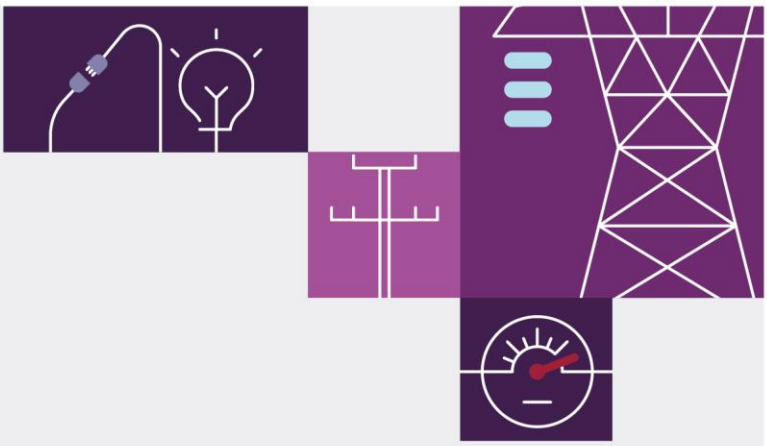
Preliminary Report – Three-phase fault at Sheffield and trip of load in Tasmania on 12 April 2024

June 2024

A preliminary operating incident report for the National Electricity Market – information as at 27/06/2024



Important notice

Purpose

AEMO has prepared this preliminary report as part of its review of the reviewable operating incident that occurred on 12 April 2024 involving a three-phase fault at Sheffield 220 kilovolt (kV) A busbar during switching to restore the Farrell – Sheffield No. 2 220 kV line, and subsequent loss of load in Tasmania, as a first step in reporting under clause 4.8.15(c) of the National Electricity Rules.

The observations in this report will be updated in AEMO's final operating incident report, where new information becomes available.

Disclaimer

AEMO has been provided with preliminary data by Registered Participants as to the status and response of some facilities before, during and after the event in accordance with clause 4.8.15 of the National Electricity Rules. In addition, AEMO has collated preliminary information from its own systems. Any analysis and conclusions expressed in this document are also of a preliminary nature.

While AEMO has made reasonable efforts to ensure the quality of the information in this report, its investigations are incomplete, and any findings expressed in it may change as further information becomes available and further analysis is conducted. Any views expressed in this report are those of AEMO unless otherwise stated and may be based on information given to AEMO by other persons.

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If you have any questions or comments in relation to this report, please contact AEMO at system.incident@aemo.com.au.

AEMO acknowledges the Traditional Owners of country throughout Australia and recognises their continuing connection to land, waters and culture. We pay respect to Elders past and present.

Abbreviations

Abbreviation	Term
A	ampere/s
AC	alternating current
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
CB	circuit breaker
FCAS	frequency control ancillary services
FCSPS	Frequency Control Special Protection Scheme
HMS	high speed monitoring
Hz	hertz
kV	kilovolt/s
LOL	loss of link
MN	market notice
ms	millisecond/s
MW	megawatt/s
NEMDE	National Electricity Market Dispatch Engine
NEM	National Electricity Market
NER	National Electricity Rules
PTR	permission to restore
PMU	phasor monitoring unit
p.u.	per unit
RRP	regional reference price
TNSP	Transmission Network Service Provider

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1 Overview

This preliminary report relates to a reviewable operating incident[1] that occurred at 1048 hrs on 12 April 2024 in Tasmania involving a three-phase fault at Sheffield 220 kilovolts (kV) A busbar during switching to restore the Farrell – Sheffield No. 2 220 kV line[2]. Prior to the event, TasNetworks[3] was working on a planned outage of the Farrell – Sheffield No. 2 220 kV line. Basslink was importing 435 megawatts (MW) into Tasmania at the time.

