

POWER SYSTEM OPERATING INCIDENT REPORT: TRIPS OF FARRELL – SHEFFIELD NO 1 AND NO 2 220 KV LINES ON 8 DECEMBER 2012

PREPARED BY: System Performance and Commercial

DATE: 27 March 2013

FINAL

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Abbreviations and Symbols

Abbreviation	Term
CB	Circuit Breaker
DI	Dispatch Interval
EMMS	Electricity Market Management System
EMS	Energy Management System
FCAS	Frequency Control Ancillary Service
kV	Kilovolt
ms	Millisecond
MW	Megawatt
MWh	Megawatt hour
NEM	National Electricity Market
NEMDE	National Electricity Market Dispatch Engine
NER	National Electricity Rules
NOS	Network Outage Schedule
SPAR	Single Pole Auto Reclose

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Incident summary

Date and time of incident	8 December 2012 at 1942 hrs
Region of incident	Tasmania
Affected regions	Tasmania
Event type	TL – Loss of transmission elements and load interruption
Primary cause	ENVI & LN – Environmental and Lightning
Impact	S – Significant
Associated reports	Nil.

1 Introduction

At approximately 1942 hrs on 8 December 2012 the Cethana – Sheffield and Sheffield – Wilmot 220 kV Transmission Lines tripped and re-closed successfully in a single pole protection operation. This was followed by the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines while reclassified as a credible contingency event due to lightning in the vicinity. This resulted in the electrical islanding of the Tasmanian West Coast power system. Approximately 1 second later, the Rio Tinto No 2 and No 3 potlines tripped due to the operation of under voltage protection, resulting in 105 MW of load interrupted. There was no loss of generation.

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. 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 could potentially be supplied by local generation via Reece, John Butters, Tribute, Bastyan and Mackintosh Power Stations. The load could also be supplied via the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines as well as via a network called the Hampshire link when network conditions are appropriate.

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 only. Bastyan was the only generating unit supplying a total estimated load of 40 MW in the Tasmanian West Coast.

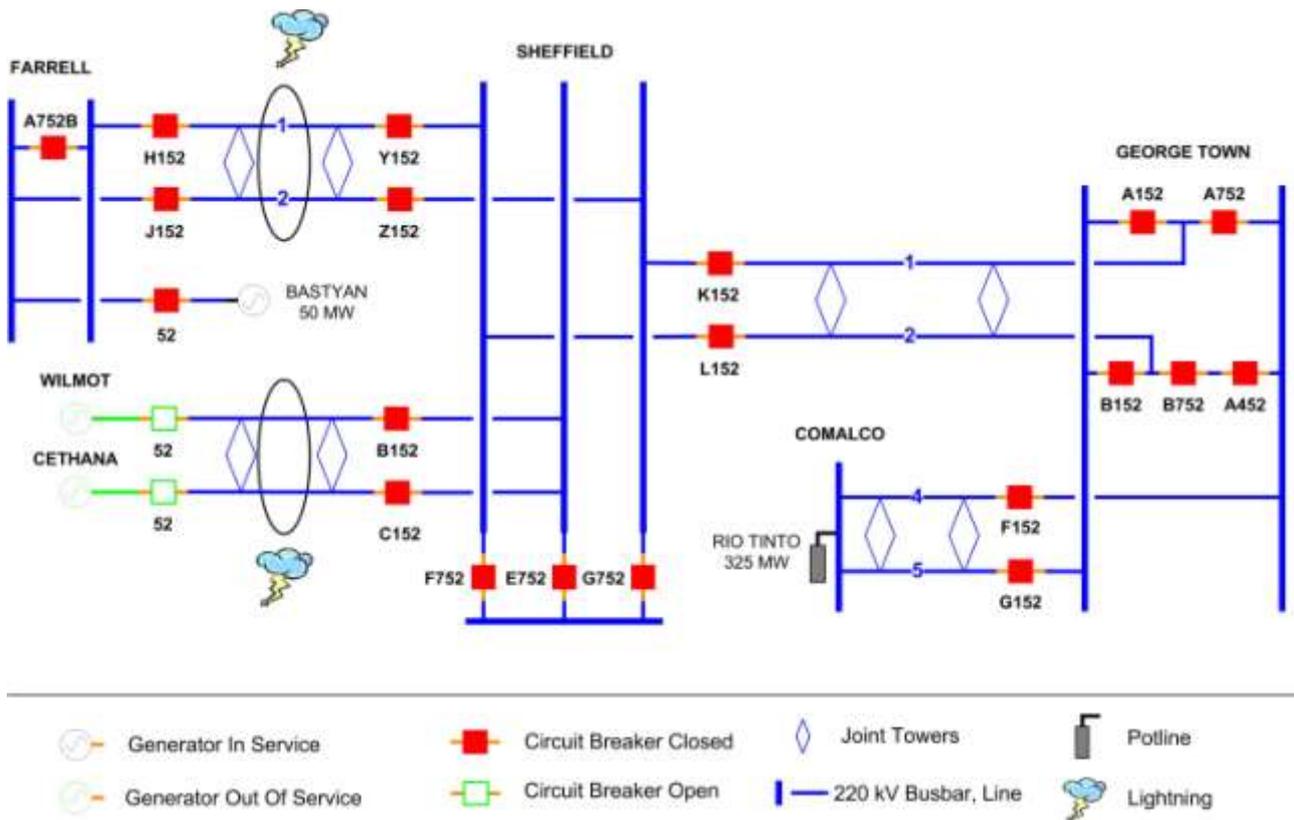
At 1910 hrs, the simultaneous trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines was reclassified as a credible contingency event due to the presence of lightning in the vicinity of the transmission lines. The transmission lines were considered vulnerable to lightning and were included in the list of vulnerable transmission lines in accordance with the AEMO Power System Security Guidelines SO_OP_3715 section 12.4.2¹. As a result the constraint sets F-T-FASH_N-2 and T-FASH_N-2_HM_0_4 were invoked. AEMO issued Electricity Market Notice No 40590 advising of the reclassification of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines trip.

