

Power System Operating Incident Report – Over Voltage on Kangaroo Valley 330 kV Busbar on 3 October 2013

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FINAL

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Version Release History

VERSION	DATE	BY	CHANGES	CHECKED BY	AUTHORISED BY
1	16 Dec 2013	R Wettimuny	FINAL	S Darnell	P Biddle

Incident Classifications

Time and date and of incident	0841 hrs Thursday 3 October 2013
Region of incident	New South Wales
Affected regions	New South Wales
Event type	OTH - Other
Primary cause	PTN & CTR – Protection and Control
Impact	NIL
Associated reports	NIL

Abbreviations

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
CVT	Capacitor Voltage Transformer
EMMS	Electricity Market Management System
EMS	Energy Management System
kV	Kilovolt
MW	Megawatt
NEM	National Electricity Market
NER	National Electricity Rules
RTCA	Real Time Contingency Analysis

1 Introduction

This report reviews a power system operating incident that occurred on 3 October 2013 in the New South Wales region at TransGrid's¹ Kangaroo Valley sub-station. 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 Rules² (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 security³.

This report is largely based upon information provided by TransGrid. 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 The Incident

The primary reason for this investigation is an overvoltage incident at Kangaroo Valley substation.

On Thursday 3 October 2013 at 0841 hrs, the Dapto-Kangaroo Valley No.18 330 kV transmission line opened at the Dapto end only. As a consequence the busbar voltage at Kangaroo Valley exceeded the emergency limit of 346 kV. The voltage exceeded the limit for 9 minutes, from 0841 hrs to 0850 hrs, reaching a maximum voltage of 351.8 kV. At 0850 hrs, the Dapto-Kangaroo Valley (18) 330 kV line was de-energised, and the voltage at Kangaroo Valley returned to within limits.

3 TNSP Investigation

TransGrid investigated the incident and found that the likely cause was a loose fuse on a secondary circuit. The fuse and secondary circuit were associated with a capacitor voltage transformer (CVT) at the Dapto end of the Dapto-Kangaroo Valley (18) 330 kV transmission line.

At 0841 hrs the loose fuse caused the No.1 protection of the Dapto-Kangaroo Valley 330 kV transmission line to operate at Dapto. This in turn opened 330 kV No. 182 Circuit Breaker (CB) at Dapto. The CB did not attempt to auto-reclose as per design. No fault was detected by the No. 2 line protection at Dapto or either line protection at the Kangaroo Valley end.

At 0849 the 330 kV No. 182 CB at Dapto reclosed, but again the No. 1 line protection at Dapto immediately tripped the circuit breaker. At 0850 hrs the line was de-energised by opening 330 kV No. 182 CB at Kangaroo Valley.

