Power System Operating Incident Report – Trip of Red Cliffs–Horsham and Red Cliffs-Wemen–Kerang 220 kV transmission lines on 15 January 2014

PREPARED BY: AEMO Systems Capability

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STATUS: FINAL

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Version Release History

VERSION	DATE	BY	CHANGES	CHECKED BY	AUTHORISED BY
1	19 May 2014	P McEniery	FINAL	S Darnell	P Biddle

Incident Classifications

Time and date and of incident	2205 hrs Wednesday 15 January 2014
Region of incident	Victoria
Affected regions	Victoria, South Australia
Event type	TL – Loss of transmission elements and load interruption
Primary cause	PTN & CTR – Protection and Control
Impact	Not Significant – Loss of load or generation less than 50 MW.
Associated reports	Nil

Abbreviations

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
EMMS	Electricity Market Management System
EMS	Energy Management System
HOTS	Horsham Terminal Station
KGTS	Kerang Terminal Station
kV	Kilovolt
MW	Megawatt
NER	National Electricity Rules
RCTS	Red Cliffs Terminal Station
SOTF	Switch On To Fault
WETS	Wemen Terminal Station

1 Introduction

This report reviews a power system operating incident that occurred on Wednesday 15 January 2014 in Victoria, and related further events that occurred on Thursday 16 January 2014. AEMO is required to review this incident as it is classified as a non-credible contingency that satisfies the requirements of a reviewable operating incident under the National Electricity Rules[1] (NER).

The purpose of this incident review is to assess power system security over the course of the incident. The NER requires AEMO 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[2].

This report is based upon information provided by AEMO and SP AusNet[3]. Data from AEMO's Energy Management System (EMS) and Electricity Market Management System (EMMS) has also been used in analysing the incident.

National Electricity Market time (Australian Eastern Standard Time) is used in this report.

2 The Incident

On Wednesday 15 January 2014 at 2205 hrs the Red Cliffs Terminal Station (RCTS) – Horsham Terminal Station (HOTS) 220 kV transmission line tripped.

In addition the circuit breakers on the RCTS – Wemen Terminal Station (WETS) - Kerang Terminal Station (KGTS) 220 kV transmission line opened at WETS and KGTS only. As a result 42 MW of load was lost at WETS.

Similar trips also occurred on the following day Thursday 16 January 2014, at 1245 hrs and 1454 hrs, with 37 MW and 11 MW of load lost at WETS respectively.

The reason for investigating this incident is that multiple transmission elements tripped, and that a transmission line did not open at one end. These are unexpected events known in power system security terms as non-credible contingencies[4]. Transmission lines do not usually trip simultaneously, and usually open at every end under fault conditions.

3 Participant Investigation

SP AusNet investigated the incident, and found the following:

- SP AusNet identified that the trip on the RCTS-HOTS 220 kV transmission line was due to a red phase to blue phase fault. The fault was due to smoke from a bushfire burning under the RCTS-HOTS 220 kV transmission line.
- The RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS due to the operation of zone 3 distance protection at WETS with its Switch on to Fault (SOTF) function enabled. This protection operation also opened the 66 kV circuit breaker at WETS and sent an inter-trip signal to open the transmission line at KGTS. These protection operations were by design.
- The protection operations on the RCTS-WETS-KGTS 220 kV transmission line would not normally be expected to occur for a fault on the RCTS-HOTS 220 kV transmission line.

[1] NER Clause 4.8.15(a)(1)(i) and AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.
[2] NER Clause 4.8.15 (b).
[3] Information provided by SP AusNet has been provided on a without prejudice basis and nothing in this report is intended to constitute, or may be taken by any person as constituting, an admission of fault, liability, wrongdoing, negligence, bad faith or the like on behalf of SP AusNet (or its respective associated companies, businesses, partners, directors, officers or employees).
[4] NER 4.2.3 - Credible and non-credible contingency events; *AEMO Power System Security Guidelines,* Section 10 - Definition of a non-credible contingency events.

- The RCTS-WETS-KGTS 220 kV transmission line did not open at the RCTS end because the protection at RCTS operates for faults in the WETS/KGTS direction.

The investigation concluded that all protection operated as designed[5]. However, the protection design did not envisage this type of incident. After completing the investigation, SP AusNet disabled the SOTF function to prevent any further re-occurrence of the incident.

SP AusNet intends to carry out a review to determine if a similar incident could occur with other similar protection schemes in the Victorian network, and if required will make the appropriate changes to protection settings.