At 1048 hrs on 12 April 2024, TasNetworks closed Sheffield 220 kV circuit breaker (CB) F752 to re-energise the Sheffield 220 kV A busbar and the Farrell – Sheffield No. 2 220 kV line. Closing of Sheffield 220 kV CB F752 resulted in a three-phase fault to the Sheffield 220 kV A busbar, and the CB re-opened. TasNetworks has advised AEMO that the three-phase fault was caused by a switching error, as a portable earth was left connected to the Sheffield 220 kV A busbar when the line was re-energised.

The three-phase fault at Sheffield resulted in depressed 220 kV bus voltages across Tasmania, including at George Town where voltage was measured at 0.15 p.u.. Basslink subsequently reversed direction momentarily due to the commutation failure. Basslink remained in-service through the incident and power flow was restored to 90% of the pre-fault value within 400 milliseconds (ms) of the three-phase fault clearance.

Co-incident with the three-phase fault at Sheffield, approximately 541 MW of load was lost. Approximately 486 MW of load was lost immediately after the three-phase fault, including:

- Loss of all load at Rio Tinto (326 MW) and Temco (53 MW).
- Partial load loss at Nyrstar (89 MW) and Norske Skog (19 MW).

This load loss resulted in a frequency increase to approximately 51.3 hertz (Hz) in Tasmania. The Basslink control system responded to the increasing system frequency by decreasing power flow from approximately 435 MW to 50 MW, and Tasmanian network frequency began to decrease towards 50 Hz.

The large power reduction and voltage rise to over 231 kV at George Town substation led to disconnection of Basslink's alternating current (AC) harmonic filters. With the trip of Basslink's harmonic filters, a current limit of 400 amperes (A) was applied by the reactive power controller to prevent overload of the remaining in-service filters[4]. The limit of 400 A corresponds to a power flow limit of 160 MW on Basslink, which resulted in a power flow difference on Basslink of 278 MW compared to the National Electricity Market Dispatch Engine (NEMDE) dispatch target of 438 MW. The Basslink power flow difference was greater than 200 MW[5] for over 500 ms, and as a result

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

[2] NER 4.2.3(e)(1) states that non-credible contingency events are likely to include three-phase electrical faults on the power system. This three-phase fault was considered by AEMO to be a non-credible contingency event.

[3] TasNetworks is a Transmission Network Service Provider (TNSP) for Tasmania.

[4] To meet the voltage and harmonic performance requirement, Basslink at George Town has one 98 MVAr and five 43 MVAr AC harmonic filters.

[5] A LOL signal is issued when the active pole current limit is reduced through AC filter unavailability, and subsequently more than 200 MW or 300 MW of transmitted power is lost for Tasmanian import and export power directions respectively.

Basslink issued a loss of link (LOL) signal triggering the Frequency Control Special Protection Scheme (FCSPS)[6]. This tripped the additional FCSPS loads[7] at Nyrstar (37 MW) and Norske Skog (18 MW).

This preliminary report provides a summary of the known facts relating to the incident as known at the date of publication and does not attempt to provide any complete analysis or recommendations. National Electricity Market (NEM) time (Australian Eastern Standard Time [AEST]) is used in this report.

2 Pre-event conditions

2.1 Generation and demand

A summary of Tasmanian operational conditions at 1045 hrs on 12 April 2024, just prior to the incident, is shown in Table 1.

Table 1 Tasmanian key system conditions and industrial loads at 1045 hrs on 12 April 2024

Quantity description	Value (MW)
Tasmanian operational demand	1,126
Tasmanian scheduled and semi scheduled generation	718
Basslink flow into Tasmania*	369
Rio Tinto (Bell Bay Aluminium) load	329
Temco load	53
Nystar load	148
Norske Skog load	82

* Immediately prior to the incident Basslink flow into Tasmania was 435 MW.

Table 2 provides a summary of Tasmanian generator dispatch at 1045 hrs on 12 April 2024.