4 Pre-Incident State

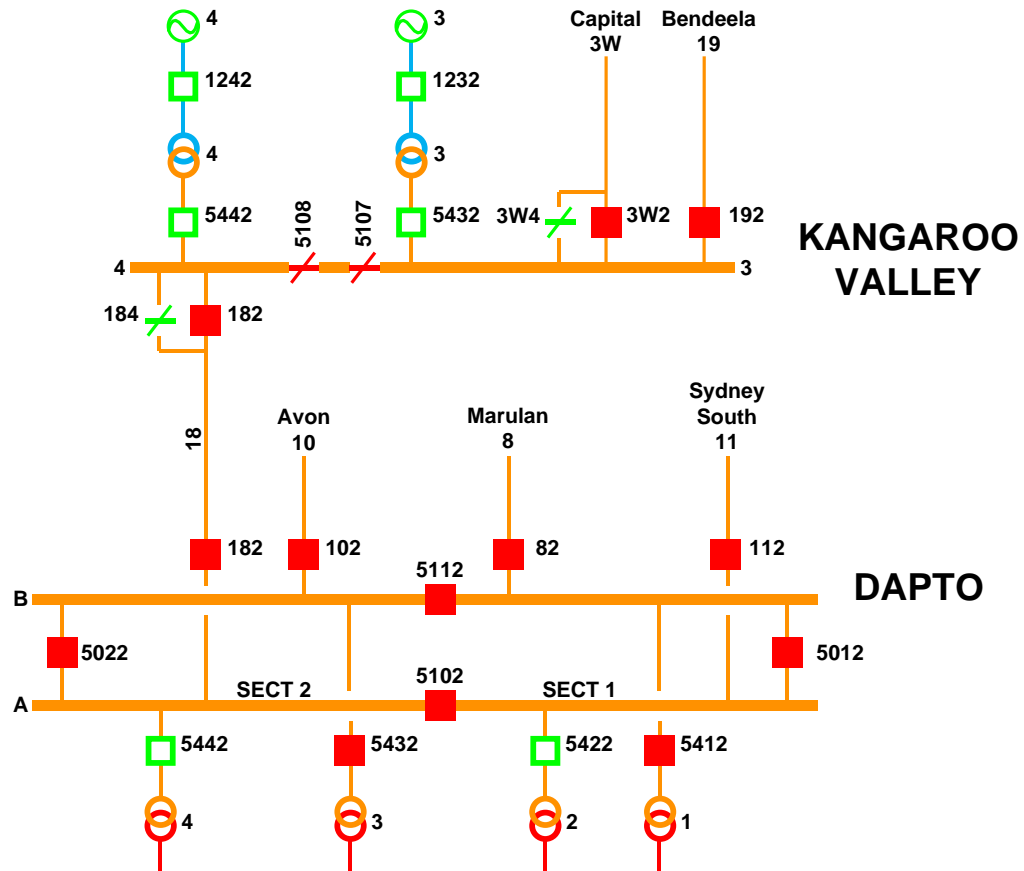
The status of the power system prior to the incident is shown in Figure 1. For clarity only equipment relevant to this incident has been included in the diagram. The diagram shows the Dapto-Kangaroo Valley 330 kV line in service.

¹ TransGrid is the Transmission Network Service Provider in New South Wales

² NER v59 Clause 4.8.15(a)(1)(i) and AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.

³ NER v59 Clause 4.8.15 (b)

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



330 kV Busbar, line	330/132 kV Transformer	Closed CB	Closed Isolator
132 kV Busbar, line	330/15 kV Transformer	Open CB	Open Isolator
15 kV Busbar, line		Generator	
Out of service Busbar, line		Out of service Generator	

5 Incident Event Log

The sequence of events comprising the incident is itemised in Table 1. The incident spanned approximately 3 hours and 15 minutes from 330 kV No. 182 CB at Dapto opening to the power system being returned to the pre-incident state.

Table 1 – Event Log

Time	Event
08:41 hrs	330 kV Dapto – Kangaroo Valley line CB No. 182 opened at Dapto
From 08:41	AEMO discussed with TransGrid the high voltage at Kangaroo Valley then requested Tumut 3 to start units to operate as a synchronous condensers
08:46	Tumut 3 Unit 5 synchronous condenser in service
08:49	Failed reclose of 330 kV CB No. 182 at Dapto

08:50	330 kV Dapto – Kangaroo Valley line de-energised by opening 330 kV CB No. 182 at Kangaroo Valley
08:50	Constraint set N-DTKV_18 invoked
09:00	Tumut 3 Unit 4 synchronous condenser in service
09:05	Market Notice 43524 issued to notify the market: <ul style="list-style-type: none"> • of a variation of inter-regional transfer limit • that constraint set N-DTKV_18 had been invoked
11:45	Dapto Kangaroo Valley 330kV line returned to service
11:55	Constraint set N-DTKV_18 revoked
12:48	Market notice 43526 issued to notify market that: <ul style="list-style-type: none"> • a non-credible contingency event had occurred • the cause had been identified and the event was unlikely to reoccur • the event would not be reclassified as a credible contingency • the line had been returned to service

6 Post-Incident State

The status of the power system immediately after the incident is shown in Figure 2. The diagram shows the Dapto – Kangaroo Valley (18) 330 kV line open at the Dapto end.

