to increase Regulation FCAS volumes above their base values. There was no notable trend in time error incidence in Quarter 4.

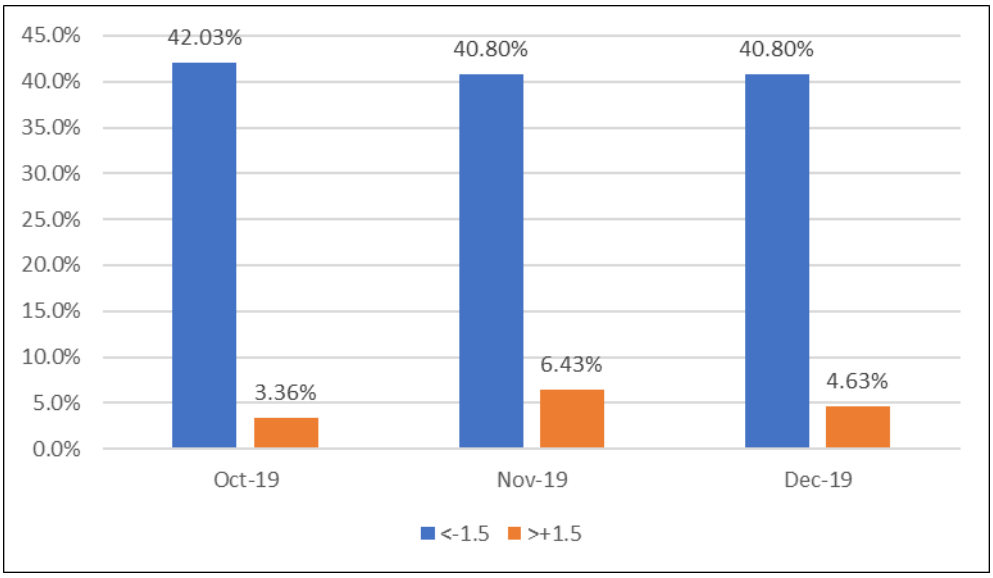

Figure 5 Proportion of time mainland time error was outside of +/-1.5s

Tasmanian frequency performance improved across Quarter 4 relative to Quarter 3 due to the return to service of Basslink on 29th September. During this separation, a different frequency control regime was adopted with the aim of improving Tasmanian frequency performance. In co-ordination with Hydro Tasmania and TasNetworks, dead-bands on the governing systems of most major units in Tasmania were voluntarily narrowed to ensure the Tasmanian frequency performance was compatible with the mainland performance. The Tasmanian frequency performance was notably improved by these adjustments. Following re-connection to the mainland, these changes were rolled back.

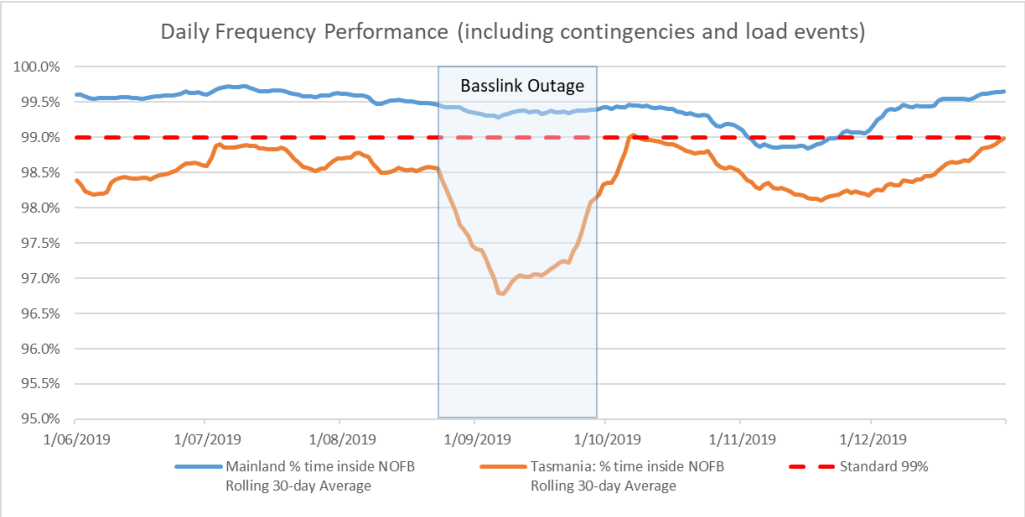

Figure 6 30-Day daily rolling average of percentage of time mainland and Tasmania frequencies remained within NOFB.