Lightning was also present in the vicinity of the Cethana – Sheffield and Sheffield – Wilmot 220 kV Transmission Lines, however these were not reclassified as credible contingency events as they were not considered vulnerable to trip during lightning storms and were not included in the list of vulnerable transmission lines, in accordance with the AEMO Power System Security Guidelines SO_OP 3715 section 12.4.2. The status of the 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.

¹ List of vulnerable transmission lines is included in section 12.4.2 of the AEMO Power System Security Guidelines SO_OP_3715 available from the AEMO website at www.aemo.com.au

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



3 Summary of Events

At 1910 hrs the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines was reclassified as a credible contingency event due to the presence of lightning in close proximity to the transmission lines. At 1942 hrs severe lightning in close proximity to Sheffield Substation resulted in two separate fault incidents in quick succession of each other.

At 19:41:56, the first incident occurred as a single phase to ground fault² on each of the Sheffield – Wilmot (Blue Phase) and Cethana – Sheffield (White Phase) 220 kV Transmission Lines. There was no load on the transmission lines at the time of the trip. The faults were cleared by protection equipment within 100 ms. The transmission lines underwent a single pole protection operation simultaneously and auto reclosed successfully (SPAR operation).

At 19:41:56, the second incident occurred as a single phase to ground fault (White Phase) resulting in simultaneous trips of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines while reclassified as a credible contingency event. The faults were cleared by protection equipment within 60 ms. This incident resulted in the islanding of the Tasmania West Coast power system with only the Bastyan generating unit in service supplying an estimated load of 40 MW, and separate to the power system in the remainder of the Tasmania region.

Approximately 1 second later, the Rio Tinto No 2 and No 3 pot lines at Comalco tripped due to the operation of under voltage protection, resulting in approximately 105 MW of load interrupted. At 1950 hrs the Rio Tinto load was restored.

At 2105 hrs the reclassification of the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines was cancelled due to the absence of lightning in close proximity to the transmission lines.

A summary of events is shown in Table 1 below.

² This is accepted power systems operation terminology. The NER terminology is ‘one phase to ground fault’.