7 Immediate Actions

AEMO instructed Tumut 3 No. 4 and No. 5 units to start and operate as synchronous condensers to reduce the voltage at the Kangaroo Valley busbar. The units synchronised at 0846 hrs and 0900 hrs respectively.

TransGrid attempted to reconnect the line at 0849 hrs via 330 kV CB No. 182 at Dapto. The circuit breaker re-opened immediately.

TransGrid opened 330 kV CB 182 at Kangaroo Valley at 0850 hrs. This de-energised Dapto-Kangaroo Valley (18) 330 kV line, which in turn returned the voltage at Kangaroo Valley to within limits.

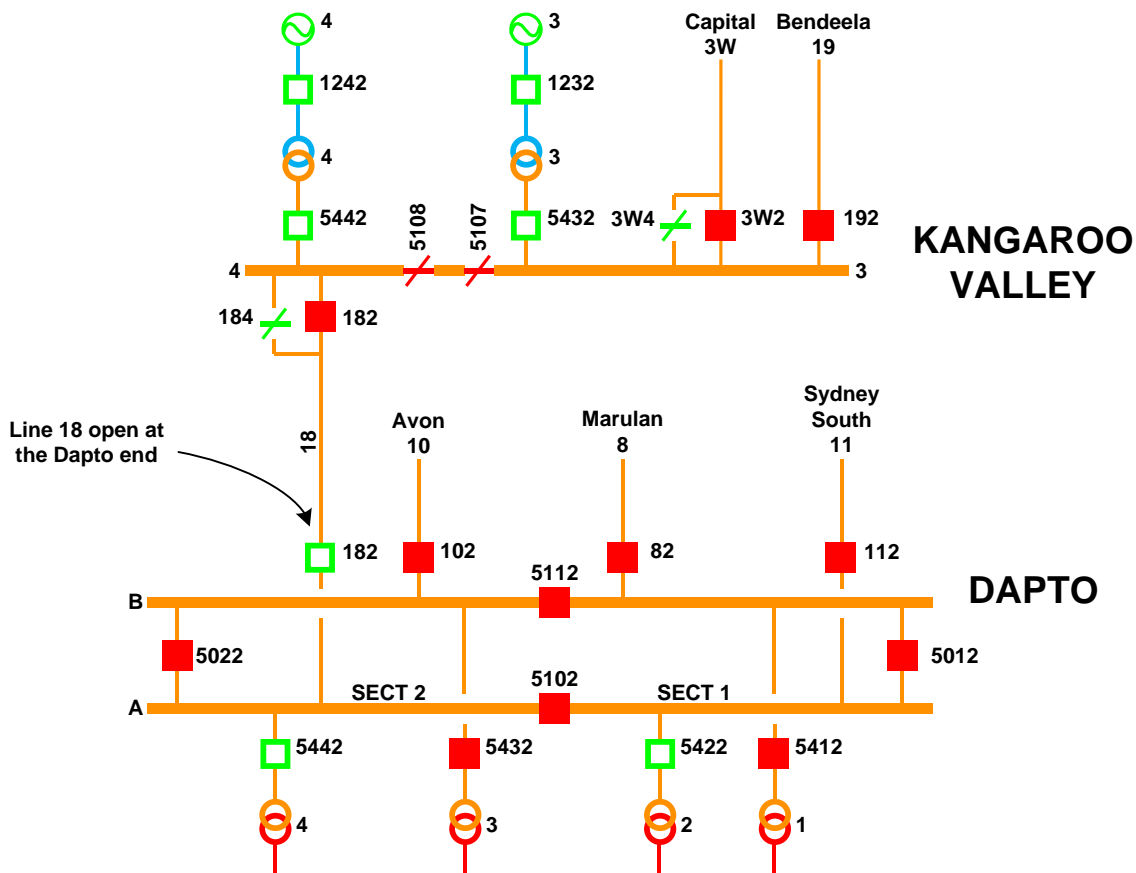
AEMO invoked constraint set N-DTKV_18 at 0850 hrs. This action ensured that the power system operated in a secure state while the Dapto – Kangaroo Valley (18) 330 kV line was out of service. AEMO invoked this constraint nine minutes after the initial event which is within the thirty minute period in which required to return the power system to a secure state.⁴

