

# POWER SYSTEM FREQUENCY AND TIME DEVIATION MONITORING

May 2011

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DOCUMENT REF: ESOPP\_33

VERSION: 2.0

DATE: 19 July 2012

FINAL

## Version Release History

| VERSION | DATE       | BY     | CHANGES   |
|---------|------------|--------|---|
| 1.0     | 14/06/2012 | HSingh | Original Report   |
| 2.0     | 19/07/2012 | HSingh | Section 4 updated with three additional events that are now identified as not meeting the Frequency Operating Standards |

# Contents

|       |   |    |
|-------|---|----|
| 1     | Disclaimer .....  | 4  |
| 2     | Introduction .....  | 5  |
| 3     | Summary of Events.....  | 6  |
| 4     | Events in the Mainland and Tasmania Regions that did not meet the Frequency Operating Standards ..... | 7  |
| 4.1   | Frequency Events in Mainland Region .....   | 7  |
| 4.2   | Low Frequency Events in Tasmania.....   | 7  |
| 4.2.1 | Event: 10/05/2011 16:05:20 .....  | 7  |
| 4.2.2 | Event: 13/05/2011 06:04:28 .....  | 9  |
| 4.2.3 | Event: 19/05/2011 06:02:08 .....  | 10 |
| 4.2.4 | Event: 24/05/2011 16:58:40 .....  | 12 |
| 4.2.5 | Event: 30/05/2011 20:03:48 .....  | 13 |
| 5     | Statistical analysis.....   | 14 |
| 5.1.1 | Daily Frequency Standard Deviation.....   | 15 |
| 5.1.2 | Time of day Analysis .....  | 16 |
| 6     | Accumulated Time Deviation.....   | 17 |
| 6.1   | Time Error Performance.....   | 19 |

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## 2 Introduction

AEMO is required to maintain the power system frequency and time deviation within the limits specified in the frequency operating standards determined for the mainland and the Tasmania Region by the Reliability Panel. This document reports on the frequency and time deviation performance observed during May 2011 in all regions of the NEM. Regions QLD, NSW, VIC and SA will be referred to as the mainland regions throughout the report.

The frequency operating standards for the mainland regions and the Tasmania region are available on the AEMC web site<sup>1</sup>.

The “Power System Frequency and Time Deviation Monitoring Report – Reference Guidelines<sup>2</sup>” outlines the calculation processes used by AEMO in the preparation of the monthly Power System Frequency and Time Deviation Monitoring reports.

The analysis of the delivery of slow raise service, slow lower service, delayed raise service and delayed lower service presented in this report are based on 4-second resolution data. Data for mainland regions is sourced from the Sydney PI server and data for Tasmania region is sourced from the Brisbane PI server. The analysis of fast raise service and fast lower service delivered is based on high-speed (50-millisecond or higher resolution) data and is only presented in this report for events where the appropriate data is available.

Table 1 below summarises events in the mainland and Tasmanian regions for the month May 2011 with frequency excursions outside the normal operating frequency band. Any events in Table 1 that are identified with frequency excursions that did not meet the frequency operating standards are evaluated in section 4 of the report.

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<sup>1</sup> The frequency operating standards for the mainland and Tasmania regions are available from <http://www.aemc.gov.au/Panels-and-Committees/Reliability-Panel/Guidelines-and-standards.html>

<sup>2</sup> The Power System Frequency and Time Deviation Monitoring Report – Reference Guidelines is available from <http://www.aemo.com.au/Electricity/Market-and-Power-Systems/NEM-Reports/Power-System-Performance-Monitoring>

### 3 Summary of Events

Table 1: Events in the Mainland and Tasmanian regions with frequency excursions outside the normal frequency operating band

| EVENT  | LOW/HIGH<br>FREQUENCY<br>EVENT | NUMBER OF EVENTS |          |
|--|--------------------------------|------------------|----------|
|  |                                | MAINLAND         | TASMANIA |
| No contingency<br>or load<br>event/Normal<br>event | LOW                            | 1                | 87       |
|  | HIGH                           | 0                | 27       |
| Load Event   | LOW                            | 0                | 82       |
|  | HIGH                           | 1                | 154      |
| Generation<br>Event                                | LOW                            | 7                | 7        |
|  | HIGH                           | 0                | 3        |
| Network Event                                      | LOW                            | 0                | 0        |
|  | HIGH                           | 0                | 0        |
| Separation Event                                   | LOW                            | 0                | 0        |
|  | HIGH                           | 0                | 0        |
| Multiple<br>Contingency<br>Event                   | LOW                            | 0                | 0        |
|  | HIGH                           | 0                | 0        |

## 4 Events in the Mainland and Tasmania Regions that did not meet the Frequency Operating Standards

In this section, details are provided of those events identified in Table 1 as not meeting the frequency operating standard applicable to each event.

### 4.1 Frequency Events in Mainland Region

There were no events recorded in Mainland Region that did not meet the Mainland Frequency Operating Standards from those identified in Table 1 during May 2011.

### 4.2 Low Frequency Events in Tasmania

There were five Low Frequency Normal Condition Events from Table 1 recorded in Tasmania during May 2011 that resulted in frequencies below 49.75 Hz. All of these events listed in Table 2 did not meet the Tasmania Frequency Operating Standards.

*Table 2: Low Frequency Normal Condition Events (No Contingency) in the Tasmania region that did not meet the Tasmania Frequency Operating Standards.*

| DATE                   | EVENT  | MIN FREQUENCY (HZ) | TIME OUTSIDE NORMAL OPERATING BAND (49.85 HZ - 50.15 HZ) |
|------------------------|--|--------------------|--|
| 10/05/2011<br>16:05:20 | No condition causing the event was identified. | 49.66              | 68   |
| 13/05/2011<br>06:04:28 | No condition causing the event was identified. | 49.64              | 132  |
| 19/05/2011<br>06:02:08 | No condition causing the event was identified. | 49.73              | 260  |
| 24/05/2011<br>16:58:40 | No condition causing the event was identified. | 49.64              | 770  |
| 30/05/2011<br>20:03:48 | No condition causing the event was identified. | 49.69              | 1017   |

#### 4.2.1 Event: 10/05/2011 16:05:20

For the Normal (Non-Contingency) low frequency event on 10<sup>th</sup> May 2011 in Tasmania, Figure 1 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 68 seconds. Two Tasmanian generating units ramped up too slowly to their respective generation targets from start-up which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 2. The flow across Basslink was approximately 470 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller did not deliver any further FCAS from Mainland to Tasmania during this event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.66 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

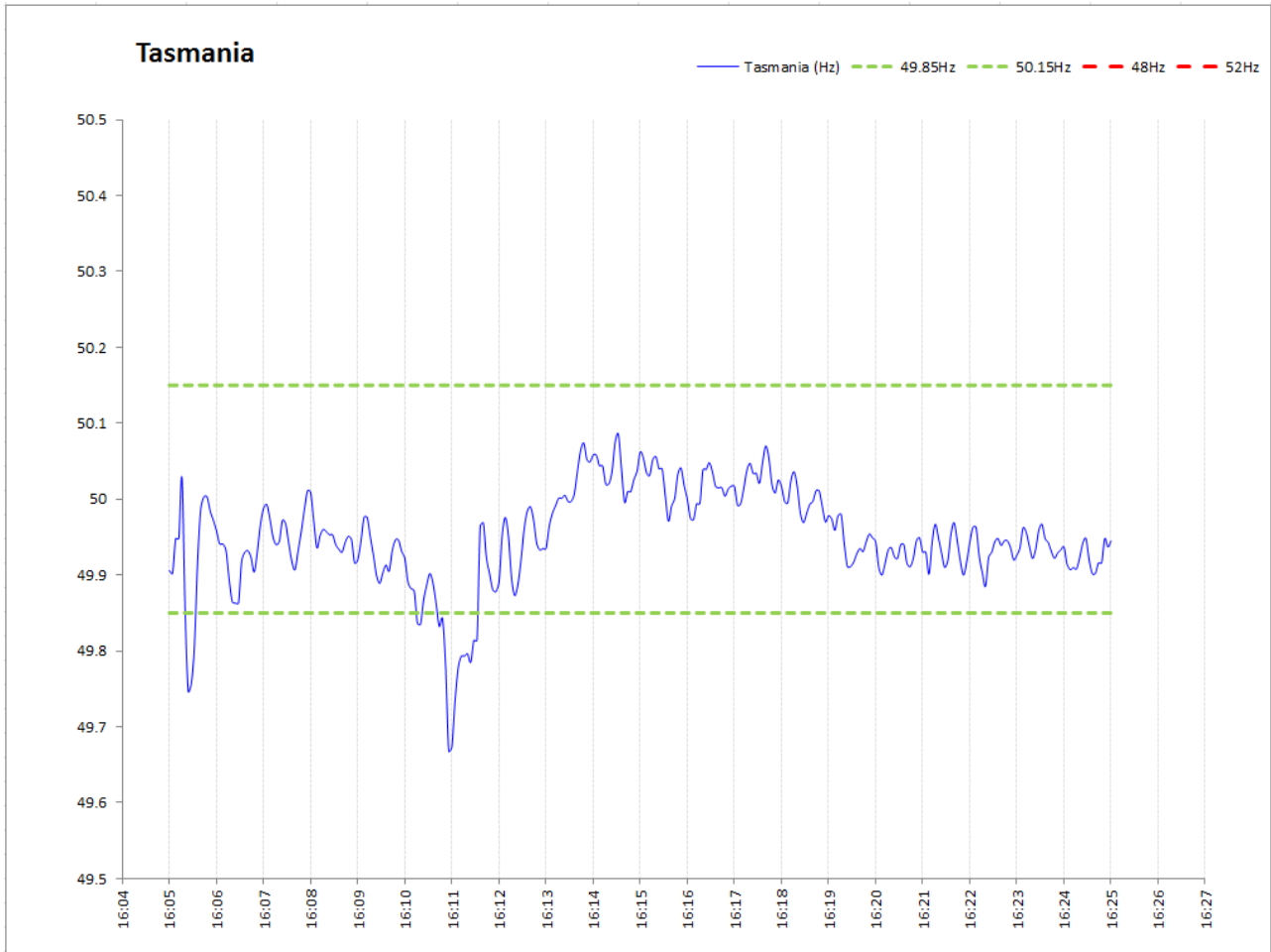


Figure 1: Low Frequency Normal Event in Tasmania refer to item 1 in Table 2 with the frequency exceeding the Tasmania Frequency Operating Standard

