Frequency and Time Error Monitoring – Quarter 3 2020

October 2020

A report for the National Electricity Market

Important notice

PURPOSE

The purpose of this report is to provide information about the frequency and time error performance in the National Electricity Market (mainland and Tasmania) for the period July to September 2020 inclusive. AEMO has prepared this report in accordance with clause 4.8.16(b) of the National Electricity Rules, using information available as at the date of publication, unless otherwise specified.

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1. Introduction

The Reliability Panel's Frequency Operating Standard (FOS)[1] specifies limits for power system frequency and time error for the mainland and Tasmanian regions. AEMO must use its reasonable endeavours to control power system frequency and ensure that the Frequency Operating Standard is achieved as required by clause 4.4.1 of the NER.

This document reports on the frequency and time error performance observed during July, August, and September 2020 in all regions of the National Electricity Market (NEM) as required by clause 4.8.16(b) of the National Electricity Rules (NER)[2]. The Queensland, New South Wales, Victoria and South Australia regions are referred to as the 'mainland' throughout the report.

The *Power System Frequency and Time Deviation Monitoring Report – Reference Guide*[3] outlines the calculation procedure used by AEMO to produce the quarterly Frequency and Time Error Monitoring report. Where applicable, analysis of the delivery of Slow and Delayed Frequency Control Ancillary Services (FCAS) presented in this report is based on 4-second resolution SCADA information derived from AEMO's systems.

Unless otherwise noted, mainland frequency data is sampled in New South Wales at 4-second intervals using the most recent Global Positioning System (GPS) clock frequency measurement preceding each 4-second interval. All Tasmanian frequency data is sampled at 4-second intervals using the most recent Network Operations and Control System (NOCS) frequency measurement preceding each 4-second interval.

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

[2] See https://www.aemc.gov.au/regulation/energy-rules/national-electricity-rules/current.

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

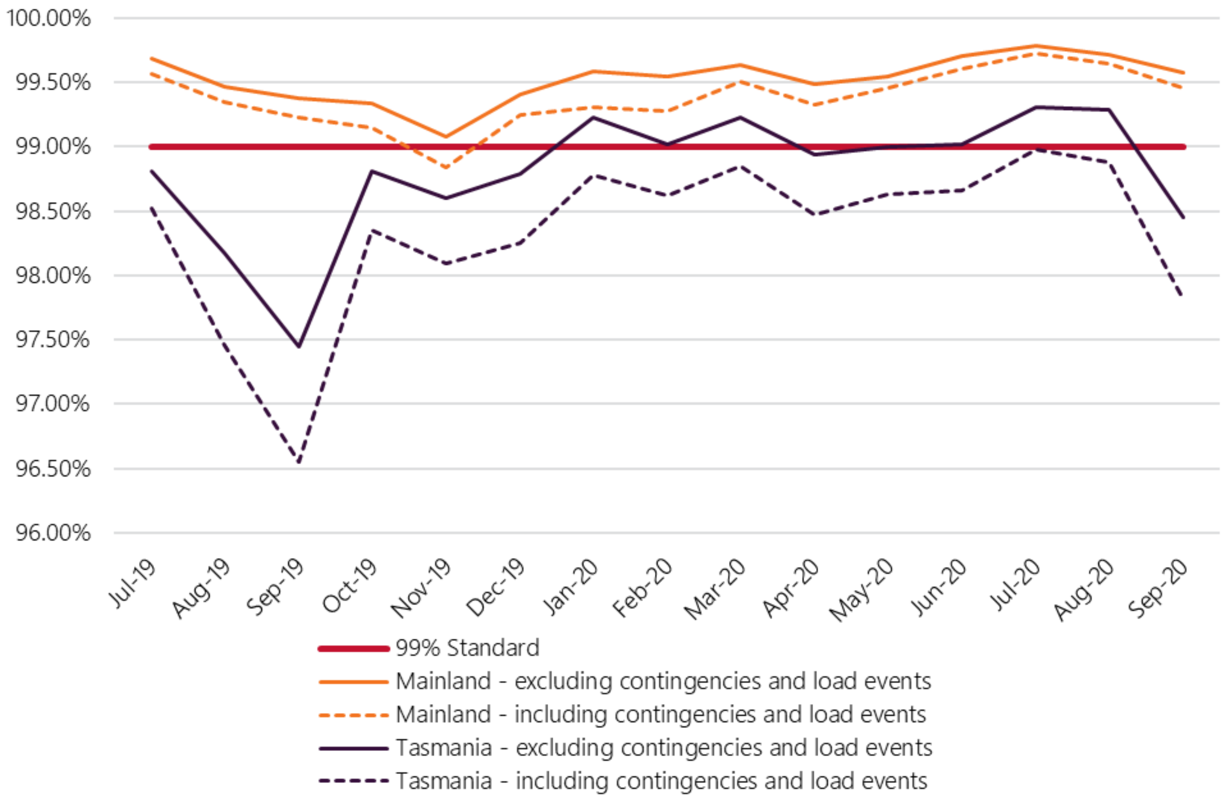
2. State of frequency performance

Frequency performance in the NEM during the quarter from July to September 2020 was broadly similar to the performance seen in recent quarters. Frequency remained within the Normal Operating Frequency Band (NOFB) in the mainland more than 99% of the time, and within the Normal Operating Frequency Excursion Band (NOFEB) at all times when there was no contingency event.

Performance drifted slightly lower during September, repeating the experience of previous years during shoulder seasons, where fewer units tend to be in operation.

The performance deterioration was particularly prevalent in Tasmania, as seen in Figure 1, dropping below the 99th percentile required by the FOS in September. The implementation of the Mandatory Primary Frequency Response (PFR) Rule commenced at the very end of September, and when substantially implemented is expected to deliver consistently improved frequency performance in Tasmania. AEMO will also monitor further changes and work with Tasmanian participants where required.

Figure 1 Frequency within the NOFB, minimum daily percentage of time over preceding 30-day window



AEMO observed a larger number of exceedances of the FOS in July to September 2020 than in the previous quarter. Section 4 of this report examines these events in detail.

Frequency was contained as required by the FOS following all major system disturbances during the quarter, but the time required to recover frequency to within the NOFB proved variable and frequently longer than the target recovery time. These long recovery times are most evident during shallow underfrequency events when the aggregate response from delayed Raise FCAS (R5) providers was partially triggered. AEMO has noted that the frequency performance during these events has not been within the FOS requirements; however, the full delayed Raise FCAS response is demonstrated during more serious frequency excursions. AEMO will continue to monitor and report these events and adjust settings where needed.

Section 4 also discusses all other identified instances where the requirements of the FOS were not met.

While the FOS requirements were met in most instances over the quarter, there remain aspects of the prevailing frequency control arrangements in the NEM that are a concern to AEMO. These risks have been discussed in various reports and forums, and include:

- Poor frequency control within the NOFB – where frequency control continues to be insufficient and exhibits aspects of oscillatory behaviour.
- Frequent excursions from the NOFB – poor control within the NOFB is contributing to a high number of events where frequency departs the NOFB, since frequency prior to a given event tends not to be close to 50 hertz (Hz), compared with historical behaviour.
- Unpredictable frequency behaviour – frequency behaviour during anything other than a clearly defined single credible contingency is difficult to predict and can be highly variable.
- Frequency events involving multiple generator and/or network elements, such as seen on 20 August 2020 and discussed in this report, concerning a range of recently commissioned units and/or control schemes.

AEMO, with support from the industry, is continuing to progress initiatives intended to improve these aspects of frequency control (among others) in the NEM, including the implementation of Mandatory PFR. Progress on these initiatives is discussed in Section 7 of this report.

The implementation of Mandatory PFR settings across a significant portion of the NEM generation fleet is scheduled to begin during the final days of Q3 2020 and continue during Q4 2020 and into 2021. AEMO will monitor the consequences for frequency performance in the NEM, and report these in the upcoming quarterly reports and other relevant reports and forums.

3. Achievement of the Frequency Operating Standard

AEMO's assessment of the achievement of the requirements of the FOS in Q3 2020 is summarised in Table 1.

