POWER SYSTEM OPERATING INCIDENT REPORT – TRIPPING OF FARRELL – SHEFFIELD 1 AND 2 220KV LINES ON 12 NOVEMBER 2012

PREPARED BY: Systems Performance and Commercial

DATE: 26 February 2013

FINAL

Disclaimer

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Abbreviations and Symbols

Abbreviation	Term
CB	Circuit Breaker
EMMS	Electricity Market Management System
EMS	Energy Management System
kV	Kilovolt
MW	Megawatt
OFGSS	Over Frequency Generation Shedding Scheme
RTU	Remote Terminal Unit

Contents

Incident summary

Date and time of incident	12 November 2012 at 1105 hrs
Region of incident	Tasmania
Affected regions	Tasmania
Event type	TT-Loss of multiple transmission elements
Primary cause	ENVI & LN – Environment and Lightning
Impact	VS - Very Significant
Associated reports	Nil

1 Introduction

At 1105 hrs on 12 November 2012, the Farrell - Sheffield No.1 and No.2 220 kV transmission lines tripped simultaneously while lightning was in the vicinity of the transmission lines, separating the West Coast from the remainder of Tasmania and resulting in the loss of all generation and load in the West Coast area of Tasmania. Approximately 340 MW of generation was shut-down and interruption to supply of 60 MW of load occurred in this incident.

The Rosebery No. 2 110/44 kV transformer also tripped during this incident.

This report has been prepared under clause 4.8.15 (c) of the National Electricity Rules (NER) to assess the adequacy of the provision and response of facilities and services and the appropriateness of actions taken to restore or maintain power system security.

This report is largely based upon information provided by Transend and Hydro Tasmania. Data from AEMO's Energy Management System (EMS) and Electricity Market Management System (EMMS) has also been used in analysing the incident.

All references to time in this report are to National Electricity Market time (Australian Eastern Standard Time).

2 Pre-Contingent System Conditions

In the Tasmanian region the West Coast load (namely Newtown, Queenstown, Rosebery, Que and Savage River) have the potential to be supplied by local generation (Reece, John Butters, Tribute, Bastyan and Mackintosh Power Stations), and via the Farrell – Sheffield No. 1 and No. 2 220 kV transmission lines and, where system conditions are appropriate also via a 110 kV network called the Hampshire link. Refer to figures 1 and 2.

At the time of the incident the West Coast load and generation was connected to the remainder of the Tasmania network via the Farrell – Sheffield No. 1 and No. 2 220 kV transmission lines. The Hampshire link was open (which is its normal state of operation). The West Coast load prior to the incident was approximately 60 MW.

Generation on the West Coast immediately prior to the incident was as per Table 1.

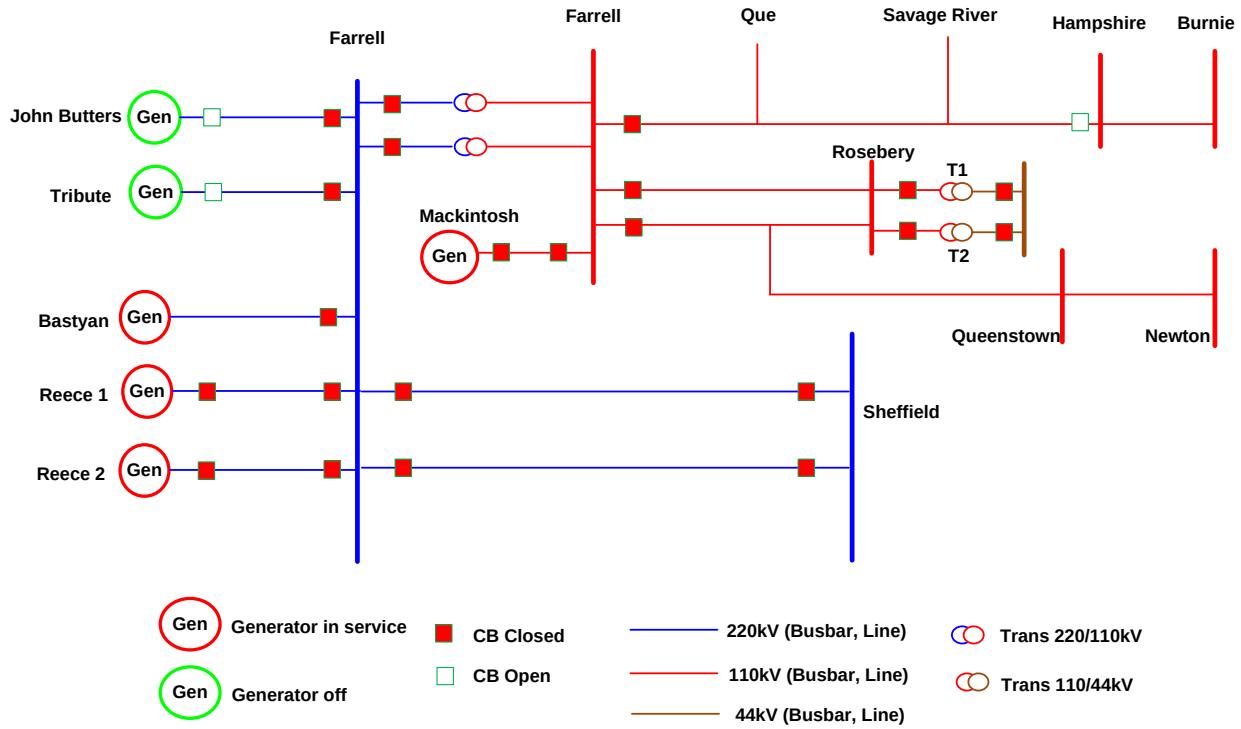
Table 1: West Coast generation prior to the incident