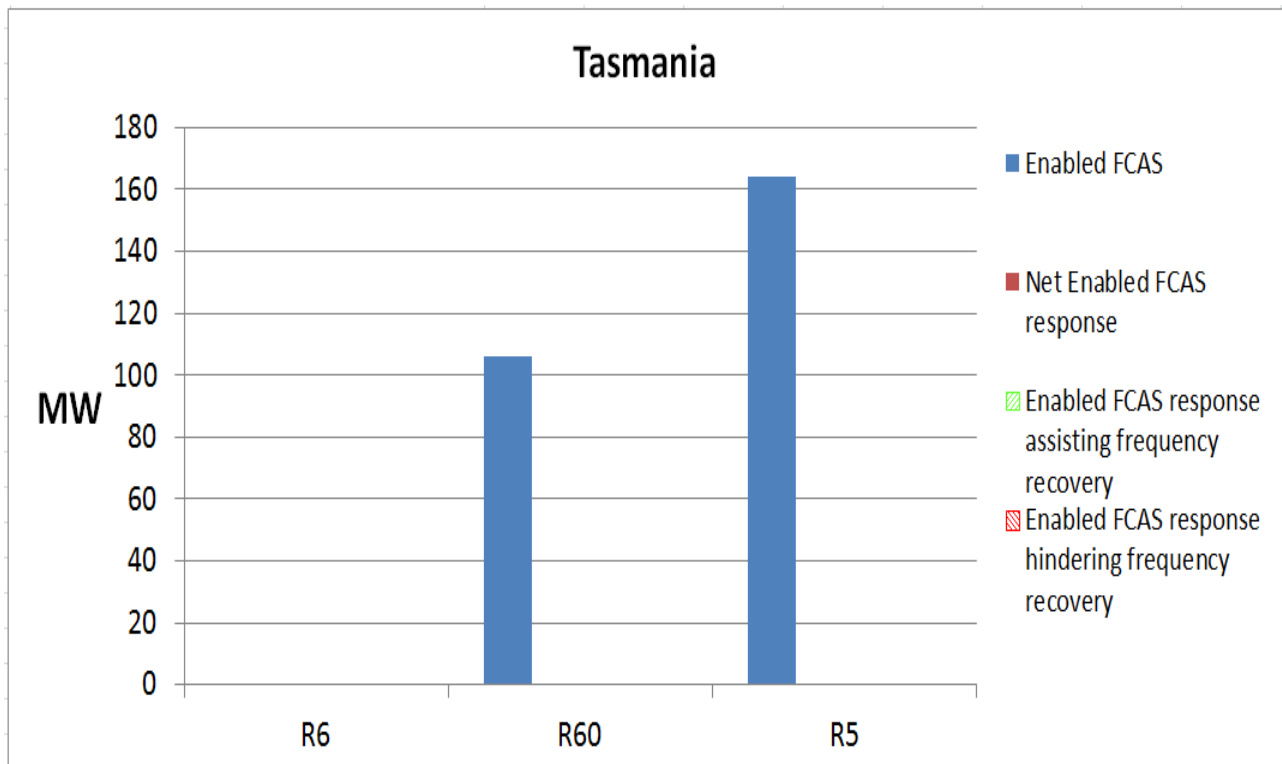


Figure 2: FCAS response to Normal (Non-Contingency) Low Frequency Event on 10<sup>th</sup> May 2011.



#### 4.2.2 Event: 13/05/2011 06:04:28

For the Normal (Non-Contingency) low frequency event on 13<sup>th</sup> May 2011 in Tasmania, Figure 3 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 132 seconds. One Tasmanian generating unit ramped up too slowly to their generation target from start-up which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, a zero amount was delivered as shown in Figure 4. The flow across Basslink was approximately 470 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller did not deliver any further FCAS from Mainland to Tasmania during this event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.64 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

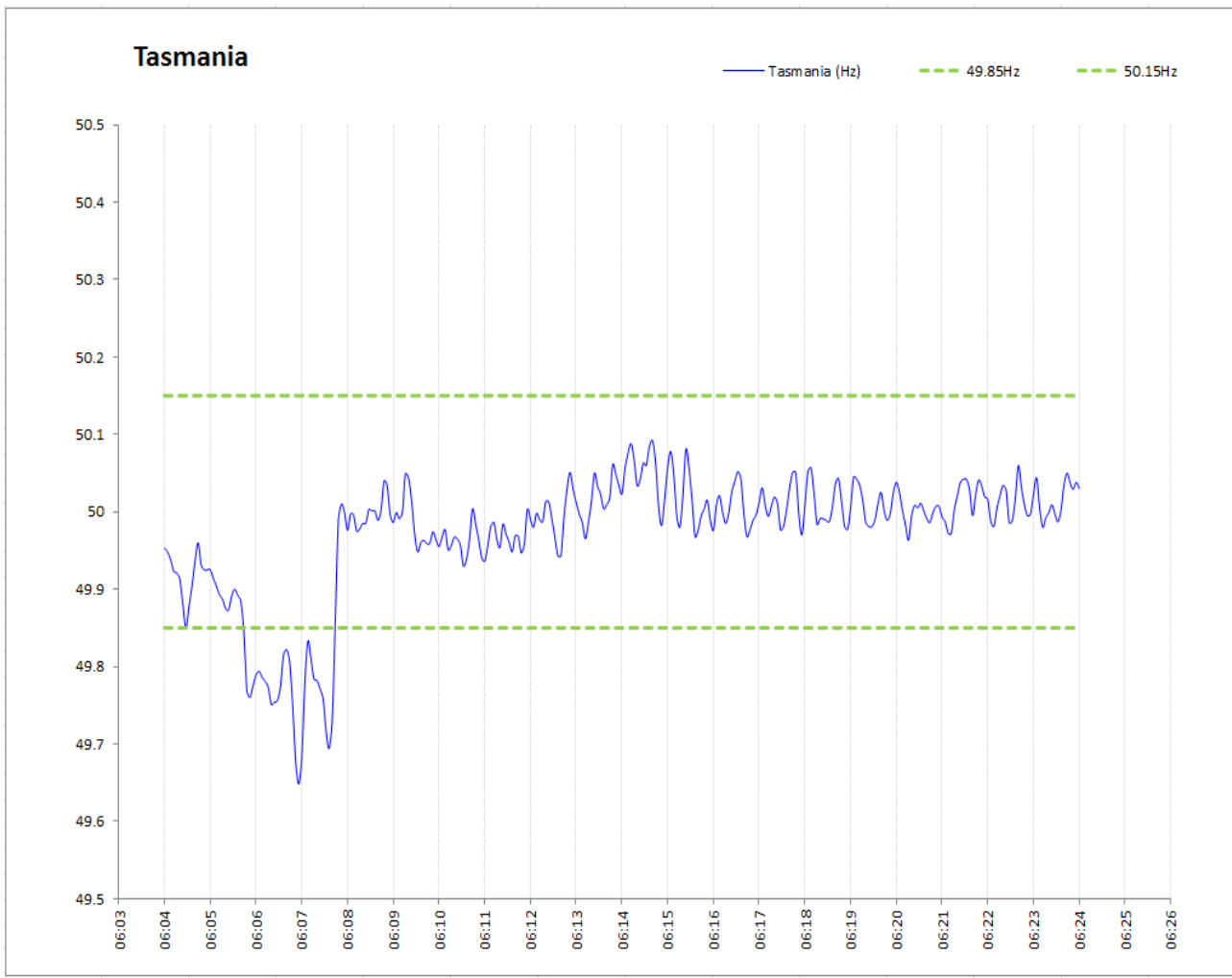


Figure 3: Low Frequency Normal Event in Tasmania refer to item 2 in Table 2 with the frequency exceeded the Tasmania Frequency Operating Standard

