AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Frequency and Time Error Monitoring – 2nd Quarter 2019

November 2019

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 April to June 2019 inclusive.

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1. 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 regions. This document reports on the frequency and time error performance observed during April, May and June 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.

The analysis of the delivery of Slow Raise, Slow Lower, Delayed Raise and Delayed Lower Frequency Controlled Ancillary Services (FCAS) presented in this report are 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

2. Operation within the Normal Operating Frequency Band

Clause A.1.2(b) of the FOS provides that in the absence of a contingency event, AEMO should maintain system frequency within the applicable normal operating frequency excursion band and should not exceed the applicable normal operating frequency band (NOFB) for more than five minutes on any occasion and not for more than 1% of the time over any 30-day period[3]. Frequency performance did not meet this standard for April in the mainland and for Quarter 2 in Tasmania.

In response to unsatisfactory performance on this measure, AEMO increased base regulation volumes in the NEM on the 22nd March, 23rd April and 23rd May 2019, in total taking base volumes from 130/120 MW (Raise/Lower) to 220/210 MW. This improved the amount of time frequency was contained within the NOFB in both areas in Quarter 2.

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. The figure shows statistics both including and excluding periods where there were contingency events.

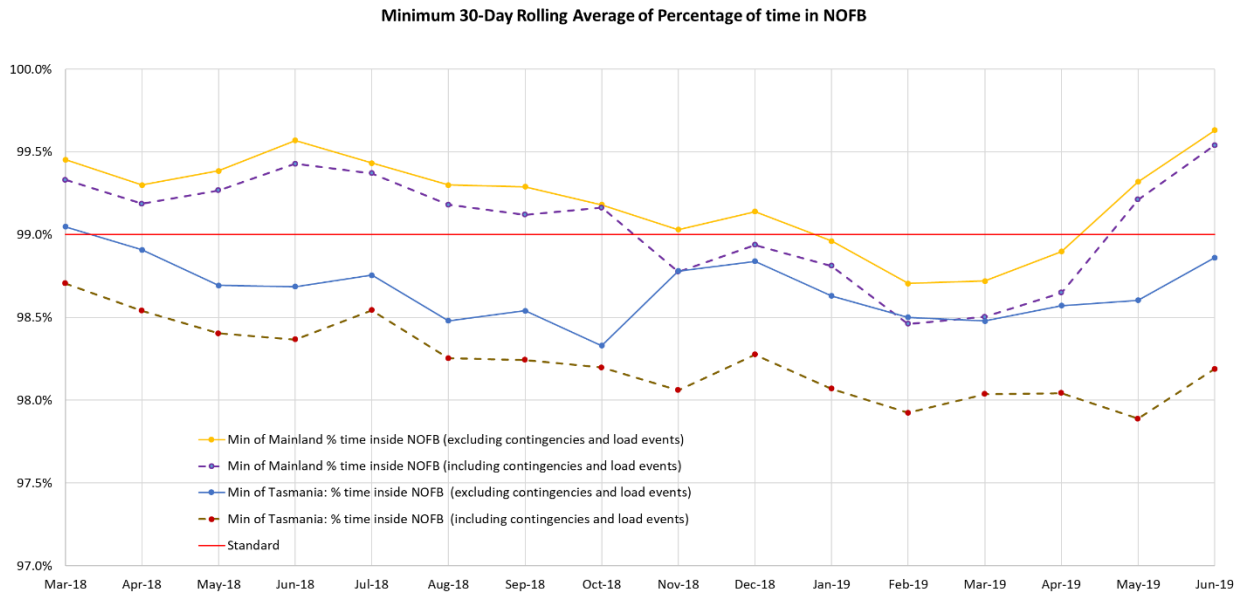

Figure 1 Minimum 30-Day rolling average of percentage of time mainland and Tasmania frequencies remained within NOFB from April 2019 to June 2019

The frequency distribution over Quarter 2 2019 is shown in Figure 2 and Figure 3. Although Quarter 2 performance against the FOS was significantly improved compared with the preceding quarter, AEMO continues to have concerns over the lack of stable control (especially within the NOFB) and in terms of general system resilience.