Table 1 Frequency Operating Standard and assessment in the mainland and Tasmania

Requirement	Mainland	Tasmania	Further commentary
1 – Accumulated time error	Achieved	Exceeded once	21 August 2020, see Section 4.1
2 – No contingency/load events			
• **Within NOFEB at all times**	Achieved	Exceeded 51 times	See Section 4.2.1
• **Recovered within five minutes**	Exceeded five times	Exceeded three times	See Section 4.2.2
• **Within NOFB 99% of the time**	Achieved	Not achieved	See Section 4.2.3
3 – Generation or load events			
• **Contained**	Achieved	Achieved	
• **Recovered within five minutes**	Exceeded six times	Achieved	See Section 4.3.2
4 – Network events			
• **Contained**	Achieved	Achieved	
• **Recovered within five minutes**	Achieved	Achieved	
5 – Separation events			
• **Contained**	No separation events	No separation events	
• **Managed within 10 minutes**	No separation events	No separation events	
6 – Protected events	No protected events	No protected events	
7 – Non-credible or multiple contingency events	Achieved	Achieved	
8 – Largest generation event in Tasmania	Not applicable	Achieved	

4. Frequency performance

Section 4 describes frequency performance in the quarter against each of the key FOS requirements.

4.1 Time error

Table A.2 of the FOS (requirement 1) specifies that the accumulated time error should be maintained within the range ±15 seconds in the mainland (except for an island or during supply scarcity) and in Tasmania (except for an island or following a multiple contingency event). The ranges of accumulated time error in the mainland and Tasmania in Q3 2020 are provided in Table 2.

Table 2 Maximum and minimum time error measurements for mainland and Tasmania

Value	Mainland	Tasmania
Highest positive time error (seconds)	5.61	3.14
Lowest negative time error (seconds)	-9.39	-18.50

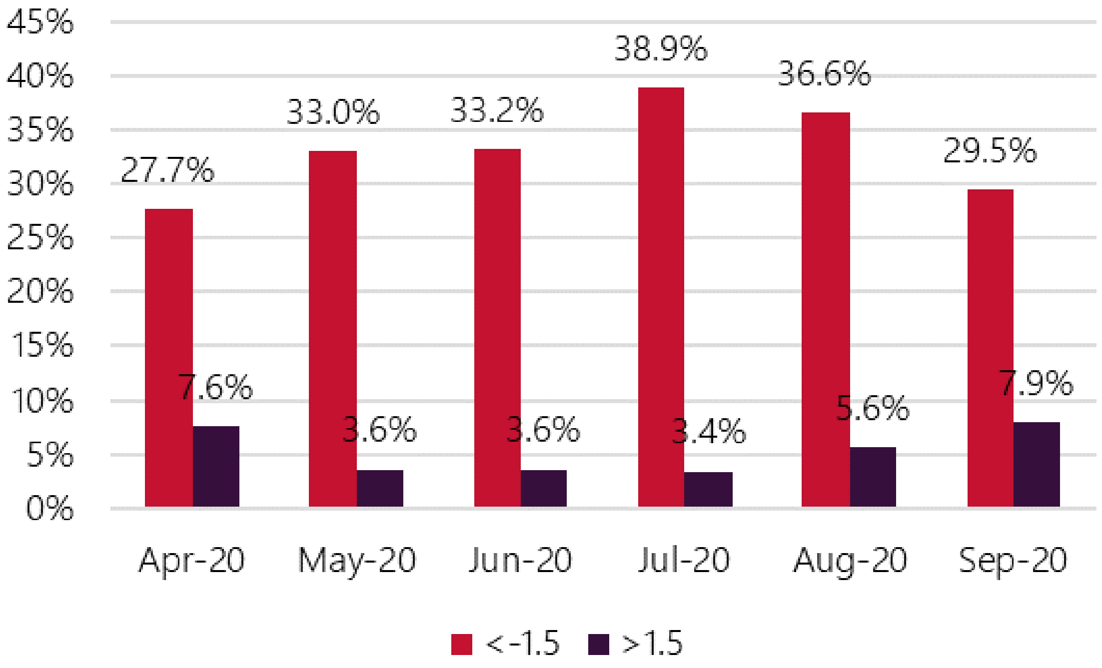
One instance of time error exceeding the FOS requirements occurred on 21 August 2020 in Tasmania:

- The accumulated time error in Tasmania exceeded -15 seconds from 1720 hrs until 2037 hrs and reached a minimum negative time error -18.5 seconds.
- Tasmanian frequency reached a minimum of 49.18 Hz at 1810 hrs during this period.
- This underfrequency event was due to the switching of Basslink power flow from import to export at the same time as a substantial rapid ramping of semi-scheduled generation in Tasmania.

AEMO is monitoring this situation and assessing options to better control time error in Tasmania. For example, revision of Automatic Generator Control (AGC) and Regulation FCAS settings for the Tasmania region are potential ways to improve this area of frequency performance. Initiatives to improve the overall tightness of frequency control (such as the Mandatory PFR rule change) are also expected to make a significant improvement to managing time error.

Figure 2 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. During Q3 2020, the incidence of negative time errors exceeding the threshold decreased over each month.

Figure 2 Proportion of time mainland time error was outside of +/-1.5 seconds



4.2 Operation during periods without contingencies or load events

When there are no associated contingency or load events in the interconnected system, table A.2 of the FOS (requirement 2) specifies that system frequency should be maintained within the applicable NOFEB and not remain outside the applicable NOFB for more than five minutes on any occasion or more than 1% of the time over any 30-day period[4]. These requirements are summarised in Table 3.

Table 3 FOS requirements for no contingency or load event in 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	

4.2.1 Frequency excursions without a contingency event outside the Normal Operating Frequency Excursion Band

Frequency excursions outside the applicable NOFEB where an associated contingency event has not been identified are shown in Table 4 for Q3 2020.

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

Table 4 Number of frequency excursions without identified contingency outside the Normal Operating Frequency Excursion Band

Event	Low/High/Both frequency event	Number of events	
		Mainland	Tasmania
No contingency or load event noted	Low	0	37
	High	0	11
	Both	0	3

Tasmania

The number of Tasmanian events where frequency exceeded the NOFEB in Q3 2020 without an associated contingency event is characteristic of the smaller Tasmania system and is in line with performance in recent quarters. Under system normal conditions, the FOS specifies largely the same requirements for Tasmania as it does for the mainland. However, as a much smaller system, Tasmania is more sensitive to supply/demand imbalances which manifest as larger frequency deviations.

In addition to this, frequency performance in Tasmania is largely dictated by the performance of the mainland due to Basslink's frequency controller, which attempts to match the frequency in Tasmania to that of the (much bigger) mainland system. This means that most frequency issues are occurring while Tasmania is interconnected and are therefore best addressed by improving frequency control in the mainland.

4.2.2 Frequency excursions without a contingency event outside the NOFB and not recovered in FOS timeframe

Frequency excursions outside the applicable NOFB where an associated contingency event has not been identified and where the frequency did not recover inside the NOFB within five minutes are shown in Table 5 for Q3 2020.

Table 5 Number of frequency excursions without identified contingency outside the NOFB and not recovered in the FOS timeframe

Event	Low/High/Both frequency event	Number of events	
		Mainland	Tasmania
No contingency or load event noted	Low	5	2
	High	0	0
	Both	0	1