Table 2 Tasmania generation dispatch at 1045 hrs on 12 April 2024

Station name	Dispatched generation (MW)	Station name	Dispatched generation (MW)
Bluff Point Wind Farm	13	**Lake Echo Power Station**	25
Cattle Hill Wind Farm	61	**Meadowbank Power Station**	5
Gordon Power Station (unit 1)	15	**Musselroe Wind Farm**	85
Gordon Power Station (unit 2)	16	**Poatina Power Station**	351
Gordon Power Station (unit 3)*	-3	**Studland Bay Wind Farm**	16
Granville Harbour Wind Farm	36	**Tarraleah Power Station**	4
John Butters Power Station	111	**Trevallyn Power Station**	25

* Gordon Power Station (unit 3) was in synchronous condenser mode.

[6] FCSPS provides high speed tripping of load or generation in Tasmania following an unplanned outage of Basslink to help manage system frequency. When power is imported into Tasmania, FCSPS is required to trip the same amount of load as the imported power. When power is exported from Tasmania, FCSPS is required to trip the same amount of generation exported ± 40 MW.

[7] FCSPS loads at Rio Tinto, Temco, Nyrstar and Norske Skog were shaken off earlier in the event.

2.2 Prior outages and network configuration at Sheffield substation

The Farrell – Sheffield No. 2 220 kV line, Farrell 220 kV B busbar, and Sheffield 220 kV A busbar were on planned outage from 0823 hrs on 9 April 2024 to replace CB J152 at Farrell 220 kV substation and to replace primary switching and protection apparatus from Z bay at Sheffield 220 kV substation (see Figure 5 in Appendix A1).

To minimise the outage time, TasNetworks had bypassed the Z bay apparatus with a dropper cable connecting Farrell – Sheffield No. 2 220 kV line to Sheffield 220 kV A busbar. To provide protection for the Farrell – Sheffield No. 2 220 kV line, all other transmission lines were disconnected from the Sheffield 220 kV A busbar and the bus-tie CB F752 was reconfigured to act as a Farrell – Sheffield No. 2 220 kV line protection CB. In this configuration, the trip of Sheffield 220 kV A busbar and Farrell – Sheffield No. 2 220 kV line connected by dropper cable was considered to be a credible contingency. However, a three-phase fault at Sheffield 220 kV A busbar was a non-credible contingency (NER clause S4.2.3(e)).

Immediately prior to the incident, TasNetworks was carrying out switching with the intent to reenergise the Farrell – Sheffield No. 2 220 kV line through the Sheffield 220 kV A busbar via bus-tie CB F752.

3 Event

3.1 Sequence of events

At 1048 hrs on 12 April 2024, TasNetworks closed Sheffield 220 kV CB F752 to re-energise the Sheffield 220 kV A busbar and the Farrell – Sheffield No. 2 220 kV line. Closing of Sheffield 220 kV CB F752 applied a three-phase fault to the Sheffield 220 kV A busbar, and the CB re-opened. TasNetworks advised AEMO that the three-phase fault was caused by a switching error, as a portable earth had been left connected to the Sheffield 220 kV A busbar when the line was re-energised.

Table 3 below summarises the key events during the incident.

Table 3 Sequence of incident events (12 April 2024)

Event sequence (hhmm.ss)	Event
1048.47 hrs	• TasNetworks closed Sheffield 220 kV CB F752, which re-energised the Farrell – Sheffield No. 2 220 kV line and the Sheffield 220 kV A busbar. • Three-phase fault occurred at Sheffield 220 kV A busbar. • Basslink experienced commutation failure and momentarily reversed flow. • Approximately 486 MW of Tasmanian industrial load was shaken off. • Sheffield 220 kV CB F752 tripped, which de-energised the Farrell – Sheffield No. 2 220 kV line and the Sheffield 220 kV A busbar.
1048.48 hrs	• Basslink flow restored to 90% of pre fault value of 435 MW. • Basslink frequency control initiated due to the alternating current (AC) system frequency (~51.3 Hz).
1048.49 hrs to 1048.51 hrs	• Basslink Filters HF1, HF3, HF4, and HF5 opened due to high voltage.
1048.51 hrs	• Basslink issued a LOL signal which triggered the FCSPS which tripped Nyrstar (37 MW) and Norske Skog (18 MW).

