Power System Operating Incident Report – Trip of Sydney West A2 330kV busbar and Sydney West - Liverpool 330kV transmission line on 17 November 2013

PREPARED BY: AEMO Systems Capability

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STATUS FINAL

Contents

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Version Release History

VERSION	DATE	BY	CHANGES	CHECKED BY	AUTHORISED BY
1	19 Feb 2014	J Duque	FINAL	S Darnell	P Biddle

Incident Classifications

Time and date and of incident	0640 hrs Sunday 17 November 2013
Region of incident	New South Wales
Affected regions	New South Wales
Event type	BB- Busbar Trip
Primary cause	OE & CON Operator Error and Non-conformance
Impact	Nil
Associated reports	Nil

Abbreviations and Symbols

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
EMMS	Electricity Market Management System
EMS	Energy Management System
kV	Kilovolt
NER	National Electricity Rules
SOTF	Switch on to fault scheme

1 Introduction

This report reviews a power system operating incident that occurred on 17 November 2013 in the New South Wales region at Sydney West substation. 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 TransGrid. Data from AEMO's Energy Management System (EMS) and Electricity Market Management System (EMMS) has also been used in analysing the incident.

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

2 The Incident

At 0640 hrs on 17 November 2013, the Sydney West A2 330 kV busbar and the Sydney West – Liverpool (30) 330 kV transmission line (Line 30) tripped.

At the time of this incident, a planned outage of Sydney West A1 330 kV busbar was underway. A switching error on Sydney West A2 330 kV busbar, whilst preparing for the A1 busbar outage, caused the incident.

At the same time as the incident, AEMO observed a reduction in demand of approximately 130 MW in the New South Wales region.

The reasons for investigating this incident are:

1. The A2 330 kV busbar at Sydney West station tripped; this is a non-credible contingency event.
2. The Sydney West – Liverpool 330 kV Transmission Line should not have tripped for the fault on the A2 330 kV busbar at Sydney West.

3 TransGrid Investigation

The incident happened during a planned outage of the Sydney West A1 330 kV busbar. TransGrid were in the process of isolating this busbar, when a switching error led to a single phase to earth fault on the A2 330 kV busbar.

This switching error resulted in the trip of the Sydney West A2 330 kV busbar and the Sydney West – Liverpool (30) 330 kV Transmission Line (Line 30). The A2 330 kV busbar protection operated correctly for the fault condition and cleared the busbar. Line 30 however should not have tripped. The Line 30 protection relay should have delayed the trip to allow the busbar protection to operate and clear the fault.

The trip of Line 30 was caused by an incorrect open-closed status indication on the line isolator at Sydney West. The indication was open when the line isolator was actually closed. The protection relay at Sydney West uses the Line 30 isolator open-closed indication, in part, to determine when it operates. In the absence of power system fault this incorrect line indication had no impact.

For the fault on A2 busbar:

At Sydney West the Line 30 protection relay operated due to the interaction of the incorrect line open indication and the Switch on-to Fault function. The relay immediately opened the Line 30 circuit breaker at Sydney West. Normally for this fault the trip signal would have been delayed.

[1] NER v60 Clause 4.8.15(a)(1)(i) and AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.
[2] NER v60 Clause 4.8.15 (b)

At Liverpool the Line 30 protection relay operated due to the incorrect line open indication at Sydney West. The relay determined that fault was on Line 30 and immediately opened the Line 30 circuit breakers at Liverpool. Normally for this fault the trip signal would have been delayed.

Both protection relays operated correctly for the given input information.

The line isolator indication has subsequently been removed from the logic that is used to determine the open-close condition of the line. This event is therefore unlikely to reoccur.

For further information about the operation of the protection relays refer to Appendix 1.

4 Power System Diagrams

The status of the power system before the incident is shown in Figure 1 and after the incident in Figure 2. For clarity only equipment relevant to this incident has been included in the diagrams. The diagrams show the status of the 330 kV busbars at Sydney West station before and after the incident.

