

Trip of Bungama – Davenport and Bungama – Blyth West 275 kV lines

July 2022

Reviewable Operating Incident
Report under the National
Electricity Rules





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.

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Contact

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Incident classifications

| Classification | Detail |
|---------------------------|--------------------------------|
| Time and date of Incident | 0945 hrs 11 February 2022 |
| Region of incident | South Australia |
| Affected regions | South Australia |
| Event type | Transmission equipment failure |
| Generation impact | None |
| Customer load impact | None |
| Associated reports | None |

Abbreviations

| Abbreviation | Term |
|--------------|---------------------------------------|
| AEMC | Australian Energy Market Commission |
| AEMO | Australian Energy Market Operator |
| AEST | Australian Eastern Standard Time |
| CB | Circuit Breaker |
| CT | Current Transformer |
| kV | kilovolts |
| MN | Market Notice |
| ms | milliseconds |
| MW | megawatts |
| NEM | National Electricity Market |
| NER | National Electricity Rules |
| PSSWG | Power System Security Working Group |
| s | seconds |
| SC | Synchronous Condenser |
| TIPS | Torrens Island Power Station |
| TNSP | transmission network service provider |
| TX | Transformer |
| WF | Wind Farm |



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1 Overview

This report relates to a reviewable operating incident¹ that occurred on 11 February 2022 in South Australia. The incident involved the simultaneous trip of the Davenport – Bungama and Bungama – Blyth West 275 kilovolts (kV) lines.

There was no loss of generation or customer load as a result of this incident.

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 security².

AEMO has concluded that:

1. The 'W' phase fault was caused by the explosive failure of the Current Transformer (CT) at Circuit Breaker (CB) 6537 at Bungama substation. Based on advice from ElectraNet, AEMO understands that the type of CT that failed in this incident is exhibiting an undesirable and elevated risk of failure. Appendix A2 contains images of the failed CT.
2. The 'W' phase fault resulted in the correct operation of the Bungama – Blyth West 275 kV line protection and the CB fail protection of CB 6537.
3. The unexpected three-phase trip of CB 6539, 255 milliseconds (ms) after the initial fault, was due to the operation of a relay logic timer which was designed to ensure three-phase tripping for developing multi-phase faults in the Bungama – Blyth West 275 kV line protection relay at Bungama. ElectraNet was not aware this timer was enabled in the relay and has since disabled it.
4. The power system remained in a secure operating state throughout 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 ElectraNet and information available to AEMO.

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

2 The incident

2.1 Pre-event conditions

Immediately prior to this incident there were no planned or unplanned outages in the vicinity of Davenport, Bungama or Blyth West 275 kV substations.

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).

2.2 The incident

At 0945 hrs on 11 February 2022, a 'W' phase fault was detected by the Bungama – Blyth West 275 kV line protections. These protections operated, causing the three-phase trip of CB 6537 at Bungama and the single phase trip of CB 6539 at Bungama and CB 8000 and CB 8001 at Blyth West³. This de-energised the 'W' phase of the Bungama – Blyth West 275 kV line.

However, due to the location of the fault, it was not cleared and the Bungama CB 6537 CB fail protection subsequently operated to clear the fault. The CB fail protection tripped CB 6538 at Bungama and inter-tripped CB 6561 and CB 6560 at Davenport. This deenergised the Davenport – Bungama 275 kV line and successfully cleared the fault from the system.

Subsequently, 255 ms after the initial fault, phases 'U' and 'V' of CB 6539 at Bungama unexpectedly tripped and CB 6539 was locked out of auto-reclose. This resulted in phases 'U' and 'V' of the Bungama – Blyth West 275 kV line being open at the Bungama end only.

CB 8000 and CB 8001 at Blyth West then successfully auto-reclosed after 1 second (s) to energise the 'W' phase of the line from Blyth West⁴. This resulted in all three phases of the Bungama – Blyth West 275 kV line being energised from the Blyth West end only.

Figure 1 and Figure 2 in Appendix A1 show which circuit breakers tripped during the incident and Appendix A2 summarises the sequence of events.

2.3 Analysis


The following is based on information provided by ElectraNet.