Table 1 – Summary of the sequence of events

Time	Events / Comments
19:10	Tripping of the Farrell – Sheffield No 1 and No 2 220 kV transmission lines reclassified as a credible contingency event due to lightning in the vicinity of the transmission lines. Constraint sets F-T-FASH_N-2 and T-FASH_N-2_HM_0_4 invoked
19:24	AEMO issues Market Notice No 40590 advising of reclassification of the Farrell – Sheffield No 1 and No 2 220 kV transmission lines
19:41:56	Single phase to ground fault on each of the Cethana – Sheffield (White Phase) and Sheffield – Wilmot (Blue Phase) 220 kV transmission lines while carrying no load, resulting in a single phase trip and auto reclose of both lines. The faults were cleared in 80 ms and 100 ms respectively
19:41:56	Farrell – Sheffield No 1 and No 2 220 kV lines trip with the fault clearing in 60 ms. Tasmanian system separated into two electrical islands. Tasmanian West Coast island total load estimated to be approximately 40 MW
19:41:57	Rio Tinto No 2 and No 3 potlines trip due to under voltage protection resulting in 105 MW total load interrupted
19:50	Rio Tinto potlines load restored
19:50	Farrell – Sheffield No 1 and No 2 220 kV transmission lines returned to service. Tasmania West Coast load reconnected to the Tasmania network and no longer operating as an electrical island
20:10	AEMO issues Market Notice No 40592 advising of the tripping of the Farrell – Sheffield No 1 and No 2 220 kV transmission lines
21:05	Farrell – Sheffield No 1 and No 2 220 kV transmission lines reclassification cancelled due to the absence of lightning. Constraint sets F-T-FASH_N-2 and T-FASH_N-2_HM_0_4 revoked
21:09	AEMO issues Market Notice No 40599 advising that the reclassification of the Farrell – Sheffield No 1 and No 2 220 kV transmission lines has been cancelled

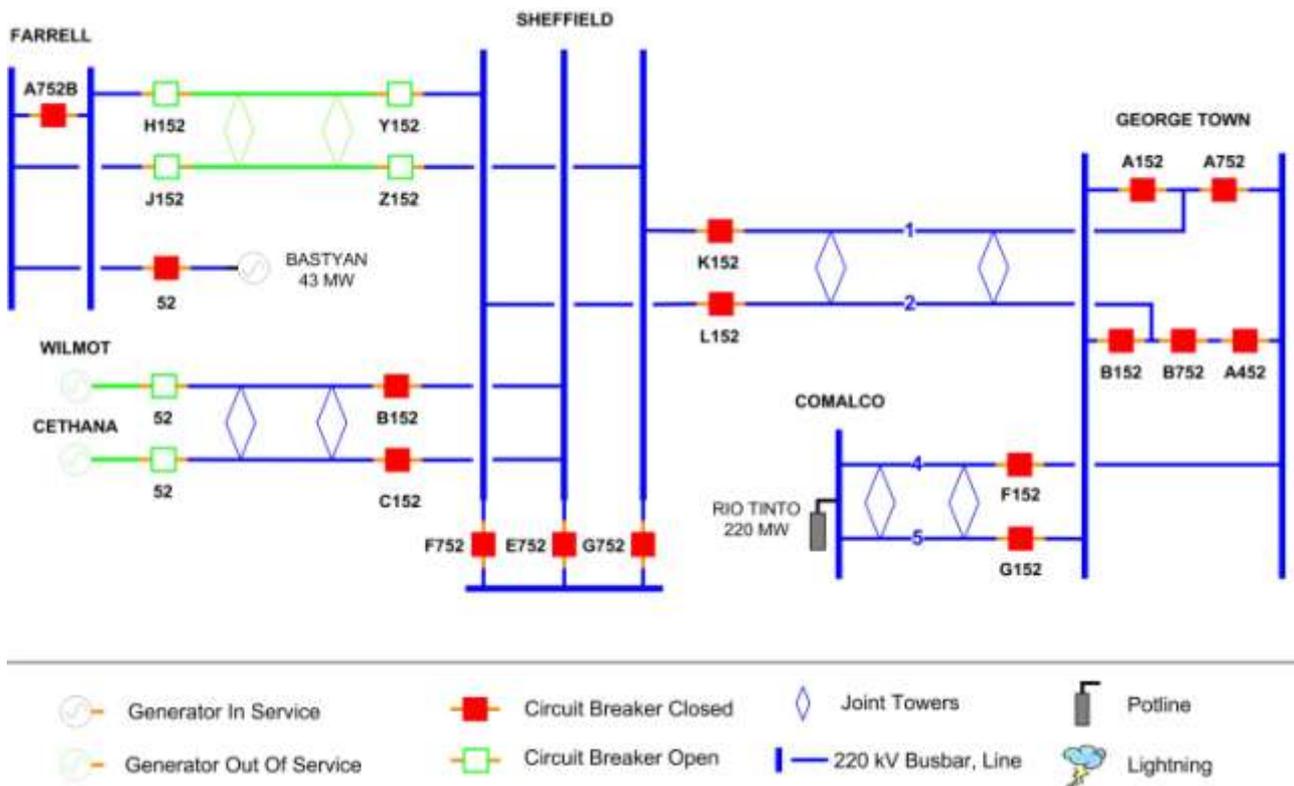
4 Post-Contingent System Conditions

The single pole trip and auto reclose operation that occurred on the Cethana – Sheffield and Sheffield – Wilmot 220 kV Transmission Lines, has resulted in the affected circuit breakers of the transmission lines reclosing after their trip and as a result the transmission lines remained in service.

The trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines resulted in the establishment of an electrical island of the Tasmanian West Coast load with only the Bastyan generating unit supplying this load. The total load on the Tasmanian West Coast island at the time was approximately 40 MW.

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

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



5 Immediate Actions Taken

The single pole auto reclose protection operations on each of the Cethana – Sheffield 220 kV Transmission Line and the Sheffield – Wilmot 220 kV Transmission Line were considered by AEMO after the incident and in accordance with Section 12.4.1 in SO_OP 3715. AEMO did not reclassify the simultaneous tripping of both lines as a credible contingency event as the transmission lines remained in service following the SPAR operation.

AEMO issued Electricity Market Notice No 40592 advising of the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines due to lightning.

At 1950 hrs the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines were returned to service and the Rio Tinto load at Comalco was restored.

At 2105 hrs the reclassification of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines was cancelled due to the absence of lightning in the vicinity of the transmission lines. AEMO issued Market Notice No 40599 to advise that the reclassification has been cancelled.

6 Follow-up Actions

On 9 December 2012, based on the information available relating to the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines and the Rio Tinto pot lines load trip, AEMO deemed it appropriate to reclassify the simultaneous trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines and Rio Tinto load of 100 MW at Comalco as a credible contingency event, whenever the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines is reclassified as a credible contingency event.

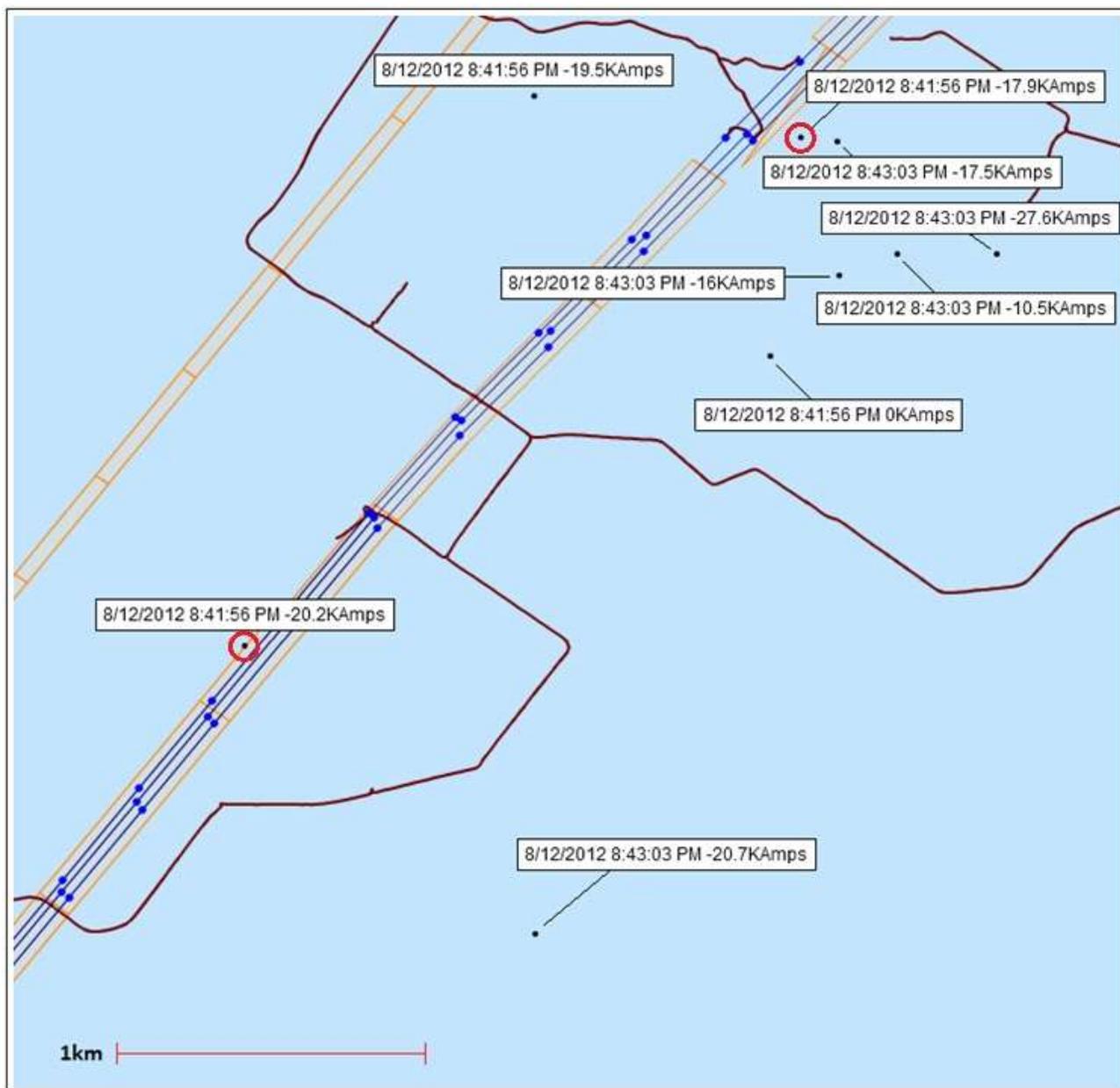
At 0644 hrs on 9 December 2012 AEMO issued Market Notice No 40617 to advise that the simultaneous trip of the Farrell – Sheffield No 1 and No 2 220 kV transmission lines and the Rio Tinto potline load of 100 MW would be reclassified as a credible contingency event whenever the trip of the Farrell – Sheffield No 1 and No 2 220 kV transmission lines is reclassified as a credible contingency event in future scenarios.