4 System Diagrams

The status of the power system before and after the incident on 15 January 2014 is shown in Figures 1 and 2. For clarity only equipment relevant to this incident has been included. Figure 2 shows the following:

- The RCTS-HOTS 220 kV transmission line tripped, with an automatic reclose at the HOTS end.
- The RCTS-WETS-KGTS 220 kV transmission line tripped at the WETS and KGTS ends. At WETS 42 MW of load was lost.
- The Murraylink interconnector reduced flow towards South Australia from 100 MW to 0 MW, due to the Murraylink runback scheme operating as designed when the transmission lines tripped.
- Due to the runback of Murraylink, the Robertstown – Northwest Bend No.1 132 kV transmission line was insecure for the trip of the Robertstown – Northwest Bend No.2 132 kV transmission line.

[5] Further detail on the RCTS-WETS-KGTS 220 kV transmission line protection scheme is in Appendix A

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

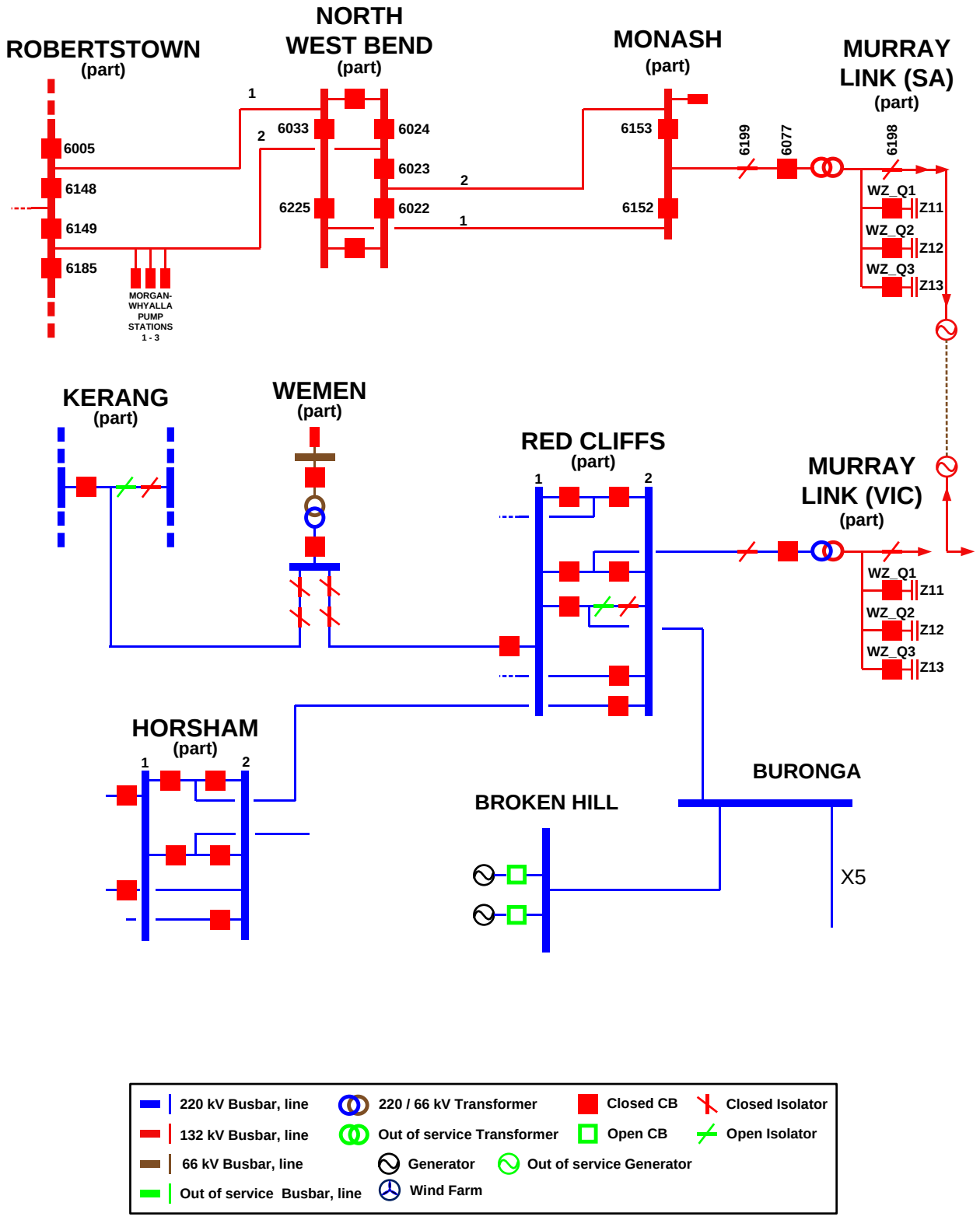
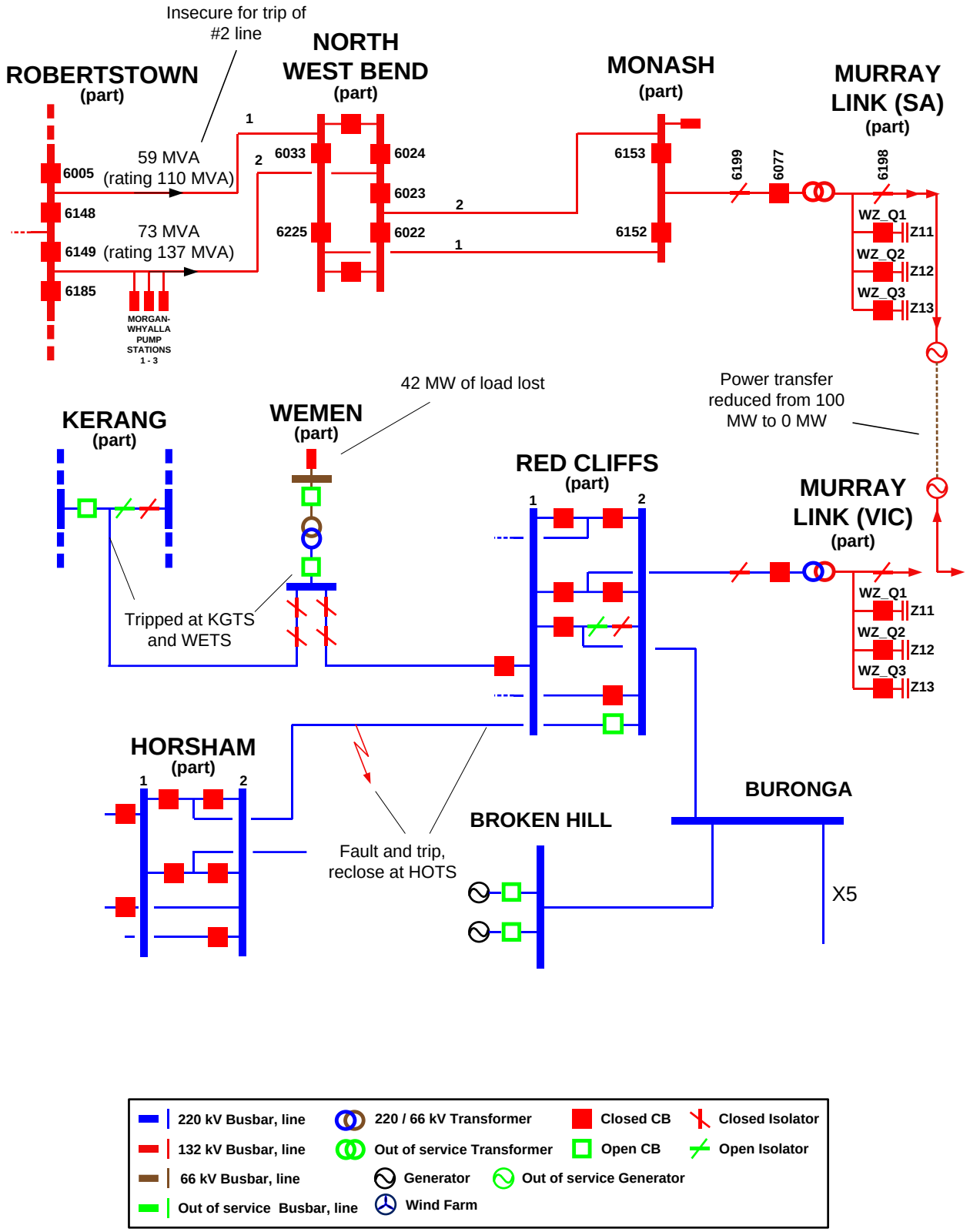


Figure 2 - Status of the power system immediately after the incident



5 Incident Event Log

The sequence of events comprising the incident is in Table 1.