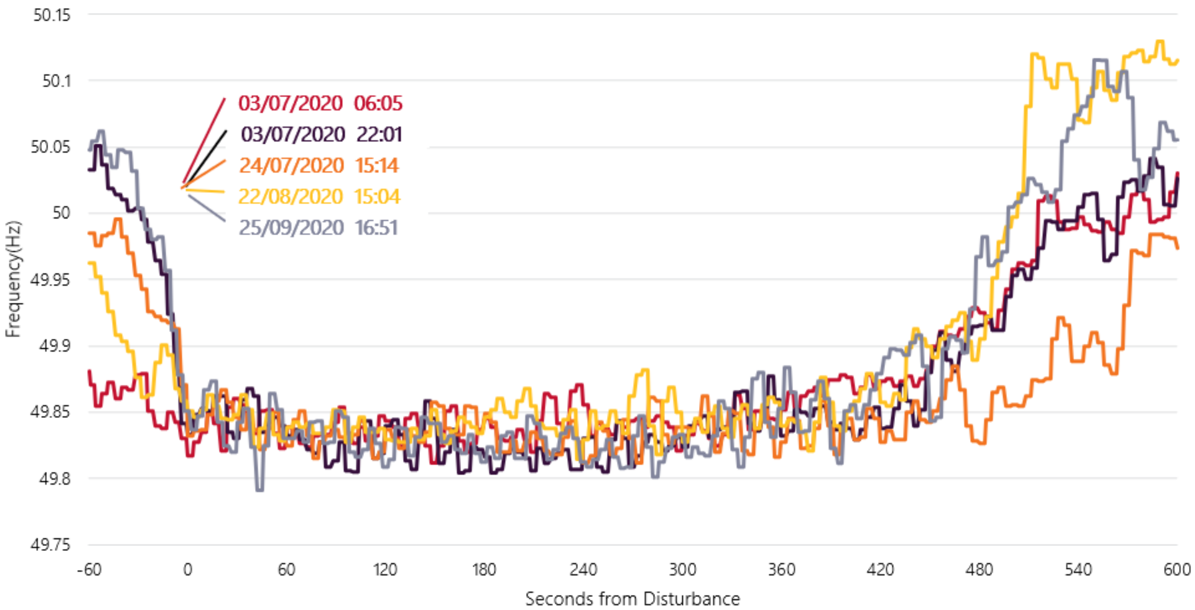
Mainland

The first instance identified began at 0604 hrs on 3 July 2020 and continued until frequency recovery at 0612 hrs on this day. This was a time of rapidly increasing system demand, but otherwise no single clear underlying cause was evident.

The second instance began at 2201 hrs on 3 July 2020 and continued until frequency recovery at 2208 hrs on this day. During this period, Lower Tumut was reducing generation from 250 MW to 0 MW in response to a dispatch target. No single clear underlying cause was evident.

Three further instances have been identified, from 1515 hrs to 1522 hrs on 24 July 2020, from 1504 hrs to 1511 hrs on 22 August 2020, and from 1651 hrs to 1658 hrs on 25 September 2020. No single clear underlying cause was evident in each case; however, in each case, the frequency deviation was only just outside the NOFB, a zone where contingency FCAS response may be limited. Initiatives such as revision of switched trigger points and the Mandatory PFR Rule are expected to help address this issue (see Section 4.3.2 for further discussion).

Figure 3 Frequency excursions without identified contingency outside the NOFB and not recovered in the FOS timeframe



Tasmania

The Tasmanian frequency remained outside the NOFB for greater than five minutes in Q3 2020 without an associated contingency on three occasions. Two of these excursions related to the events on 3 July 2020 at 0604 hrs and 24 July 2020 discussed above.

The third instance identified began at 1601 hrs on 21 August 2020 and continued until frequency recovery at 1607 hrs on this day. This event was triggered by rapid ramping of semi-scheduled generation in Tasmania at a time of near-maximum Basslink imports. AEMO notes that a similar event occurred 5 April 2020 and was considered to be a generation event in the Q2 Frequency and Time Error Monitoring Report [5].

Such events, caused by generation ramping, will now be considered as no-contingency events when they do not meet the FOS guidelines for a generation event, principally a change in output greater than 50 MW over 30 seconds.

4.2.3 Frequency within the NOFB over 30-day rolling average

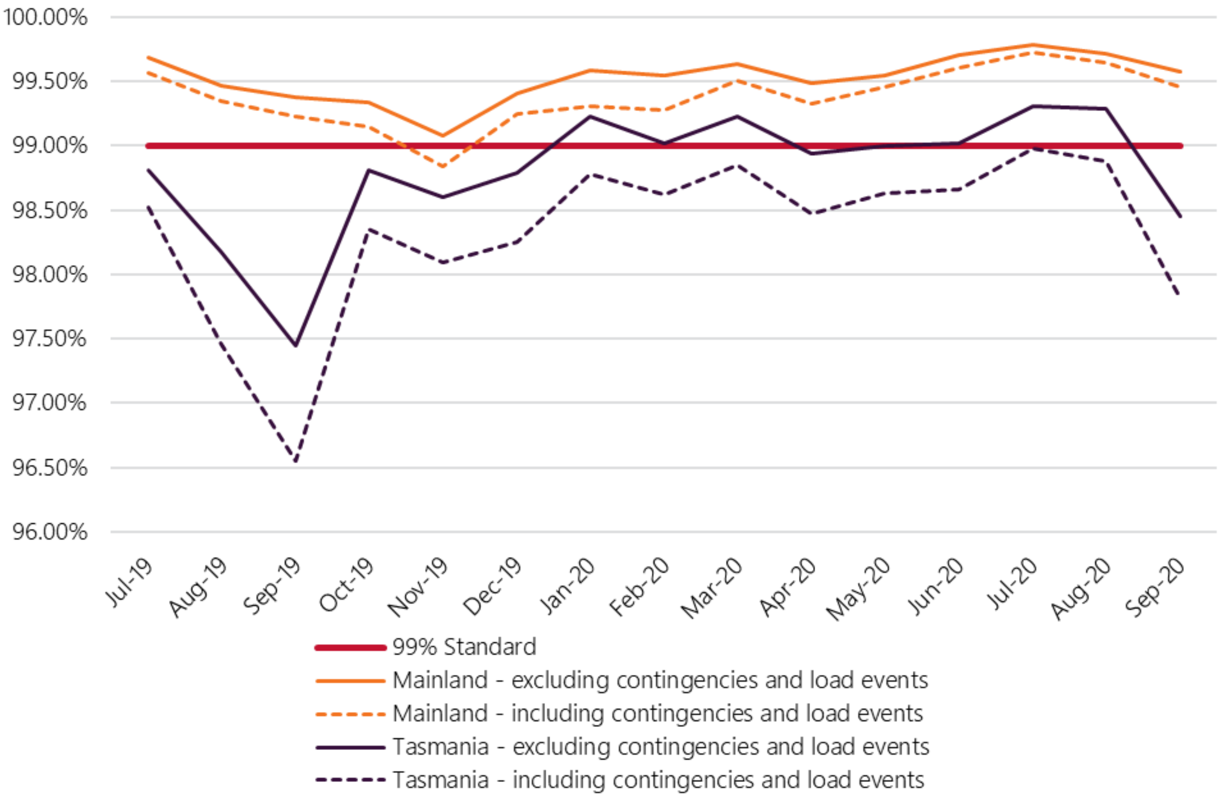
AEMO calculates the percentage of time that frequency remained inside the NOFB daily. The minimum daily estimate in the preceding 30-day window from the last day of each month is reported in Figure 4. The figure shows statistics both including and excluding data during contingency events. The FOS requirement excludes periods of contingency or load events.

[5] See https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/ancillary_services/frequency-and-time-error-reports/quarterly-reports/2020/frequency-and-time-error-monitoring-2nd-quarter-2020.pdf.

Frequency in the mainland continued to remain well within the NOFB for more than 99% of the time in Q3 2020.

Tasmania's frequency performance within the NOFB improved over July and August before dropping below the 99th percentile required by the FOS in September. Throughout September, Tasmanian frequency excursions lasted longer than those observed in August, contributing to this outcome.

Figure 4 Frequency within the NOFB, minimum daily percentage of time over preceding 30-day window



4.2.4 Frequency performance within the NOFB

The FOS does not include requirements for the control of frequency *within* the NOFB. However, frequency performance within the NOFB is important, because it demonstrates the overall tightness and stability of frequency and indicates the likelihood of frequency being close to nominal when a contingency event occurs, increasing the prospects of good containment and fast recovery.

The frequency distribution in the mainland and Tasmania over Q3 2020 is shown in Figure 5 and Figure 6, compared with data from 2010, as an example of a period where frequency control was tighter.