Event sequence (hhmm.ss)	Event
1052 hrs	• AEMO issued TasNetworks with permission to restore (PTR) the lost load.
1122 hrs	• AEMO issued market notice (MN) 116095 to advise of a non-credible contingency event involving trip of the Farrell – Sheffield No. 2 220 kV line during restoration due to fault on the line.
1304 hrs	• The Farrell – Sheffield No. 2 220 kV line returned to service.
1339 hrs	• AEMO issued MN 116098 to advise that the Farrell – Sheffield No. 2 220 kV line had returned to service at 1304 hrs.

3.2 Power system response

High speed monitoring (HSM) and phasor measurement unit (PMU) data is still being collated and analysed to confirm the exact sequence of events. In the final incident report, ordering of events could change from what is presented here.

Figure 1 below shows frequency measured during the event by PMUs at George Town and Chapel Street in Tasmania and Thomastown in Victoria. It shows that measured frequencies in north (George Town) and south (Chapel Street) Tasmania were closely aligned as expected. Frequency increased to approximately 51.3 Hz before recovering. The effects of the disturbance were also experienced on the mainland via the Basslink interconnector, as the voltage disturbance from the commutation fault can be seen in the frequency data, and mainland frequency rose to 50.13 Hz following a reduction in Basslink power transfer to Tasmania.

Figure 1 Frequency during the event on 12 April 2024

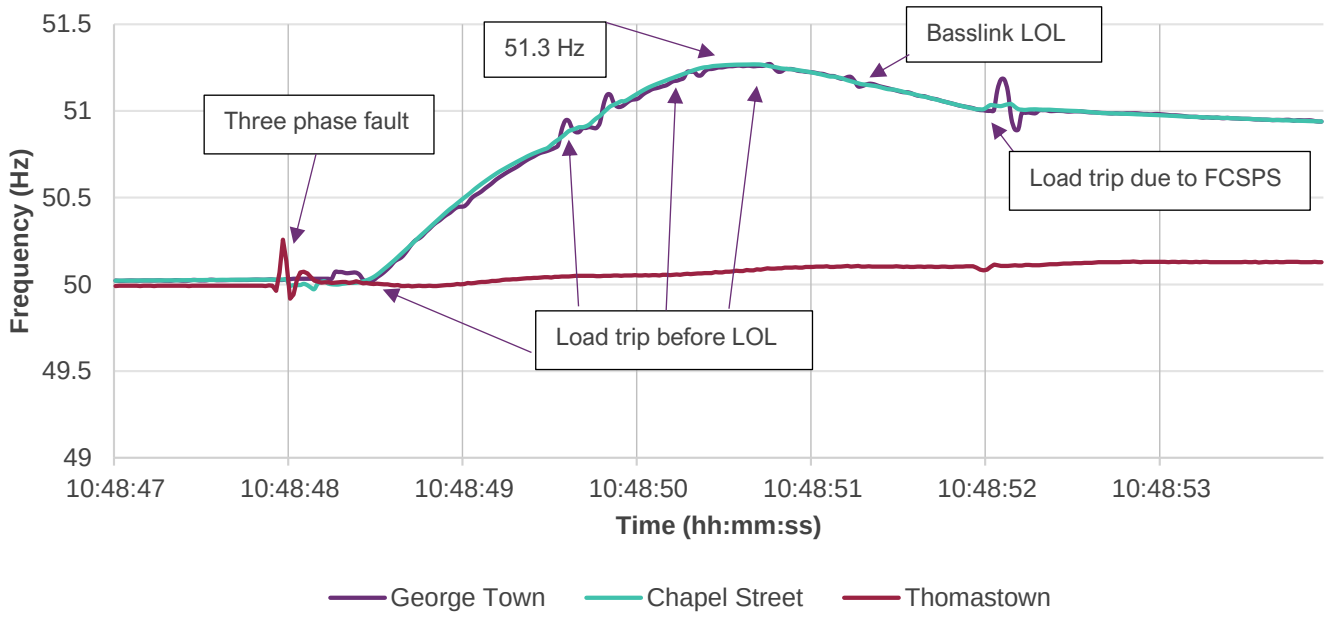
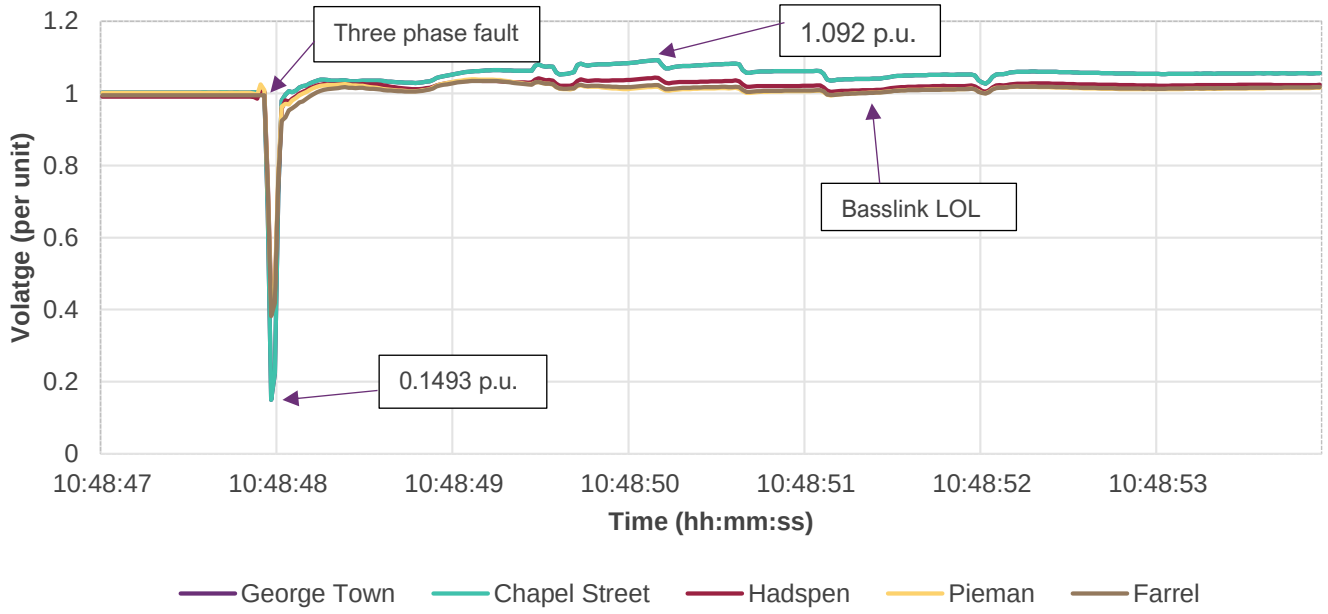


