Power System Operating Incident Report - Trip of Davenport-Bungama-Blyth-Para 275 kV transmission lines on 1 December 2013

PREPARED BY: AEMO Systems Capability

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Contents

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Version Release History

VERSION	DATE	BY	CHANGES	CHECKED BY	AUTHORISED BY
1	10 Feb 2014	S Darnell	FINAL	P Biddle	P Biddle

Incident Classifications

Time and date and of incident	0808 hrs 1 December 2013
Region of incident	South Australia
Affected regions	South Australia
Event type	TT – Loss of Multiple Transmission Elements
Primary cause	TE - Transmission Equipment Failure
Impact	Nil
Associated reports	Nil

Abbreviations

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
CT	Current Transformer
ElectraNet	Transmission Network Service Provider in the South Australia Region
EMMS	Electricity Market Management System
EMS	Energy Management System
kV	Kilovolt
NER	National Electricity Rules
TNSP	Transmission Network Service Provider

1 Introduction

This report reviews a power system operating incident that occurred on 1 December 2013 in the South Australia region at Davenport, Bungama, Blyth West and Para substations. 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 ElectraNet[3]. 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

On Sunday 1 December 2013, at 0808 hrs, a current transformer failed at Bungama substation (Bungama). As a result, three 275 kV transmission lines tripped (Bungama – Davenport, Blyth West – Bungama, Blyth West – Para) and the Snowtown North and South winds farms were islanded. The wind farms were not generating at the time of the incident. No load was lost due this incident.

The reason for investigating this incident is that a circuit breaker a Para substation (Para) - CB6510 - should not have opened for this type of event. In turn, the Blyth West - Bungama and the Blyth West – Para 275 kV transmission lines should not have been de-energised[4].

3 Participant Investigation

ElectraNet investigated this incident and found that the current transformer at CB 6538 at Bungama was damaged. The current transformer suffered an internal failure. The reasons for the internal failure remain under investigation[5].

This event should have resulted in:

- at Bungama: 275 kV CBs 6537 6538 and 6539 open, and 132 kV CB 6242 open
- at Davenport: 275 kV CBs 6561 and CB 6560 open
- Davenport – Bungama 275 kV transmission line de-energised
- Blyth West – Bungama 275 kV transmission line off-loaded

However, CB 6510 at Para also opened, and with CB 6511 already out-of-service[6], this resulted in:

- Blyth West – Bungama 275 kV transmission line de-energised
- Blyth West – Para 275 kV transmission line de-energised
- Snowtown North and South wind farms islanded

[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)

[3] ElectraNet is the Transmission Network Service Provider in South Australia

[4] Generally transmission lines are required to remain connected to the power system for faults that occur in other parts of the power system that are correctly cleared. The trip of Blyth West – Bungama and the Blyth West – Para 275 kV transmission lines is an unexpected event and is identified in power system security terms as a non-credible contingency.

[5] Lightning was reported in the region at the time of the incident

[6] CB 6511 at Para Substation was out-of-service awaiting repair.