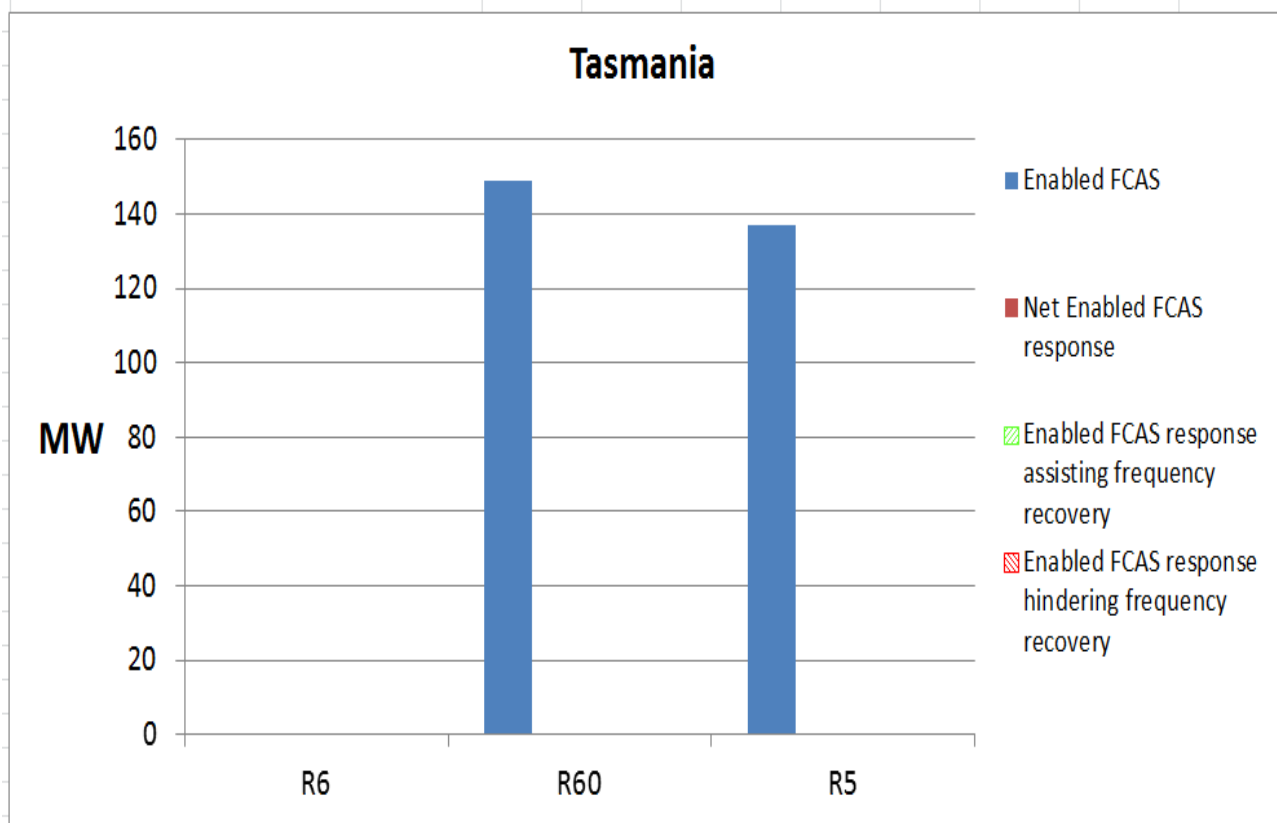


Figure 4: FCAS response to Normal (Non-Contingency) Low Frequency Event on 13<sup>th</sup> May 2011.

#### 4.2.3 Event: 19/05/2011 06:02:08

For the Normal (Non-Contingency) low frequency event on 19<sup>th</sup> May 2011 in Tasmania, Figure 5 shows that the Tasmania region frequency exceeded the Tasmania Frequency Operating Standards and was outside the normal operating band for 260 seconds. Two Tasmanian generating units ramped up slowly to their respective generation targets from start-up which contributed to the frequency excursion. Compared to the enabled slow raise and delayed raise FCAS, 15% of the slow raised FCAS was delivered as shown in Figure 6. The flow across Basslink was approximately 470 MW towards Tasmania during the time of the frequency excursion. Basslink frequency controller did not deliver any further FCAS from Mainland to Tasmania during this event. The frequency excursion was not sufficient to trigger switched controllers to deliver delayed FCAS during the event. Frequency fell to a minimum of 49.73 Hz in the Tasmania region. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

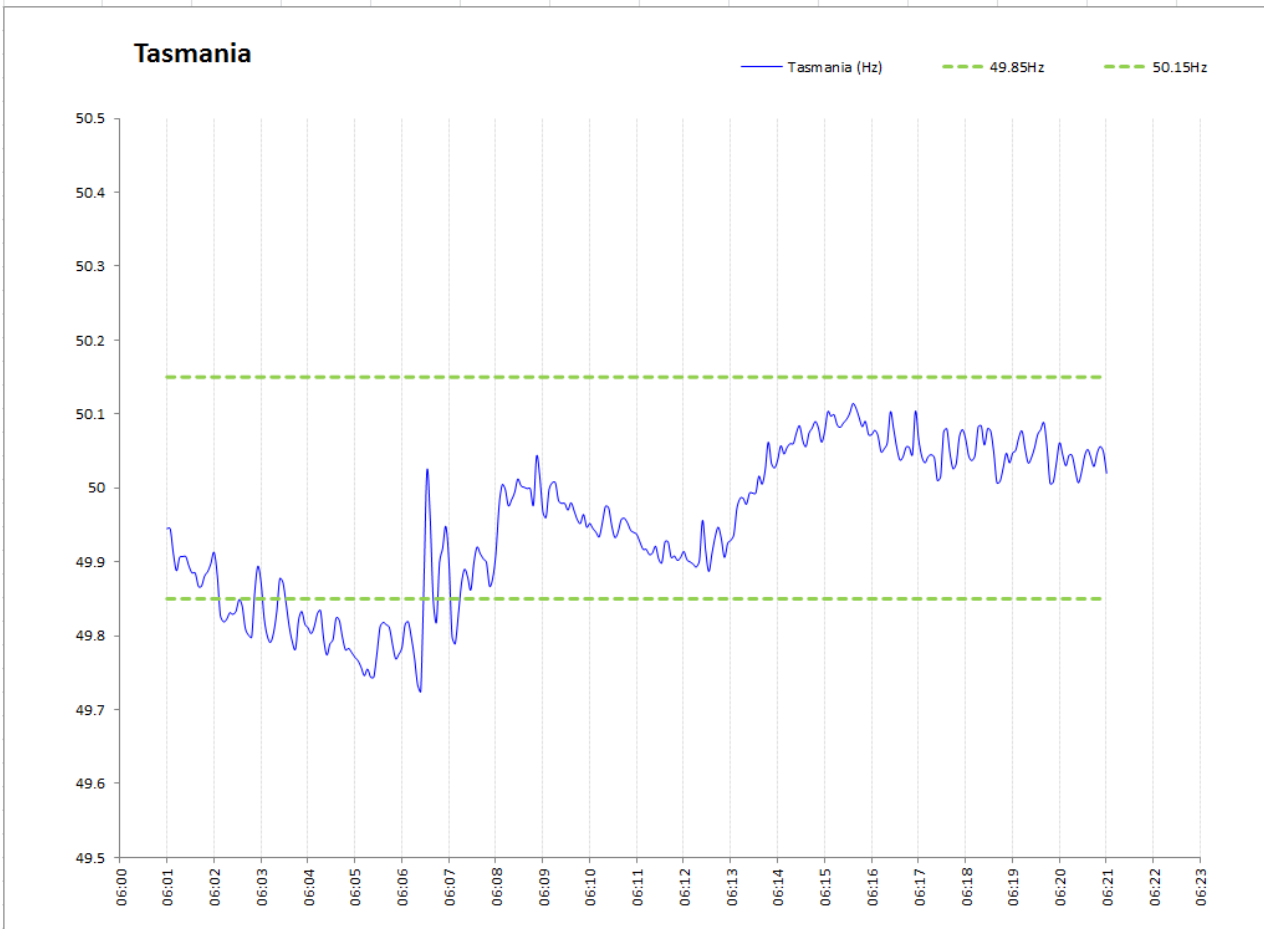


Figure 5: Low Frequency Normal Event in Tasmania refer to item 3 in Table 2 with the frequency exceeded the Tasmania Frequency Operating Standard