AEMO then issued Market Notice 43524 to notify the market of:

- of a variation of inter-regional transfer limit
- that constraint set N-DTKV_18 had been invoked

⁴ NER v 59 Clause 4.2.6 (b)

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



330 kV Busbar, line	330/132 kV Transformer	Closed CB	Closed Isolator
132 kV Busbar, line	330/15 kV Transformer	Open CB	Open Isolator
15 kV Busbar, line		Generator	
Out of service Busbar, line		Out of service Generator	

8 Follow-up Actions

TransGrid investigated and rectified the fuse and secondary circuit of the CVT, and returned the 330 kV Dapto – Kangaroo Valley line to service at 1146 hrs.

Following a non-credible contingency event, AEMO is required to assess whether or not to reclassify the event as a credible contingency⁵, and to report how re-classification criteria were applied⁶. AEMO has to determine if the condition that caused the non-credible contingency event has been resolved. AEMO did not reclassify the opening of 330 kV Dapto – Kangaroo Valley line on one end because the cause of this non-credible contingency was identified and considered unlikely to reoccur.

AEMO issued Market Notice 43526 at 1248 hrs to notify the market that:

- a non-credible contingency had occurred
- the Dapto- Kangaroo Valley 330 kV transmission line had opened at the Dapto end only

⁵ NER v59 Clause 4.2.3A (c)

⁶ NER v59 Clause 4.8.15 (ca)

- the cause of the credible contingency had been identified and was unlikely to reoccur
- the incident was not to be reclassified as a credible contingency
- the line had been returned to service

AEMO issued Market notice 43526 approximately four hours after the incident. AEMO failed to meet its obligation to notify the market of a non-credible contingency event⁷ within two hours of the event.

9 Power System Security

AEMO is responsible for power system security in the NEM and is required to operate the power system in a secure operating state⁸. AEMO must thereby ensure that the power system is maintained in, or returned to, a secure operating state within 30 minutes following a contingency event.

In reviewing this incident AEMO considered why the Kangaroo Valley voltage breached limits resulting in an unsatisfactory operating state. In analysing this issue AEMO also found that the power system was insecure prior to the incident. Analysis also shows that this has occurred repeatedly in the past.

9.1 Non Satisfactory State

Figure 3 shows the voltage on Kangaroo Valley No. 3 and 4 busbars (Green) for an 18 hour period straddling the incident. From 0841 to 0850 hrs - nine minutes - the voltage exceeded the emergency limit of 346 kV (dashed Blue line).

When a voltage limit such as this is breached the power system is in an unsatisfactory state⁹. For such a condition AEMO is required to return the power system to a satisfactory state as soon as reasonably possible to prevent damage to plant.

The high voltage was mitigated by a combination of AEMO initiating synchronous condensers and TransGrid de-energising the 330 kV Dapto – Kangaroo Valley line. AEMO then invoked the constraint set N-DTKV_18 to manage power system security whilst 330 kV Dapto – Kangaroo Valley line was out-of-service.

These actions taken by AEMO and TransGrid were appropriate and correct. The power system was returned to a satisfactory state in nine minutes.

9.2 Non Secure State

A secure operating state is when the power system remains in at least a satisfactory state following a credible contingency event. That is, the power system should be operated so that it in the event of a credible contingency, power system limits, such as voltages, are not breached (Satisfactory State).

To comply with this obligation AEMO continuously monitors the state of the power system for credible contingencies using real time contingency analysis (RTCA). Should RTCA find that the power system is insecure (the system would not be satisfactory following a credible contingency), AEMO is required to take action and return the system to a secure state within 30 minutes.

RTCA does not however monitor the opening of a transmission line at one end - or any other non-credible contingencies. The opening of a transmission line at one end is a non-credible contingency because transmission lines are generally designed to open at both ends under fault conditions – the opening of both ends being a credible contingency.

