AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Frequency and Time Error Monitoring – 3rd Quarter 2019

January 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 July to September 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 July, August and September 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 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].

As a result of increasing the NEM base regulation volumes on the 22nd March, 23rd April and 23rd May 2019, the frequency performance in mainland improved in Quarter 3. Refer to section 4.4 for more details on the actions taken by AEMO to improve the performance of frequency.

Frequency performance in Tasmania decreased significantly at the end of Quarter 3. This was because of a Basslink outage that separated Tasmania from the rest of the NEM for the period 24 August to 29 September. During this time, a less stringent set of FOS requirements apply, which is not represented in this chart. Following re-connection to the mainland, Tasmanian frequency performance has been similar to that prior to the Basslink outage.

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. The figure shows statistics both including and excluding data during contingency events.

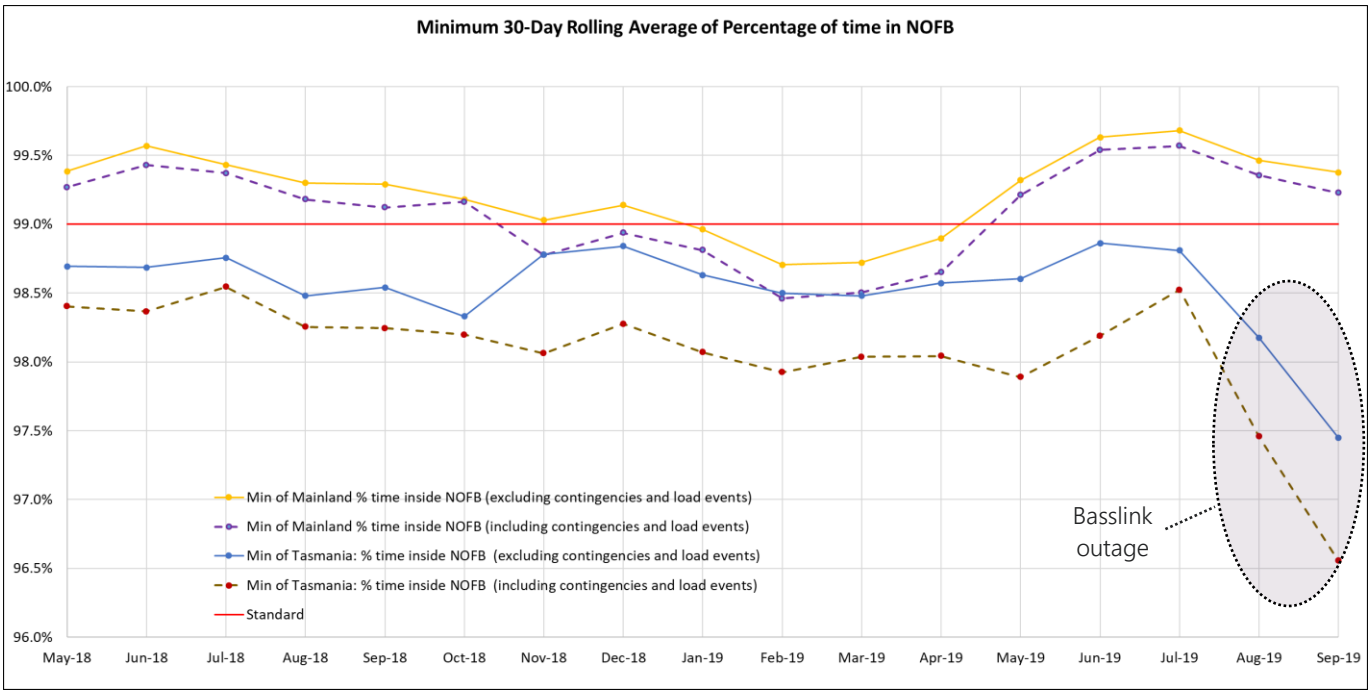

Figure 1 Minimum 30-Day rolling average of percentage of time mainland and Tasmania frequencies remained within NOFB from July 2019 to September 2019

[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 3 2019 is shown in Figure 2 and Figure 3.