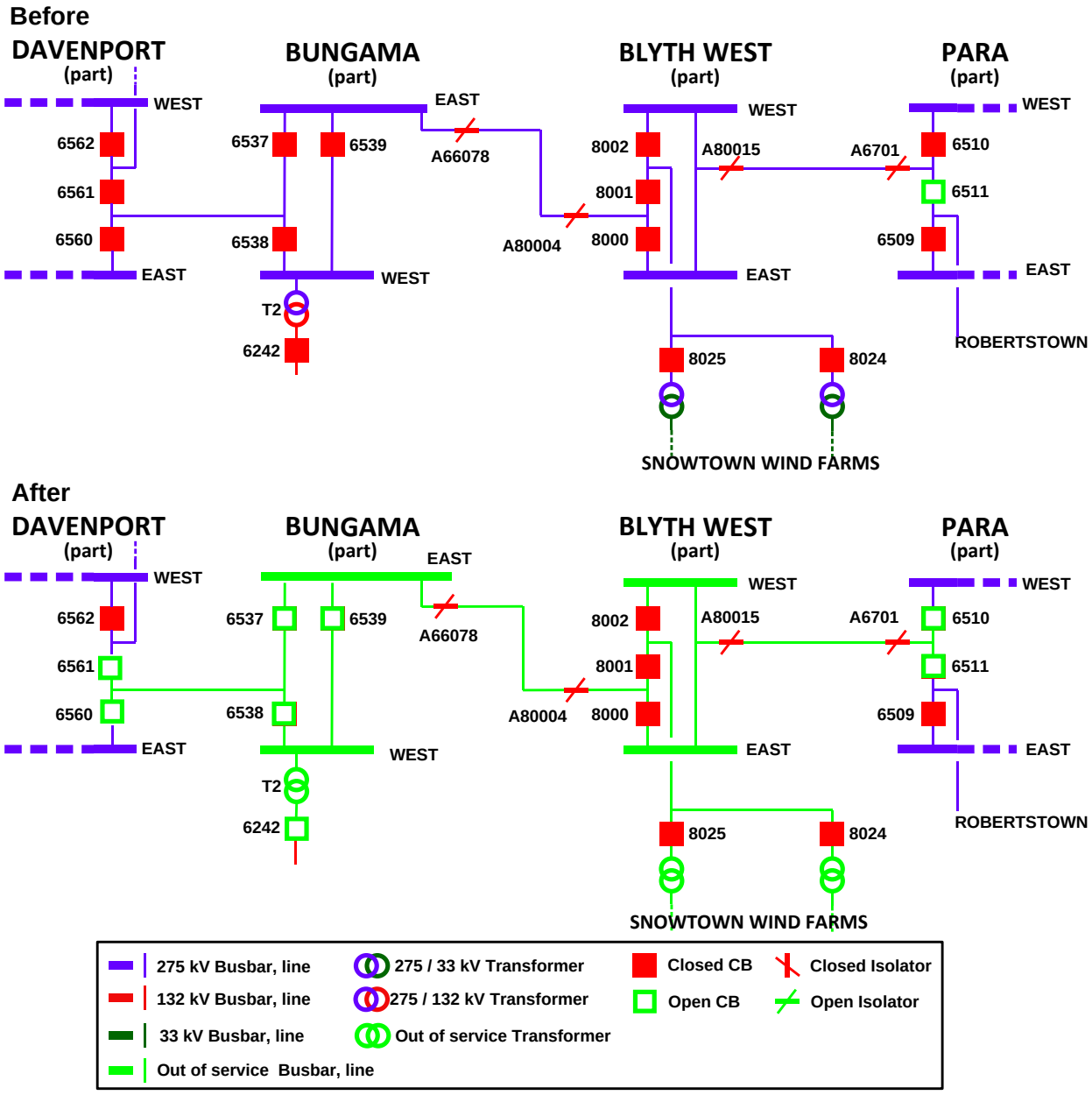
CB 6510 at Para should not have opened for the fault at Bungama. ElectraNet found that CB6510 opened via Directional Earth Fault (DEF) on the Blyth West – Para 275 kV line Y Protection Relay at Para.

The relay operated due to an incorrect relay setting – refer to Appendix 1 for further information. The incorrect relay setting has since been rectified and the relay has been re-tested to prove it operates correctly.

4 Power System Diagrams

The status of the power system before and after the incident is shown in Figure 1. For clarity only equipment relevant to this incident has been included in the diagrams.

Figure 1 - Status of the power system before and after the incident



5 Incident Event Log

The sequence of events comprising the incident are itemised in Table 1. The incident spanned approximately 3 hours and 30 minutes from the CT failure to power system restoration.