[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

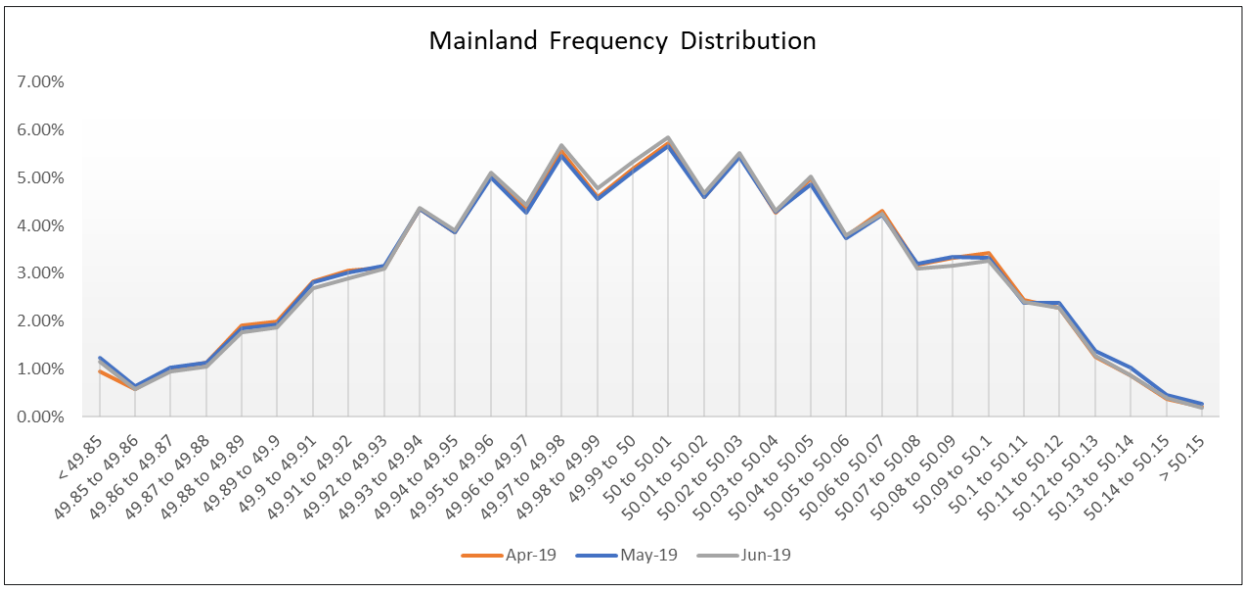

Figure 2 Mainland frequency distribution

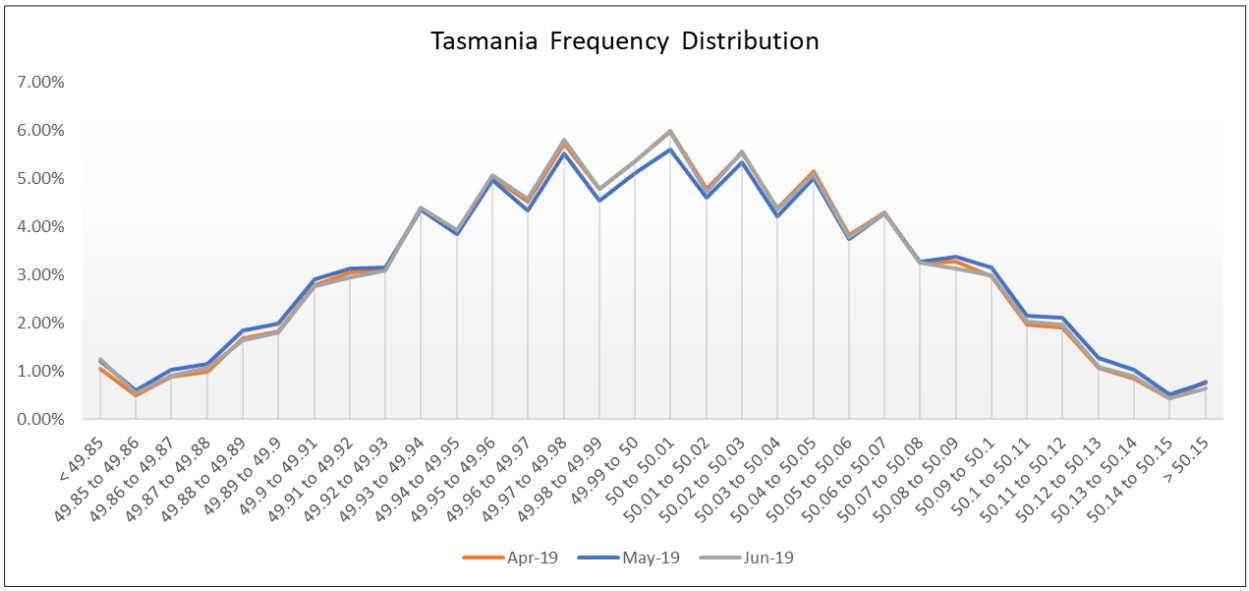

Figure 3 Tasmania frequency distribution

3. Events outside the Normal Operating Frequency Excursion Band

Table 1 and Table 2 summarise the events in the mainland and Tasmania with frequency excursions outside the Normal Operating Frequency Excursion Band (NOFEB) [4].

For all mainland and Tasmania events listed in Table 1, frequency returned to the NOFB within the times specified in the FOS. For the events in Table 2, it did not. These events are discussed further in Section 4.

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	43
	HIGH	1	27
	BOTH	0	7
Load Event	LOW	0	51
	HIGH	0	133
	BOTH	0	123
Generation Event	LOW	4	12
	HIGH	0	4
	BOTH	0	3
Network Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0

[4] Frequency range of 49.75 Hz – 50.25 Hz

Event	Low/High/Both Frequency Event	Number of Events	
		Mainland	Tasmania
Separation Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0
Multiple Contingency Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0

Table 2 Mainland and Tasmania: Frequency excursions outside the NOFEB not returned in FOS timeframes

Event	Low/High/Both Frequency Event	Number of Events	
		Mainland	Tasmania
No contingency or load event noted	LOW	0	2
	HIGH	0	0
	BOTH	0	2
Load Event	LOW	0	0
	HIGH	0	2
	BOTH	0	18
Generation Event	LOW	0	0
	HIGH	0	0
	BOTH	0	1
Network Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0

Event	Low/High/Both Frequency Event	Number of Events	
		Mainland	Tasmania
Separation Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0
Multiple Contingency Event	LOW	0	0
	HIGH	0	0
	BOTH	0	0

4. Events Outside the Frequency Operating Standards

This section analyses the events identified as not meeting the standards in the FOS.

4.1 Mainland Events