Generating Unit	MW
Bastyan	70
Reece 1	100
Reece 2	100
Mackintosh	70
John Butters	0
Tribute	0
Total	**340**

The status of the relevant part of the Tasmania power system prior to the incident is shown in Figure 1.

For clarity only equipment relevant to this incident has been included in the diagram.

Figure 1 - Status of the power system prior to the incident



3 Summary of Events

The table below provides a summary of the events

Table 2: Summary of events

Time	Events	Comments
11:04:58	Farrell – Sheffield No.1 and No.2 220 kV transmission lines tripped.	Lightning was in the vicinity of the transmission lines.
11:04:58	Rosebery No.2 110/44 kV transformer tripped.	
11:04:59	Farrell – John Butters 220 kV line tripped via the OFGSS[1].	The John Butters generating unit operating mode continued to be selected to Synchronous Condenser mode from the previous occasion the unit went offline on 08 February 2012 at

[1] The Tasmanian Over Frequency Generation Shedding Scheme (OFGSS) is an automatic control scheme designed to maintain the Tasmanian frequency to within the Tasmanian frequency operating standards should a separation occur between North and South Tasmania due to tripping of transmission circuits.

The generating units involved in the OFGSS are all West Coast generation, specifically; Bastyan, John Butters, Mackintosh, Reece 1 and 2 and Tribute generating units which would manage the high power system frequency events in North Tasmania and Gordon generating units 2 and 3 would manage the high power system frequency events in South Tasmania when required. The frequency is measured locally to each generating unit.

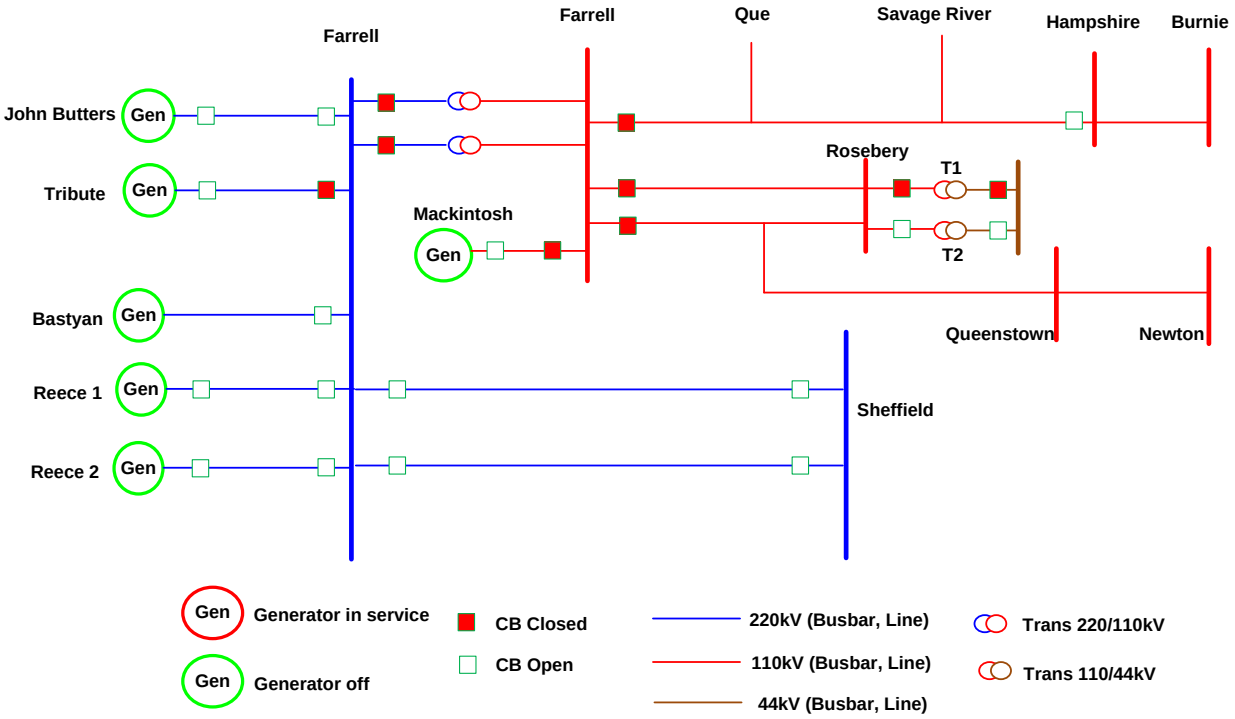
At Farrell Substation, the OFGSS would disconnect the required generation, sending a trip command to the line's CBs instead of tripping the units directly.