5. Area Control Error

As per the Regulation FCAS Contribution Factors Procedure[5], AEMO first calculates an area control error (ACE), representing the MW equivalent size of the current frequency deviation and accumulated frequency deviation (time error) of the system.

EQ. 1 $$ACE = 10 \cdot Bias \cdot (F - FS - FO)$$

Where:

(i) Bias is the area frequency bias and is a tuned value that represents the amount of response AGC will provide for 0.1Hz of frequency deviation;

(ii) F is the current measured system frequency;

(iii) FS is the scheduled frequency (50.0Hz); and

(iv) FO is a frequency offset representing accumulated frequency deviation, i.e. time error.

Figures 7 and 8 show a comparison of the minimum and maximum ACE per dispatch intervals in the mainland and Tasmania in the last quarter.

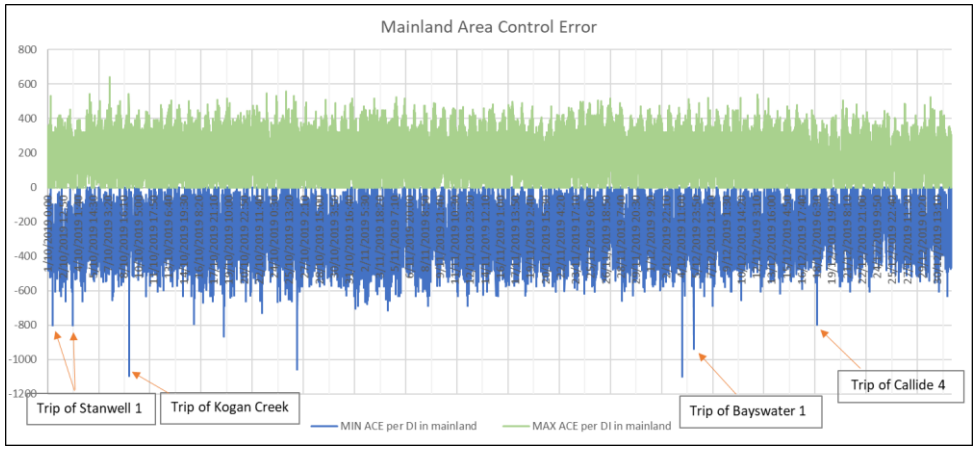

Figure 7 Minimum and maximum ACE per DI in mainland

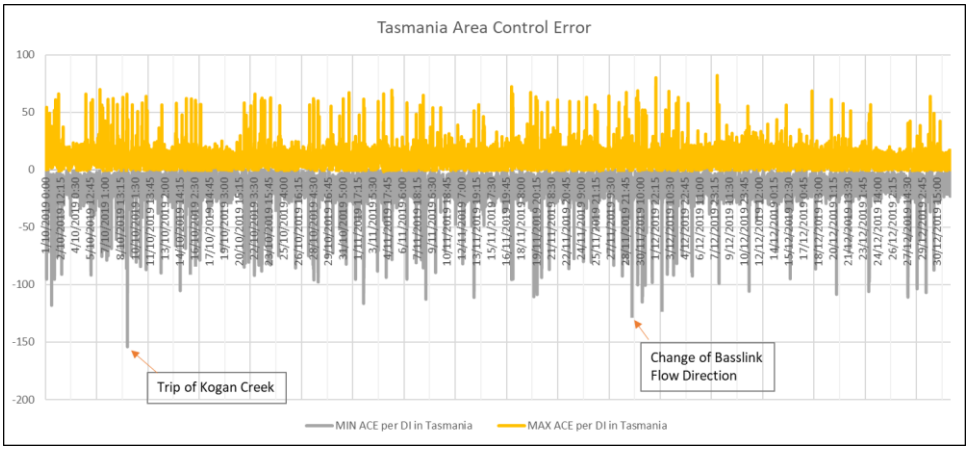

Figure 8 Minimum and maximum ACE per DI in Tasmania

[5] http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Regulation-FCAS-Contribution-Factors-Procedure.pdf