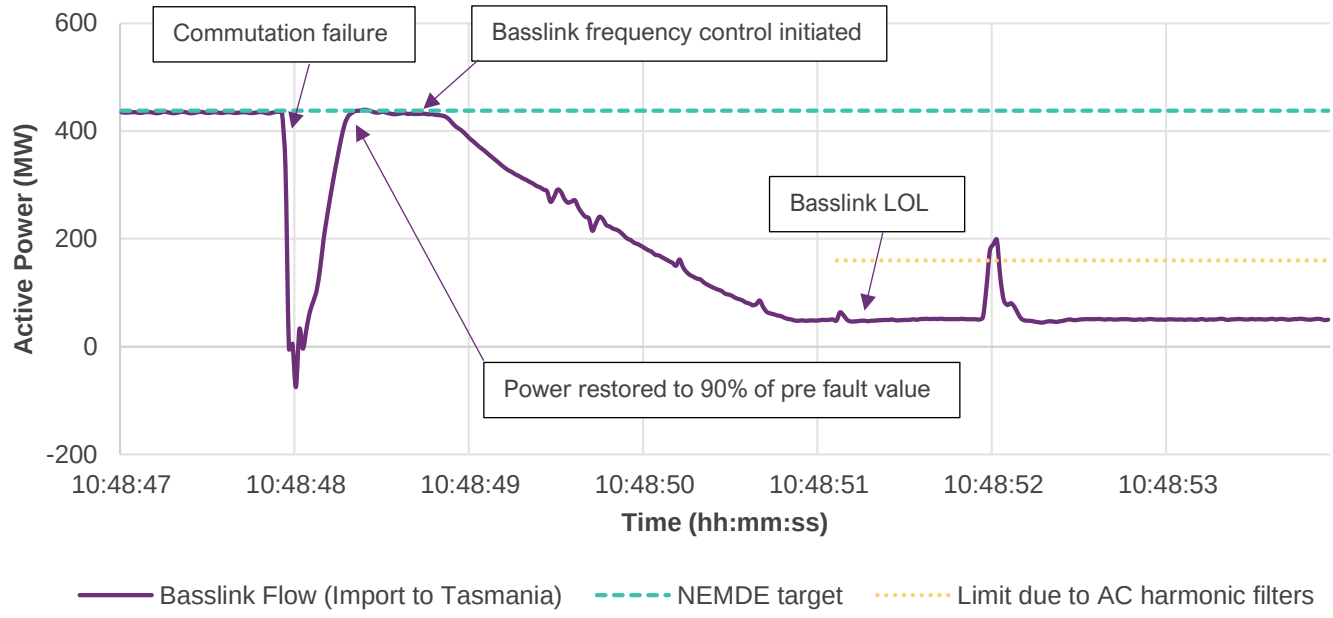
Figure 2 shows positive sequence voltages at various locations across Tasmania during the incident. Voltage depression was experienced throughout Tasmania during the fault and was observed to be as low as 0.15 per unit (p.u.) at George Town. Following clearance of the fault, voltage at George Town reached a maximum of approximately 1.092 p.u..