ElectraNet has confirmed that the cause of the 'W' phase fault on the Bungama – Blyth West 275 kV line was a failed CT on the 'W' phase of CB 6537 at Bungama. Cores of the CT of CB 6537 are part of both the Bungama – Blyth West 275 kV line protection scheme and the Bungama – Davenport 275 kV line protection scheme. The position of the failed 'W' phase CT at Bungama was on the Davenport feeder side of CB 6537, but the location of the flashover within the CT was inside the protected zone of the Bungama – Blyth West 275 kV line protection. This resulted in the fault being identified as in-zone by the Bungama – Blyth West 275 kV line protection and out-of-zone by the Bungama – Davenport 275 kV line protection. The fault was detected correctly by the Bungama – Blyth West 275 kV line Set X differential and Set Y distance protections, which initiated the three-phase trip of CB 6537 at Bungama and the single-phase trip of the 'W' phase of CB 6539 at Bungama and CB 8000 and CB 8001 at Blyth West⁵. The protection operated as designed and successfully de-energised the 'W' phase of the Bungama – Blyth West 275 kV line in 49 ms.

³ U-V-W phase sequences are equivalent to A-B-C, R-W-B, or R-Y-B phase sequence. U-V-W are used to denote the phases of 275 kV lines.

⁴ Transmission system circuit breakers are typically capable of single-phase or three-phase auto-reclose. The auto-reclose function means that after a fault is detected, the breaker will open (either a single phase or all three phases), clearing the fault, and then attempt to reclose again after a specified deadtime/delay. If the fault is still present, the breaker will lockout auto-reclose and remain open. Transient, single-phase faults constitute the majority of faults on high voltage transmission lines. It is therefore common practice to employ single-phase trip and auto-reclose functionality on high voltage transmission lines to minimise the impact of these faults on power system security. The dead time for auto-reclose, in this case, is approximately 1 s for 275 kV.

⁵ Many elements of transmission equipment have two sets of primary protection systems to provide redundancy. Both these protection systems monitor the protected equipment and both systems will attempt to trip the equipment should a monitored (or in zone) fault occur. To differentiate between one primary protection system and another, ElectraNet refers to one system as the X protection and the other as the Y protection.



Given that the position of the failed 'W' phase CT at Bungama was on the Davenport feeder side of CB 6537, the operation of the Bungama – Blyth West 275 kV line protection did not clear the fault from the system. As a result, the Set X and Set Y CB fail protection for CB 6537 at Bungama operated as designed to trip CB 6538 at Bungama and inter-trip CB 6561 and CB 6560 at Davenport, clearing the fault in 220 ms.

Subsequently, 255 ms after the initial fault, CB 6539 at Bungama, which had already opened phase 'W' due to the operation of the Bungama – Blyth West 275 kV line protection, was unexpectedly three-phase tripped by the Bungama – Blyth West 275 kV line Set X protection and therefore locked out of auto-reclose. ElectraNet has confirmed that the trip was due to the operation of a relay logic timer which was designed to ensure three-phase tripping for developing multi-phase faults. This timer is not implemented in the line protection relay at Blyth West. The protection operated as designed, however ElectraNet was not aware that it was enabled in the Bungama – Blyth West 275 kV line protection relay at Bungama, so the three-phase trip of CB 6539 for this event was not expected. In response to this incident, the logic timer in the Bungama – Blyth West 275 kV line protection relay at Bungama was disabled on 6 April 2022. ElectraNet has confirmed that the three-phase tripping of line circuit breakers for developing multi-phase faults is already ensured by other features of the line protection relays.

CB 8000 and CB 8001 successfully auto-reclosed within 1 s of the initial fault, re-energising the 'W' phase of the Bungama – Blyth West 275 kV line from the Blyth West end. This resulted in all three phases of the Bungama – Blyth West 275 kV line being energised at the Blyth West end only. At 0958 hrs, the Bungama – Blyth West 275 kV line was de-energised by ElectraNet operators.


At 1049 hrs on 11 February 2022, a site inspection carried out by maintenance personnel confirmed that the 'W' phase CT at CB 6537 at Bungama had failed and was the cause of the 'W' phase fault. As a consequence, CB 6537 and the failed CT were isolated. ElectraNet also isolated CB 6538 to allow for the cleaning of oil on the associated isolators and the testing of its CTs.