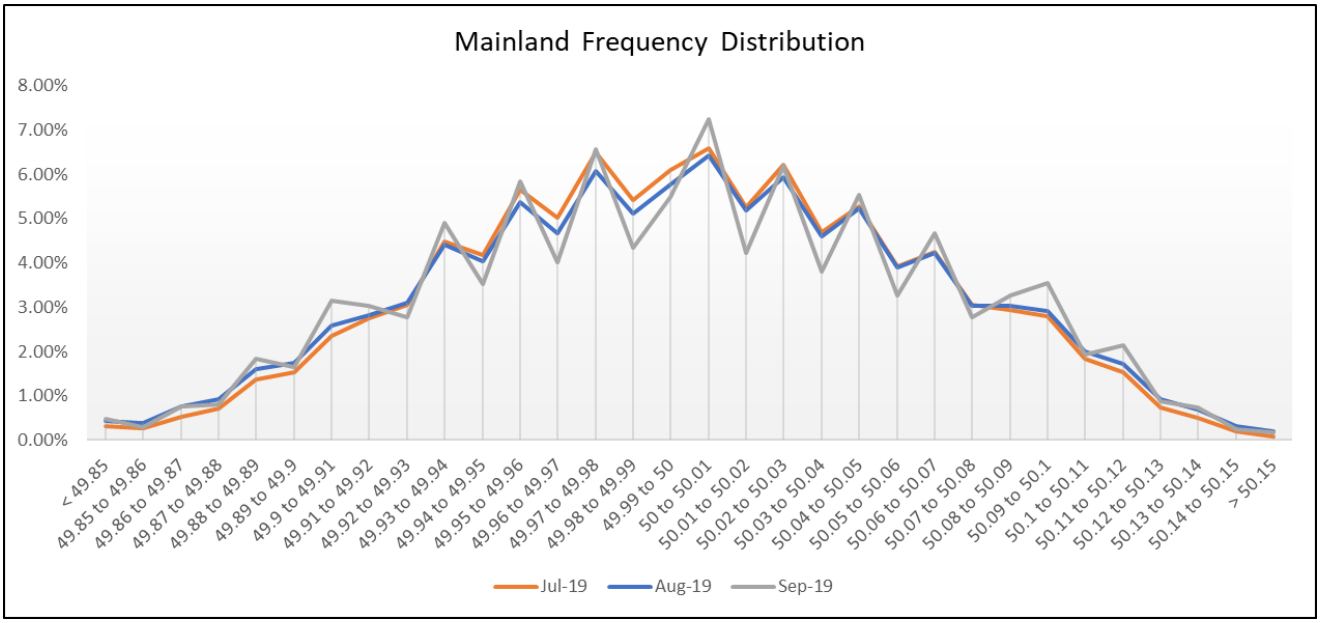

Figure 2 Mainland frequency distribution

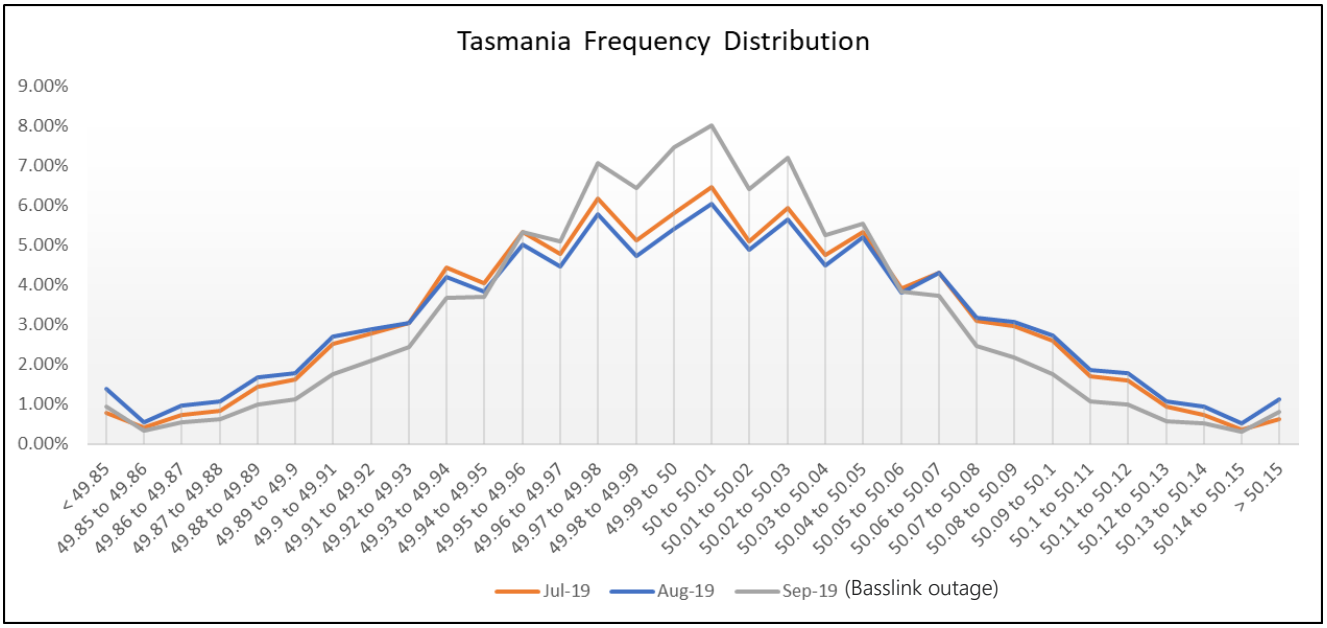

Figure 3 Tasmania frequency distribution

3. 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 3 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 4 of this report examines any events that did not meet the requirements of the FOS; in the case of Quarter 3 2019, there were no such events.

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	9
	HIGH	0	6
	BOTH	0	4
Load Event	LOW	0	30
	HIGH	0	65
	BOTH	0	32
Generation Event	LOW	3	7
	HIGH	0	0
	BOTH	0	4
Network 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

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 frequency events identified as not having met at least one of the requirements set out in the FOS.

4.1 Mainland Events

During this reporting period, there were no events that did not meet the requirements of the FOS. There was one event of longer than usual duration, but this was in fact a multiple contingency event, as the loss of both Tomago potlines is considered a non-credible event. In a multiple contingency event, the FOS requires that AEMO use 'reasonable endeavours' to return frequency to the NOFB within 600 seconds.

Table 2 Frequency event on 3 September 2019