Figure 5 Mainland frequency distribution

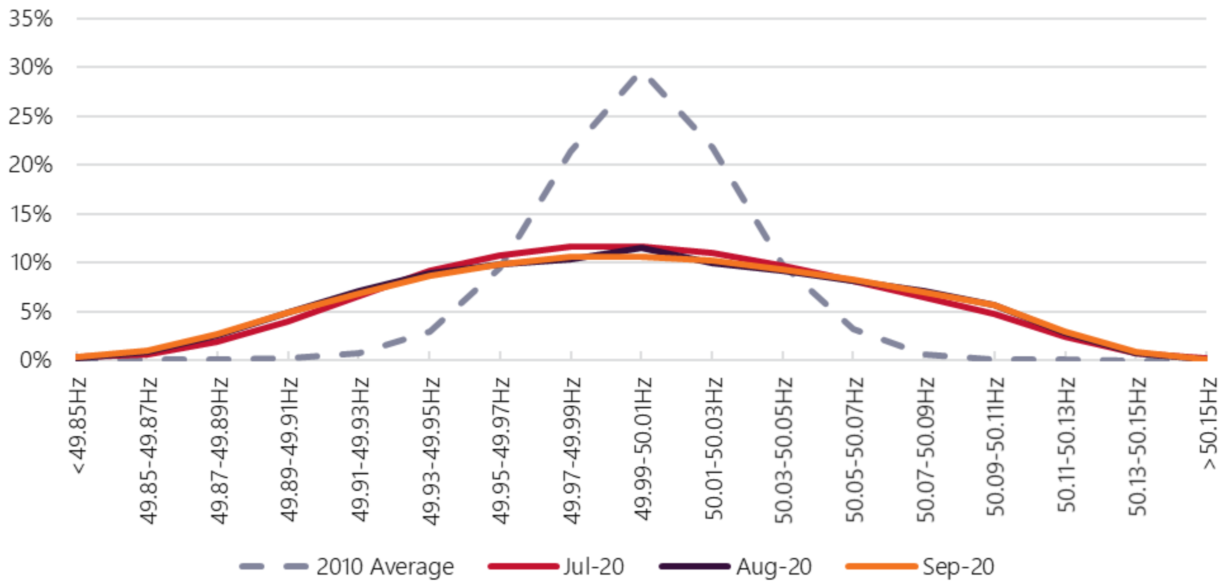


Figure 6 Tasmania frequency distribution

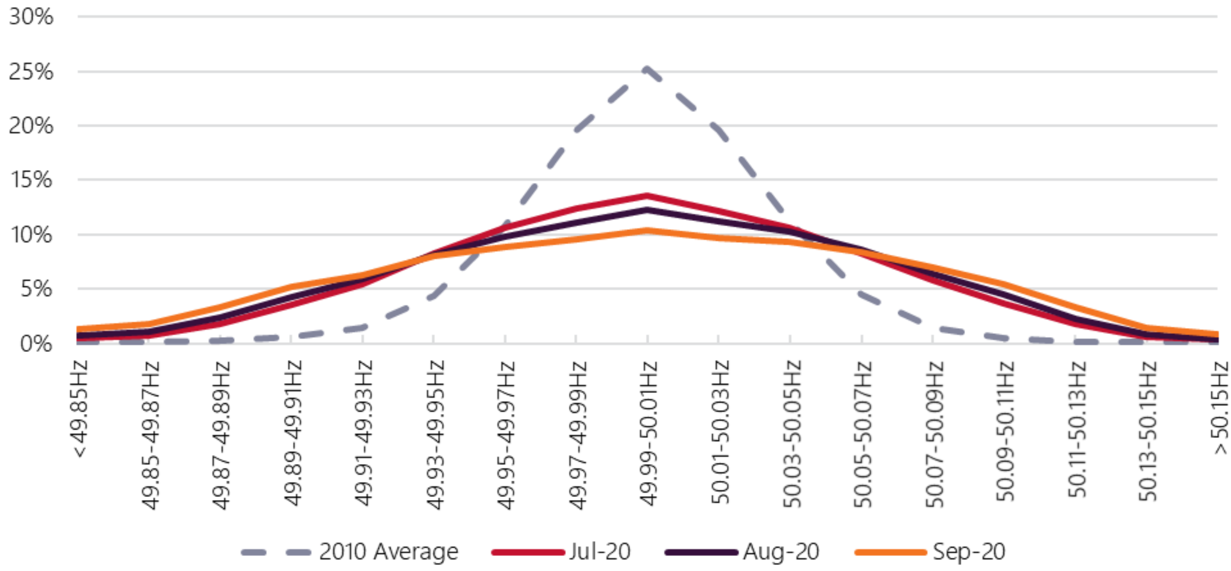
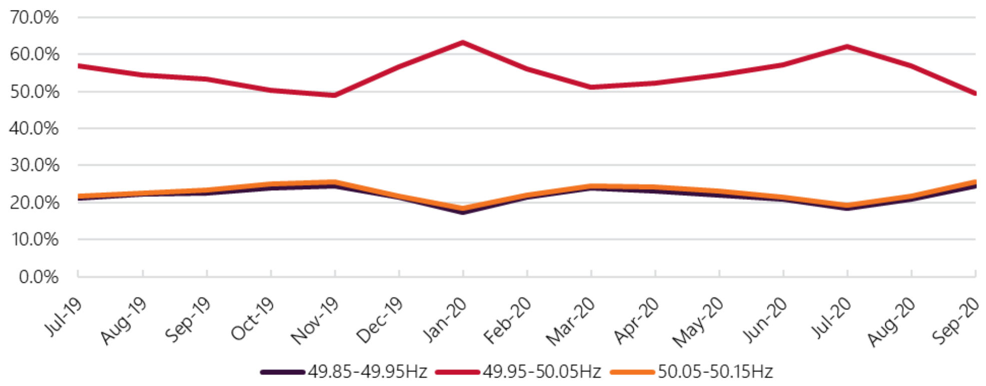


Figure 7 shows that when the frequency is *within* the NOFB in the mainland, the proportion of time that frequency is closer to the boundaries of the NOFB increased throughout September in Q3 2020.

Figure 7 Mainland frequency time percentage spent within selected bands within the NOFB



4.3 Operation during generation or load contingency events

When there is an associated generation or load event in an interconnected system, table A.2 of the FOS (requirement 3) specifies that while the entire system is interconnected, system frequency should be maintained within the applicable Generation and Load Change Band (GLCB) and not remain outside the applicable NOFB for more than five minutes in the mainland or more than 10 minutes in Tasmania, as described in Table 6.

Table 6 FOS requirements for a generation or load event in an interconnected system

Region	Containment	Stabilisation	Recovery
Mainland	49.5 to 50.5 Hz	49.85 to 50.15 Hz within five minutes	
Tasmania	48.0 to 52.0 Hz	49.85 to 50.15 Hz within 10 minutes	

4.3.1 Frequency excursions following a generation or load event outside Generation and Load Change Band

During Q3 2020, there were no events in either the mainland or Tasmania where a frequency excursion following a generation or load event resulted in system frequency deviating outside of the applicable GLCB.

4.3.2 Frequency excursions following a generation or load event not recovering to the NOFB within the FOS timeframe

Table 7 summarises the number of events during Q3 2020 following a generation or load event in the mainland or Tasmania where there was a frequency excursion that was not recovered to the NOFB within the applicable FOS timeframe (typically five minutes in the mainland, and 10 minutes in Tasmania).

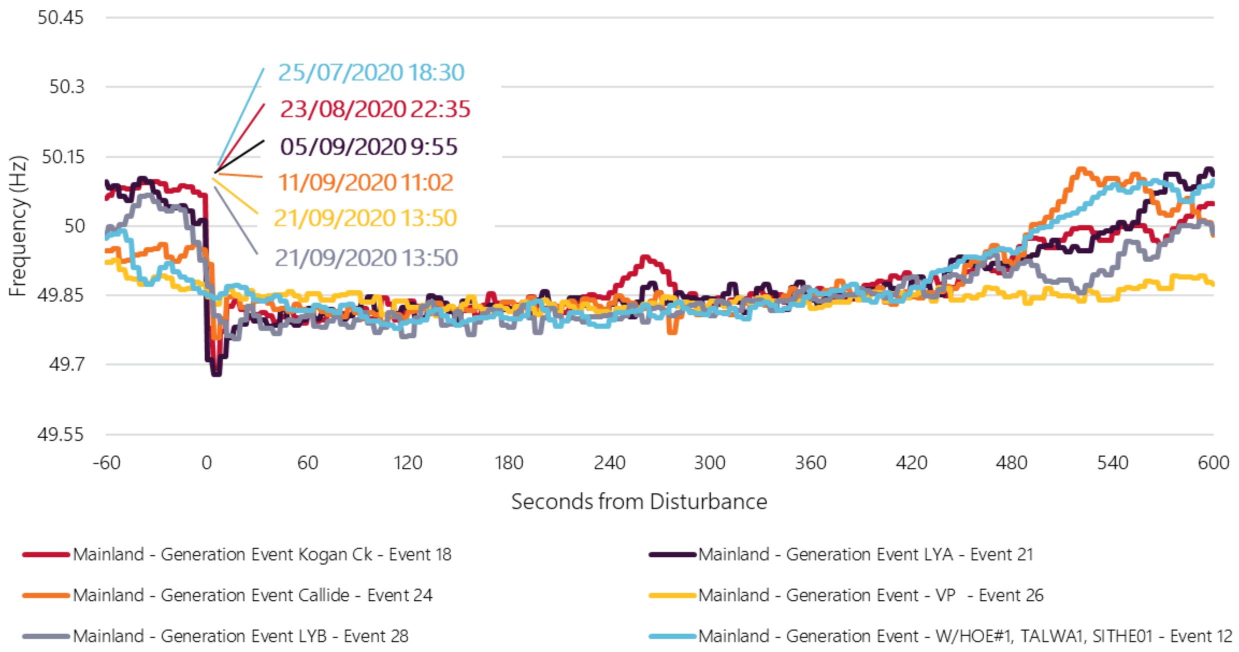
Table 7 Number of frequency excursions following a generation or load event not recovered to the NOFB within the FOS timeframe