At 1225 hrs on 11 February 2022, CB 6539 at Bungama was closed to return the Bungama – Blyth West 275 kV line to service. At 1509 hrs on 13 February 2022, CB 6538 was closed re-energising the Bungama – Davenport 275 kV line. ElectraNet replaced the CT at CB 6537 at Bungama and returned it to service at 1231 hrs on 25 February 2022.

2.4 Related power system incidents

There have been several contingency events in the South Australia region that were caused by similar CT failures. The details of the relevant power system incidents are listed below:

- **1 April 2022:** The Torrens Island Power Station (TIPS) B3 bus tie CBs tripped and the TIPS B – Lefevre 275 kV line tripped and successfully auto-reclosed. This event was not determined to be reviewable by AEMO under Clause 4.8.15 of the NER; however, ElectraNet has confirmed that this incident was attributed to the explosive failure of the CT on the west side of the 275 kV CB BC3.
- **12 March 2021:** The TIPS A West 275 kV busbar and the TIPS B West 275 kV busbar tripped simultaneously. The TIPS B busbar trip disconnected Barker Inlet Power station from the system, and the trip of TIPS A busbar disconnected the Torrens West 275/66 kV West transformer. The trip of TIPS A and TIPS B busbars was caused by a failure of the CT associated with the Torrens West bus section CB. Oil from the failed CT caught fire during the failure damaging secondary systems such as control cables, communication fibres, and the



Torrens Island Power Station B (TIPSB) 275 kV CB compressed air line. This incident was reviewed by AEMO under Clause 4.8.15 of the NER⁶.

- **16 October 2020:** The explosive failure of the 'U' phase CT located on the busbar side of CB 6530 at Brinkworth resulted in the trip of the Brinkworth – Davenport 275 kV line, the Brinkworth – Templers West 275 kV line and the Brinkworth 275/132 kV No.3 transformer. This incident was reviewed by AEMO under Clause 4.8.15 of the NER⁷.
- **1 December 2013:** The CT at Bungama CB 6538 failed, which resulted in the trip of the Bungama – Davenport 275 kV line, the Bungama – Blyth West 275 kV line, and the Blyth West – Para 275 kV line. This incident was reviewed by AEMO under Clause 4.8.15 of the NER⁸.

ElectraNet has confirmed to AEMO that its network contains 324 CTs of the same type involved in the incidents described above, spread across 18 sites. This fleet of CTs has been in service for approximately 15 years. ElectraNet has advised AEMO that it is progressing the following mitigating actions:

- A detailed analysis is currently being undertaken, in partnership with the CT manufacturer, to determine the root cause of the CT failures and the associated failure risk.
- A replacement strategy for high-risk locations is currently being developed.

ElectraNet is also actively sharing any information and findings related to the CT performance issues with other Australian transmission network service providers (TNSPs).

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 NER⁹.

The power system was in a secure operating state throughout this incident, and no action was required by AEMO to restore or maintain power system security.

3.1 Reclassification

AEMO assessed whether to reclassify this incident as a credible contingency event¹⁰.

On 14 February 2022, ElectraNet advised AEMO that the cause of the non-credible contingency event was the explosive failure of the CT at CB 6537 at Bungama. AEMO requested information from ElectraNet relating to


⁶ Refer to the AEMO final incident report on the Trip of Torrens Island A and B West 275 kV busbars on 12 March 2021, at https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2021/final-report-torrens-island-275-kv-west-busbar-trip.pdf?la=en.

⁷ Refer to the AEMO final incident report on the Failure of 275 kV Current Transformer at Brinkworth Substation on 16 October 2020, at https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2020/ct-failure-at-brinkworth-on-16-oct-2020.pdf?la=en.

⁸ Refer to the AEMO final incident report on the Trip of Davenport Bungama Blyth Para 275 kV Transmission Lines, at https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2014/psior_trip_of_davenport_bungama_blyth_para_275kv_transmission_lines_1_dec_13_v2.pdf?la=en&hash=A0D7A98646D686E609A04A52E160DAEE.

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 AEMO is required to assess whether or not 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).



whether similar CT failures were reasonably possible at other sites, and whether it was necessary to reclassify relevant contingency events from non-credible to credible. ElectraNet advised that the CTs that had failed were exhibiting an undesirable and elevated risk of failure and were being managed in a manner consistent with its normal asset management practices. Therefore, AEMO correctly identified that reclassification was not required.

