AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Multiple contingency event at Broken Hill on 17 May 2019

November 2019

Reviewable Operating Incident Report under the National Electricity Rules

INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	1142 hrs on 17 May 2019
Region of incident	New South Wales
Affected regions	New South Wales
Event type	Protection mal-operation
Generation impact	301 MW of generation capacity and 20 MW of actual generation was disconnected as a result of this incident
Customer load impact	36 MW of customer load was disconnected as a result of this incident
Associated reports	Nil

ABBREVIATIONS

Abbreviation	Term
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
CB	Circuit Breaker
HV	High voltage
kV	Kilovolt
NEM	National Electricity Market
NER	National Electricity Rules
TNSP	Transmission Network Service Provider

Important notice

PURPOSE

AEMO has prepared this report in accordance with clause 4.8.15(c) of the National Electricity Rules, using information available as at the date of publication, unless otherwise specified.

DISCLAIMER

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Contents

1. Overview

This report relates to a reviewable operating incident[1] that occurred on 17 May 2019 at Broken Hill in New South Wales. The incident initially involved the trip of the No. 1 220/22 kilovolt (kV) Transformer and No. 1 22 kV busbar, then subsequently the No. 2 220/22 kV transformer, the 220 kV X4 line to the Broken Hill mines (X4 line), and the 220 kV X6 line from the Silverton Wind Farm (X6 line).

There was 301 megawatts (MW) of generation capacity and 20 MW of actual generation, along with 36 MW of customer load, disconnected as a result of this incident.

While this incident was a multiple contingency event the impact in terms of generation and load loss would nornally be no worse than the loss of the Buronga – Broken Hill X2 220kV line.

As this was a reviewable operating incident, AEMO is required 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]. AEMO has concluded that:

1. The trip of the No. 1 Transformer and No. 1 22 kV busbar was an expected operation for the type of fault with all protection operating correctly.
2. The trip of the No. 2 Transformer and the X4 and X6 lines was not an expected outcome, and was caused by a faulty protection relay. The faulty protection relay has been replaced.
3. The multiple close/open operations on the No. 1 Transformer and X4 and X6 lines were also not expected, and were caused by a design error in the X2 Auto-Reclose Scheme. Modifications have been made to this scheme to prevent a reoccurrence of this type of operation.
4. AEMO correctly reclassified the simultaneous trip of the No. 2 Transformer, the X4 and X6 lines, and the No. 2 22 kv busbar as a credible contingency after this incident.
5. The power system remained in a secure operating state during this incident.

This report is prepared in accordance with clause 4.8.15(c) of the National Electricity Rules (NER). It is based on information provided by TransGrid[3] and AEMO.

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

2. The incident

2.1 The incident

At 1142 hrs on 17 May 2019, No. 1 Transformer and No. 1 22 kV busbar at Broken Hill tripped, resulting in the disconnection of 4 MW of customer load and 50 MW of generation capacity[4].

At 1208 hrs on 17 May 2019, at Broken Hill, the No. 2 Transformer, the 220 kV X4 line to the Broken Hill Mines, and the 220 kV X6 line from the Silverton Wind Farm tripped, resulting in the disconnection of a further

[1] See NER clause 4.8.15(a)(1)(i), as the event relates to a non-credible contingency event; and the AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.

[2] See NER clause 4.8.15(b).

[3] TransGrid is a Transmission Network Service Provider (TNSP) in New South Wales.

[4] The two Broken Hill gas turbines

251 MW of generation capacity[5] and 30 MW of actual generation[6], along with a further 32 MW of customer load. The Broken Hill 220 kV busbar remained energised via the 220 kV X2 line from Buronga.

The No. 2 Transformer was returned to service at 1321 hrs on 17 May 2019, with load restoration commencing at 1332 hrs. The remaining equipment was returned to service on 17 May 2019:

- No. 1 Transformer at 1334 hrs.
- Broken Hill Solar Farm at 1344 hrs.
- X6 line to the Silverton Wind Farm at 1345 hrs.
- X4 line to the Broken Hill mines at 1413 hrs.

2.2 TransGrid investigation

The following is based on information provided by TransGrid.

2.2.1 Trip of No. 1 22k V busbar

The trip of the No. 1 22 kV bus section resulted from a bird strike on a 22 kV disconnector adjacent to the 22 kV 1-2 Bus Section Circuit Breaker (CB) 2112. This resulted in the trip of the No. 1 Transformer and all CBs connected to the No. 1 22 kV bus section. This was a correct outcome for a fault in this location. Appendix A1 shows diagrams of Broken Hill before and immediately after the trip of the No. 1 Transformer.