Event	Min/Max Mainland Frequency (Hz)	Duration outside NOFB - 49.85 – 50.15 Hz (sec) for min/max frequency
Load Event	50.3	464

Following the load event on 3 September 2019, the frequency exceeded 50.25 Hz and took 464s to return to the NOFB. This was a multiple contingency event where Tomago potlines 1 and 2 both tripped and frequency reached 50.3 Hz. Market notices pertaining to this event are may be found on the AEMO website[5].

The lower contingency services dispatched are shown in Table 4 and the ratio of delayed lower service over the FCAS dispatched by scheduled units is shown in Table 5.

Table 3 Enabled FCAS for 3 September 2019 event

Event Date and Time	FCAS enabled in dispatch interval / MW		
	Fast Lower	Slow Lower	Delayed Lower
Tuesday 3rd September 2019, 0122 hrs	192	306	221

Table 4 Percentage of delayed FCAS delivered vs enabled FCAS for the lower contingency services

Event Date and Time	FCAS delivered in dispatch interval / MW
	Delayed Lower
Tuesday 3 September 2019, 0122 hrs	198%

An assessment of the delivery of slow and delayed lower services following the event was conducted. Following the load event, the slow and delayed lower service delivered was more than the amount enabled

[5] https://aemo.com.au/Market-Notices?searchString=69728

by the market. AEMO follows up under- or non-delivery of FCAS to ensure issues are identified and corrected.