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 market¹¹ 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 event¹².
 - AEMO issued Market Notice (MN) 94577 at 1053 hrs on 11 February 2022, 68 minutes after the event, to advise of the non-credible contingency event.
2. Reclassification, details, and cancellation of a non-credible contingency – notify as soon as practical¹³.
 - AEMO issued MN 94579 at 1308 hrs on 11 February 2022 to advise that:
 - The Bungama – Blyth West 275 kV line was returned to service at 1225 hrs on 11 February 2022.
 - The cause of the non-credible contingency event had been identified and AEMO was satisfied that another occurrence was unlikely and would therefore not reclassify the event 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 ‘W’ phase fault was caused by the explosive failure of the CT at CB 6537 at Bungama substation. Based on advice from ElectraNet, AEMO understands that the type of CT that failed during this incident is exhibiting an undesirable and elevated risk of failure.
2. The location of the failed CT resulted in the correct operation of the Bungama – Blyth West 275 kV line protection and the CB fail protection of CB 6537.
3. The unexpected three-phase trip of CB 6539 255 ms after the initial fault was due to the operation of a relay logic timer which was designed to ensure three-phase tripping for developing multi-phase faults in the

¹¹ AEMO generally informs the market about operating incidents as they progress by issuing Market Notices – see <https://www.aemo.com.au/Market-Notices>.

¹² 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 7.3.

¹³ 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).



Bungama – Blyth West 275 kV line protection relay at Bungama. ElectraNet was not aware this timer was enabled in the relay and have since disabled it.

4. The power system remained in a secure operating state throughout this incident.

6 Recommendations

1. AEMO will share the details of this incident with the Power System Security Working Group (PSSWG) in August 2022.
2. AEMO recommends that ElectraNet continues the detailed analysis of the root cause of the recent CT failures in and works to minimise the elevated risk of failure at relevant sites.
3. AEMO recommends that ElectraNet prioritises development of its replacement strategy and advises AEMO promptly of any changes to risks, including whether any abnormal conditions exist that would warrant reclassifications by AEMO.

A1. System diagram

The diagrams below provides an overview of part of the power system immediately after the incident.

Figure 1 Simplified network configuration approximately 49 ms after the incident following initial CB operations