After the loss of the No. 1 Transformer, and in accordance with TransGrid procedures, TransGrid enabled the Broken Hill Anti-Islanding control scheme at 1151 hrs on 17 May 2019. Also, the X2 Auto-Reclose or Station Reclose Scheme was already enabled at Broken Hill, in accordance with TransGrid procedures. Refer to Appendix A2 for details of these control schemes.

2.2.2 Trip of the 220 kV busbar

At 12:08:10 hrs on 17 May 2019, the No. 2 Transformer and the X4 and X6 lines tripped, along with the remaining 22 kV CBs on the No. 2 22 kV bus section, resulting in a loss of supply to Broken Hill and the Broken Hill mines. Generation from the Broken Hill Solar Farm and the Silverton Wind Farm was also disconnected. This was not an expected operation, because there was no associated high voltage fault on the power system. The 220 kV busbar remained energised via the X2 line from Buronga. Refer to Appendix A1.3 for a diagram of Broken Hill immediately after the trip of the 220 kV busbar.

At 12:08:11 hrs on 17 May 2019, the No. 1 Transformer 22 kV CB 2412, the X4 line 220 kV CB X42, and a number of 22 kV load CBs at Broken Hill auto-reclosed via the X2 Auto Reclose scheme. These CBs tripped again immediately on closing. Approximately 15 seconds later, these CBs auto-reclosed then immediately tripped again. This cycle of auto-reclose and trip was repeated 15 times before CB X42 failed to reclose at 1213 hrs on 17 May 2019. TransGrid disarmed the X2 Auto-Reclose scheme at 1252 hrs on 17 May to prevent any further operations.

The No. 2 Transformer was returned to service at 1312 hrs on 17 May 2019, and load restoration commenced at 1332 hrs on 17 May. The X6 line was returned to service at 1357 hrs on 17 May, and the X4 line was returned to service at 1413 hrs on 17 May after a thermal overload on the drive motor for CB X42 was reset.

Investigations by TransGrid revealed the No. 1 Transformer No. 2 Protection relay instantaneous overcurrent output was intermittently high[7] due to a fault in the relay. This, coupled with the latched multitrip relay[8] for the No. 1 Transformer, resulted in the initiation of the No. 1 Transformer local back up protection, which in turn initiated the 220 kV busbar protection at Broken Hill tripping the No. 2 Transformer and the X4 and X6

[5] Based on nameplate capacity at Silverton Wind Farm and Broken Hill Solar Farm.

[6] 18 MW from the solar farm and 2 MW from the wind farm.

[7] That is an intermittent trip signal.

[8] Multitrip relays are used to take the output from protection relays and directly operate the circuit breaker trip coils. These relays automatically latch in the close (or operated) condition after a protection operation and require manually resetting prior to restoration of tripped equipment.

lines. This trip signal, coupled with the X2 Auto-Reclose Scheme, then resulted in the multiple CB open/close cycling that occurred. It is likely the No. 2 Protection relay had been faulty for some time, but the fault only became evident after the trip of the No. 1 Transformer. TransGrid has advised the faulty protection relay has been replaced. TransGrid has reviewed internally the population of the failed relay. There is no indication of a type fault .This type of relay is 40 years with approximately 60 still in service in the TransGrid network. There has been no observed increase in failure rates for these relays, and it is presumed to be an individual faiulure of a relay in a comparatively harsh physical and electrical environment.

Although there is no CB on the X2 line at Broken Hill, the X2 line CB at Buronga did not trip, because the protection at Buronga has to identify an actual high voltage fault before tripping the line in response to an intertrip from the busbar protection at Broken Hill. In this case, there was no high voltage fault on the 220 kV busbar at Broken Hill, and the X2 line and the Broken Hill 220 kV busbar remained energised during this incident.

In response to this incident, TransGrid disabled the X2 Auto-Reclose Scheme, pending design changes to prevent multiple open/close operations as seen during this incident. TransGrid has advised that changes to prevent the scheme operating for a 220 kV busbar protection operation have been completed, and the X2 Auto-Reclose Scheme was returned to service on 8 July 2019.

3. Power system security

AEMO is responsible for power system security in the NEM. This means AEMO is required to operate the power system in a secure operating state to the extent practicable and take all reasonable actions to return the power system to a secure state following a contingency event in accordance with the NER[9].