4.2 Tasmanian Events

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

Following the generator and load events that occurred throughout the quarter, frequency was contained between 48.0 Hz to 52.0 Hz and recovered within the applicable NOFB in the FOS timeframe of 10 minutes.

On the 19 occasions where there was no specific reported contingency or load events, frequency was recovered within the applicable NOFB in the FOS timeframe of 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	

Figure 4 shows that when the frequency is within the NOFB in the mainland, the percentage of the times that frequency is close to the boundaries of the NOFB has decreased from Quarter 2. The probability of the frequency leaving the NOFB has decreased as the performance of frequency within the NOFB has improved.

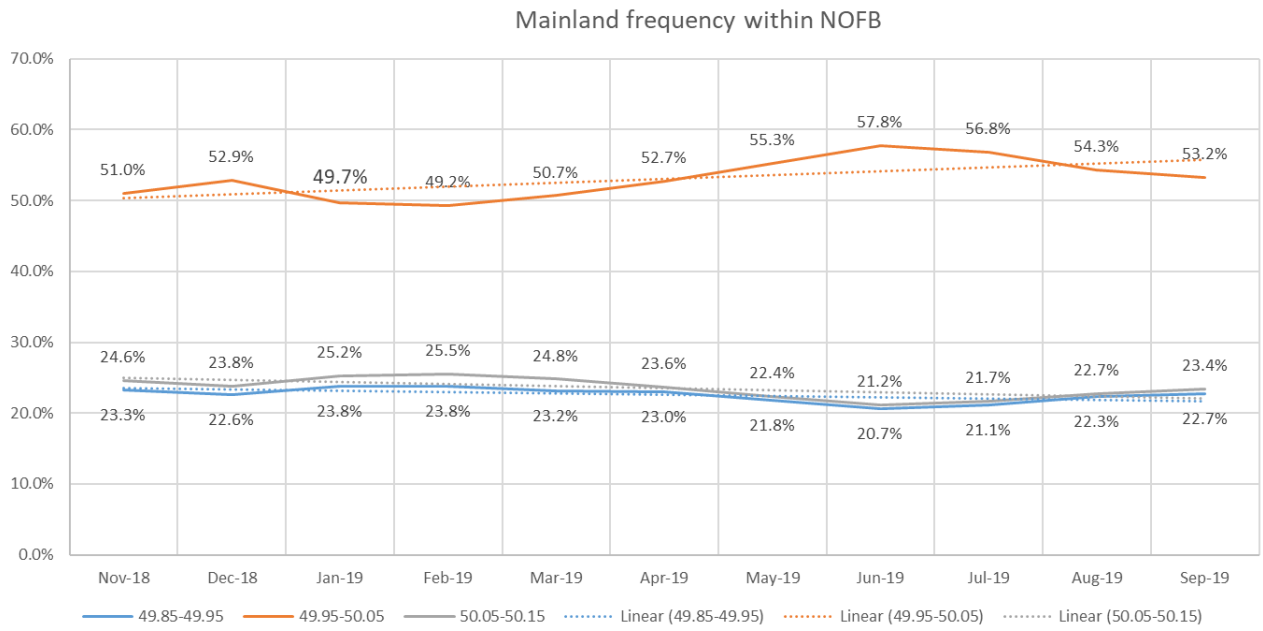

Figure 4 Mainland frequency performance within the NOFB

4.4 Actions to improve frequency control performance

The general decline in frequency control performance under normal conditions in the NEM has been well noted, and is the subject of many inter-related areas of work. The following measures were underway to improve frequency control performance in line with the requirements of the FOS.