		0210 hrs. The John Butters generating unit was not online at the time of the incident.
11:04:59	Farrell – Reece No.1 220 kV line tripped via the OFGSS.	Disconnecting Reece unit 1.
11:04:59	Farrell – Reece No.2 220 kV line tripped via the OFGSS.	Disconnecting Reece unit 2.
11:05:06	Bastyan generating unit tripped via its own over frequency protection.	The Farrell – Bastyan 220 kV line should have tripped via the OFGSS.
11:05:06	Mackintosh generating unit tripped via its own over frequency protection.	The Farrell – Mackintosh 110 kV line should have tripped via the OFGSS.
11:10	Constraint set T-WESTCOAST_0 invoked.	Invoked as a result of West Coast generation = 0 MW.
11:14:19	Farrell – Sheffield No.1 220kV transmission line returned to service.	
11:15:24	Farrell – Sheffield No.2 220kV transmission line returned to service.	
11:22	West Coast load restoration was initiated.	Over 80% of the load was restored by 1256 hrs. The load was totally restored at approximately 1400 hrs.
11:30	Farrell – Sheffield No.1 and No.2 220 kV transmission lines were included in AEMO's Vulnerable Lines List.[2]	
11:33	Market Notice No.40252 issued advising of non-credible contingency event.	
11:45	Constraint set T-WESTCOAST_0 revoked.	
11:45	Reece and Mackintosh generating units returned to service.	
11:46	Bastyan generating unit returned to service.	

The status of the power system immediately after the incident is shown in Figure 2.

[2] List found in AEMO's document SO_OP_3715 – Power System Security Guidelines. Available from www.aemo.com.au.

Figure 2 - Status of the power system immediately after the incident



4 Immediate Actions Taken

At 1110 hrs, due to the loss of the generation in the West Coast area, AEMO invoked constraint set T-WESTCOAST_0.

Transend advised that the incident occurred as a result of lightning in the area, and consequently AEMO issued Market Notice No.40252 at 1133 hrs informing the market of a non-credible contingency event and the reclassification of the loss of both Farrell – Sheffield No.1 and No.2 220 kV transmission lines[3] as a credible contingency event.

In accordance with its operating procedure SO_OP 3715 Power System Security Guidelines, AEMO determined that it was appropriate to declare the Farrell-Sheffield No.1 and No. 2 220 kV lines as vulnerable and reclassify the lines as a credible contingency event when lightning is detected in proximity of the lines.

Before the event on 12 November 2012, the Farrell – Sheffield No. 1 and No. 2 220 kV transmission lines were not included in AEMO's list of vulnerable transmission lines, so no reclassification was required if lightning was detected in the area.

5 Follow-up Actions

At 1115 hrs, the Farrell – Sheffield No.1 and No.2 220 kV transmission lines were returned to service.

At 1122 hrs, the West Coast load restoration was initiated. Most of the load (over 80%) was restored by 1256 hrs and the entire load was restored by approximately 1400 hrs.