Figure 2 Voltages during the event on 12 April 2024



The George Town PMU recorded Basslink importing approximately 435 MW prior to the incident, as shown in Figure 3.

Figure 3 Basslink power flow measured at George Town on 12 April 2024



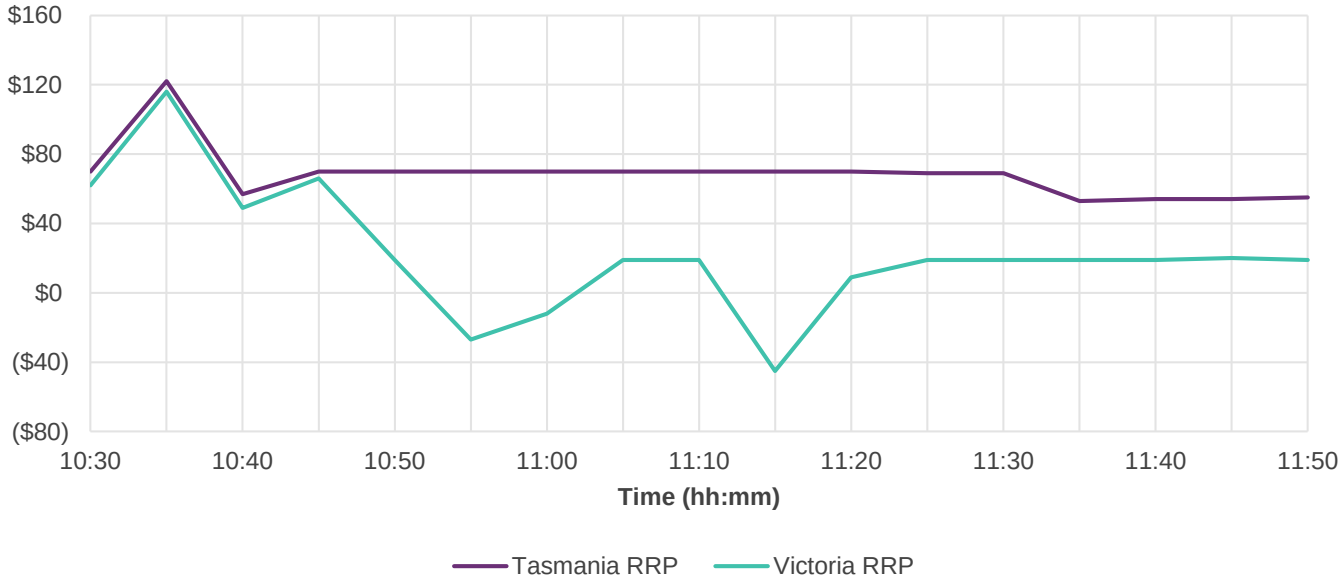
Following commutation failure during the three-phase fault, power flow was restored to 90% of the pre-fault level within 400 ms. Approximately 515 ms after the fault, Basslink frequency control responded to the increasing frequency by decreasing power flow to approximately 50 MW. The large power reduction and voltage rise to over 231 kV (1.05 p.u) at the George Town substation led to disconnection of Basslink's AC harmonic filters. With the trip of Basslink's harmonic filters, a current limit of 400 A was applied by the reactive power controller to prevent