Table 1 – Event Log

Date and Time	Event
0808 hrs 1 Dec 2013	Fault occurred on CT associated with CB 6538 at Bungama Three 275 kV transmission lines de-energised: Bungama - Davenport, Blyth West – Bungama, and Blyth West to Para Seven circuit breakers opened: 6537, 6538, 6539 and 6242 at Bungama, 6560 and 6561 at Davenport, and 6510 at Para Snowtown North and Snowtown South wind farms islanded
0815-20 hrs 1 Dec 2013	Constraint sets S-BGDV, S-BGBW and S-BWPA, S-SNOWNTH1_ZERO and S-SNOWSTH1_ZERO invoked
0840 hrs 1 Dec 2013	Market Notice 44065 issued: non-credible contingency event at 0808 hrs
0851 hrs 1 Dec 2013	Market Notice 44066 Issued: AEMO invoked constraints at 0820 hrs
0915 hrs 1 Dec 2013	ElectraNet notified AEMO that the CT associated with CB 6538 was damaged.
0920 hrs 1 Dec 2013	Constraint set S-X_BGDV+BGPA invoked. Constraint sets S-BGDV, S-BGBW, S-BWPA revoked
0921 hrs 1 Dec 2013	Market Notice 44067 Issued: AEMO invoked one constraint set and revoked three sets
0935 hrs 1 Dec 2013	Bungama line isolator A80004 opened at Blyth West, isolating Blyth West from Bungama.
0937 hrs 1 Dec 2013	CB 6510 at Para closed. Supply restored to Blyth West and Snowtown wind farms.
0945 hrs 1 Dec 2013	Constraint sets S-SNOWNTH1_ZERO and S-SNOWSTH1_ZERO revoked
1141 hrs 1 Dec 2013	Circuit breakers closed: 6537, 6539, and 6242 at Bungama, 6560 and 6561 at Davenport. Lines restored: Davenport – Bungama 275 kV line, Bungama – Blyth West 275 kV Isolator A80004 at Blyth West closed.
1145 hrs 1 Dec 2013	Constraint Set S-X_BGDV+BGPA revoked
1243 hrs 1 Dec 2013	Market Notice 44068 issued: reclassification as a credible contingency: a 275 kV fault at Bungama and Blyth West - Para 275 kV transmission line
9 Dec 2013	ElectraNet rectified the relay setting that caused CB 6510 to open
1629 hrs 9 Dec 2013	Market Notice 44163 issued: AEMO cancelled the reclassified credible contingency

6 Immediate Actions

This section assesses the immediate actions taken in response to the incident.

AEMO invoked five constraint sets (from 0815 to 0820 hrs) to manage power system security while the tripped lines were out of service: S-BGDV[7], S-BGBW[8], S-BWPA[9], S-SNOWNTH1_ZERO[10] and S-SNOWSTH1_ZERO[11]. These constraints ensured that the power system was in a secure operating state[12].

[7] S-BGDV - for the outage of Davenport - Bungama 275 kV transmission line
[8] S-BGBW - for the outage of Blyth West – Bungama 275 kV transmission line
[9] S-BWPA - for the outage of Blyth West – Para 275 kV transmission line
[10] S-SNOWNTH1_ZERO - constrains Snowtown North Wind Farm to 0W
[11] S-SNOWSTH1_ZERO - constrains Snowtown South Wind Farm to 0W

AEMO then issued Market Notice 44065 at 0840 hrs to notify the market of the non-credible contingency event. AEMO issued this notice approximately 32 minutes after the event which is within two hours of the event in which AEMO is required to notify the market of a non-credible contingency event[13].

AEMO issued Market Notice 44066 at 0851 hrs to notify the market of the constraints invoked, and of interconnectors on the left-hand-side of any constraint equations[14].

7 Follow-up Actions

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

At 0920 hrs AEMO invoked constraint set S-X_BGDV+BGPA[15] and revoked the three constraint sets invoked earlier. AEMO considered that this single outage constraint set was more appropriate for this event. AEMO issued Market Notice 44067 at 0921 hrs to notify the market of the change in constraint sets.

At 0937 hrs ElectraNet closed CB 6510 at Para to restore supply to Blyth West. This re-connected the Snowtown wind farms to the network. AEMO then revoked constraint equations S_SNOWNTH1_ZERO and S_SNOWNTH2_ZERO.

At 1141 hrs ElectraNet reclosed the open isolator at Blyth West, and reclosed all open circuit breakers at Bungama and Davenport - except for the damaged circuit breaker (CB6538) at Bungama. This re-energised the Bungama – Davenport and Blyth West – Bungama 275 kV transmission lines.

At 1235 hrs AEMO reclassified as a credible contingency a 275 kV fault at Bungama together with the trip of the Blyth West - Para 275kV line. AEMO considered that this event could re-occur because ElectraNet had yet to identify why CB 6510 had opened.[16]

On 9 December AEMO cancelled the reclassified credible contingency. ElectraNet had informed AEMO that an incorrect relay setting had caused CB6510 at Para to open, and that the incorrect setting had been rectified. AEMO considered that the event was now unlikely to reoccur. AEMO issued Market Notice 44163 at 1243 hrs to notify the market that the reclassified credible contingency had been cancelled and that constraint set S-NIL_BG+BWPA_N-3 had been revoked.