Event	Low/High/Both frequency event	Number of events	
		Mainland	Tasmania
Load event	Low	0	0
	High	0	0
	Both	0	0
Generation event	Low	6	0
	High	0	0
	Both	0	0

Mainland

Six mainland generation events did not see recovery to the NOFB within the FOS timeframe of five minutes (300 seconds). The mainland frequency during the pre-event and post-event periods is provided in Figure 8.

Figure 8 Frequency excursions following generation or load events not recovered to the NOFB within the FOS timeframe



Recovery of frequency following such events is assisted by the operation of the Slow and Delayed FCAS services. Assessments of the delivered Delayed Raise FCAS during these six events indicate that only a portion of the enabled Delayed Raise (R5) FCAS was supplied, as seen in Table 8.

The delivered quantities represent assessed FCAS response, which is different to actual megawatt (MW) output change from enabled generators. Full details on calculation of the FCAS response are provided in the

Market Ancillary Services Specification (MASS[6]). The assessments here exclude several new providers of FCAS, including virtual power plants and load aggregators, as relevant data was not available at the time of reporting.

Table 8 Delayed service delivery during generation events not recovered to the NOFB within the FOS timeframe

Event	Time	Recovery NOFB Time (s)	R5 Enabled (MW)	R5 Assessed/ (Not Assessed) (MW)	R5 Assessed Delivered (MW)	R5 Assessed Switch Controlled Triggered/ Not Triggered (MW)	R5 Assessed Proportional Delivered/ Not Delivered (MW)
Generation event – Wivenhoe, Tallawarra, Smithfield	25/07/2020 18:29	368	476	441/ (35)	45	6/ 289	39/ 142
Generation event – Kogan Ck	23/08/2020 22:35	316	481	438/ (43)	235	156/ 161	79/ 42
Generation event – Loy Yang A	05/09/2020 9:55	332	356	306/ (50)	218	138/ 44	80/ 44
Generation event – Callide	11/09/2020 11:02	376	375	330/ (45)	89	10/ 176	79/ 65
Generation Event – Vales Point	21/09/2020 13:50	444	288	264/ (24)	106	36/ 89	70/ 68
Generation Event – Loy Yang B	28/09/2020 16:31	384	318	277/ (41)	56	5/ 149	51/ 72

These six events were all characterised by a shallow frequency nadir, not lower than 49.70 Hz. A number of providers of Delayed Raise FCAS using switching controllers would not have been triggered during these events, as their assigned trigger settings tend to be lower. The MASS allows a trigger setting between 49.8 Hz to 49.6 Hz for switching controllers in the mainland. Without the contribution of all the enabled providers with switching controllers, the FCAS response to assist recovery to the NOFB would rely heavily on AGC (via Regulation FCAS), which is not its usual role.

At these frequency levels, proportional controllers with relatively wide deadbands (for example, +/- 150 millihertz [mHz]) are also generally not providing a significant response. Importantly, these events may also have been influenced by other factors, for example, lower than expected output from variable renewable plant, and/or underestimation of system load by the forecasting system.

Nonetheless, it is apparent that for some events, the 'gap' between the edge of the NOFB and the frequency band where FCAS providers with switching controllers are active warrants further attention, and as a result AEMO is in the process of revising the switching controller FCAS settings for a number of ancillary service facilities.

[6] See https://aemo.com.au/en/energy-systems/electricity/national-electricity-market-nem/system-operations/ancillary-services/market-ancillary-services-specification-and-fcas-verification-tool.

4.3.3 Frequency performance following generation or load events

AEMO assesses frequency performance over time with metrics that complement the requirements of the FOS. Several generation and load events occurred in Q3 2020 which demonstrate the frequency response characteristic of the system, despite these events remaining within the boundaries of the FOS.

There continued to be adequate containment of generation and load events, well within the GLCB, and frequency recovered to the NOFB within the FOS timeframe during most events, except those discussed in Section 4.3.2.

4.4 Operation during separation contingency events

When there is a separation event, table A.2 of the FOS (requirement 5) sets out expectations for the initial frequency containment, recovery, and revised requirements for further contingency events in the islanded region. AEMO is required to maintain system frequency within the applicable containment band and should recover frequency in the NOFB within the FOS timeframe.

No separation events occurred during Q3 2020 in the mainland or Tasmania.

4.5 Operation during network, protected, non-credible, or multiple contingency events

When there is a network contingency, protected event, non-credible contingency, or multiple contingency event in an interconnected system, table A.2 of the FOS (requirements 4 to 7) specifies that while the entire system is interconnected, system frequency should be maintained within the applicable containment band and recover to the NOFB within the FOS timeframe.

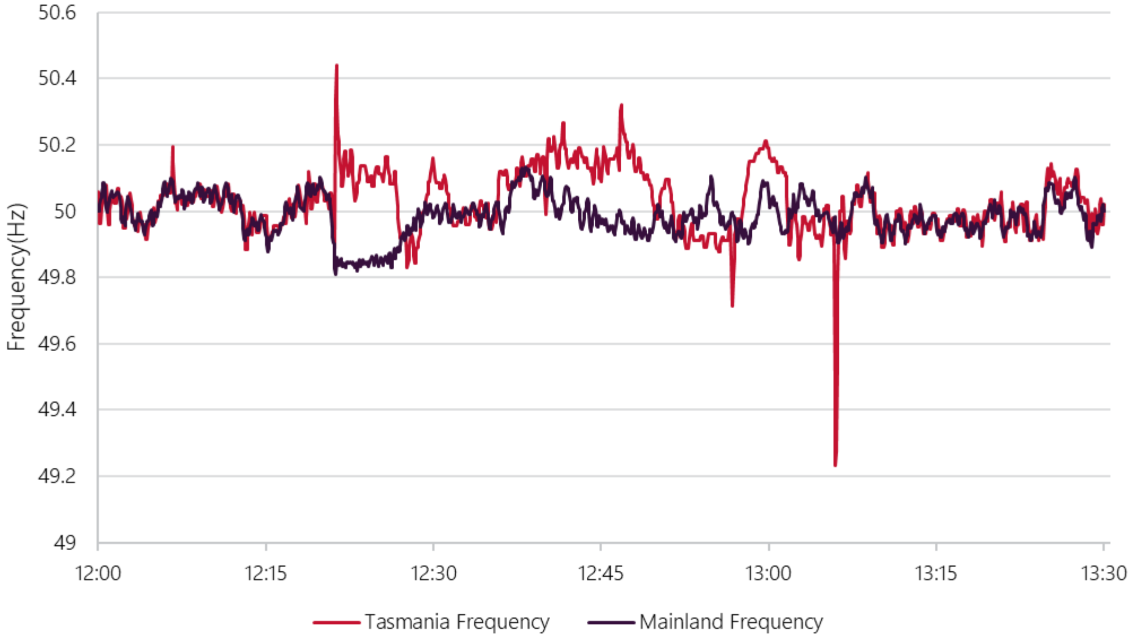
4.5.1 Frequency excursions following network, protected, non-credible or multiple contingency events not within the FOS

In both the mainland and Tasmania, there were no instances during Q3 2020 where a frequency excursion following a network event, protected event, non-credible event, or multiple contingency event was not contained within the applicable containment band and/or not recovered to the NOFB within the FOS timeframe.