Five frequency events were recorded in the mainland that did not meet the FOS during this reporting period. This occurred due to the event duration, or where the frequency was outside the NOFEB for a reason other than a contingency event or a load event. For most situations, the FOS states that frequency should not remain outside the NOFB for more than 300 seconds. Mainland frequency events exceeding FOS restoration timeframes are listed in Table 3.

Table 3 Mainland frequency events outside the FOS

Event	Number of Events	Min/Max Mainland Frequency (Hz)	Duration outside NOFB - 49.85 – 50.15 Hz (sec) for min/max frequency
No contingency or load event	5	49.79 50.16	320

Over Quarter 2 2019, there were no instances where the system did not recover from a frequency event within the required 5 minutes following a generation event. This shows a significant improvement from Quarter 1; the increased regulation requirements applied over the course of Quarter 2 2019 would have contributed to this improvement in performance. Refer to Regulation FCAS changes on AEMO website[5] for further information on the regulation FCAS changes that have occurred.

On 5 occasions the frequency exceeded the NOFB in the absence of noted contingency or load events, but was not stable and did not recover within 5 minutes. However, the frequency was contained within the NOFEB on all 5 occasions.

4.2 Tasmanian Events

As shown in Table 4, 82 frequency events were recorded in Tasmania during this reporting period that did not meet the standards in the FOS. AEMO continues to work on actions to improve frequency performance in Tasmania. Due to the Basslink interconnector's frequency controller, when Tasmania is connected to the Mainland its frequency performance is largely dictated by the performance of the Mainland. Therefore, initiatives to improve Mainland frequency performance also affect Tasmanian frequency performance.