At 0701 hrs on 9 December 2012 AEMO issued Market Notice No 40618 to advise corrections to references made to earlier Market Notices No 40617 and No 40590.

Transend have advised that the reason for the Rio Tinto potline load trip at Comalco was due to the operation of under voltage protection as a result of an apparent extended fault duration. The fault duration was a result of the first incident of the trip of the Cethana – Sheffield and Sheffield – Wilmot 220 kV Transmission Lines, and the second incident of the trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines which occurred very soon after the first incident.

Figure 3 below shows the GPATS (Global Positioning and Tracking System) map for the Sheffield substation area on 8 December 2012 at approximately 1942 hrs³.

Figure 3 – GPATS map for Sheffield substation area at approximately 1942 hrs on 8 December 2012 showing Lightning strike times and magnitudes.

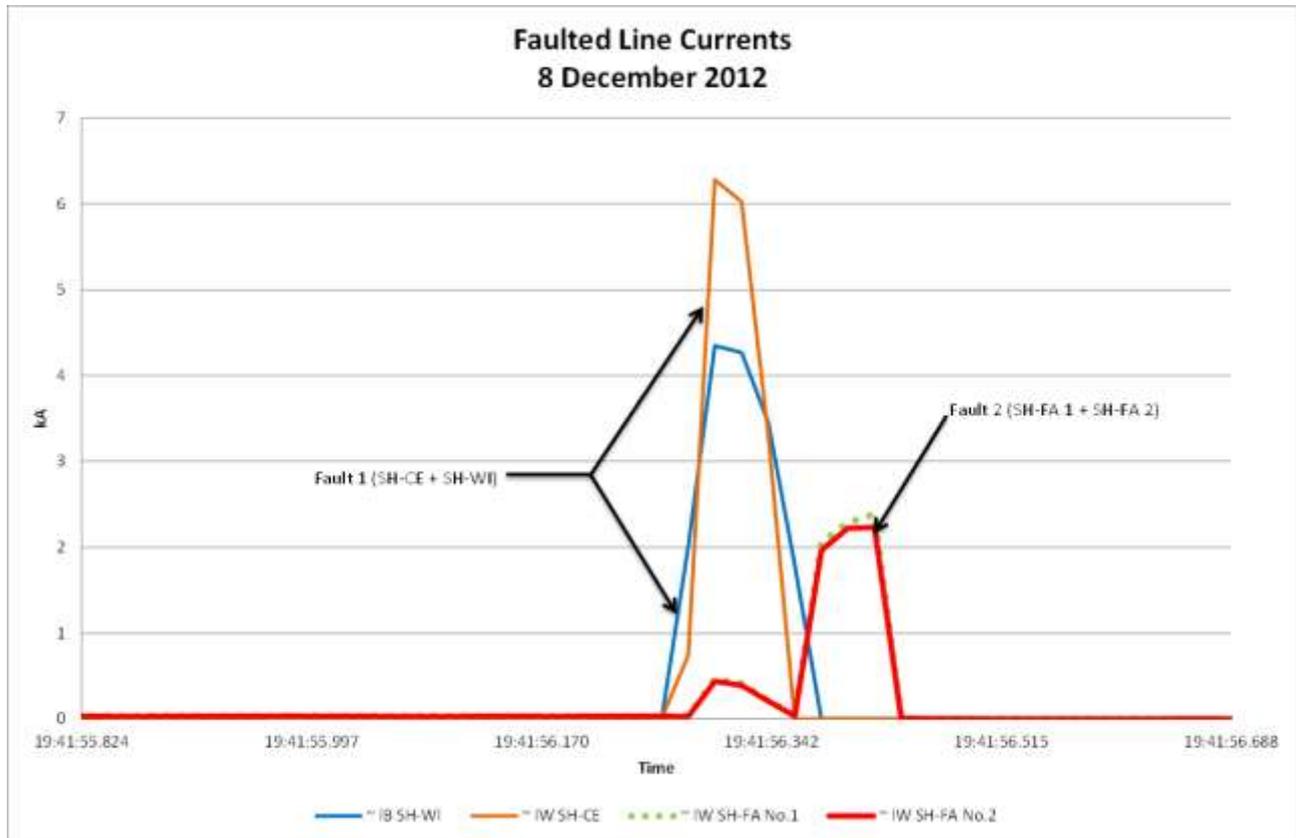


All times in Figure 3 are shown in Australian daylight savings time. The Farrell – Sheffield No 1 and No 2, Cethana – Sheffield and Sheffield – Wilmot 220 kV transmission lines are shown in blue within an orange easement. Four lightning strikes were detected at 19:41:56 with the two closest to the transmission lines most likely to have caused the incidents encircled in red.

³ Figures 3 to 5 sourced from Transend Operations Group Report – 8 December 2012

Figure 4 below shows the fault currents as a result of the two incidents.

Figure 4 – Fault line currents for the two separate incidents near Sheffield substation that occurred within a very close time interval with one another.



As shown in Figure 4 the two incidents occurred within a very close time interval and the figure shows that the fault on the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines begins at a time when the fault on the Sheffield – Wilmot 220 kV Transmission Line has not yet been fully cleared.

Georgetown Substation is an intermediate location that connects the Sheffield Substation and Rio Tinto potlines. Refer to Figures 1 and 2 for further information. Figure 5 below shows the voltage at Georgetown Substation for each of the White, Blue and Red phases.

Figure 5 – Voltages at Georgetown Substation for each of the White, Blue and Red phases