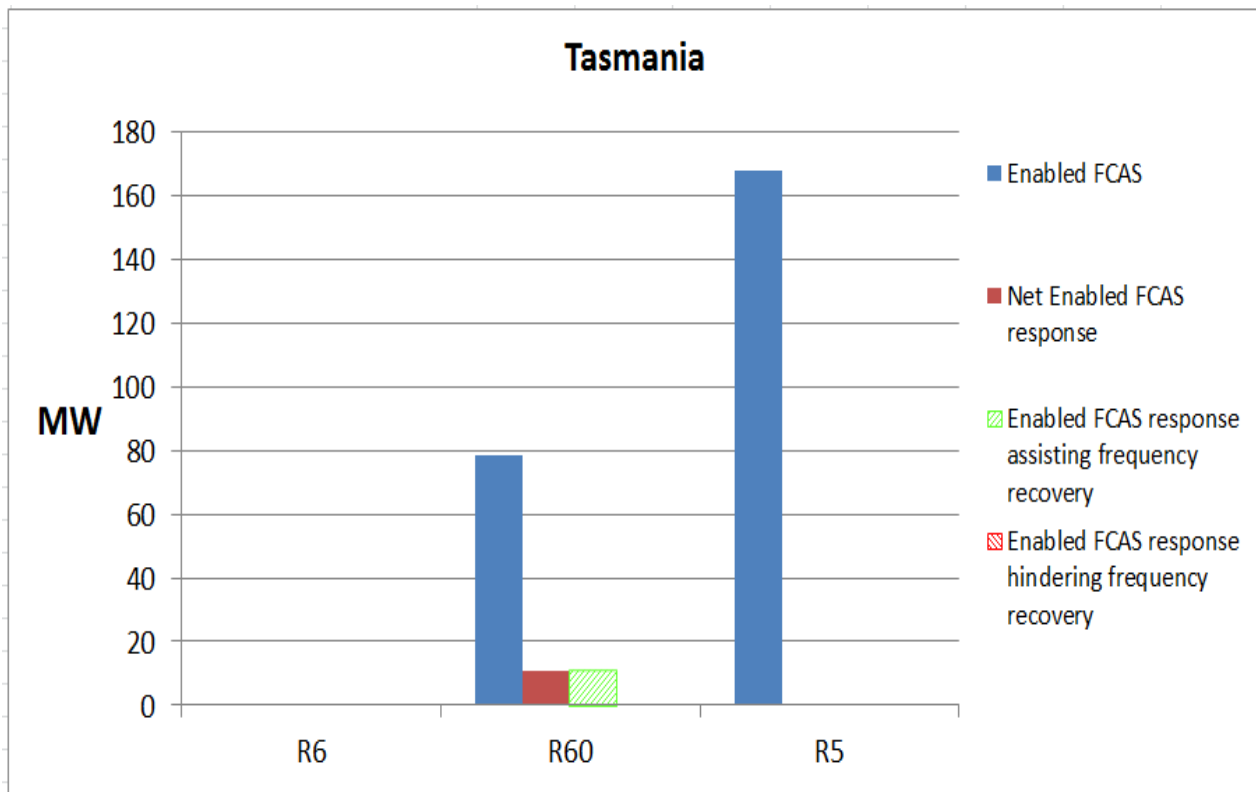


Figure 6: FCAS response to Normal (Non-Contingency) Low Frequency Event on 19<sup>th</sup> May 2011.

#### 4.2.4 Event: 24/05/2011 16:58:40

For the Non-Contingency low frequency event on 24<sup>th</sup> May 2011 in Tasmania, insufficient FCAS was delivered to maintain the Tasmanian frequency within the Tasmania Frequency Operating Standards. Two Tasmanian generating units ramped up too slowly to their respective generation targets from start-up which contributed to the frequency excursion. Compared to the enabled slow FCAS, an amount of only about 25% was delivered as shown in Figure 8. The flow across Basslink was approximately 46 MW towards Victoria during the time of the frequency excursion. Since Basslink cannot transfer FCAS where the provision of the FCAS would cause the Basslink flow to enter the no-go zone, the FCAS transfer from Basslink would have been limited during this time. The frequency excursion was not sufficient to trigger switched controllers providing delayed FCAS during the event. Frequency fell to a minimum of 49.64 Hz in the Tasmania region. The Tasmania frequency as shown in figure 7 below exceeded the Tasmania Frequency operating Standards and was outside the normal operating band for 770 seconds. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

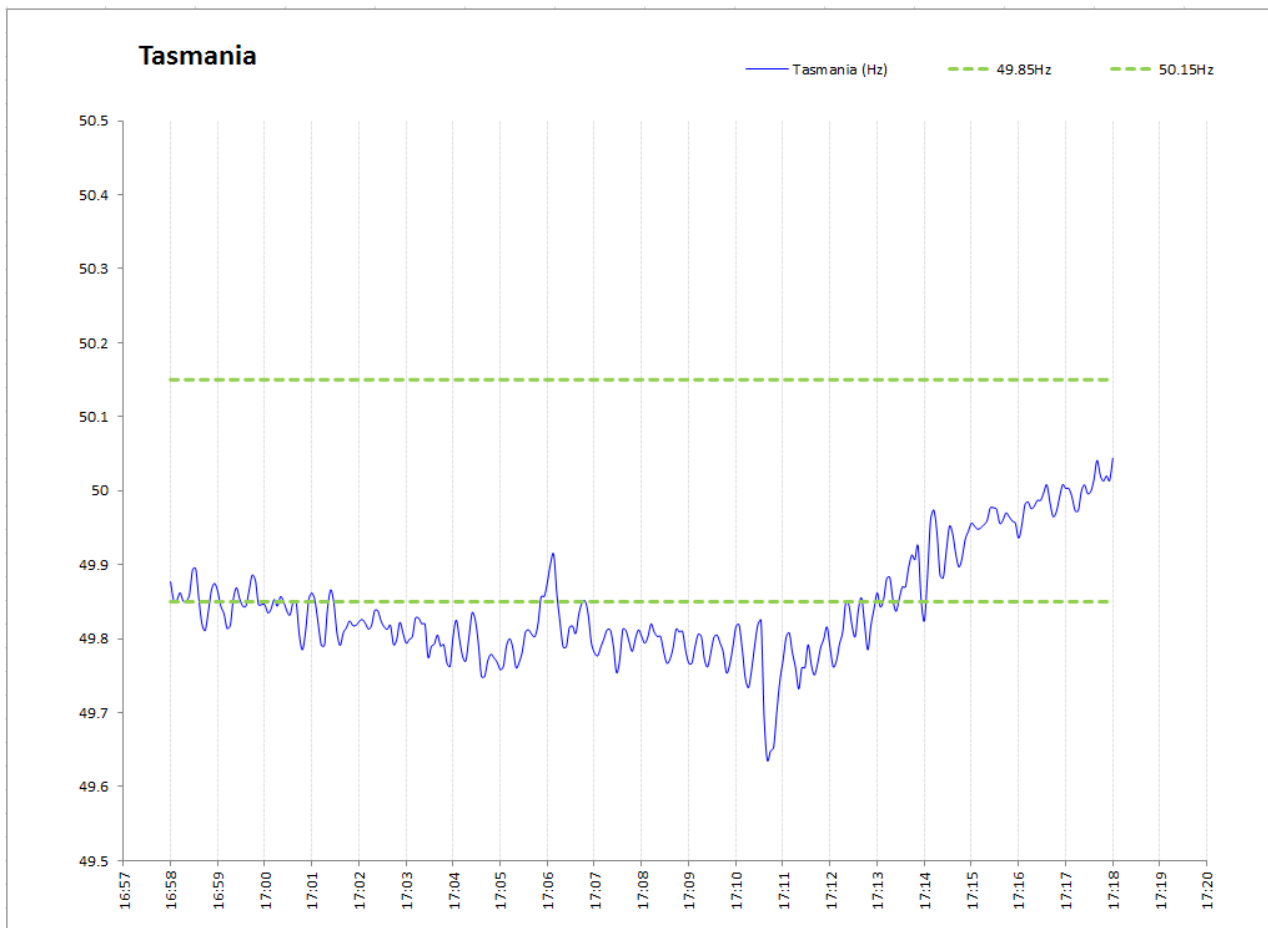


Figure 7: Low Frequency Generation Event refer to item 4 in Table 2 with the frequency exceeded the Tasmania Frequency Operating Standard

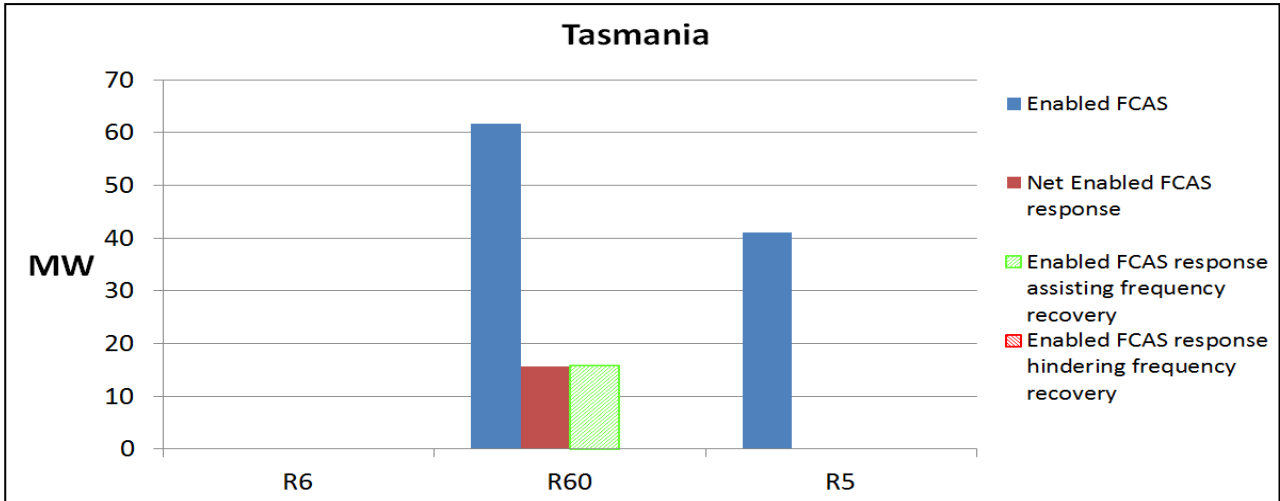


Figure 8: FCAS response to Normal (Non-Contingency) Low Frequency Event on 24<sup>th</sup> May 2011