Table 1 – Event Log

Time and Date	Event
2205 hrs 15 Jan2014	Trip of RCTS-HOTS 220 kV transmission line, and RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS only. 42 MW of load lost at WETS.
2211 hrs 15 Jan 2014	RCTS-HOTS 220 kV transmission line returned to service
2220 hrs 15 Jan 2014	Constraint set V-KGRC invoked.
2231 hrs 15 Jan 2014	RCTS-WETS-KGTS 220 kV transmission line returned to service.
2239 hrs 15 Jan 2014	Market Notice 44596 issued: non-credible contingency occurred.
2240 hrs 15 Jan 2014	Constraint set V-KGRC revoked.
2311 hrs 15 Jan 2014	Market Notice 44602 issued: reclassification declared.
1245 hrs 16 Jan 2014	Trip of RCTS-HOTS 220 kV transmission line, and RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS only. 37 MW of load lost at WETS.
1454 hrs 16 Jan 2014	Trip of RCTS-HOTS 220 kV transmission line, and RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS only. 11 MW of load lost at WETS.
1600 hrs 16 Jan 2014	Direction issued to Broken Hill Gas Turbines.
1645 hrs 16 Jan 2014	SOTF function at WETS disabled.
1700 hrs 16 Jan 2014	RCTS-HOTS 220 kV transmission line returns to service.
1814 hrs 16 Jan 2014	Market Notice 44645: reclassification cancelled.
2040 hrs 16 Jan 2014	Direction to Broken Hill Gas Turbines cancelled.

6 Immediate Responses

This section assesses the actions taken as the immediate response to the initial incident on 15 January.

- The Murraylink interconnector resumed transferring power to South Australia in the next dispatch interval, approximately five minutes after the incident. This reduced the loading on the Robertstown-Northwest Bend No.1 132 kV transmission line to below its secure limit.
- At 2211 hrs the RCTS-HOTS 220 kV transmission line was returned to service.
- AEMO invoked constraint set V-KGRC[6] at 2220 hrs approximately 15 minutes after the incident. This action ensured that the power system was in a secure operating state. AEMO is required to return the power system to a secure state within thirty minutes following a contingency event.
- At 2231 hrs the RCTS-WETS-KGTS 220 kV transmission line was returned to service.
- At 2239 hrs AEMO issued Market Notice 44596 to notify the market of the non-credible contingency event[7].
- Constraint set V-KGRC was revoked at 2240 hrs.

[6] Outage = Kerang to Red Cliffs 220 kV line

[7] This was within two hours of the event – AEMO is required to notify the market of a non-credible contingency within two hours of the event – AEMO, *Power System Security Guidelines,* Section 10.3.

- At 2311 hrs AEMO issued Market Notice 44602 to notify the market that the non-credible contingency event had been reclassified as a credible contingency[8].

7 Follow-up Responses

This section assesses the follow-up actions taken to resolve the incident.

Protection operation data indicated a fault occurred on the RCTS-HOTS 220 kV transmission line, approximately 110 km south of RCTS. AEMO's bushfire monitoring system indicated that a bushfire was burning near the RCTS-HOTS 220 kV transmission line. SP AusNet commenced a patrol of the RCTS-HOTS 220 kV transmission line on 16 January 2014, to confirm the cause of the trip.

During the line patrol the incident repeated itself twice:

- At 1245 hrs, the RCTS-HOTS 220 kV transmission line tripped and the RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS only. As a result 37 MW of load was lost at WETS. All transmission elements were returned to service at 1256 hrs.
- At 1454 hrs, the RCTS-HOTS 220 kV transmission line tripped and the RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS only. As a result 11 MW of load was lost at WETS. The RCTS-WETS-KGTS 220 kV transmission line was returned to service at 1459 hrs. The RCTS-HOTS 220 kV transmission line remained out of service until the SP AusNet investigation could be completed.

During the outage of the RCTS-HOTS 220 kV transmission line, the power system was not secure, as the trip of the X5 220 kV transmission line would overload the RCTS-WETS-KGTS 220 kV transmission line.

AEMO arranged a contingency plan with SP AusNet for immediate post-contingent load shedding should this contingency occur. At 1600 hrs AEMO issued a direction to the Broken Hill Gas Turbines to synchronise and dispatch to full load, replacing the contingency plan for load shedding. This action reduced the power transfer on the X5 220 kV transmission line and ensured that power system security was maintained.

The SP AusNet line patrol found a bushfire burning under the transmission line. The fire services were attending other bushfires at the time and were not fighting this bushfire. Bushfire smoke was determined to be the cause of the fault on the RCTS-HOTS 220 kV transmission line.

SP AusNet completed its investigation of the incident and found that all protection operated by design. However, the protection design did not envisage this type of incident, resulting in the trip of RCTS-WETS-KGTS 220 kV transmission line.