On 12 and 13 December, ElectraNet end-to-end tested the X and Y protection for the Para-Blyth West 275kV transmission line. The test was successful.

8 Power System Security

This section assesses how AEMO managed power system security over the course of the incident[17]

Before the incorrect relay setting was identified and resolved the underlying non-credible contingency had a broader scope than that assessed by AEMO. An earth fault anywhere on the South Australia 275 kV system, as opposed to a 275 kV earth fault at Bungama, may have caused the incorrectly configured relay

[12] AEMO is required to return the power system to a secure state within thirty minutes following a contingency event (NER v60 Clause 4.2.6 (b)).

[13] AEMO, *Power System Security Guidelines,* v54 Section 10.3

[14] For an unplanned outage AEMO is required to notify the market of constraint sets invoked and any interconnectors on the Left-Hand-Side of those constraints (AEMO SO_OP 3715 Power System Security Guideline v61, Section 22)

[15] S-X_BGDV+BGPA for the outage of Bungama – Davenport and Bungama – Para 275 kV transmission lines (this off-loads Bungama 275/132 kV transformer)

[16] AEMO is required to assess whether or not to reclassify a non-credible contingency event as a credible contingency (NER v60 Clause 4.2.3A (c)) and to report how re-classification criteria were applied (NER v60 Clause 4.8.15 (ca)). AEMO has to determine if the condition that caused the non-credible contingency event has been resolved.

[17] AEMO is responsible for power system security in the NEM and is required to operate the power system in a secure operating state. AEMO must thereby ensure that the power system is maintained in, or returned to, a secure operating state following a contingency event (NER v60 Clause 4.2.4 (a))

at Para to operate and open CB 6510 (and 6511 when in service). However as the details of the relay fault were not identified until after testing as part of the investigation by ElectraNet, the actions taken by AEMO and ElectraNet were appropriate given the information available at the time.

Over the duration of the incident AEMO invoked appropriate constraint sets to maintain power system security, issued the required market notifications in a timely manner, and assessed contingencies correctly.

These actions ensured power system security was maintained over the course of the incident.

9 Conclusions

1. The 275 kV fault at Bungama was internal failure of the CT associated with CB 6538.
2. CB 6510 at Para should not have opened for the fault at Bungama. An incorrect relay setting caused the trip of this CB. The relay setting has since been rectified.
3. Power system security was maintained over the course of the incident.

10 Recommendations

There are no recommendations arising from this incident review.

Appendix 1

The protection relay that operated incorrectly at Para was part of a directional earth fault scheme. The scheme protected the Blyth West – Para 275 kV transmission line. This protection scheme was designed for the relays to be configured in blocking mode (as opposed to permissive mode).

The protection relay at Para was however incorrectly configured in permissive mode. The associated relay at the remote end (Blyth West) was correctly configured in blocking mode.

A blocking relay will trip immediately if it detects a fault and does not receive a (block) signal from the remote end. The remote end sends a block signal if the remote relay identifies the fault as out-of-zone (not on the transmission line protected by the particular protection scheme) to prevent an immediate trip, and allow protection on the faulted line time to operate.

A permissive relay will trip immediately if it detects a fault and it receives a (permission) signal from the remote end. The remote end sends a permission signal if the remote relay identifies the fault as in-zone (on the transmission line protected by the particular protection scheme).

For the fault at Bungama:

1. At Blyth West the protection relay on the Para line identified the fault as out-of-zone (beyond Blyth towards Bungama) and sent a blocking signal to the relay at Para.

2. At Para the protection relay identified a fault and received a blocking signal from Blyth West. Due to the incorrect relay configuration this was interpreted as a permissive signal allowing the relay to trip CB 6510 immediately.

This incorrect configuration of the directional earth fault (DEF) protection relay at Para Substation could have tripped CB 6510 (and 6511 when in service) for any earth fault on the 275 kV system for which the fault current flowing in the Para to Blyth West line exceeded the DEF setting.