The power system was in a secure operating state prior to this incident and remained in a secure operating state for the duration of the incident. The only actions required by AEMO in relation to power system security were to invoke constraint sets N-BROKENH1_ZERO[10]and N-STWF1_ZERO[11] to ensure these generating units did not receive dispatch targets while disconnected. Both constraint sets were invoked at 1215 hrs on 17 May 2019 and revoked at 1404 hrs on the same day.

3.1 Reclassification

AEMO assessed whether or not to reclassify this incident as a credible contingency event[12].

After the simultaneous trip of the No. 2 Transformer, the X4 and X6 lines, and the No. 2 22 kV busbar, AEMO considered a further simultaneous loss of these elements as reasonably possible and reclassified the loss of these elements as a credible contingency at 1418 hrs on 17 May 2019. No constraint sets were required to be invoked at a result of this reclassification. The reclassification was cancelled at 1730 hrs on 22 May after TransGrid advised AEMO that the cause of the trip had been identified and the faulty protection had been replaced.

[9] Refer to AEMO's functions in section 49 of the National Electricity Law and the power system security principles in clause 4.2.6 of the NER.

[10] Upper limit on Broken Hill Solar Farm of zero MW.

[11] Upper limit on Silverton Wind Farm of zero MW.

[12] AEMO is required to assess whether to reclassify a non-credible contingency event as a credible contingency event – NER clause 4.2.3A(c) – and to report how the reclassification criteria were applied – NER clause 4.8.15(ca).

4. Market information

AEMO is required by the NER and operating procedures to inform the market about incidents as they progress.

This section assesses how AEMO informed the market[13] over the course of this incident.

For this incident, AEMO informed the market on the following matters:

1. A non-credible contingency event – notify within two hours of the event[14].
   - AEMO issued Market Notice 68390 at 1236 hrs on 17 May 2019, to advise of the non-credible contingency event (the trip of the No. 1 Transformer and No. 1 22 kV busbar). The Market Notice was issued 53 minutes after the contingency event.
   - AEMO issued Market Notice 68391 at 1238 hrs on 17 May 2019, to advise of the non-credible contingency event (the trip of the No. 2 Transformer, the No. 2 22 kV busbar, and the X4 and X6 lines). The Market Notice was issued 30 minutes after the contingency event.
2. Reclassification, details, and cancellation of a non-credible contingency – notify as soon as practical[15].
   - AEMO issued Market Notice 68392 at 1411 hrs on 17 May 2019 to advise that the cause of the trip of the No. 1 Transformer and the No. 2 22 kV busbar had been identified and reclassification as a credible contingency event was not required.
   - AEMO issued Market Notice 68394 at 1418 hrs on 17 May 2019 to advise that the simultaneous trip of the No. 2 Transformer, the No. 2 22 kV busbar, and the X4 and X6 lines had been reclassified as a credible contingency event.
   - AEMO issued Market Notice 68444 at 1730 hrs on 20 May 2019 to advise that the simultaneous trip of the No. 2 Transformer, the No. 2 22 kV busbar, and the X4 and X6 lines was no longer considered as a credible contingency event.

5. Conclusions

AEMO has assessed this incident in accordance with clause 4.8.15(b) of the NER. In particular, AEMO has assessed the adequacy of the provision and response of facilities or services, and the appropriateness of actions taken to restore or maintain power system security.

AEMO has concluded that:

1. The trip of the No. 1 Transformer and No. 1 22 kV busbar was an expected operation for the type of fault with all protection operating correctly.
2. The trip of the No. 2 Transformer and the X4 and X6 lines was not an expected outcome, and was caused by a faulty protection relay. The faulty protection relay has been replaced.

[13] AEMO generally informs the market about operating incidents as the progress by issuing Market Notices – see https://www.aemo.com.au/Market-Notices.

[14] AEMO is required to notify the Market of a non-credible contingency event within two hours of the event – AEMO, Power System Security Guidelines, Section 10.3, available at SO_OP3715 Power System Security Guidelines.