4.5.2 Frequency performance following network events

A trip of Basslink occurred at 1221 hrs on 25 July 2020. At the time, Basslink was exporting 163 MW to the mainland. Frequency in Tasmania was contained at 50.46 Hz and did not remain outside the applicable NOFB (49.85-50.15 Hz) for longer than 10 minutes during the event. Frequency in the mainland was contained at 49.81 Hz and recovered to within the NOFB by 1224 hrs. Basslink resumed operation at 1306 hrs.

Figure 9 Frequency during trip of Basslink 25 July 2020



4.5.3 Frequency performance following non-credible events

AEMO assesses frequency performance over time with metrics that complement the requirements of the FOS. Several non-credible events occurred in Q3 2020 which demonstrate the frequency response characteristic of the system, despite these events remaining within the boundaries of the FOS

16 July 2020

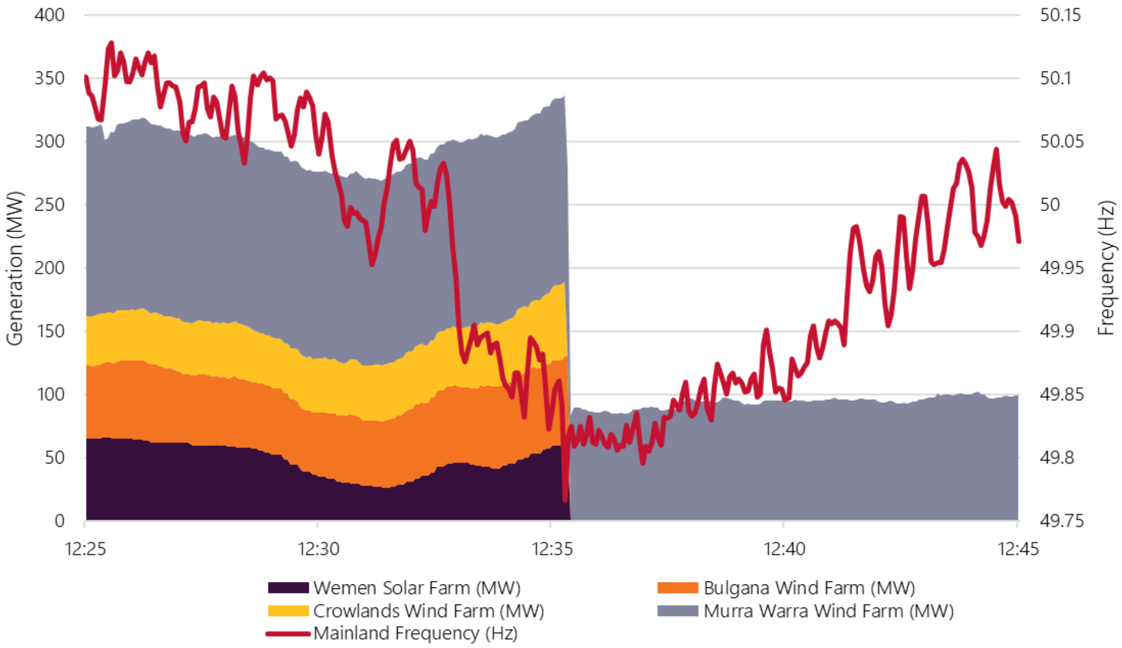
A non-credible trip of Bell Bay Aluminium Potline 2 and Potline 3 occurred at 0842 hrs on 16 July 2020; 204 MW industrial load was shed. Frequency in Tasmania increased to 50.53 Hz within six seconds and returned to within the NOFB by 0846 hrs. Frequency was contained due to an increase in Basslink export by 135 MW and a rapid reduction in Tasmanian generation by 60 MW.

Figure 10 Tasmanian system during 16 July 2020 non-credible load event

20 August 2020

A non-credible trip of Ararat – Crowlands 220 kilovolt (kV) Line and Wemen Solar Farm occurred at 1235 hrs on 20 August 2020. Multiple generating units, including Bulgana Wind Farm, Crowlands Wind Farm and Murrawarra Wind Farm, simultaneously reduced their generation due to the action of control schemes. Generation affected was estimated to be 247 MW. Mainland frequency was contained at 49.74 Hz and recovered to the NOFB by 1238 hrs.

Figure 11 Victorian wind and solar generators during 20 August 2020 non-credible network event



4.6 Reviewable operating incidents

AEMO is required to review operating incidents that meet the criteria in the NER and Reliability Panel guidelines for identifying reviewable operating incidents[7]. No such incidents were reported during Q3 2020 which affected power system frequency.

[7] See https://www.aemc.gov.au/sites/default/files/2018-02/Final-revised-guidelines.pdf.

5. Rate of change of frequency

5.1 ROCOF methodology

The rate of change of frequency (ROCOF) following a frequency event is an indicator of the evolving system response to frequency disturbances. Measuring a system variable such as ROCOF is influenced by several assumptions concerning the available data and measurement methodology. This ROCOF methodology uses snapshots of measured frequency from the AEMO/Transmission Network Service Provider (TNSP) Phasor Measurement Unit (PMU) system at 1-second intervals, which is a higher resolution than is available from the GPS clock system and therefore more appropriate for assessing ROCOF.

For the purposes of this report, ROCOF has been assessed as the recorded change in frequency per second over an interval of one second, or over an interval of two seconds when a measurement is not available. ROCOF assessment has not been attempted for periods longer than two seconds without data. For the purposes of this report, the maximum ROCOF recorded between five seconds prior and 30 seconds after each frequency event is considered to be the ROCOF associated with that event.

$$If\ 1s\ data\ available\ then\ ROCOF_t = MAX\left(ABS\left(\frac{f_{t+1} - f_t}{t_{t+1} - t_t}\right)\right)\ \forall\ t$$

$$else\ \ if\ 2s\ data\ available\ then\ ROCOF_t = MAX\left(ABS\left(\frac{f_{t+2} - f_t}{t_{t+2} - t_t}\right)\right)\ \forall\ t$$

$$else\ no\ measurement\ attempted$$

Where:

(i) **f** is system frequency

(ii) **t** is time in seconds

5.2 ROCOF during frequency events

The maximum ROCOF recorded each month, and any other ROCOF exceeding the standard frequency ramp rate for the mainland as specified in the MASS of 0.125 Hz/s, is provided in Table 9. The MASS's standard frequency ramp rate is used as a standardised value for assessing FCAS capability. In real events, and in islanded systems, the ROCOF can be quite different.

Table 9 ROCOF during frequency events in Q3 2020 in the mainland

Month	ROCOF (Hz/s)	Associated event	Event time
July	-0.069	Trip of Loy Yang A3 unit	15/07/2020 04:29
August	-0.121	Trip of Kogan Creek unit	23/08/2020 22:35
September	-0.118	Trip of Loy Yang A3 unit	05/09/2020 09:55

Note: Estimates of ROCOF may vary depending on data source, sampling window and calculation method.

6. Automatic Generation Control

6.1 Area Control Error (ACE) methodology

As per the Regulation FCAS Contribution Factors Procedure[8], AEMO calculates an ACE representing the MW equivalent size of the current frequency deviation and accumulated frequency deviation (time error) of the system.