At 1145 hrs, constraint T-WESTCOAST_0 was revoked, Mackintosh and both Reece generating units were returned to service.

At 1146 hrs, Bastyan generating unit was returned to service.

[3] The Farrell-Sheffield No. 1 and No. 2 220 kV transmission lines are constructed on dual circuit towers.

AEMO included the Farrell – Sheffield No.1 and No.2 220 kV transmission lines in its Vulnerable Transmission Lines list and will reclassify the trip of these transmission lines as a credible contingency event when lightning is reported in the area. This will continue until the lines are removed from the Vulnerable Transmission Lines list according to the process indicated in AEMO's Power System Security Guidelines (SO_OP_3715)

After the incident, further investigations indicated that the Over Frequency Generation Shedding Scheme (OFGSS) correctly tripped the Farrell - Reece No.1 and No.2 220 kV lines (disconnecting both Reece units); however it failed to trip the Farrell - Mackintosh 110 kV line and Farrell - Bastyan 220 kV line. Mackintosh and Bastyan generating units subsequently tripped via their own over frequency protection schemes[4] when the frequency exceeded 60 Hz

Transend is investigating the operation and performance of the OFGSS during this event, including the tripping command to the Farrell - John Butters 220 kV line while the John Butters generating unit was selected to Synchonous Condensor mode. A report is expected by 31 March 2013.

Additionally, Transend has informed that the trip of the No. 2 110/44 kV transformer at Rosebery was caused by over current protection operation. A protection grading issue due to an incorrect current transformer ratio setting was identified by Transend. This issue has already been rectified at the time of preparation of this report.

There is no evidence to indicate that the OFGSS mal-operation and the trip of the Rosebery No.2 110/44 kV transformer are related.

6 Power System Security Assessment

This incident resulted in the electrical separation of the West Coast area of Tasmania from the rest of the region. Even though the generation and load in the West Coast area were lost, the rest of the Tasmanian system remained secure and the frequency standards were satisfied during this event.

As a consequence of this incident, the OFGSS tripped the Farrell - Reece No.1 and No.2 220 kV lines; but the scheme failed to trip the Farrell - Mackintosh 110 kV line and Farrell - Bastyan 220 kV line. Mackintosh and Bastyan units tripped due to their own over frequency protection schemes.

This matter is being investigated further by Transend.

6.1 Over Frequency Generation Shedding Scheme

Table 3 below provides the frequency tripping thresholds for the listed generating units.

Table 3: OFGSS Frequency tripping thresholds – West Coast generation

Generating Unit	OFGSS frequency tripping threshold	Comments
John Butters	Freq > 52.7 Hz	The unit was not in service; however its operation mode was set to Synchronous Condenser mode.
Reece 1	Freq > 53.0 Hz	Farrell – Reece No.1 220 kV line tripped via the OFGSS.
Reece 2	Freq > 53.2 Hz	Farrell – Reece No.2 220 kV line tripped via the OFGSS

[4] The over frequency protection for the West Coast machines are set at 60 Hz for 5 seconds.