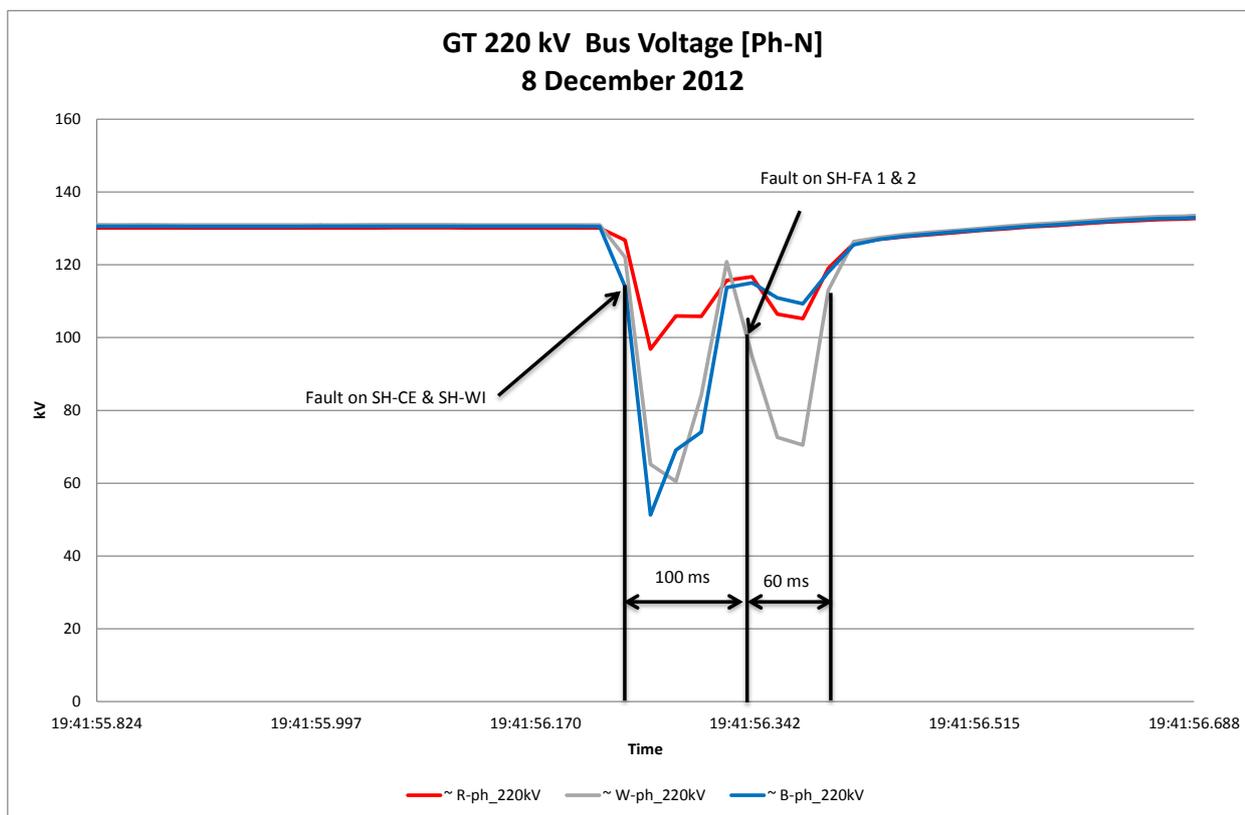


Figure 5 shows the voltages indicating the general profiles of the two independent faults and similar to Figure 4, shows that the voltage does not recover fully after the first fault occurs and before the second fault begins.

The fault current and voltage profiles shown in Figures 4 and 5 are consistent with the statement from Transend that the trip of Rio Tinto load occurred due to an extended fault duration caused by two separate lightning trips within a very close time interval and where an overlap of the two incidents is observed.