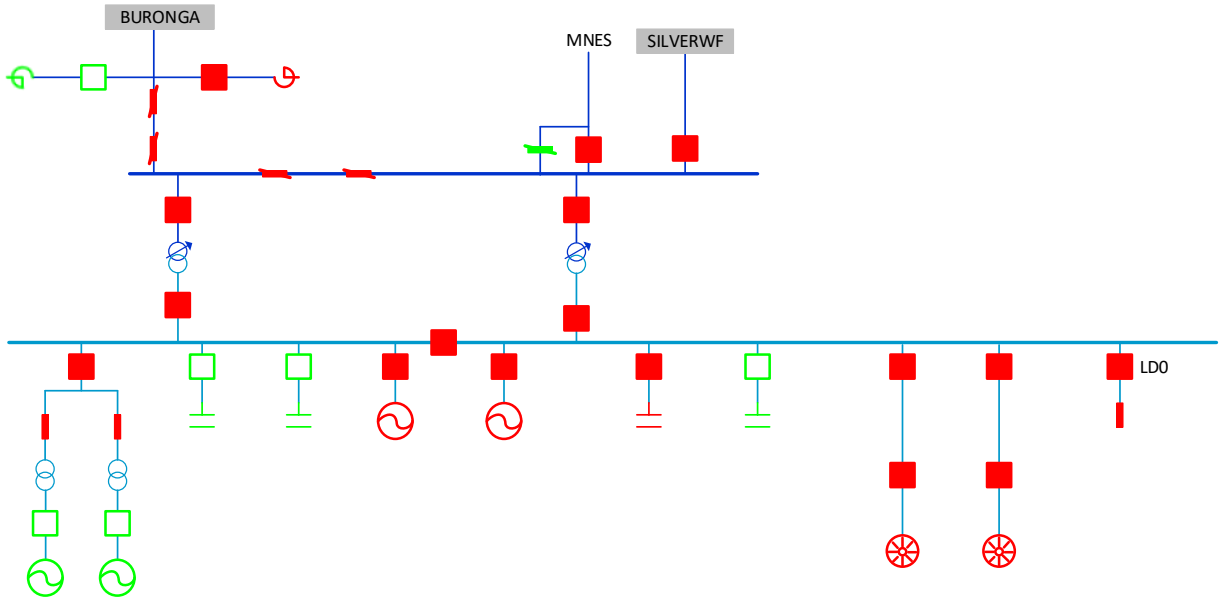
[15] AEMO is required to notify the market of a reclassification – NER clause 4.2.3(g), details of the reclassification – 4.2.3(c), and when AEMO cancels the reclassification – 4.2.3(h).

3. The multiple close/open operations on the No. 1 Transformer and X4 and X6 lines were also not expected, and were caused by a design error in the X2 Auto-Reclose Scheme. Modifications have been made to this scheme to prevent a reoccurrence of this type of operation.
4. AEMO correctly reclassified the simultaneous trip of the No. 2 Transformer, the X4 and X6 lines, and the No. 2 22 kV busbar as a credible contingency after this incident.
5. The power system remained in a secure operating state during this incident.

A1. System diagrams

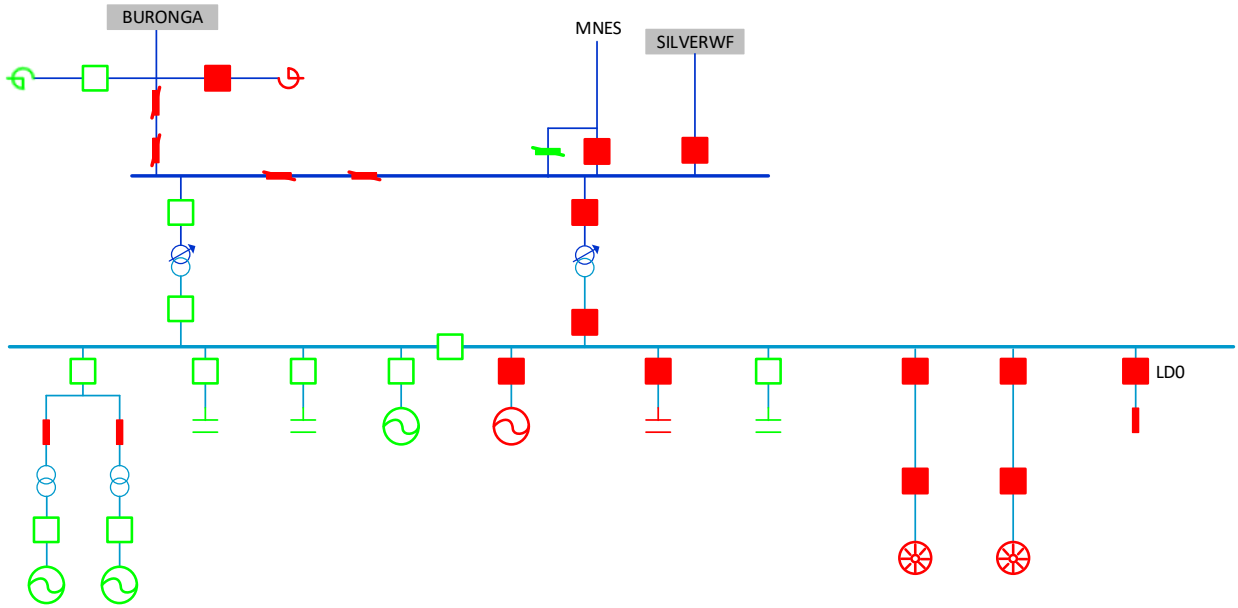
A1.1 Broken Hill prior to the incident

Broken Hill (prior to incident)