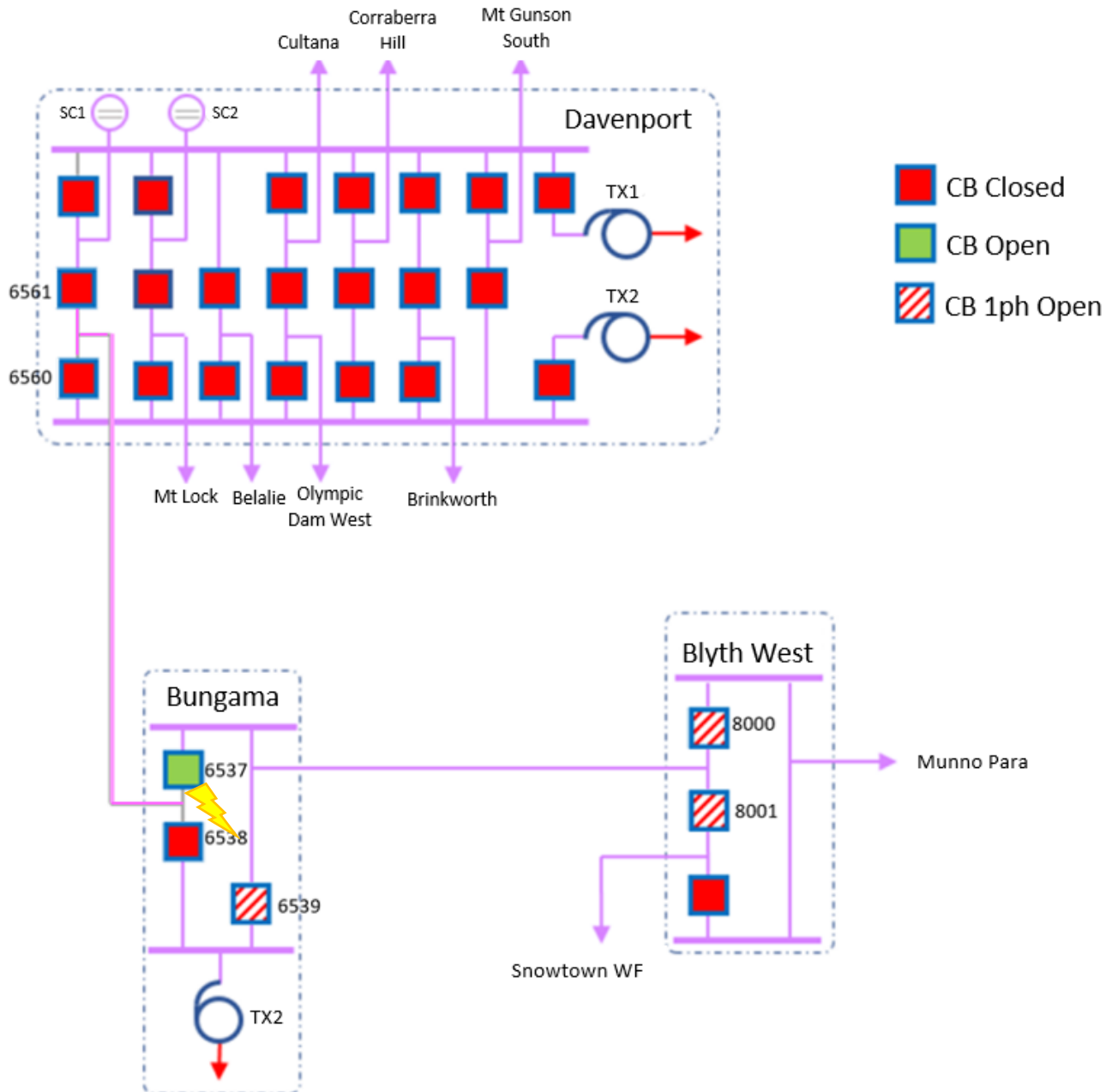
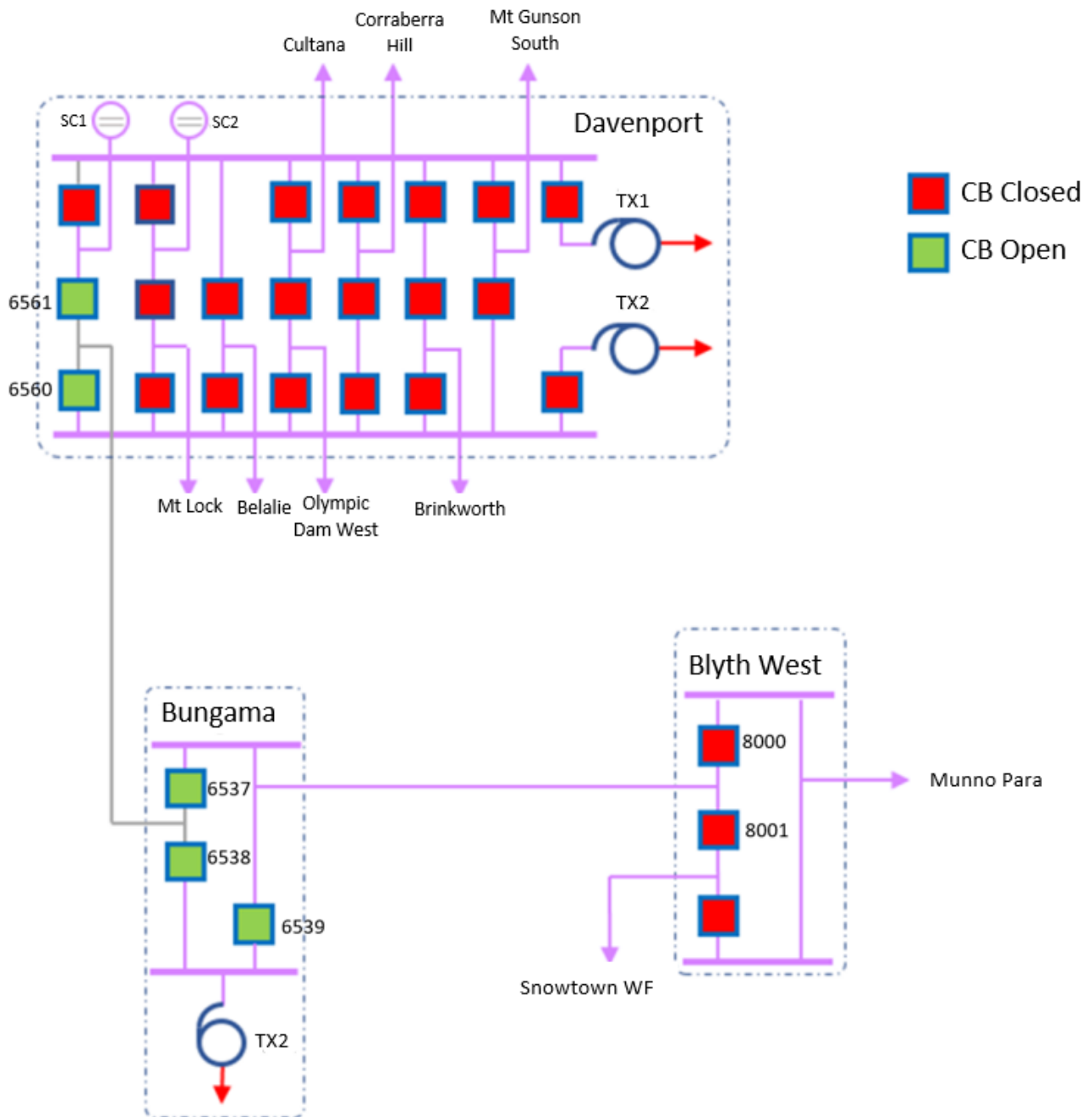