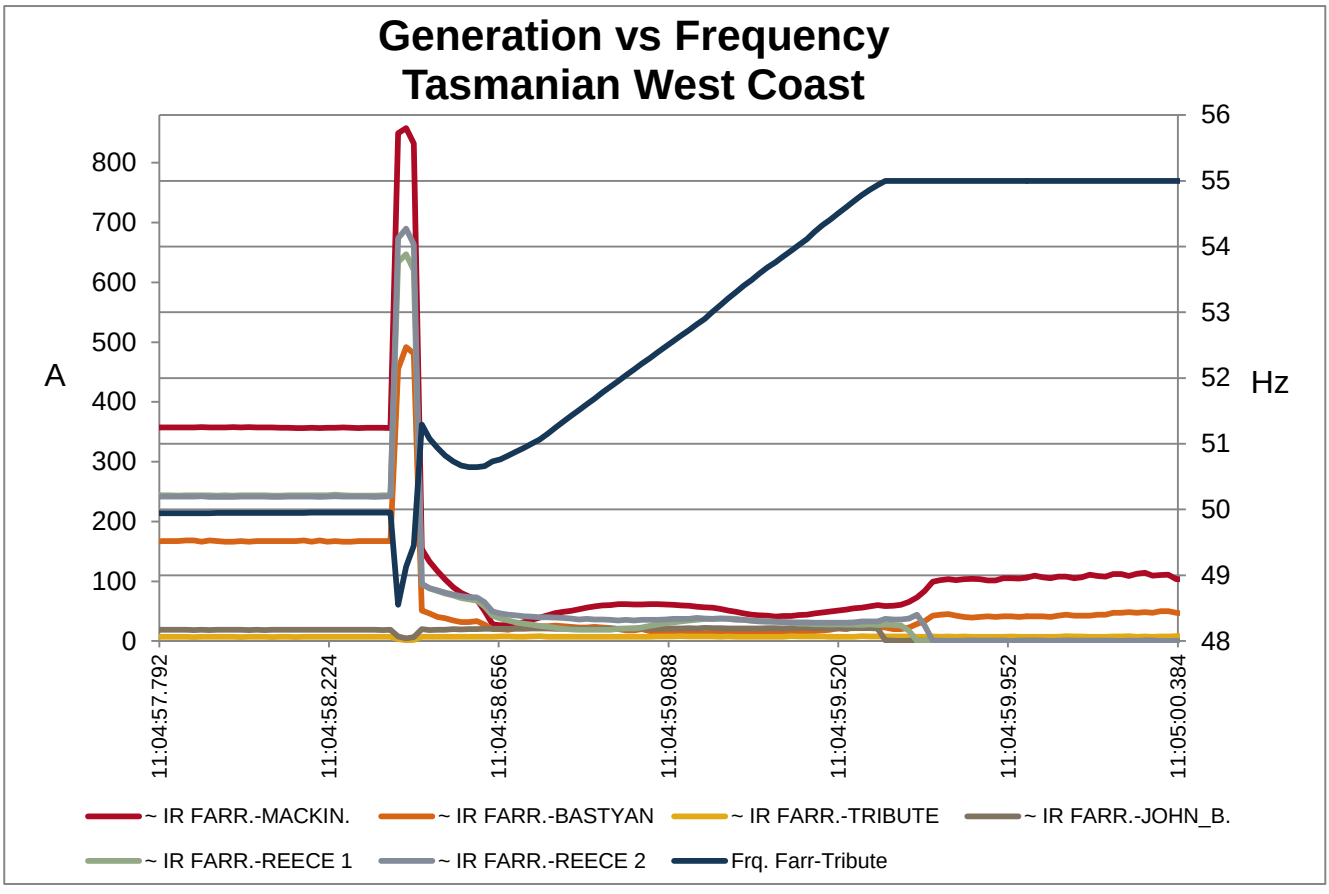
Tribute	Freq > 54.7 Hz	The Tribute generating unit was not in service at the time of the incident.
Bastyan	Freq > 55.0 Hz	The Bastyan generating unit was tripped by its own over frequency protection.
Mackintosh	Freq > 55.0 Hz	The Mackintosh generating unit was tripped by its own over frequency protection.

Although the frequency monitoring provided by Transend at Farrell Substation did not capture the frequency excursion (as the transducer saturates at 55 Hz), information from Hydro Tasmania for Bastyan and Reece Power Stations showed that frequency on the West Coast exceeded the OFGSS frequency tripping thresholds. A maximum frequency in the West Coast of approximately 64.9 Hz was observed.

Figure 3 shows the frequency at Farrell Substation and the current on the “Red” phase of every line connecting generation to Farrell 220 kV busbars. These current trends provide indications of the relative amounts of generation injected into each transmission line.

The Reece units were disconnected as intended according to the OFGSS tripping thresholds shown in Table 3.

Figure 3 – Generation vs. Frequency on Tasmanian West Coast area – measured at Farrell substation