**4.2.5 Event: 30/05/2011 20:03:48**

For the Non-Contingency low frequency event on 30th May 2011 in Tasmania, insufficient FCAS was delivered to maintain the Tasmanian frequency within the Tasmania Frequency Operating Standards. Some Tasmanian generating units did not follow dispatch targets which contributed to the frequency excursion. Compared to the enabled slow FCAS, only a fraction was delivered with some units providing a negative response as shown in Figure 10. The flow across Basslink was approximately 46 MW towards Victoria during the time of the frequency excursion. Since Basslink cannot transfer FCAS where the provision of the FCAS would cause the Basslink flow to enter the no-go zone, the FCAS transfer from Basslink would have been limited during this time. The frequency excursion was not sufficient to trigger switched controllers providing delayed FCAS during the event. Frequency fell to a minimum of 49.69 Hz in the Tasmania region. The Tasmania frequency as shown in figure 9 below was outside the Tasmania Frequency operating Standards for 1017 seconds. The amount of Fast Raise services delivered was not calculated since 50 ms data was not requested for this event.

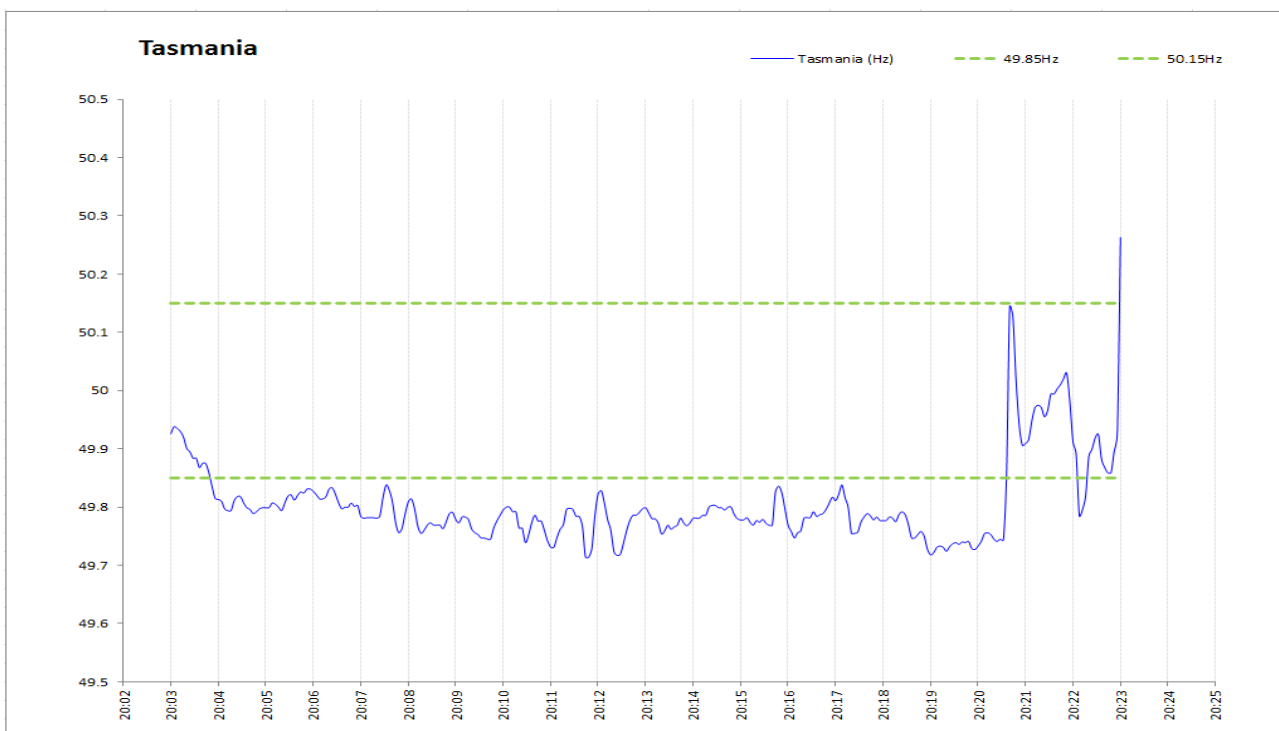


Figure 9: Low Frequency Generation Event refer to item 5 in Table 2 with the frequency exceeded the Tasmania Frequency Operating Standard

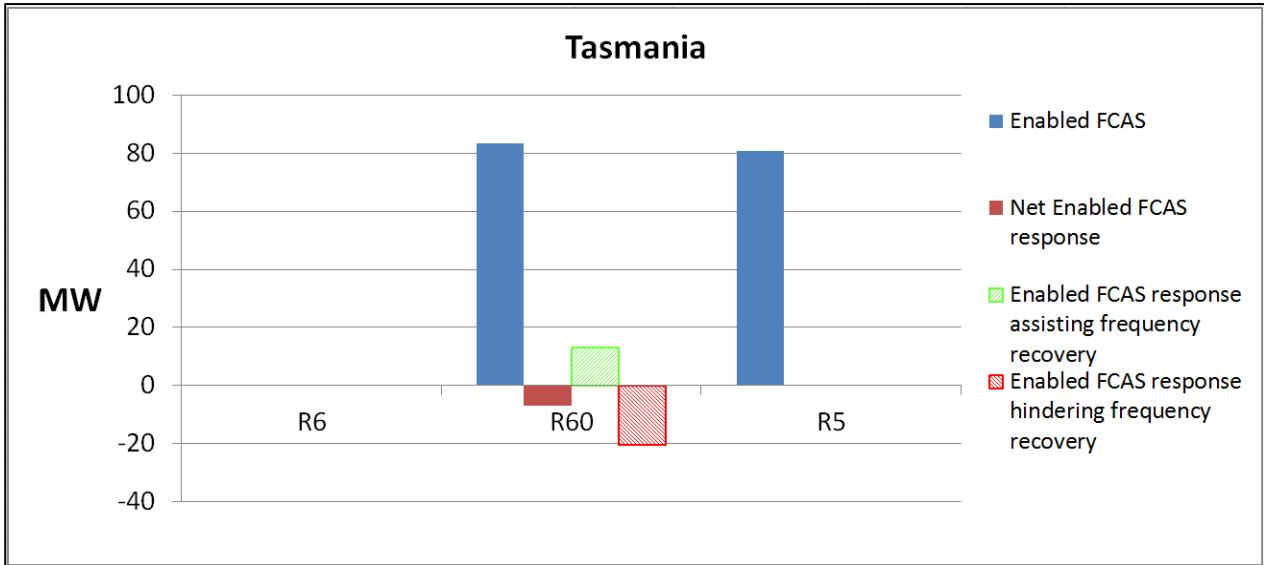


Figure 10: FCAS response to Normal (Non-Contingency) Low Frequency Event on 30<sup>th</sup> May 2011

## 5 Statistical analysis

With exception of major power system disturbances which are excluded, the frequency distribution for the Mainland and Tasmanian regions were within the frequency operating standards in the month of May 2011.

Frequency in the Mainland regions was within the range 49.91 Hz – 50.07 Hz for 99% of the time. The frequency was within the range 49.75 Hz – 50.25 Hz for 100% of the time. The mean value of frequency during May 2011 was 50 Hz with a standard deviation of 0.031 Hz.

Frequency in the Tasmania region was within the range 49.89 – 50.10 Hz for 99% of the time. The frequency was within the range 49.75 Hz – 50.25 Hz for 99.96 % of the time. The mean value of frequency during May 2011 was 50 Hz with a standard deviation of 0.038 Hz.

### 5.1.1 Daily Frequency Standard Deviation

Figure 11 and Figure 12 below plot the daily standard deviation of the Mainland and Tasmanian frequency for the past 13 months, and do not exclude load and contingency events.