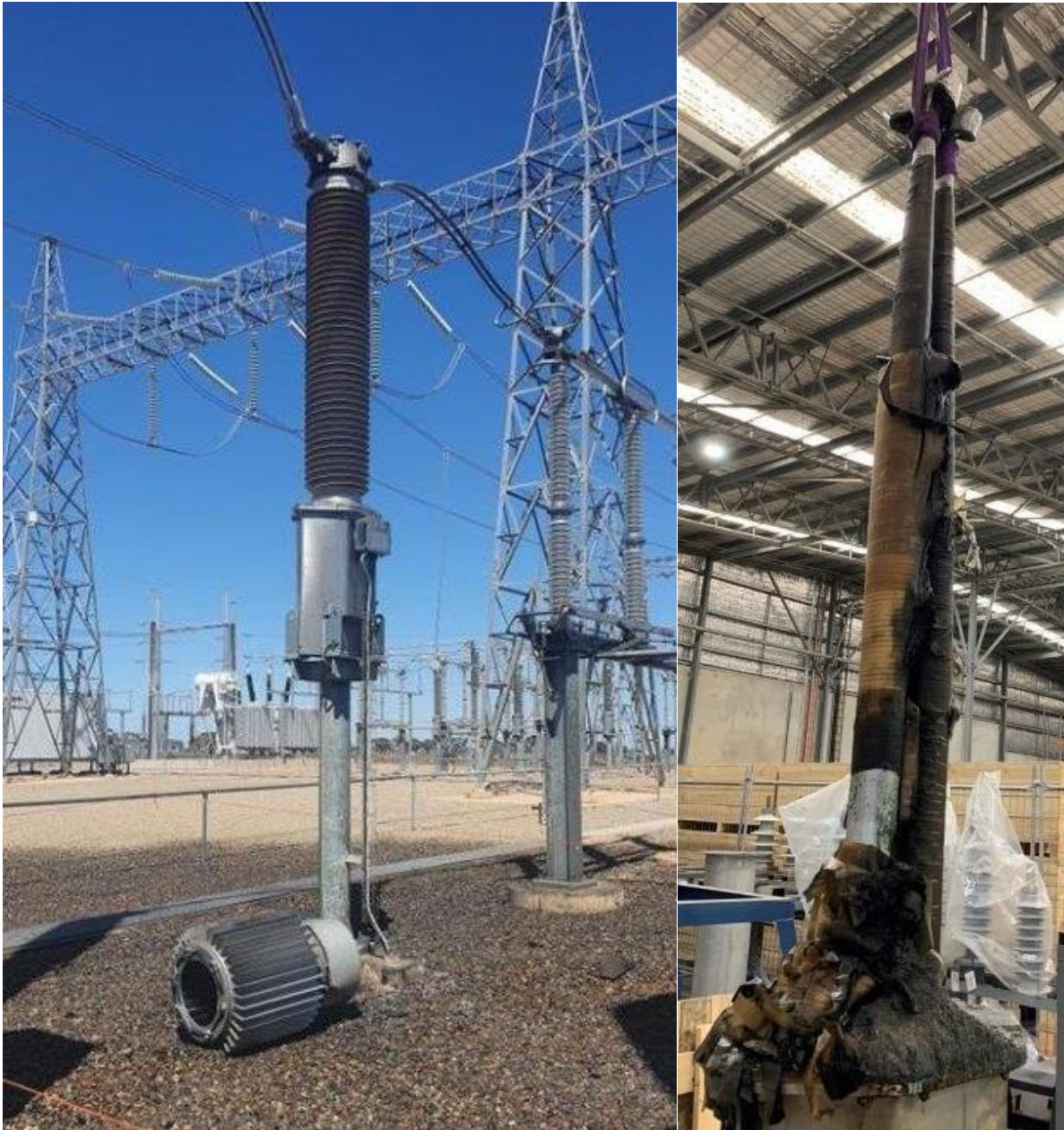