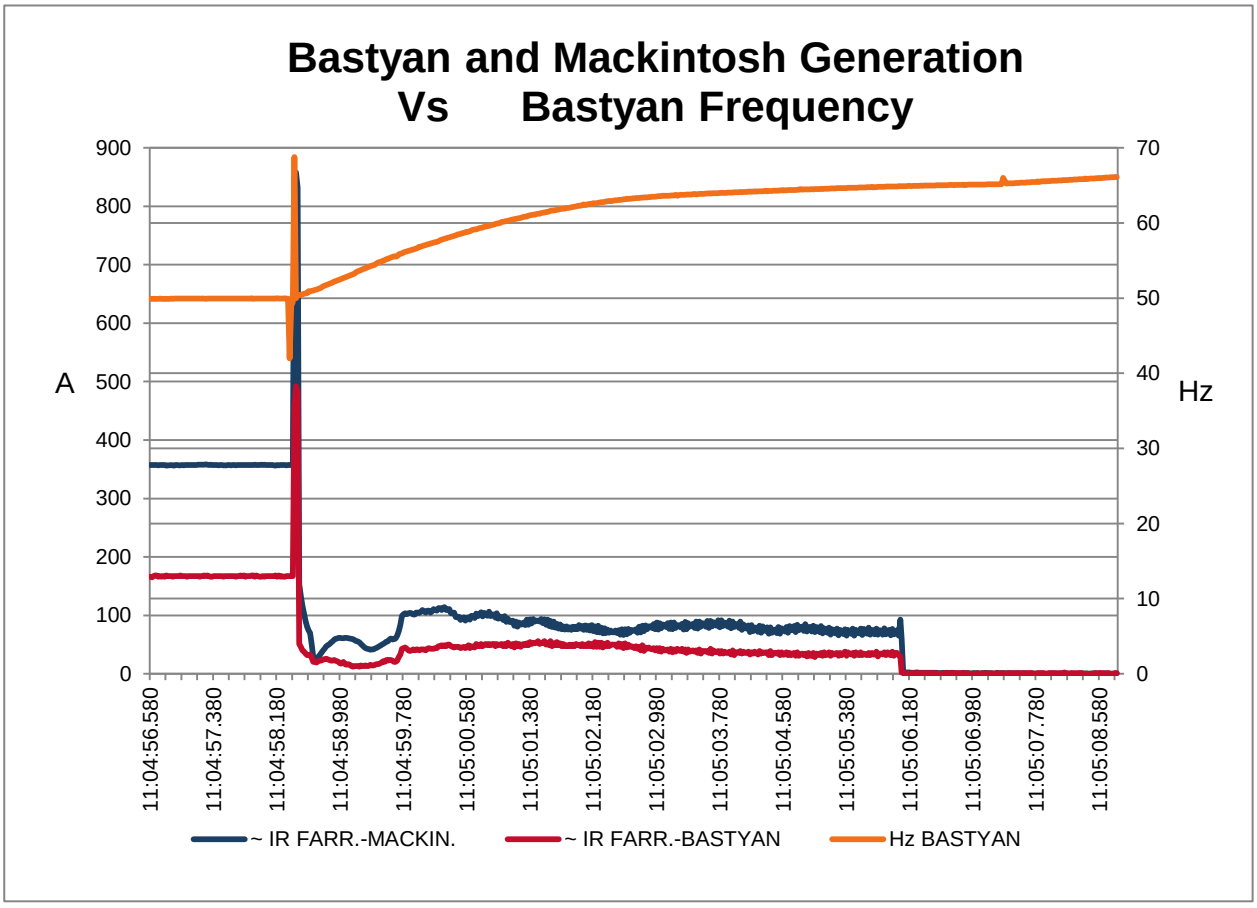
Even though the West Coast power system frequency exceeded 55 Hz, Mackintosh and Bastyan generating units were not disconnected by the OFGSS and remained on line for a further 6

seconds until the operation of their over frequency protection schemes tripped the generating units. This does not conform to the OFGSS tripping thresholds as per Table 3.

Figure 4 below has been created using data provided by Transend and Hydro Tasmania. The figure shows the current on the "Red" phase of the Farrell – Bastyan 220 kV line and the Farrell – Mackintosh 110 kV line (providing indication of the generation of the Bastyan and Mackintosh generating units) against the frequency recorded at Bastyan power station.

The Bastyan and Mackintosh generating units tripped approximately 5 seconds after the frequency reached 60 Hz; consistent with their over frequency protection settings.

Figure 4 – Bastyan and Mackintosh generation Vs. Bastyan frequency



The OFGSS is designed to block disconnection of generation that is in synchronous condenser mode. The John Butters generating unit was out of service since 08 November 2012 at 0200 hrs and was configured to synchronous condenser mode operation since around the same time. Despite this, the OFGSS sent a trip command to the Farrell – John Butter 220 kV line for this event.

On the day of the incident, the John Butters generating unit was still out of service.

An event on 30 October 2012[5] also revealed issues with the operation of the OFGSS where Reece 1 and 2 units were blocked from tripping although the units were not in synchronous condenser operation mode at the time. It was discovered later that this situation was due to a conflict between the Reece OFGSS relays indication and the Farrell RTU information. That particular issue has been resolved.

[5] The report relating to the power system incident that occurred on 30 October 2012 is available from www.aemo.com.au.

Transend has advised that they are investigating the response of the OFGSS during this event and will inform of any findings by 31 March 2013.