overload of the remaining in-service filters. The limit of 400 A corresponds to a power flow limit of 160 MW on Basslink, which resulted in a power flow difference on Basslink of 278 MW compared to the NEMDE dispatch target of 438 MW. The Basslink power flow difference was greater than 200 MW for over 500 ms, and as a result Basslink issued a LOL signal triggering the FCSPS at 1048.51 hrs. Approximately 110 seconds after the fault, the NEMDE target reduced to 48 MW.

3.3 Market impact

The regional reference price (RRP) impacts for Tasmania and Victoria are shown in Figure 4. RRPs were not materially affected in any region by the incident. There was no additional frequency control ancillary services (FCAS) enabled in Tasmania. Following the Tasmanian load loss and subsequent reduction in Basslink export from Victoria, a reduction in price was seen in Victoria while the load was restored.

Figure 4 Price impact in Tasmania and Victoria



4 Reclassification

On 12 April 2024, TasNetworks advised AEMO that during restoration of Farrell – Sheffield No. 2 220 kV line, a fault and trip of the line was caused by a switching error as an earth was not removed from the Sheffield A 220 kV busbar.

Based on this advice, AEMO did not reclassify this event, because the cause of this non-credible contingency event had been identified and AEMO was satisfied that another occurrence of this event was unlikely under the current circumstances.

AEMO will continue to seek information about this event and assess whether a recurrence is more likely to occur under any prevailing conditions. If during its full investigation AEMO becomes aware of a need for reclassification,

AEMO will put in place the required reclassification(s), issue any necessary MNs, and report on them in the final incident report.

5 Market notices

The MNs listed below were issued on 12 April 2024 as a consequence of the event[8]:

- At 1122 hrs on 12 April 2024, AEMO issued MN 116095 to advise of a non-credible contingency event involving trip of the Farrell – Sheffield No. 2 220 kV line during restoration due to fault on the line.
- At 1339 hrs on 12 April 2024, AEMO issued MN 116098 to provide an update on the non-credible contingency event. AEMO confirmed that:
  - At 1304 hrs on 12 April 2024, the Farrell – Sheffield No. 2 220 kV line was returned to service.
  - The cause of the non-credible contingency had been identified and AEMO was satisfied that another occurrence of this event was unlikely under the current circumstances.

6 Next steps

AEMO will continue its investigation in collaboration with TasNetworks and other registered participants and will publish a detailed power system event report. The investigation is expected to include, but not be limited to:

- Confirmation of exact timing and sequence of events based on available high speed recordings.
- Confirmation of the root cause of the three-phase fault at Sheffield 220 kV A busbar.
- Analysis of Basslink response throughout the incident.
- Identification of the cause of all load loss during incident, if possible, including analysis of FCSPS operation.
- Further assessment of system security throughout the event.
- Investigation of frequency performance of the power system.
- Any commonalities between this event, and an event[9] in Tasmania in 2023 when an earth switch was also left connected.
- Key findings and recommendations arising from AEMO's investigation.

[8] Published at https://aemo.com.au/market-notices.