Table 4 Tasmania frequency events outside the FOS

Event	Number of Events	Min/Max Tasmanian Frequency (Hz)	Duration outside NOFB - 49.85 – 50.15 Hz (sec) for min/max frequency
No contingency or load event	82	49.24 50.52	164 232

[5] See Regulation FCAS changes on https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Frequency-and-time-error-monitoring

Following the generator and load events, the frequency was contained between 48.0Hz to 52.0Hz and recovered within the FOS timeframe of 10 minutes.

On 82 occasions when there were no reported contingency or load events, the frequency exceeded the NOFEB and the frequency was not stable and did not recover within 5 minutes.

4.3 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 5.

Table 5 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	

Across the mainland and Tasmania, a total of 87 frequency excursions outside the NOFB were not associated with a contingency or load event. For these deviations, the frequency either exceeded the NOFEB (only in Tasmania) or did not stabilise and recover within the NOFB in 5 minutes.

Figure 4 below shows that when the frequency is within the NOFB in the mainland, the percentage of the time that it is closer to the edge of the NOFB has decreased compared to Quarter 1. The probability of the frequency leaving the NOFB has decreased as the performance of frequency within the NOFB has improved.

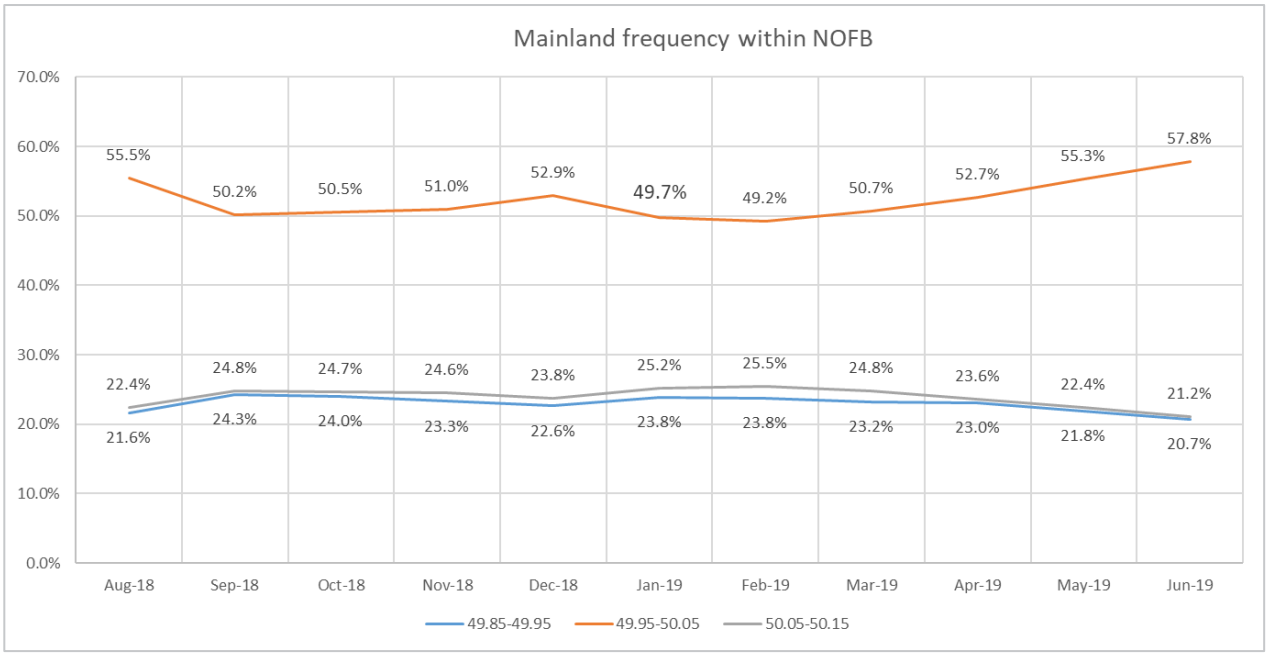

Figure 4 Mainland frequency performance within the NOFB

5. Accumulated Time Error

The FOS specifies that the accumulated time error should be maintained within the range ± 15 seconds in the mainland and Tasmania. Time error correction is performed by AEMO's AGC system using Regulation FCAS. Dynamic constraint equations can increase the amount of Regulation FCAS enabled if time error exceeds certain thresholds. The ranges of accumulated time error recorded for measurements in mainland and Tasmania during Quarter 2 2019 are provided in 06. As shown, time error was kept within the limits required by the FOS.