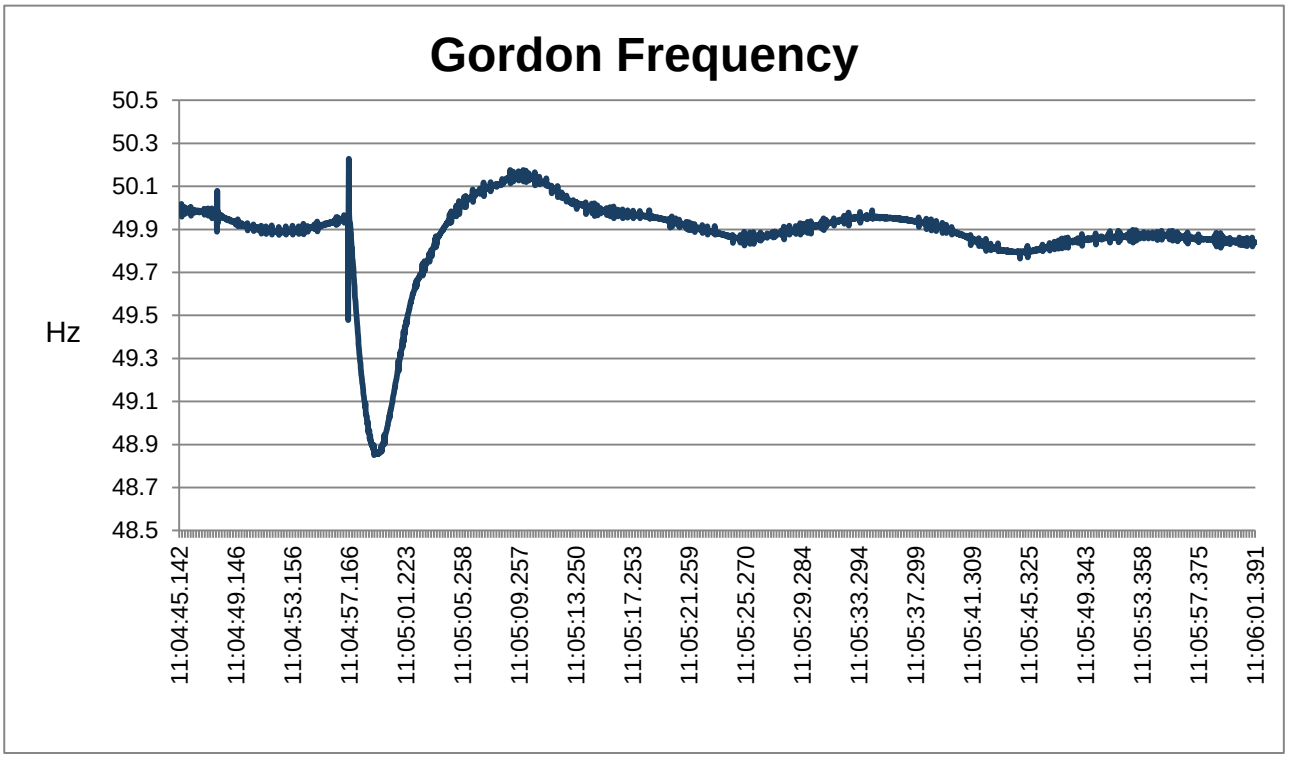
6.2 Tasmanian Frequency (South region post incident)

The separation event and sudden loss of generation in the West Coast area resulted in a low frequency excursion in the remaining part of the Tasmania region.

Figure 6 below shows the frequency recorded at Gordon Power Station during this event. The lowest frequency recorded was approximately 48.88 Hz.

The frequency standard for Tasmania in relation to a multiple contingency event was met and this was achieved primarily due to the response of Basslink.