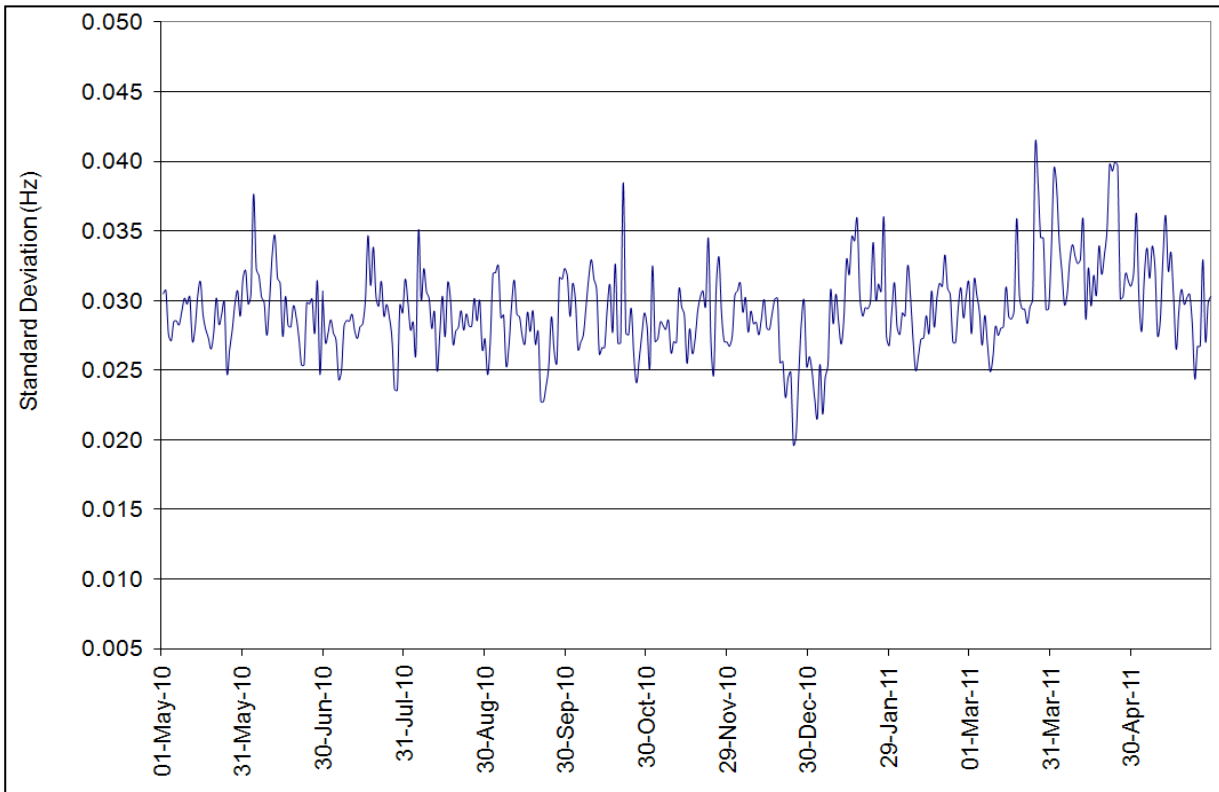


Figure 11: Daily standard deviation of Mainland frequency

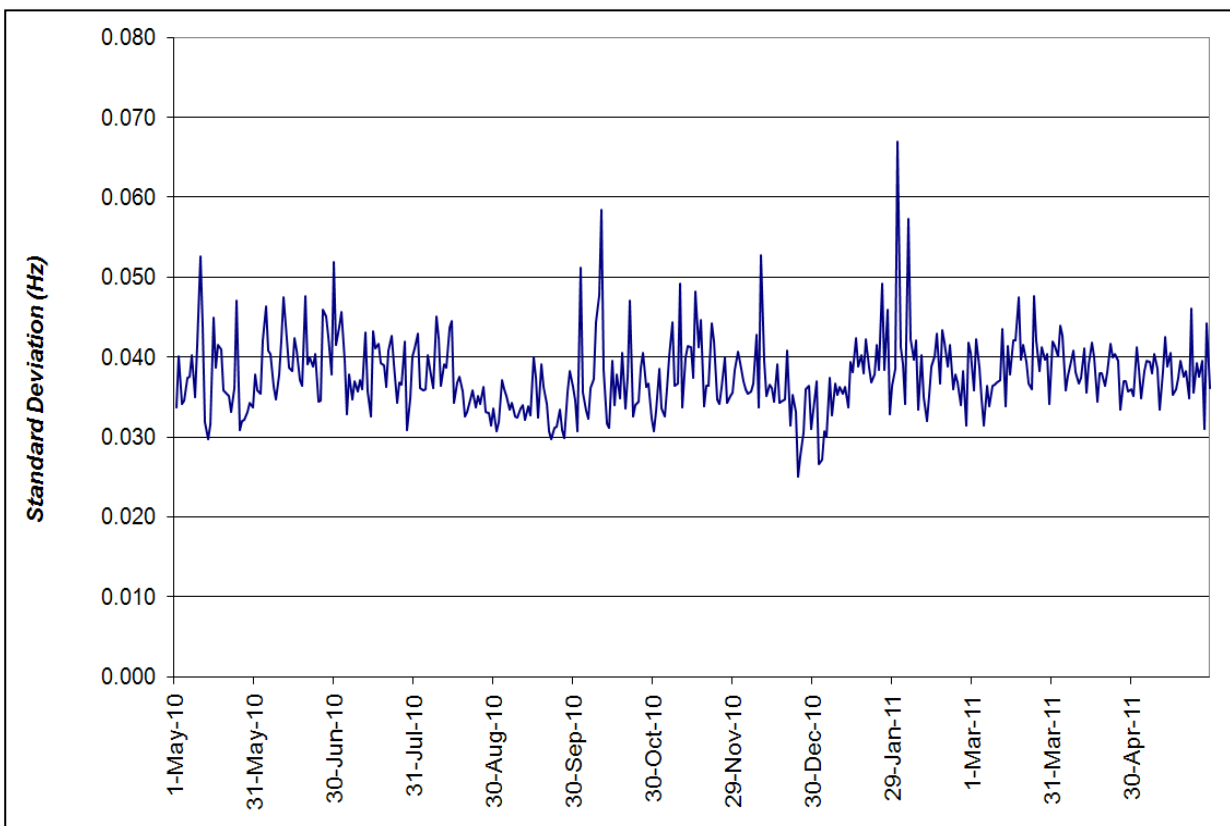


Figure 12: Daily standard deviation of frequency in Tasmania

### 5.1.2 Time of day Analysis

This section details the standard deviation of system frequency on a monthly and daily basis. Figure 13 and Figure 14 show the average half-hourly standard deviation of the Mainland regions and Tasmania frequency for March, April and May 2011. The effects of contingency events have not been filtered from this time of day analysis.

The theoretical limit of 0.049 Hz shown in Figure 13 and Figure 14 would ensure that 99% of observed values were in the range 49.85 - 50.15 Hz with a very small probability of being less than 49.75 Hz and greater than 50.25 Hz. (This assumes that the frequency distribution follows an ideal normal distribution).

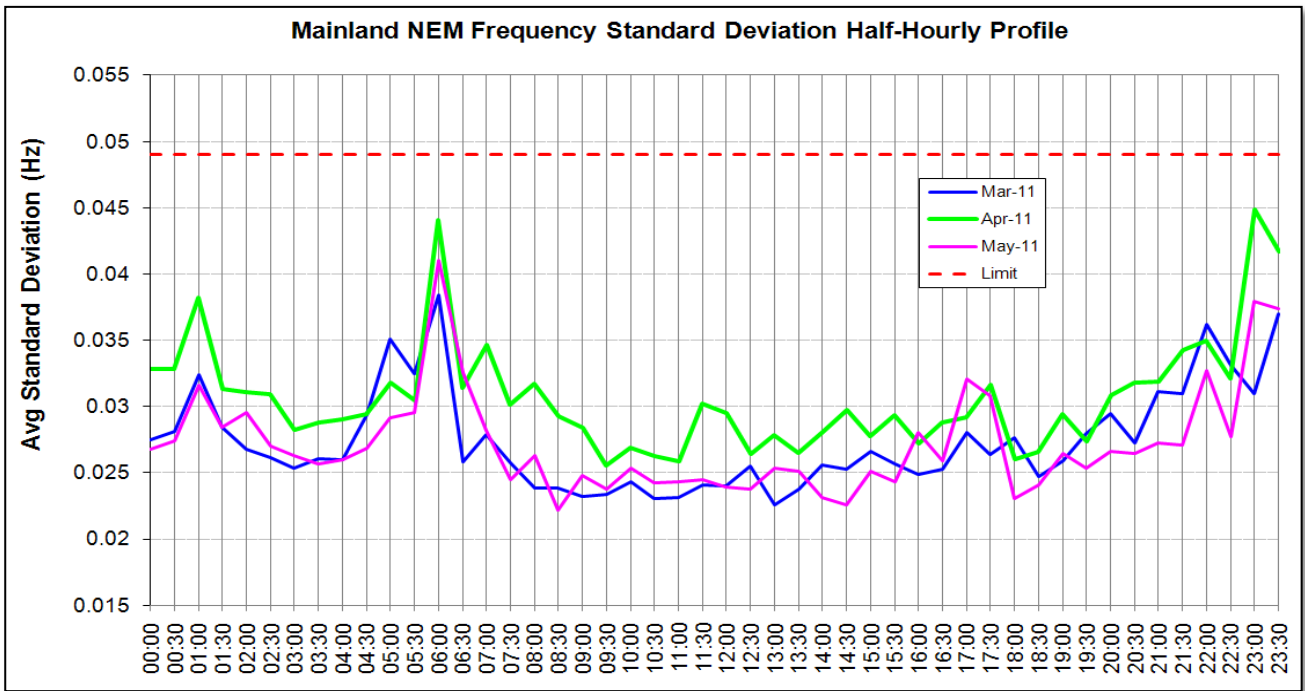


Figure 13: Daily profile of standard deviation for the frequency in the Mainland regions