- AEMO has progressively increased base Regulation FCAS volumes in several stages starting from 22 March 2019, with base volumes now at 220/210MW Raise/Lower. This is monitored regularly and further adjustments (up or down) are done as required. The stages that Regulation FCAS volumes were increased are as follows.
    - +50 MW on 22 March 2019 to 180/170 MW Raise/Lower
    - +20 MW on 23 April 2019 to 200/190 MW Raise/Lower
    - +20 MW on 23 May 2019 to 220/210 MW Raise/Lower.
- AEMO is progressing a range of other frequency control initiatives such as:
    - Reviewing and assessing revised Automatic Generator Control (AGC) settings
    - Progressively increasing Contingency FCAS volumes, in line with revised estimations of load relief[6]
    - Progressing a Rule Change removing identified disincentives for providing primary frequency response (i.e. generators automatically responding to frequency change within the NOFB)[7]
    - Progressing a proposed Rule Change relating to introducing frequency response requirements for all capable facilities[8].

Figure 5 below shows the regulation FCAS volumes increased in stage and the frequency performance.

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

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

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

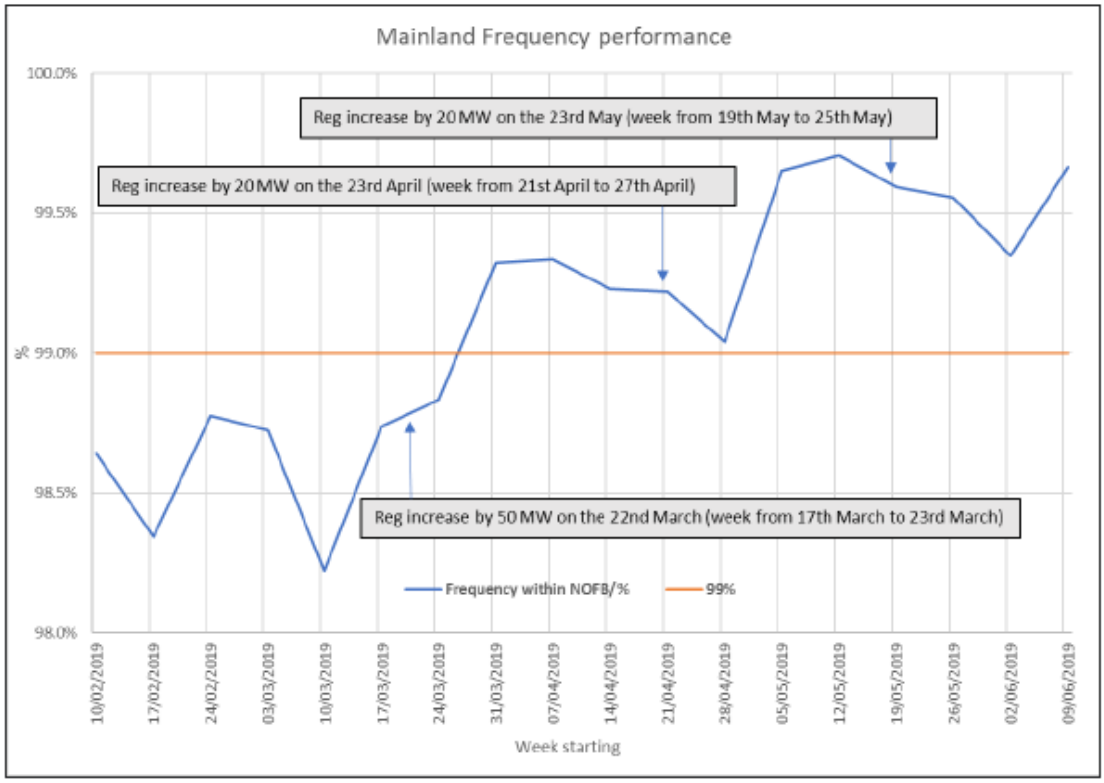

Figure 5 Regulation FCAS changes – June Update[9]

[9] http://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Ancillary_Services/Frequency-and-time-error-reports/Regulation-FCAS-changes_June-update.pdf

5. 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 control 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 6.