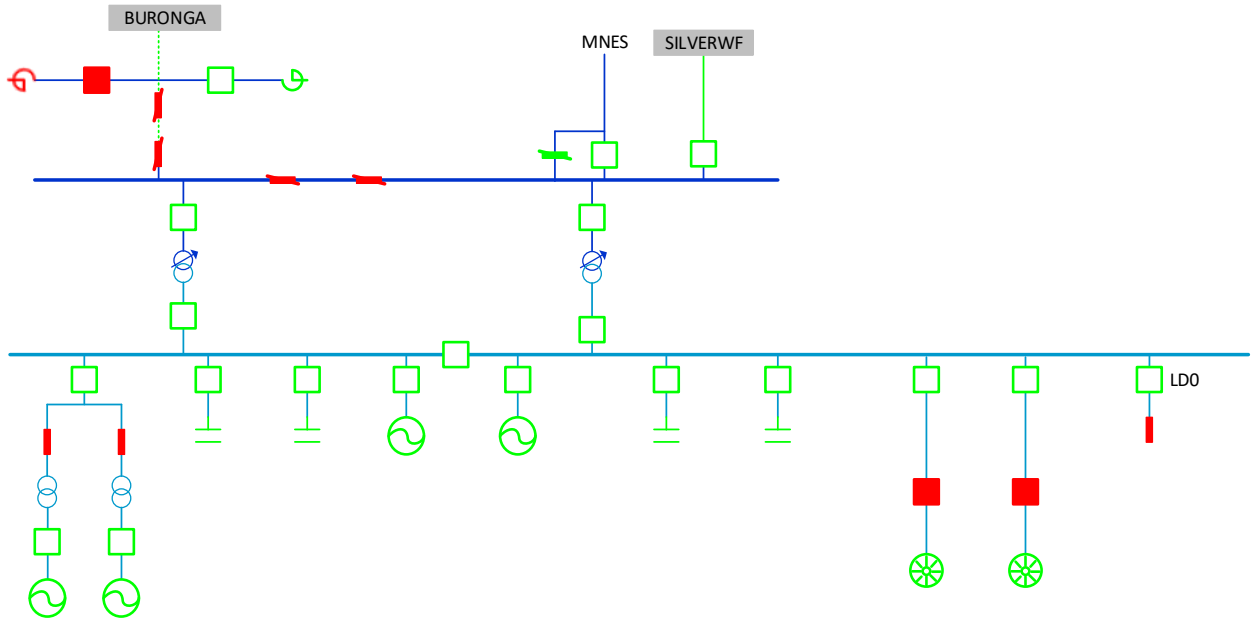
A1.2 Broken Hill after the trip of No. 1 Transformer and No. 1 22 kV busbar

Broken Hill (during incident – Stage 1)



A1.3 Broken Hill after the trip of the 220 kV busbar

Broken Hill (during incident – Stage 2)



A2. Control schemes

A2.1 Broken Hill Anti-Islanding scheme

This scheme is armed by TransGrid during the outage of one of the 220/22 kV Transformers at Broken Hill. The purpose of this scheme is to ensure an island is not created between generation and load at Broken Hill after the loss of the second 220/22 kV Transformer or the X2 line. The scheme will automatically trip the 22 kV generation (gas turbine and solar farm) and reactive plant CBs and then, after a two second delay, attempt to restore the second transformer to service.

A2.2 X2 Auto-Reclose scheme

After a trip of the X2 line from either the X2 line protection or other protection at Broken Hill, this scheme initiates the following sequence of events to ensure Broken Hill is returned to service as soon as possible.

Trip :

- All Transformer CBs.
- All 22 kV load CBs.
- X4 line 220 kV CB.
- Gas Turbine 22 kV CB.
- All in service capacitor CBs.

Close:

- X4 line 220 kV CB.
- No. 1 Transformer CBs.
- All 22 kV load CBs.