Table 6 Maximum and minimum time error measurements for mainland and Tasmania

Value	Mainland	Tasmania
Highest positive time error (seconds)	4.93	2.52
Lowest negative time error (seconds)	-11.45	-13.90

Figure 5 below shows the percentage of time that the time error was less than or greater than 1.5 seconds, which is the threshold at which accumulated time error begins to increase Regulation FCAS volumes above base values.

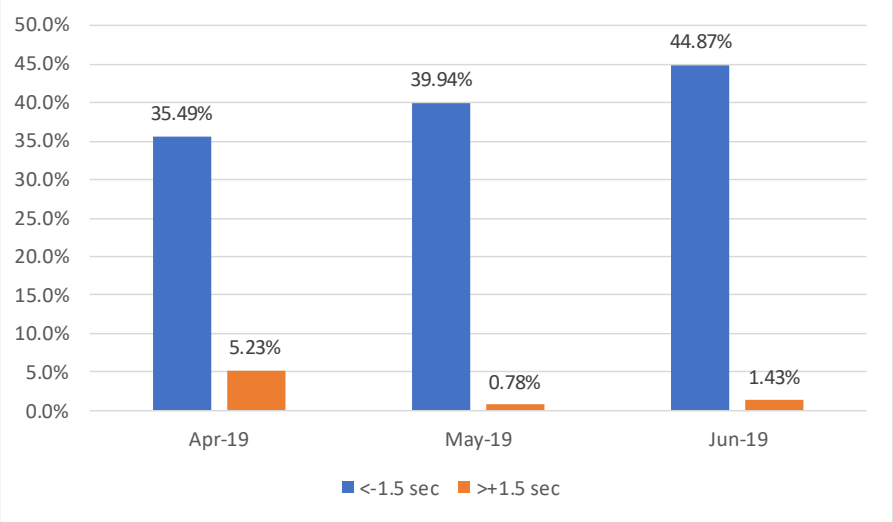

Figure 5 Percentage of time where Mainland time error exceeds 1.5s threshold

Over Quarter 2 2019, time error was kept within 1.5 seconds an increasing proportion of the time. This means that the dynamic time-error thresholds that increase Regulation FCAS were utilised less frequently. This can be largely attributed to the increased base regulation requirements applied over the course of Quarter 2 2019 [6].

[6] See Regulation FCAS changes on https://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Ancillary-services/Frequency-and-time-error-monitoring

6. Area Control Error

Trends in Area Control Area (ACE) give an indication of how frequency is performing from the perspective of AGC. For the absence of doubt, there are no specific requirements pertaining to ACE in the FOS, but it is reported on here due to its relationship with usage of Regulation FCAS and its inclusion in the AEMC's rule change on frequency control performance[7].

AEMO calculates area control error (ACE), representing the MW equivalent size of the current frequency deviation and accumulated frequency deviation (time error) of the system in accordance with the following equation:

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 conversion ratio between MW and 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 6 and 7 show minimum and maximum ACE values recorded in each dispatch interval in the mainland and Tasmania over Quarter 2 2019.