This represents an unusual event where two incidents related to lightning have occurred in close chronological order and there is a time overlap in the incidents' beginning and end times. This has resulted in an extended fault duration and a trip due to the operation of under voltage protection.

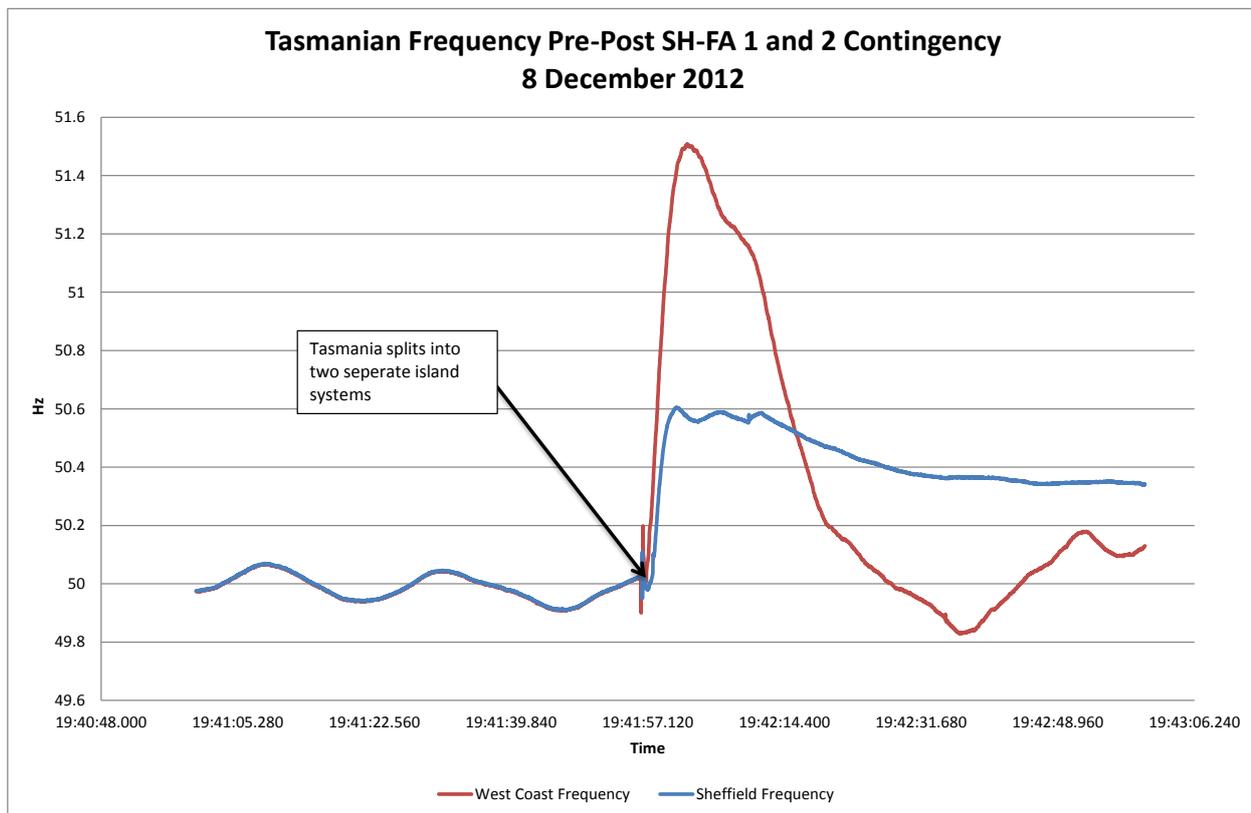
After reviewing the circumstances leading to the tripping of the Farrell - Sheffield No 1 and No 2 220 kV transmission lines and the Rio Tinto potline, and although the elements tripped near to the same time, AEMO is now satisfied that they were independent events and unrelated to each other.