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

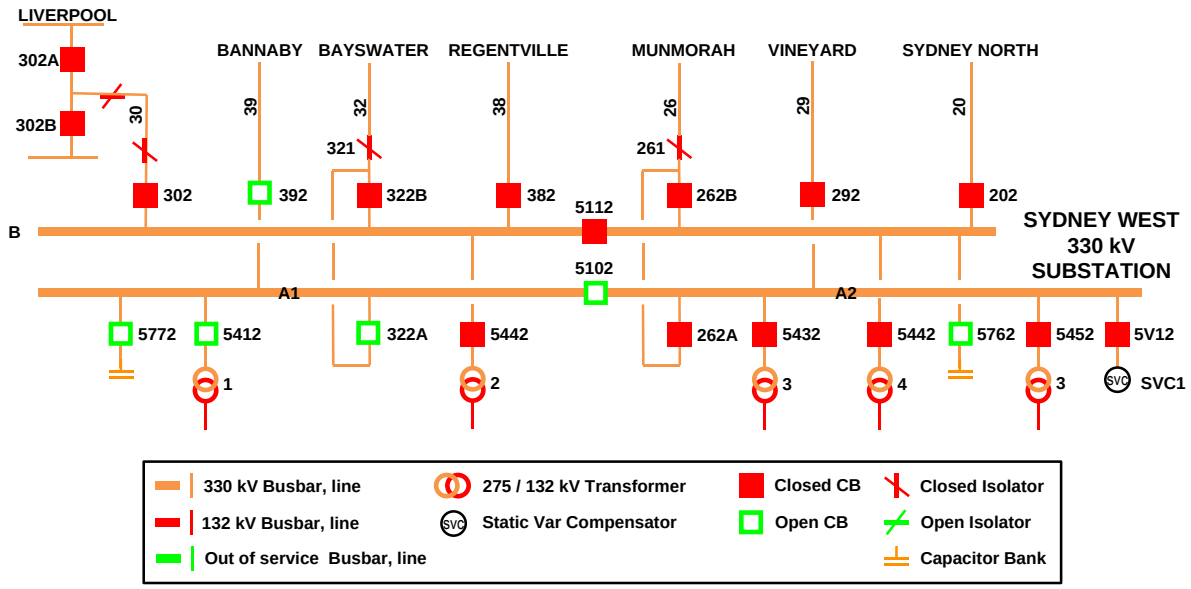
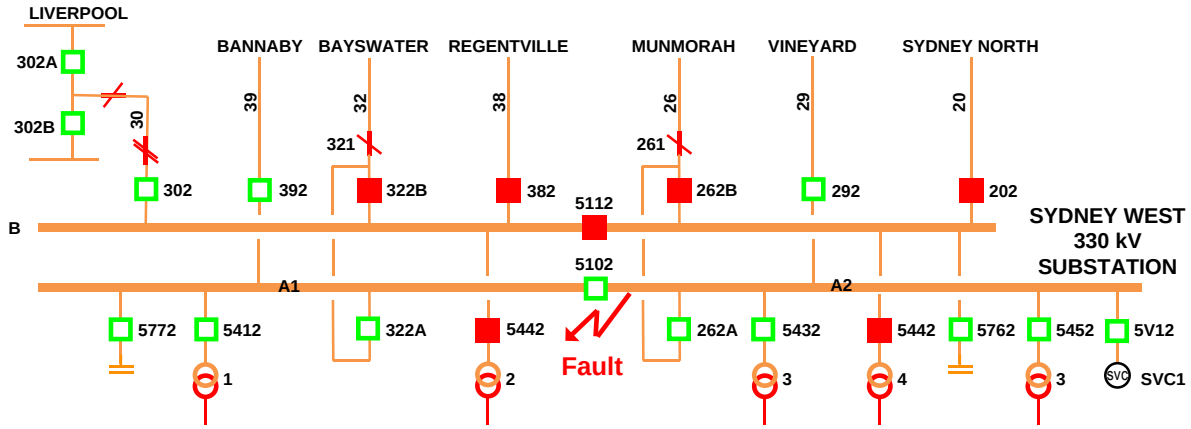


Figure 2 - Status of the power system immediately after the incident



5 Incident Event Log

The sequence of events comprising the incident are itemised in Table 1.