⁷ AEMO, *Power System Security Guidelines*, v54 Section 10.3

⁸ NER v59 Clause 4.2.4 (a)

⁹ NER v59 Clause 4.2.2 (b)

To further investigate the status of the power system for this incident AEMO considered recent RCTA results for the opening of the 330 kV Dapto – Kangaroo Valley line at both ends (a credible contingency). This is the closest credible contingency, and a more conservative scenario, to the non-credible contingency of opening the line at one end. This results of this analysis found that voltage limit violations would have occurred on the 330 kV Kangaroo Valley busbars if the 330 kV Dapto – Kangaroo Valley line had tripped at both ends. Voltage violations would have occurred:

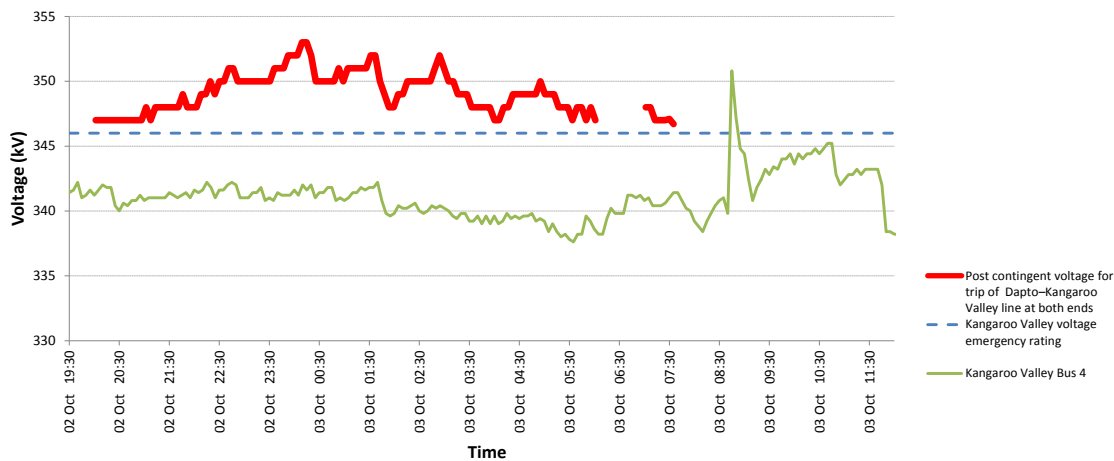
- from 2000 hrs on 2 Oct 2013 to 0601 hrs on 3 Oct 2013, and
- from 0701 hrs to 0735 hrs on 3 October 2013

Figure 3 shows the voltage violations (Red Line) for the trip of the 330 kV Dapto – Kangaroo Valley line at both ends. This analysis shows that, in the recent past, in addition to the incident, the power system had been periodically insecure for periods of greater than 30 minutes via contingent voltage violations at Kangaroo Valley. This means that had the 330 kV Dapto – Kangaroo Valley line tripped, the power system would have been unsatisfactory – voltage limits breached - for these periods.

During these periods when the power system was in an insecure operating condition, AEMO had instructed synchronous condensers at Upper Tumut and Lower Tumut power stations to operate¹⁰. However, the amount of synchronous condenser capacity called upon was insufficient to alleviate the post contingent violations during this time. When the RTCA violations ceased at 0601 on 3 October 2013, AEMO withdrew its instruction for synchronous condensers at Upper Tumut and Lower Tumut.

Further analysis shows that had AEMO dispatched synchronous condensers immediately prior the incident - to ensure power system was secure for the credible trip Dapto – Kangaroo Valley 330 kV line at both ends - the power system would have still resulted in an unsatisfactory state following the trip of the 330 kV line at one end.

Figure 3 - Kangaroo Valley busbar voltages and post contingent voltages



Further historical analysis indicates that from 1 January 2013 to 6 November 2013 the power system had been repeatedly insecure for the trip of 330 kV Dapto – Kangaroo Valley line. See Appendix 1 for further details.