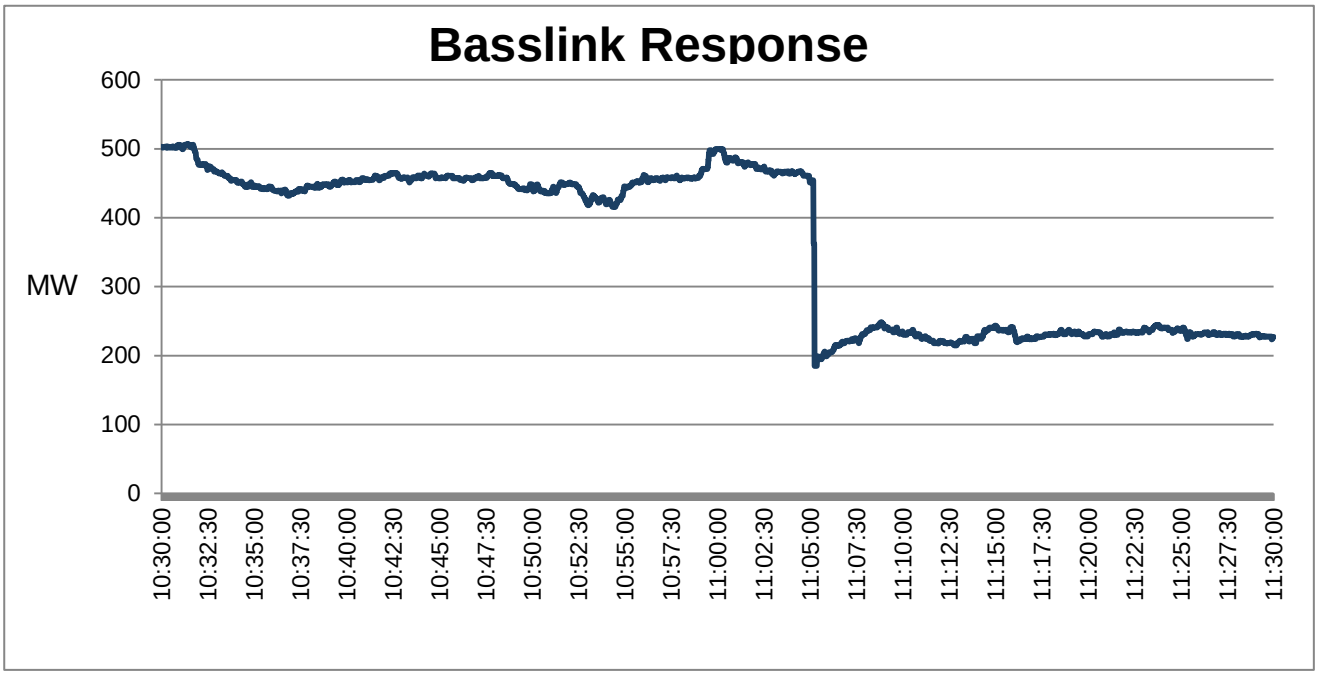
Figure 6 – Power system frequency measured at Gordon Power Station



6.3 Basslink Response

Prior to the incident Basslink was exporting approximately 454 MW to the Victorian region. With the loss of generation and load in the West Coast area the Basslink frequency controller responded to reduce the export to 184 MW approximately as shown in Figure 7.

Figure 7 – Basslink Power Transfer



Basslink response was in accordance with its design, reflecting the loss of generation and load in Tasmania.

7 Conclusions

1. The simultaneous trips of the Farrell – Sheffield No.1 and No.2 220 kV transmission lines were attributed to lightning in the area.
2. AEMO has included the Farrell – Sheffield No.1 and No.2 220 kV transmission lines in its Vulnerable Transmission Lines list and they will be reclassified as a credible contingency event when there is lightning in the area according to AEMO's Power System Security Guidelines (SO_OP_3715)[6].
3. AEMO correctly applied the criteria published in section 12 of its operating procedure SO_OP 3715 Power System Security Guidelines in assessing the reclassification of the Farrell-Sheffield No.1 and 2 220 kV transmission lines as a credible contingency event when lightning is detected in the vicinity of the lines.
4. The West Coast load restoration process started at 1122 hrs approximately. Most of the load was restored before 1300 hrs. The entire load was restored by 1400 hrs.
5. The remainder of the Tasmanian power system was in a secure state and the applicable Frequency Operating Standards were met at all times during this event.
6. The OFGSS operated correctly in disconnecting Reece units 1 and 2.
7. The OFGSS operated incorrectly in relation to tripping the Farrell - John Butters 220 kV line with the John Butters generating unit selected to synchronous condenser mode.
8. The OFGSS failed to disconnect the Bastyan and Mackintosh generating units when the power system frequency exceeded the OFGSS over frequency tripping thresholds.
9. The provision and response of facilities and services were adequate in relation to power system security. Appropriate actions were taken to maintain power system security.

[6] Available from the AEMO website at www.aemo.com.au.

8 Recommendation

Transend will investigate the operation of the OFGSS and inform AEMO and Hydro Tasmania of its findings and any corrective actions required or taken by 31 March 2013.