Table 1 – Event Log

Time	Event
05:00	Sydney West A1 330 kV busbar de-energised for a planned outage.
06:40	Sydney West A2 330 kV busbar and the Sydney West – Liverpool 330 kV line tripped.
06:50	AEMO invoked constraint sets N-SWVY_29[3] and N-LPSW_30[4] to maintain system security for the new topology.
07:37	AEMO issued Market Notice 43873 informing the market of the non-credible contingency event.
07:45	AEMO issued Market Notice 43874 informing the market that constraint sets N-SWVY_29 and N-LPSW_30 were invoked at 06:50 hrs.
08:41	Sydney West A2 330 kV busbar reenergised.
08:55	AEMO revoked constraint set N-SWVY_29.
09:58	AEMO issued Market Notice 43875 informing the market that the cause of the event has been identified and was unlikely to reoccur. AEMO did not reclassify this event as a credible contingency event.
15:33	Sydney West – Liverpool 330 kV line returned to service.
15:40	AEMO revoked constraint set N-LPSW_30.

6 Immediate Actions

Due the changes in topology, AEMO invoked constraint sets N-LPSW_30 and N-SWVY_29 approximately ten minutes after the event. This action ensured that the power system remained in a secure operating state.[5]

At 0737 hrs AEMO issued Market Notice 43873 informing the market of the non-credible contingency event[6]. At 0745 hrs AEMO issued Market Notice 43874 informing that the market that constraint sets N-SWVY_29 and N-LPSW_30 were invoked at 0650 hrs.

7 Follow-up Actions

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

TransGrid identified operator error as the cause for the trip of the A2 330 kV busbar, and considered the event unlikely to reoccur. Based on this assessment, AEMO did not to reclassify the event as a credible contingency event. AEMO issued Market Notice 43875 at 0958 hrs to notify the market of this assessment.

TransGrid found that an incorrect line isolator status indicator caused the trip of the Sydney West – Liverpool 330 kV transmission line. The status of this isolator has been removed from the logic used to determine the open-close state of the line. This logic is now based upon the status of the Circuit Breaker alone.

[3] Constraint to cover for outage of the Sydney West – Vineyard 330 kV line.
[4] Constraint to cover for outage of the Sydney West – Liverpool 330 kV line.
[5] AEMO is required to return the power system to a secure state within thirty minutes following a contingency event NER v 60 Clause 4.2.6 (b).
[6] This notice was issued within one hour of the event. AEMO is required to notify the market of a non-credible contingency event within two hours of the event - AEMO *Power System Security Guidelines,* v54 Section 10.3

8 Power System Security

This section assesses how AEMO managed power system security over the course of the incident.[7]

Following the event, AEMO invoked the required constraints to return the system promptly to a secure state. AEMO then issued the required market notice in a timely manner. AEMO did not reclassify this incident as a credible contingency because the cause of the fault was identified as human error and was considered unlikely to reoccur.

Simultaneously with this event AEMO observed a reduction in the electrical demand in the New South Wales region of approximately 130 MW. AEMO did not instruct load shedding and has not been advised of any disconnection of bulk electrical load. The load reduction was likely a consequence of the voltage disturbance caused by the fault.

Power system security was maintained over the duration of the incident.

9 Conclusions

1. A switching error caused the earth fault the Sydney West A2 330 kV busbar. The Sydney West A2 330 kV busbar protection correctly opened all circuits connected to the busbar.
2. An incorrect line isolator indication caused the trip of the Sydney West – Liverpool 330 kV line.
3. The protection logic to determine the open-close state of the line has been modified to remove the line isolator status.
4. The voltage disturbance caused by the busbar fault reduced electrical demand in the New South Wales region by 130 MW.
5. Power System security was maintained over the duration of the incident.