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

Where:

(i) **Bias** is the area frequency bias and is a tuned value that represents the conversion ratio between MW and 0.1 Hz of frequency deviation;

(ii) **F** is the current measured system frequency;

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

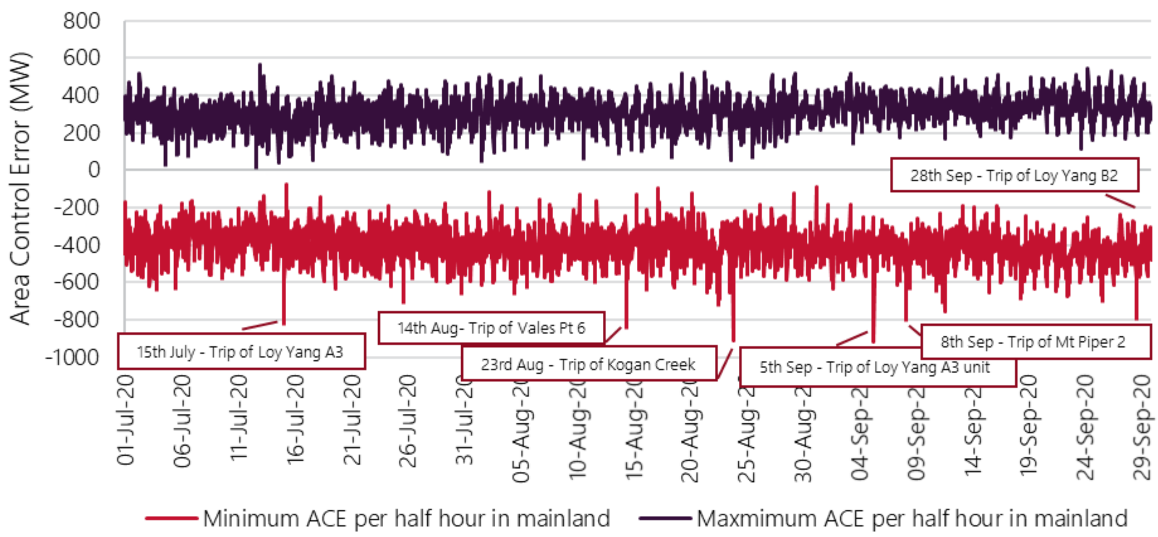
(iv) **FO** is a frequency offset representing accumulated frequency deviation, that is, time error.

6.2 ACE reporting

Figure 12 and Figure 13 show a comparison of the minimum and maximum ACE per trading interval in the mainland and Tasmania in Q3 2020.

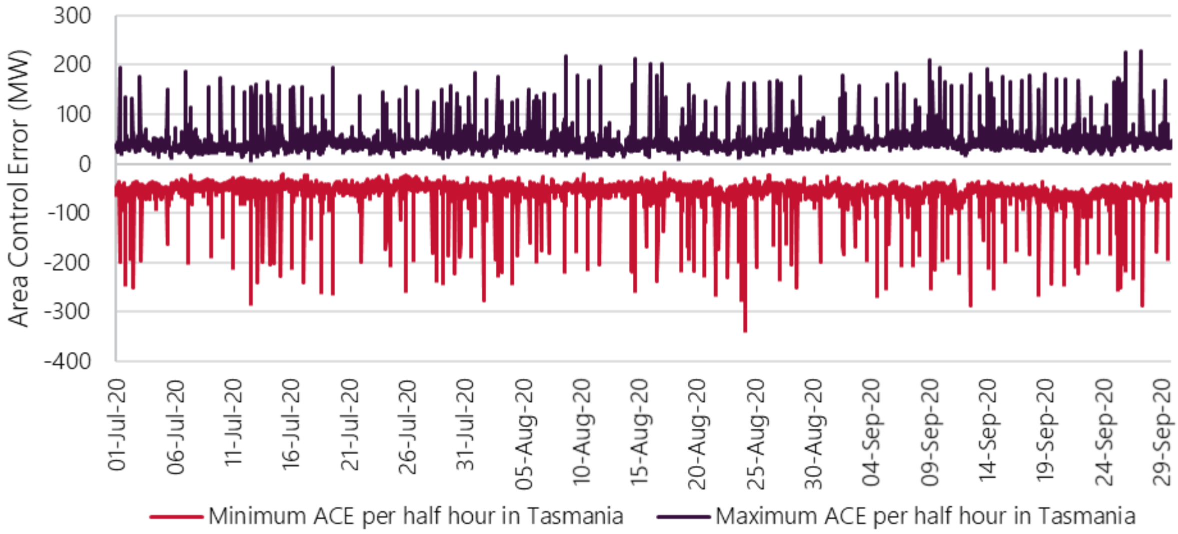
Over time, ACE may be considered to represent a rough proxy for the required Regulation FCAS volume.

Figure 12 Minimum and maximum ACE per half-hour in mainland



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

Figure 13 Minimum and maximum ACE per half-hour in Tasmania



7. Actions to improve frequency control performance

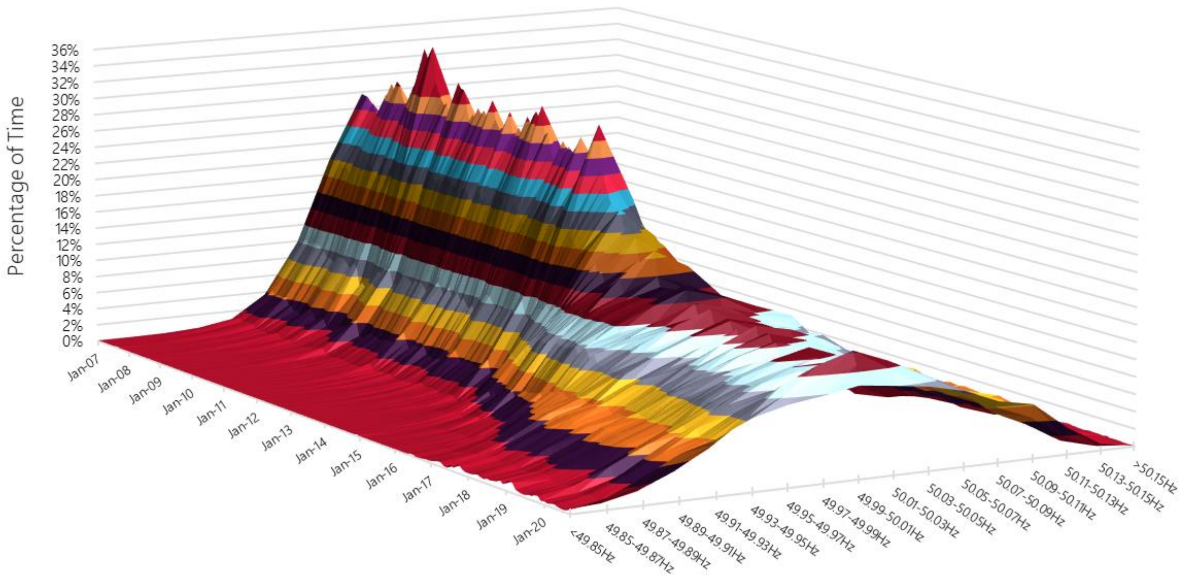
The general decline in frequency control performance under normal conditions in the NEM has been well documented and is the subject of many inter-related areas of work. In this quarterly report, AEMO has published a range of metrics which are intended to document aspects of frequency control that are not related to requirements in the FOS but are important indicators of frequency stability. These also form a basis for assessing the impacts of current actions, such as the implementation of the Mandatory PFR rule; this came into effect from 4 June 2020, but actual physical implementation at generators commenced in the final days of Q3 2020[9].

7.1 Measure 1 – distribution of frequency within NOFB

This measure examines the distribution of frequency within the NOFB. It is apparent that over time, and particularly since 2014-15, there has been a substantial flattening of the frequency distribution within the NOFB. This means frequency is spending more time out towards the edges of the NOFB than it used to. Among other things, this means that when a contingency event occurs, the resulting frequency change is more likely to deviate significantly away from 50 Hz.

A small improvement was observed in July of Q3 2020, but this improvement proved to be temporary.

Figure 14 Monthly frequency distribution



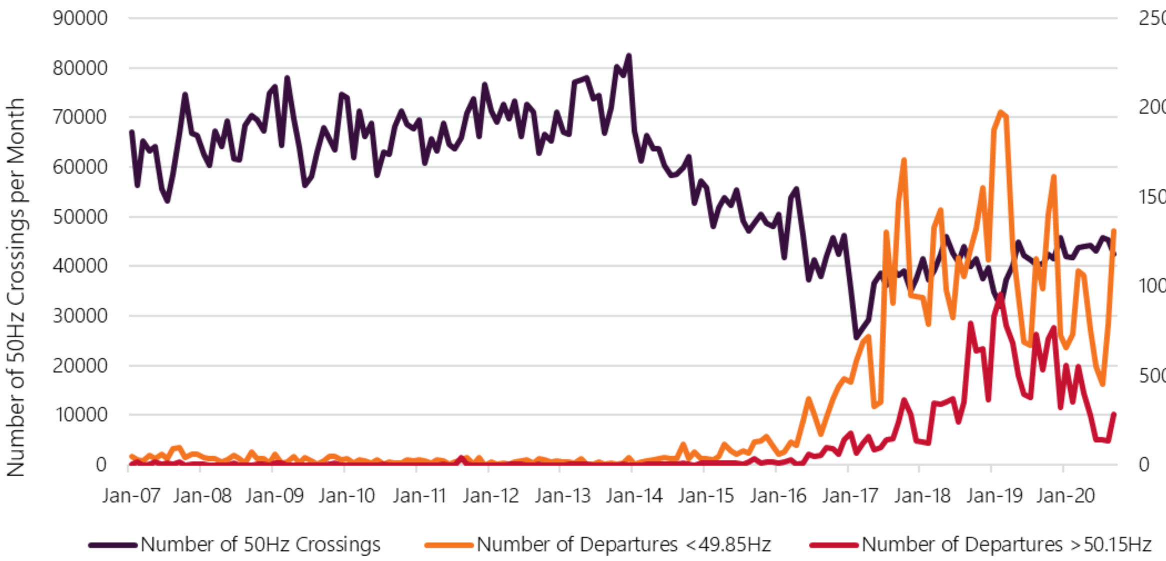
9 See https://www.aemc.gov.au/rule-changes/mandatory-primary-frequency-response.