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

Value	Mainland	Tasmania
Highest positive time error (seconds)	4.46 (during Basslink outage) 5.67 (while Basslink was in service)	9.32 (during Basslink outage) 4.18 (while Basslink was in service)
Lowest negative time error (seconds)	-13.47(during Basslink outage) -8.88 (while Basslink was in service)	-18.33 (during Basslink outage) -13.24 (while Basslink was in service)

Figure 6 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. Across the quarter, the incidence of negative time errors increased. The lack of frequency support from Tasmania via Basslink throughout part of August and most of September may have influenced this, although many other factors are at play too.

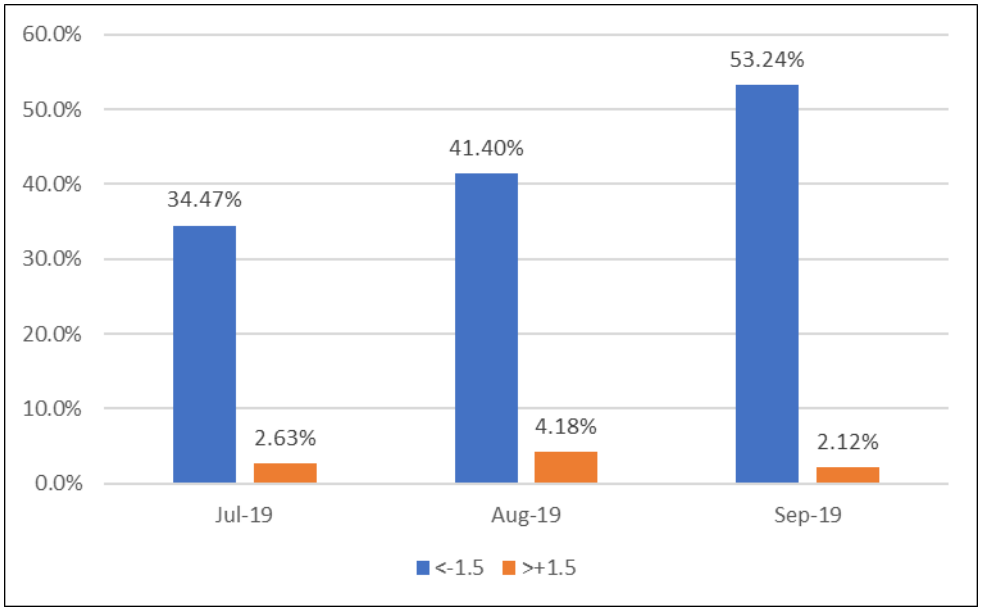

Figure 6 Proportion of time Mainland time error was outside of +/-1.5s

Tasmanian frequency performance was quite varied across Quarter 3, in particular owing to the extended separation from the mainland. 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, deadbands on the governing systems of some major units in Tasmania were voluntarily narrowed to increase primary frequency response, and revised AGC settings were adopted. The Tasmanian frequency performance (and thus time error) was notably improved by these adjustments. Following re-connection to the mainland, these changes were rolled back.