Figure 2 Simplified network configuration after fault clearance and three-phase trip of CB 6539 due to protection maloperation



A2. Images of failed current transformer

Figure 3 Failed CT in substation yard (left) and interior of failed CT after it was dismantled (right)



A3. Sequence of events

Table 1 Summary sequence of events

| Date | Time | Event type | Event |
|-----------|------|--------------|---|
| 11/2/2022 | 0945 | Transmission | Bungama – Blyth West 275 kV line: <ul style="list-style-type: none"> • A 'W' phase fault was detected at Bungama by the Bungama – Blyth West 275 kV line protections, which initiated the three-phase trip of Circuit Breaker (CB) 6537 at Bungama and the single-phase trip of CB 6539 at Bungama and CB 8000 and CB 8001 at Blyth West. • Protection operated within 49 ms. |
| 11/2/2022 | 0945 | Transmission | Bungama – Davenport 275 kV line: <ul style="list-style-type: none"> • CB fail protection for CB 6537 at Bungama operated. • This circuit breaker fail protection initiated the three-phase trip of CB 6538 at Bungama and the inter-trip of CB 6561 and CB 6560 at Davenport. • The fault was cleared in 220 ms. |
| 11/2/2022 | 0945 | Transmission | Bungama – Blyth West 275 kV line: <ul style="list-style-type: none"> • 255 ms after the initial fault, the CB 6539 at Bungama was three-phase tripped, resulting in the Bungama – Blyth West 275 kV line being open at the Bungama end only and remaining energised at the Blyth West end. |
| 11/2/2022 | 0945 | Transmission | Bungama – Blyth West 275 kV line: <ul style="list-style-type: none"> • CB 8000 and CB 8001 at Blyth West successfully single-phase auto-reclosed within 1 s. |
| 11/2/2022 | 0958 | Transmission | Bungama – Blyth West 275 kV line: <ul style="list-style-type: none"> • Line was de-energised by ElectraNet Operators. |
| 11/2/2022 | 1049 | Transmission | A site inspection carried out by maintenance personnel confirmed that the 'W' phase CT at CB 6537 at Bungama had failed and was the cause of the 'W' phase fault. ElectraNet isolated CB 6537 and the failed CT as well as CB 6538 to allow for the cleaning of oil on the associated isolators and the testing of its CTs. |
| 11/2/2022 | 1053 | Notice | MN 94577 issued, 68 minutes after the event, to advise of the non-credible contingency event. |
| 11/2/2022 | 1225 | Transmission | Bungama – Blyth West 275 kV line: <ul style="list-style-type: none"> • CB 6539 at Bungama was closed to return the Bungama – Blyth West 275 kV line to service. |
| 11/2/2022 | 1308 | Notice | MN 94579 issued to advise that the Bungama – Blyth West 275 kV line was returned to service at 1225 hrs on 11 February 2022. |
| 13/2/2022 | 1509 | Transmission | Bungama – Davenport 275 kV line: <ul style="list-style-type: none"> • CB 6538 was closed to re-energise the Bungama – Davenport 275 kV line. |
| 25/2/2022 | 1231 | Transmission | ElectraNet successfully replaced the CT at CB 6537 at Bungama and returned it to service at 1231 hrs on 25 February 2022. |