6. Actions to improve frequency control performance

The general decline in frequency control performance under normal conditions in the NEM, and particularly since approximately 2014/15 has been well noted and is the subject of many inter-related areas of work within AEMO, the AEMC and the broader industry[6]. The following provides an overview of various pieces of work that have occurred throughout recent months or that are planned to proceed in the near future:

- From the start of January 2020, AEMO has commenced publication of weekly frequency performance measures, which provide more timely information to the market. These publications are available on AEMO's website[7].
- Contingency FCAS volumes have been progressively increased since September as a result of revised mainland load relief assumptions. This has been fully implemented as of Q1 2020[8] with load relief settling at 0.5%. AEMO plans to re-assess in approximately 12 months' time.

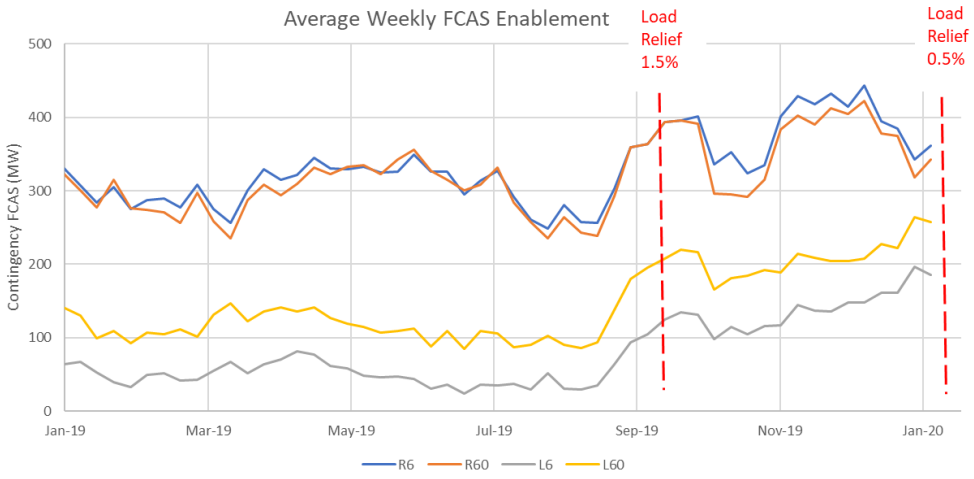

Figure 9 Average Weekly FCAS Enablement

- Base Regulation FCAS volumes were increased over the course of 2019, with base volumes now at 220 MW (Raise) and 210 MW (Lower). AEMO continues to monitor performance of Regulation FCAS as seen in Figure 1 of this report[9]. Should any further adjustments be needed, AEMO will advise the market in due course.
- A proposed Rule Change is progressing relating to introducing frequency response requirements for all capable facilities[10]. A Draft Rule has been made by the AEMC, with the Rule intended to come into effect from early June 2020. This rule will require all scheduled and semi-scheduled generators to operate in a frequency responsive mode with a narrow deadband well within the NOFB, which is expected to result in

[6] For example, refer to the AEMC's Frequency Control Frameworks Review: https://www.aemc.gov.au/markets-reviews-advice/frequency-control-frameworks-review

[7] https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/frequency-and-time-deviation-monitoring

[8] https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/2019/Update-on-Contingency-FCAS-Nov-2019.pdf

[9] https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/frequency-and-time-error-reports/regulation-fcas-changes_june-update.pdf

[10] https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response

a significant improvement in the tightness of frequency control within the NOFB, increase system resilience, and provide AEMO much greater clarity as to the dynamic behaviour of the power system during disturbances. As of March 2020, AEMO has commenced pre-consultation with the industry regarding implementation of the Rule.

- A proposed Rule Change aiming to remove identified disincentives for providing primary frequency response (i.e. generators automatically responding to frequency change within the NOFB) has been deferred until September 2020 to consider improved incentive arrangements for primary frequency control[11].
- AEMO is considering the case for region-specific FCAS requirements, and the ways in which these could be implemented if needed. AEMO will ensure the market is consulted and advised prior to of any potential changes.

[11] https://www.aemc.gov.au/rule-changes/removal-disincentives-primary-frequency-response