¹⁰ Synchronous condenser is an operating mode of a generator unit that is used to alleviate high or low power system voltages

10 Conclusions

1. The opening of the 330 kV Dapto – Kangaroo Valley transmission line at the Dapto end was caused by a loose fuse on one secondary circuit of the 330 kV Dapto – Kangaroo Valley line CVT at Dapto.
2. Over the course of the incident, the response of AEMO and TransGrid was appropriate and power system was returned to a secure condition within nine minutes.
3. AEMO has not maintained power system security for trip of the 330 kV Dapto – Kangaroo Valley line (at both ends) for a significant number of periods during 2013.
4. AEMO failed to meet its obligation to notify the market of a non-credible contingency event within two hours of the event.

11 Recommendations

1. AEMO to review, and if necessary amend, its training programmes for control room staff to reinforce the need to ensure power system security under all conditions. To be completed by 31 December 2013.
2. AEMO to extend the current system of performance reporting to measure the effectiveness of managing RTCA violations. To be completed by 28 February 2014.
3. AEMO to extend the use of contingency timer alarms to voltage violations for the RTCA application. This will alert operators when RTCA contingency violations are present for more than a defined time frame. To be completed by 31 January 2014.

12 Appendix 1

Figure 4 illustrates insecure incidents for the trip of 330 kV Dapto – Kangaroo Valley line for the period 1 January 2013 to 6 November 2013. Each incident consists of continuous violations of the 330 kV Kangaroo Valley busbar voltage emergency limit for at least 30 minutes. Figure 5 shows the magnitude of the voltage violations.

Figure 4 – Incidents from Jan 2013 to 6 Nov 2013

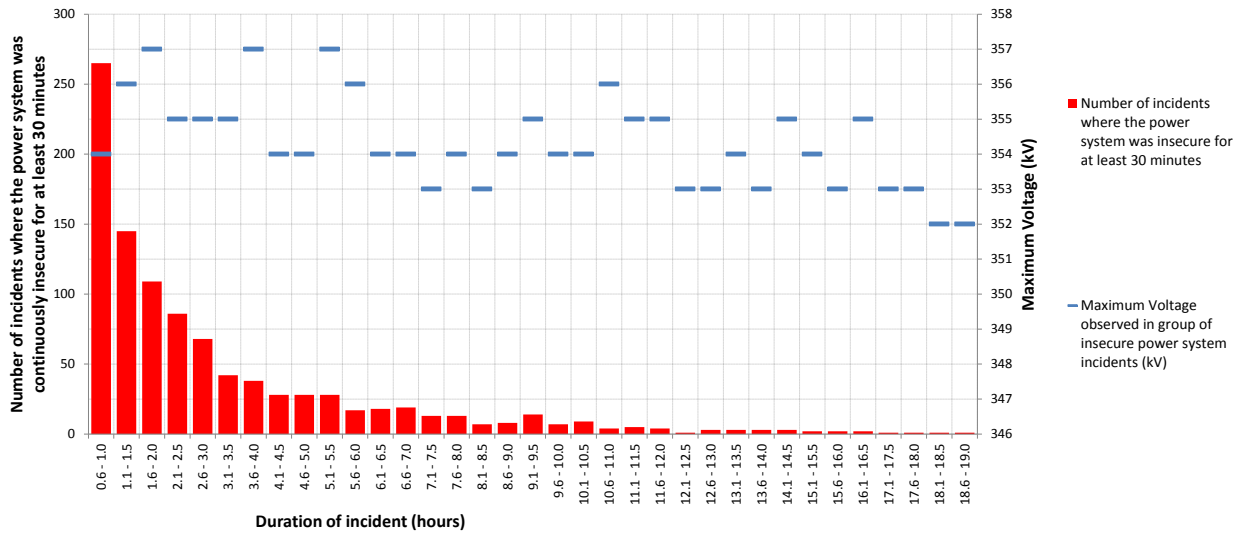


Figure 5 – Violation magnitudes of incidents from Jan 2013 to 6 Nov 2013