At 1645 hrs 16 January 2014 SP AusNet disabled the SOTF function on the transmission line protection at WETS to prevent further incidents from occurring. SP AusNet returned the RCTS-HOTS 220 kV transmission line to service at 1700 hrs.

After the line was returned to service, demand in north-western Victoria remained unusually high. AEMO retained the direction on the Broken Hill Gas Turbines to ensure power system security. This was because although the power system was in a secure operating state, if the RCTS-HOTS 220 kV transmission line tripped and the Broken Hill Gas Turbines were out of service, it would have taken longer than 30 minutes to restart the Broken Hill Gas Turbines and restore power system security.

At 1814 hrs AEMO issued Market Notice 44645, cancelling the reclassification issued in Market Notice 44602.

Later that evening demand in north-western Victoria had reduced and the direction to the Broken Hill Gas Turbines was rescinded at 2040 hrs.

[8] For a non-credible contingency event AEMO is required to assess whether or not to reclassify a non-credible contingency event as a credible contingency (NER Clause 4.2.3A (c)) and to report how reclassification criteria were applied (NER Clause 4.8.15 (ca)). AEMO has to determine if the condition that caused the non-credible contingency event has been resolved before cancelling the reclassification.

8 Power System Security

This section assesses how AEMO managed power system security over the course of the incident[9].

The Robertstown – Northwest Bend No.1 132 kV transmission line was briefly loaded above its secure limit during the incident. When Murraylink returned to service in the dispatch interval following the initial incident, the transmission line was once again loaded below its secure limit.

AEMO correctly assessed the incident and reclassified the incident as a credible contingency, and appropriate notifications were issued.

AEMO implemented plans for post-contingent load shedding, and issued a direction, on 16 January 2014. These actions were appropriate to maintain power system security.

Over the course of the incident the provision and response of facilities and services were adequate to maintain power system security.

9 Conclusions

1. The RCTS-HOTS 220 kV transmission line tripped at 2205 hrs 15 January 2014 due to a bushfire.
2. The RCTS-WETS-KGTS 220 kV transmission line opened at WETS and KGTS due to the operation of zone 3 distance protection at WETS with a SOTF function enabled.
3. All protection operated as designed, however this type of incident was not envisaged in the design.
4. The SOFT protection function at WETS has been disabled to avoid a repeat of this incident.
5. AEMO took the appropriate actions to maintain power system security.

10 Recommendations

1. SP AusNet to carry out a review to determine if a similar incident could occur with other similar protection schemes in the Victorian network, and if required will make the appropriate changes to protection settings. To be completed by 31 December 2015.

[9] AEMO is responsible for power system security in the NEM and is required to operate the power system in a secure operating state (NER Clause 4.2.4 (a)). AEMO must thereby ensure that the power system is maintained in, or returned to, a secure operating state following a contingency event.

Appendix A - Details of protection on RCTS-WETS-KGTS 220 kV transmission line

Distance protection is installed at Wemen Terminal Station (WETS).

- Zone 3 of the distance protection operates for faults on the RCTS-HOTS 220 kV transmission line with a time delay, as remote backup protection.
- When the distance protection operates for a zone 3 fault, both circuit breakers at WETS are opened, and an inter-trip signal is sent to open the RCTS-WETS-KGTS 220 kV transmission line at the KGTS end.
- The distance protection has a Switch On To Fault (SOTF) function. The purpose of the SOTF function is to immediately open circuit breakers if it has closed on to a fault.
- The SOTF function operates for faults detected in the 300 milliseconds following a secondary current increase from less than 0.5 amperes to greater than 0.5 amperes. The increase in current is used to detect whether a circuit breaker has closed.
- Before the RCTS-HOTS 220 kV transmission line tripped at 2205 hrs 15 January 2014, the secondary current at WETS was less than 0.5 amperes.
- When the fault occurred on the RCTS-HOTS 220 kV transmission line on 2205 hrs, fault current flowed along the RCTS-WETS-KGTS 220 kV transmission line. The secondary line current at WETS transitioned from less than 0.5 amperes to greater than 0.5 amperes.
- The SOTF function evaluated that the circuit breakers at WETS had just closed and therefore was ready to operate for faults in the following 300 milliseconds.
- The distance protection detected the fault on the RCTS-HOTS 220 kV transmission line in zone 3.
- Due to the SOTF function and the detected zone 3 fault, the distance protection immediately tripped the WETS circuit breakers, and sent an inter-trip signal to open the RCTS-WETS-KGTS 220 kV transmission line at the KGTS end.