7.2 Measures 2 and 3 – number of frequency crossings and NOFB excursions

These measures examine the number of times frequency crosses the nominal 50 Hz target and how often frequency departs the NOFB. There has been a dramatic increase in the number of instances where frequency departs the NOFB over the last few years. Interestingly, there has also been a significant decline in the number of zero crossings, which relates to the fact frequency tends to spend much more time away from 50 Hz, and therefore does not have as much opportunity to cross. Therefore, the average number of zero crossings is likely to increase if frequency is held much more tightly around 50 Hz.

Q3 2020 saw a continuation in the trend of increased departures from the NOFB, which will be monitored with interest as the Mandatory PFR rule continues to roll out in Q4 2020.

Figure 15 Monthly frequency crossings – under 49.85 Hz, across 50 Hz, beyond 50.15 Hz



7.3 Measure 4 – frequency 'mileage'

This measure examines the total amount of change in frequency over time. It is another way of measuring how stable frequency is; that is, more stable frequency will see a lower mileage. A simple demonstration of the calculation method is provided below in Table 10. The final estimate of mileage is dependent on the selection of the length of time interval. The measurements below are derived from 4-second intervals.

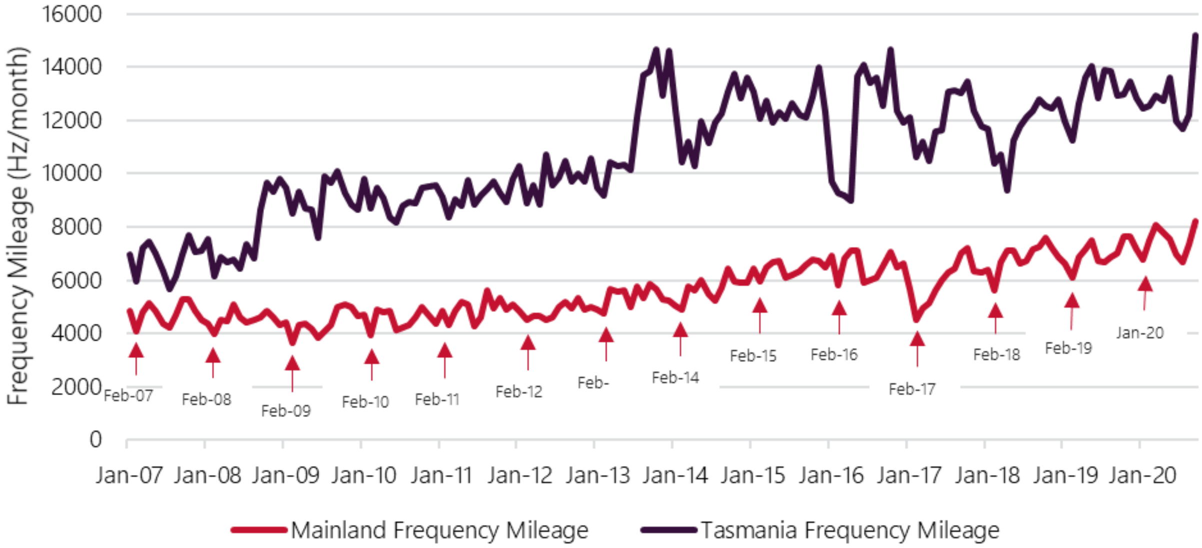
Table 10 Example frequency mileage calculation for a series of four-second intervals

Sample	0s	4s	8s	12s	Mileage sum
NSW frequency (Hz)	50	50.5	49.5	50	
Mileage (Hz)		ABS(50.5-50)=0.5	ABS(49.5-50.5)=1.0	ABS(50-49.5)=0.5	0.5+1.0+0.5 = 2.0Hz

Frequency mileage per month has been increasing since 2007, as demonstrated in Figure 16. Observed frequency mileage in September 2020 is estimated to be the greatest monthly mileage recorded. Recent increases in Regulation FCAS and Contingency FCAS volumes do not appear to have had any discernible impact on frequency mileage.

Within the long-term trend of increasing mainland frequency mileage since 2007, a seasonal cycle is observed, which is lowest in February, low over winter, and highest in the shoulder seasons of autumn and spring. This is likely due to there being more units in service over summer and winter serving the higher demands, with higher unit numbers contributing to greater overall frequency control.

Figure 16 Monthly frequency mileage



7.4 Progress on primary frequency response initiative

Implementation of the Mandatory PFR rule is a major work program currently underway. The Australian Energy Market Commission (AEMC, or Commission) summarised the rule as follows[10]:

On 26 March 2020, the Commission made a final rule to require all scheduled and semi-scheduled generators in the NEM to support the secure operation of the power system by responding automatically to changes in power system frequency.

The final rule is designed to address the immediate need to improve frequency control as identified by AEMO and the other rule change proponent Dr Peter Sokolowski. The substantive elements of the final rule commence on 4 June 2020 and sunset after 3 years on 4 June 2023.

Key aspects of the final rule include:

- *All scheduled and semi-scheduled generators, who have received a dispatch instruction to generate to a volume greater than 0 MW, must operate their plant in accordance with the performance parameters set out in the Primary frequency response requirements (PFRR) as applicable to that plant.*
- *AEMO must consult on and publish the PFRR, which will specify the required performance criteria for generator frequency response, which may vary by plant type.*

Generators may request and AEMO may approve variations or exemptions to the PFRR for individual generating plant.

While the Mandatory PFR rule commenced from 4 June 2020, actual physical changes to generating plant controls (and therefore frequency performance) are subject to a staged implementation strategy based on generator size.

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

Actual physical implementation of PFR settings at generators commenced in the final few days of Q3 2020. Current plans are for at least Tranche 1 of this rollout, which affects generators 200 MW or greater, to be completed to the degree reasonably possible prior to summer 2020.

AEMO has created a new area on its website for information and documentation relating to Mandatory PFR implementation, including periodic updates on the rollout of the Mandatory PFR rule[11].

7.5 Other recent actions

Other measures taken to improve frequency control in the last 12 months include:

- Publication of the Frequency Control Work Plan which summarises ongoing and planned work by AEMO and the AEMC to address frequency control challenges[12].
- Following a detailed review, mainland load relief was adjusted progressively down from 1.5% to 0.5% over the period up to January 2020. This series of changes resulted in an increase in Contingency FCAS volumes, particularly for Fast Raise and Lower services. No further changes are currently planned to mainland load relief, however AEMO will continue to monitor load relief observed during actual events.
- AEMO has commenced work with TNSP TasNetworks to undertake a review of load relief in the Tasmanian region. The result of this review will be published when available.
- AEMO has commenced revising switching controller settings to better distribute response across the relevant frequency bands.
- Weekly frequency reporting commenced from 1 January 2020 as required by NER 4.8.16(a). All available weekly reports are available on AEMO's website[13].
- Quarterly frequency reporting has been aligned with the requirements in NER 4.8.16(b).
- A revision of the MASS was completed 1 June 2020 (effective 1 July 2020) which made some changes to the measurement of FCAS to help ensure frequency response within the NOFB was recognised towards Contingency FCAS providers' obligations.

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[11] See https://aemo.com.au/initiatives/major-programs/primary-frequency-response.

[12] See https://aemo.com.au/-/media/files/electricity/nem/system-operations/ancillary-services/frequency-control-work-plan/external-frequency-control-work-plan.pdf

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