At 1132 hrs on 21 March 2013 AEMO issued Market Notice No 41957 cancelling the reclassification of the simultaneous trip of of both Farrell - Sheffield No 1 and No 2 220 kV transmission lines and the Rio Tinto potline.

7 Power System Security Assessment

This incident resulted in the formation of two electrical islands within the Tasmanian Region. The first island comprised the West Coast load with only the Bastyan generating unit supplying load and the second island comprised the remainder of the power system in the Tasmanian region. Figure 6 below shows the power system frequencies recorded in each of the West Coast and remainder of Tasmania electrical islands.

Figure 6 – Frequencies of Tasmania West Coast and remainder of Tasmania.



Following the incident, the West Coast island frequency reached a maximum of 51.5 Hz and the remainder of the Tasmanian region frequency rose to 50.6 Hz as a result of the Rio Tinto pot line load trip. All frequency values remained within limits following the contingency as required by the Tasmania Frequency Operating Standards⁴.

Protection systems operated to clear faults on each of the Sheffield – Wilmot, Cethana – Sheffield and Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines within 120ms as required by the NER for a fault on a 220 kV network. System voltages also remained within satisfactory limits.

The incident also resulted in the tripping of the Rio Tinto potlines with a combined load of 105 MW. Transend advised that the reason for the potlines tripping was due to the apparent extended duration of the fault detected. While the two separate fault incidents described above each cleared within 120ms as required by the NER, both events occurred within approximately 160ms in close chronological order. As a result, an apparent extended fault duration appeared to have occurred resulting in the tripping of the Rio Tinto potline loads. Transend have confirmed that the potlines tripping was due to under voltage protection.

There was no loss of generation as a result of this contingency event.

8 Conclusions

AEMO correctly applied the criteria published in section 12 of its Power System Security Guidelines in assessing that the circumstances of this incident. AEMO's actions were appropriate and timely.

Severe lightning in close proximity to the Sheffield Substation resulted in a single phase trip and auto reclose on the Sheffield – Wilmot and Sheffield – Cethana Transmission Lines and the simultaneous trip of the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines. The loss of

⁴ Frequency Operating Standards (Tasmania) available from the AEMC website at <http://www.aemc.gov.au/Panels-and-Committees/Reliability-Panel/Guidelines-and-standards.html>

the Farrell – Sheffield No 1 and No 2 220 kV Transmission Lines caused the islanding of the West Coast of Tasmania with only the Bastyan generating unit supplying load.

Two separate fault incidents in close chronological order, resulted in an apparent extended fault duration and caused the tripping of the Rio Tinto potline loads.

The post-contingent frequencies for each of the West Coast and remainder of Tasmania electrical islands remained within limits according to Tasmanian Frequency Operating Standards. All faults were also cleared within 120ms as required by the NER, and system voltages remained within satisfactory limits.

AEMO is satisfied that coincident faults of this type are unlikely to occur often and is satisfied with the response from Rio Tinto via Transend.

9 Recommendations

There are no recommendations arising from this incident.