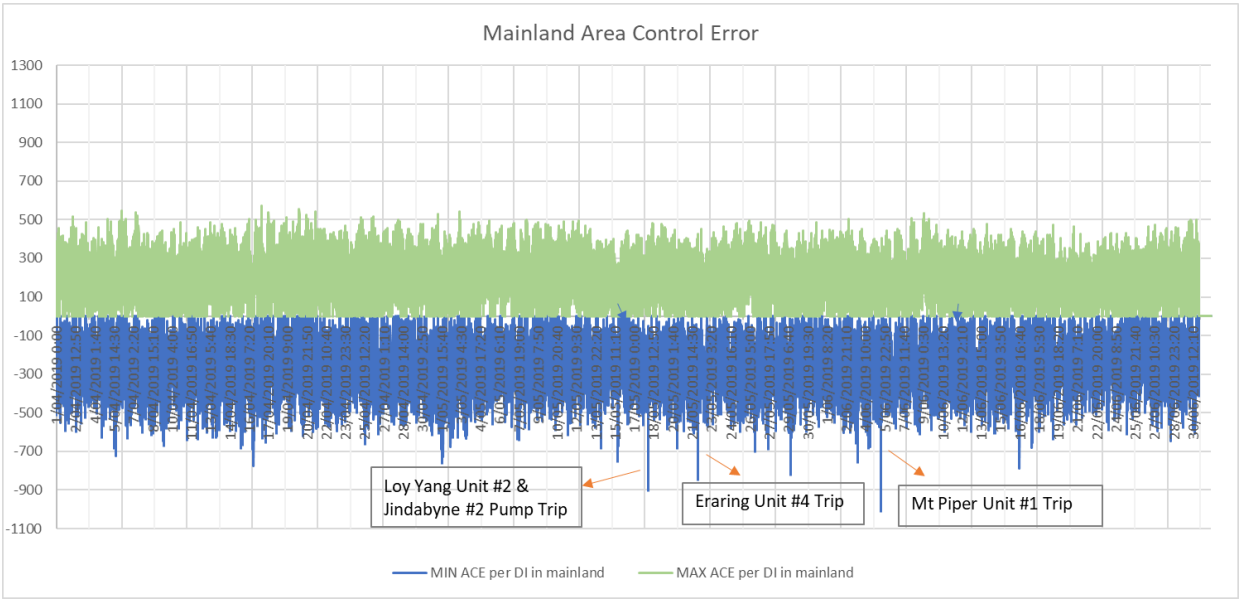

Figure 6 Minimum and maximum ACE per DI in mainland

[7] https://www.aemc.gov.au/rule-changes/monitoring-and-reporting-frequency-control-framework

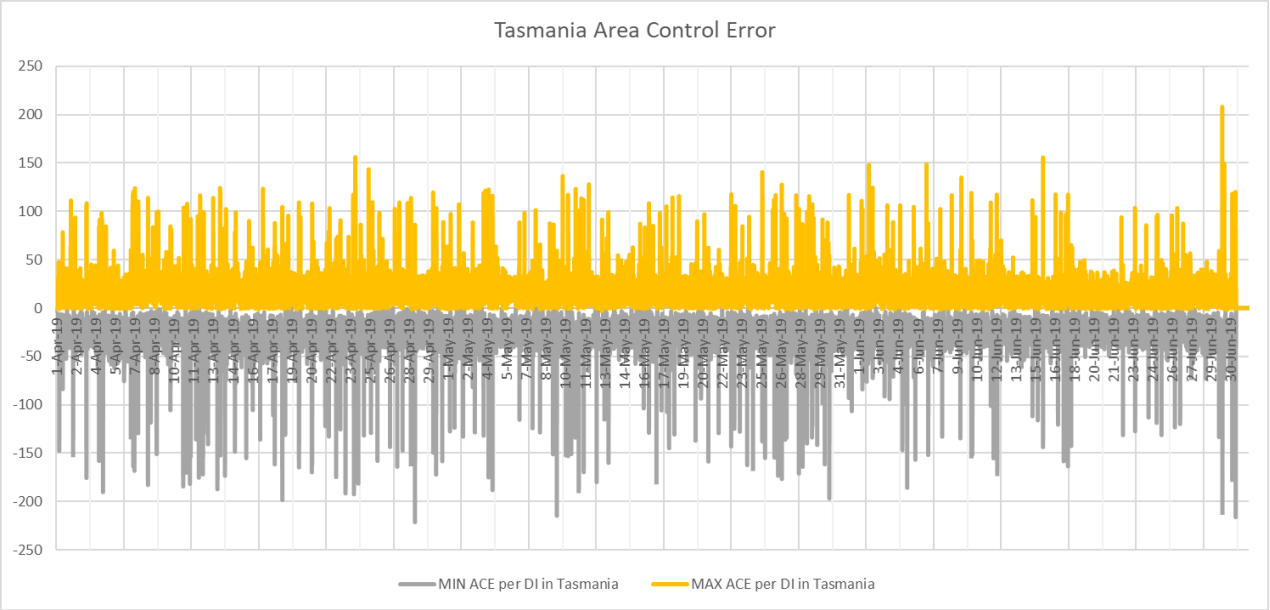

Figure 7 Minimum and maximum ACE per DI in Tasmania