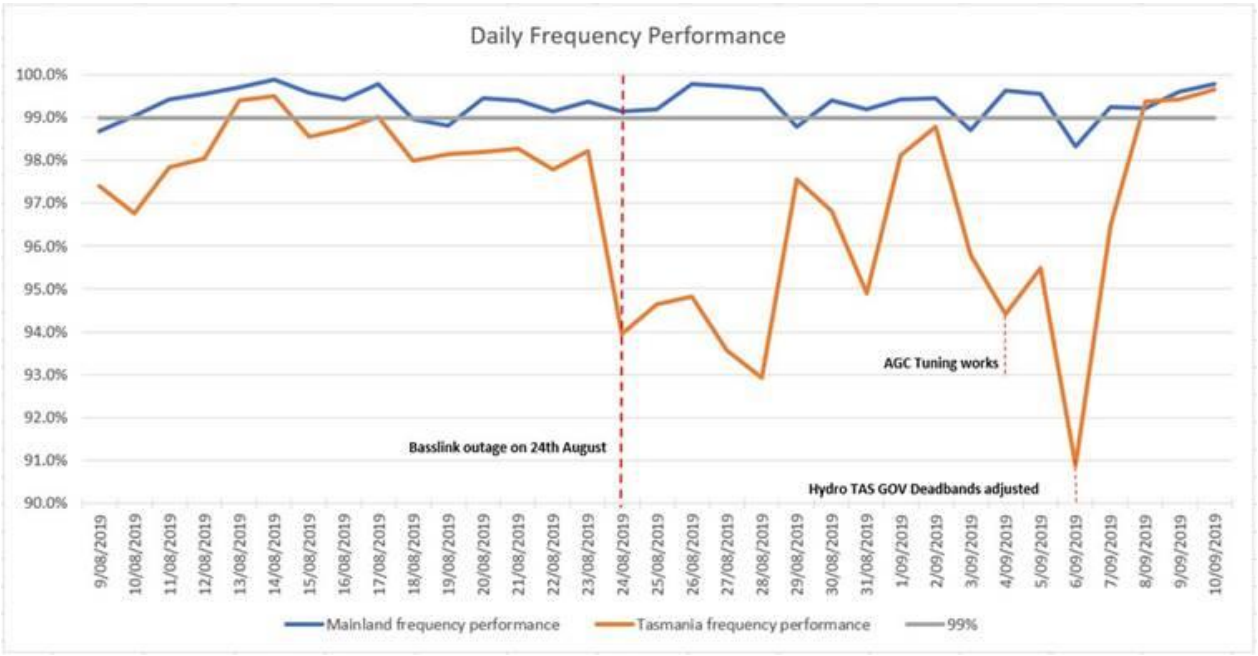

Figure 7 Daily frequency performance before and during Tasmanian separation

6. Area Control Error

As per the Regulation FCAS Contribution Factors Procedure[10], 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 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 8 and 9 show a comparison of the minimum and maximum ACE per dispatch intervals in the mainland and Tasmania in the last quarter.