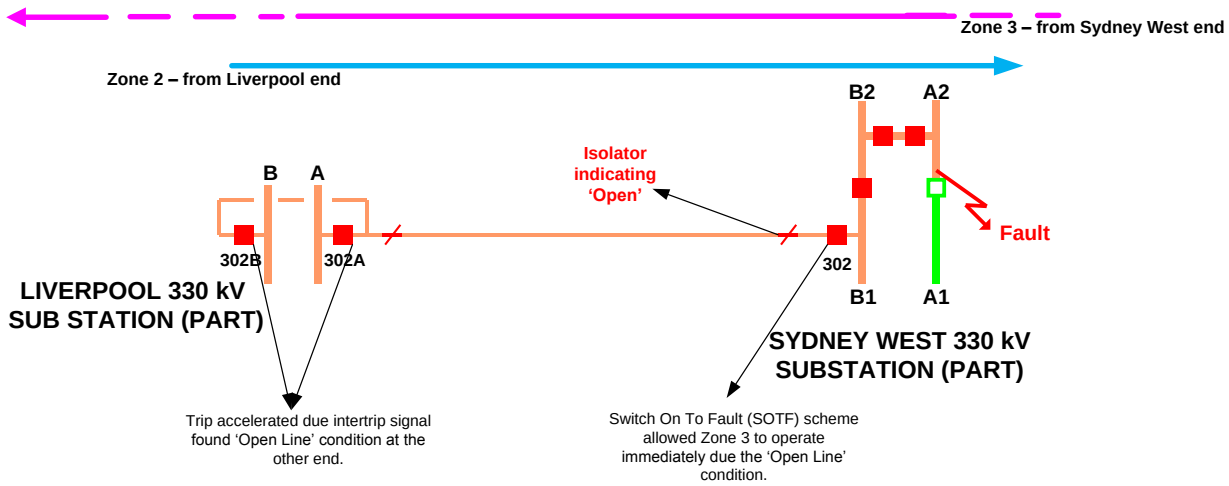
10 Recommendations

There are no recommendations arising from this report.

[7] 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 1 - Operation of protection schemes

The figure below shows a simplified representation of the zones covered by the zone[8] protections that operated at the Liverpool and Sydney West substations for the busbar fault at Sydney West. These protection operations resulted in the trip of the Sydney West – Liverpool 330 kV transmission line (the line).



The busbar fault was correctly identified and cleared by the busbar zone protection at Sydney West.

The fault was also correctly identified at Liverpool as being in protection Zone 2, and at Sydney West as being in protection Zone 3. The trip times associated with the Zone 2 and Zone 3 faults are normally delayed to prevent inadvertent trips for faults not on the protected line. For this incident the fault was not on the protected line and the line circuit breakers should not have opened immediately.

The line protection relays at Liverpool and Sydney West were unexpectedly accelerated to trip immediately. The Zone 2 and Zone 3 trip signals were accelerated because of a false line open indication from the 330 kV line isolator at Sydney West. The line isolator was closed but incorrectly indicating open. This incorrect open indication was an input to the line protection relay at Sydney West.

At the Liverpool end, the protection relay identified that the fault was in Zone 2 and sent a permission to trip signal to Sydney West. At Sydney West the trip signal was echoed back to Liverpool as the line was indicating open at Sydney West[9]. For this condition - a fault, and a trip signal from the remote end - the protection at Liverpool immediately opened the line circuit breakers. The protection operated correctly for the given input information.

At the Sydney West end, the protection relay identified that the fault was in Zone 3, and that the line was indicating open at Sydney West. For this condition – a fault, and the line open at the local end - the protection relay at Sydney West determined a Switch onto Fault (SOTF) condition and immediately opened the line circuit breaker at the Sydney West end. The protection operated correctly for given the input information.

[8] The normal setting for Zone 1 is 80% of the impedance of the line in order to not reach the remote end. Zone 2 is normally set at 120% of the impedance of the line in order to ensure any fault in the line is identified. Zone 3 is sometimes disabled or set to cover adjacent equipment.

[9] Because the line was *indicating* open at the Sydney West end, the fault was logically deemed to be on the line.

Switch on-to Fault (SOTF) Protection

The main purpose of the switch-on-to fault (SOTF) function is to operate immediately when switching onto a close in fault (e.g. when a earth switch is closed at the local end).

In such circumstances, neither Zone 1 nor Zone 2 at the local end will detect the fault because the voltage will be near to zero. Zone 3 however derives a voltage value and can thereby detect such close in faults.

SOTF protection is initiated when a circuit breaker is open (for this incident the open indication was derived from the line isolator), and then operates when a fault current is detected. The objective is to detect when a circuit breaker is being closed onto a fault.

The SOTF logic is such that for a busbar fault:

1. If the circuit breaker is closed and indicates closed, SOTF is not initiated. When Zone 3 detects the busbar fault, it does not trip immediately.
2. If the circuit breaker is open and indicates open, SOTF is initiated but Zone 3 does not detect the busbar fault, so no trip is initiated (no fault contribution via the circuit breaker).
3. If the circuit breaker is closed but indicates open, SOTF is initiated, Zone 3 detects the busbar fault - as there is contribution from the line into the busbar fault - and a trip is initiated immediately.