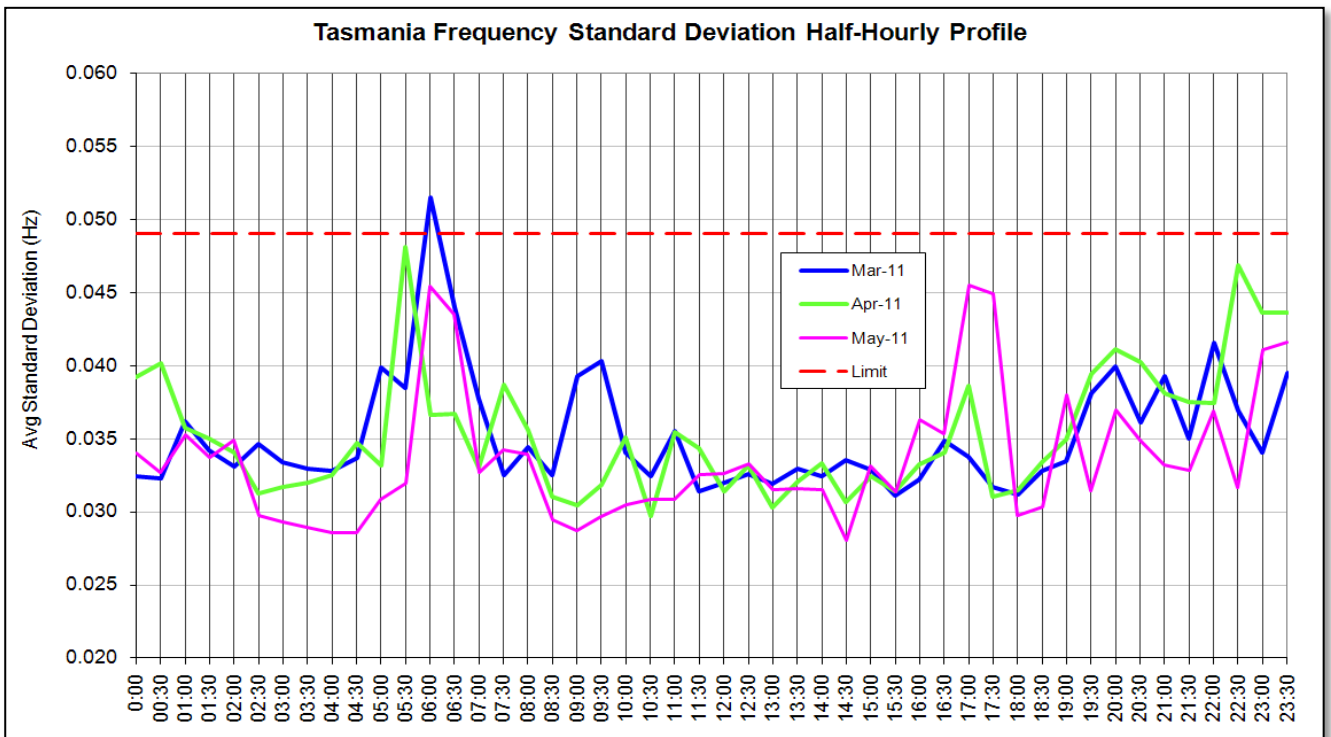


Figure 14: Daily profile of standard deviation for the frequency in Tasmania



## 6 Accumulated Time Deviation

The frequency operating standards require that the accumulated time deviation be maintained within the range  $\pm 5$  seconds in Mainland regions and  $\pm 15$  seconds in Tasmania.

For a separation event there is no requirement in the frequency operating standards that time deviation be maintained within the ranges specified above.

The range of accumulated time deviations recorded throughout the NEM during May 2011 is provided in Table 3.

Table 3: Accumulated time deviation statistics

|                                | QUEENSLAND | NSW   | VIC    | SA     | TAS    |
|--------------------------------|------------|-------|--------|--------|--------|
| Maximum Positive Deviation (s) | 1.83       | 2.20  | 2.08   | 1.72   | 8.99   |
| Maximum Negative Deviation (s) | -3.63      | -3.32 | -3.38  | -3.74  | -12.97 |
| Mean Value (s)                 | -0.298     | 0.028 | -0.065 | -0.508 | -1.699 |
| Standard Dev (s)               | 0.747      | 0.744 | 0.745  | 0.745  | 2.91   |

The distribution of time deviations based on the Mainland regions measurement is provided in Figure 15 below.

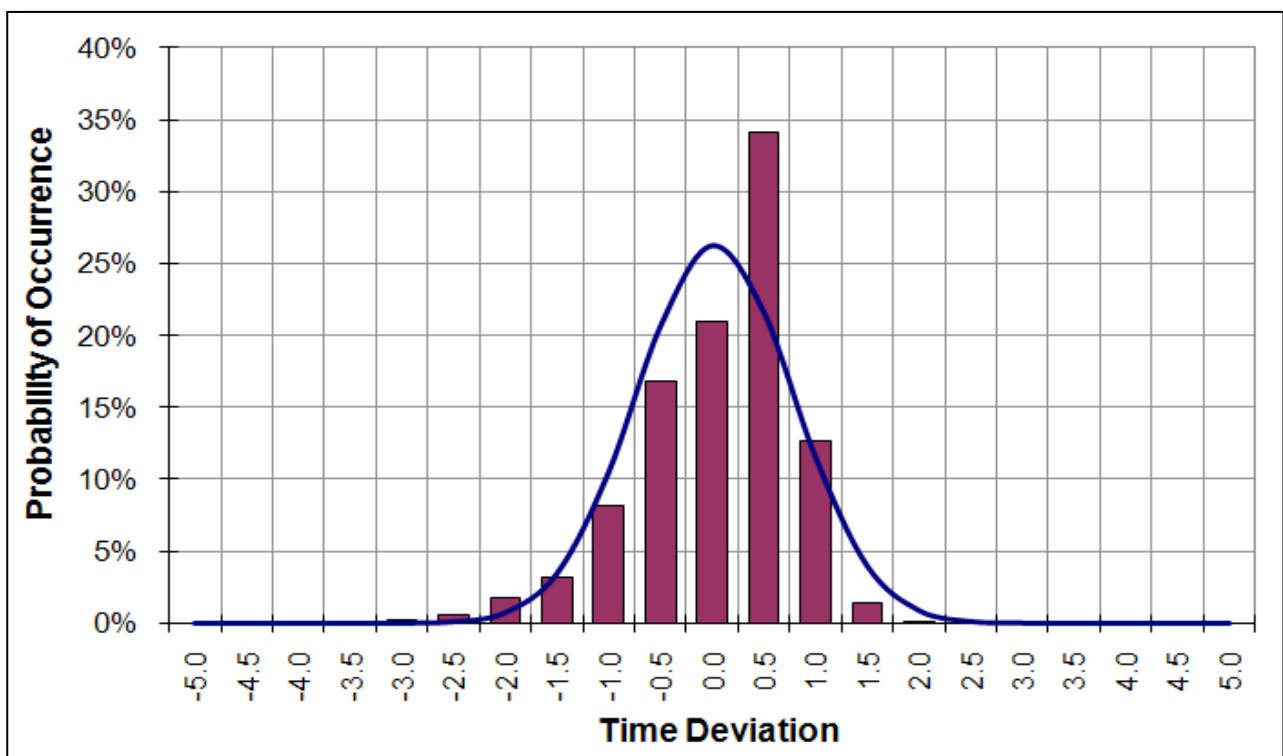


Figure 15: Mainland time deviation distribution for May 2011

The distribution of time deviations based on the Tasmania region measurement is provided below in Figure 16 below.