[9] See https://aemo.com.au/-/media/files/electricity/nem/market_notices_and_events/power_system_incident_reports/2023/farrell--reece--pieman-220-kv-no-2-line-three-phase-fault.pdf?la=en.

A1. System diagram

Figure 5 Network configuration at the time of the incident

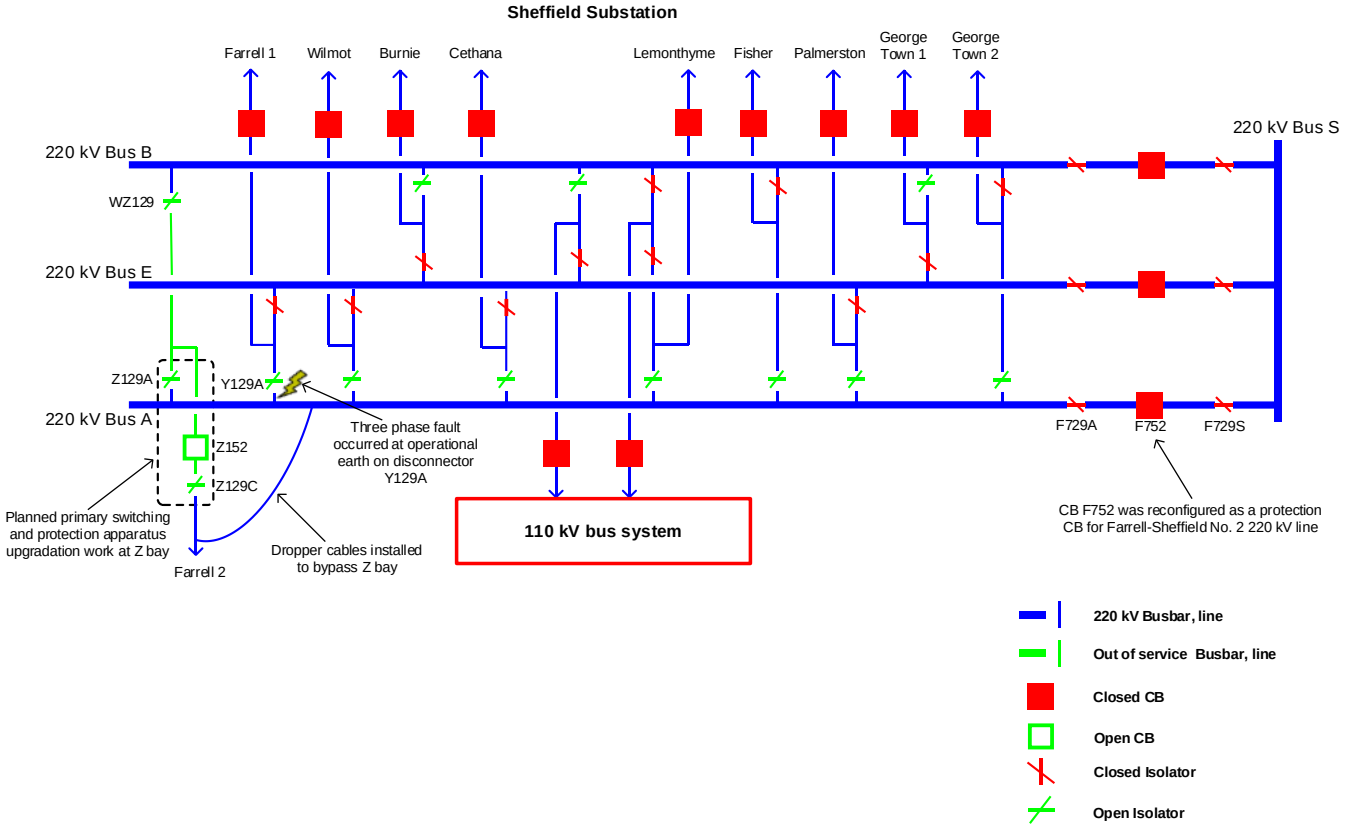


Figure 6 Incident overview