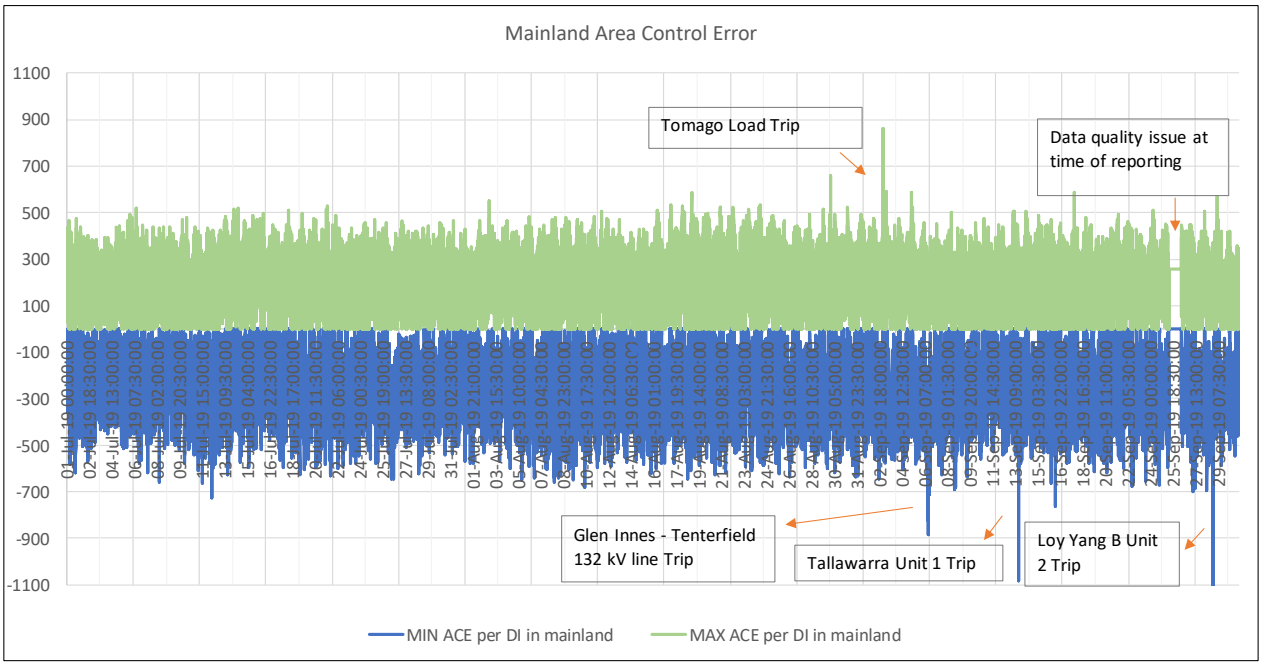

Figure 8 Minimum and maximum ACE per DI in mainland

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

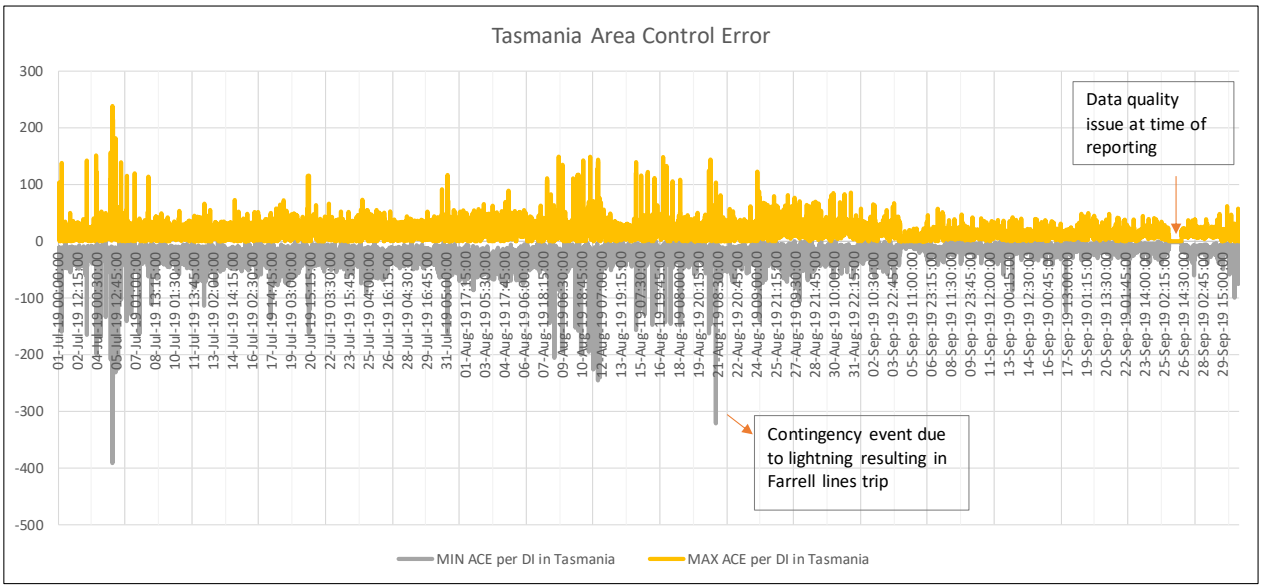

Figure 9 Minimum and maximum ACE per DI in Tasmania