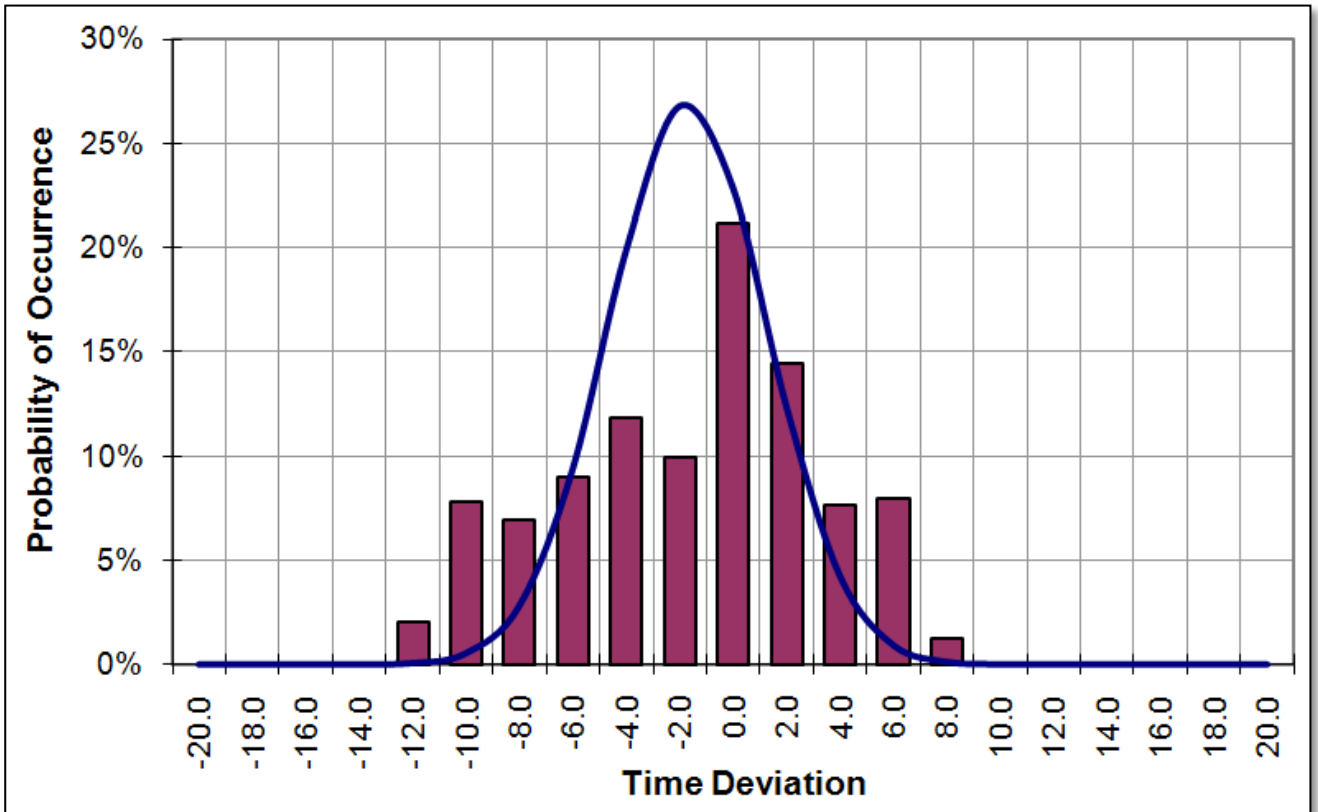


Figure 16: Tasmania time deviation distribution for May 2011

### 6.1 Time Error Performance

Figure 17 below presents the daily maximum and minimum values of the Mainland regions time error observed for the past 13 months.

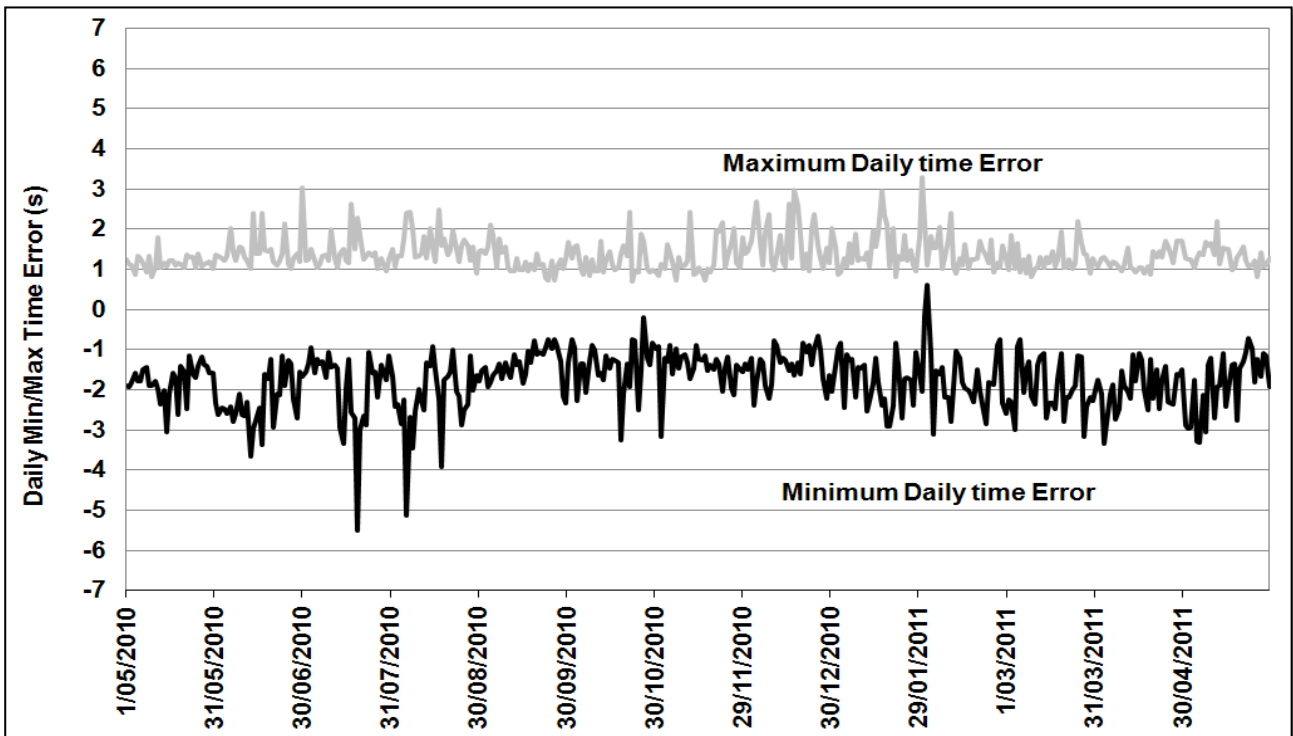


Figure 17: Mainland regions daily maximum and minimum time deviation

Figure 18 below presents the daily maximum and minimum values of Tasmania time error observed for the past 13 months.

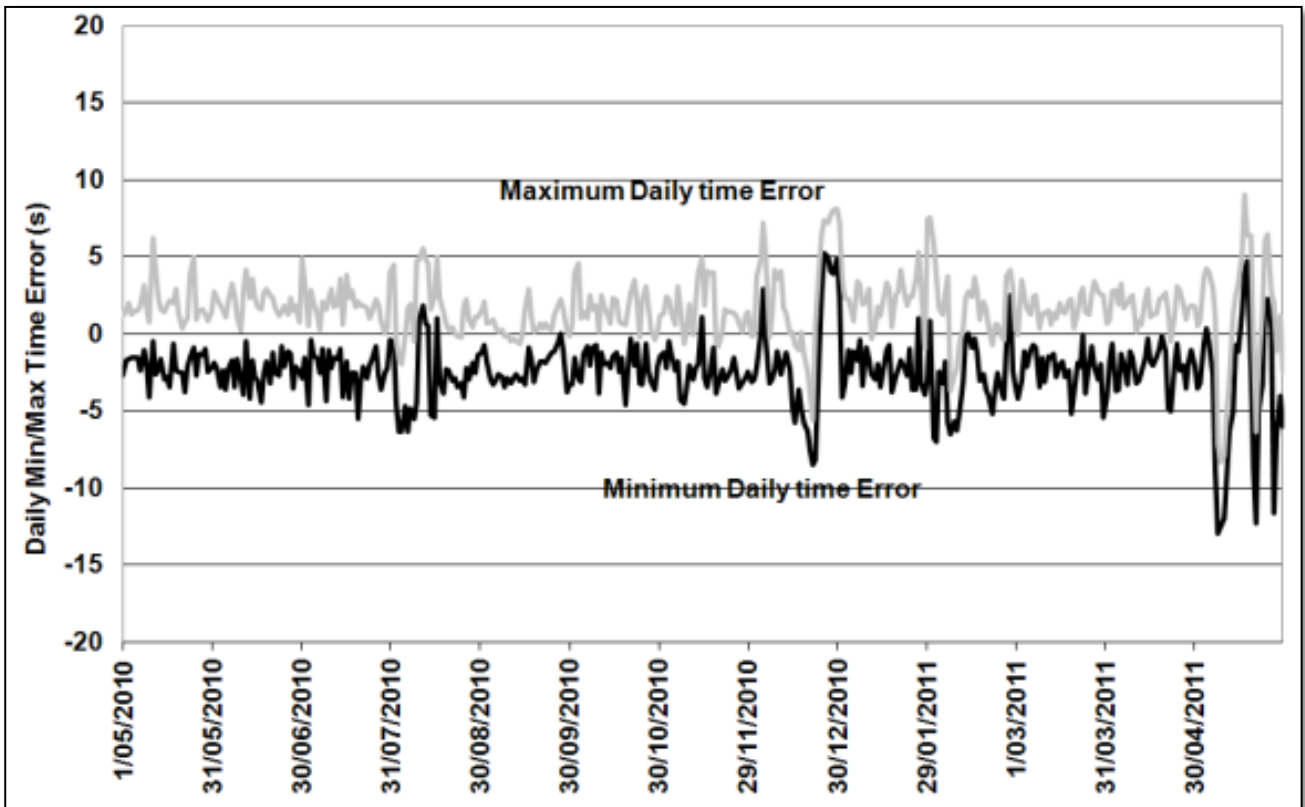


Figure 18: Tasmania daily maximum and minimum time deviation