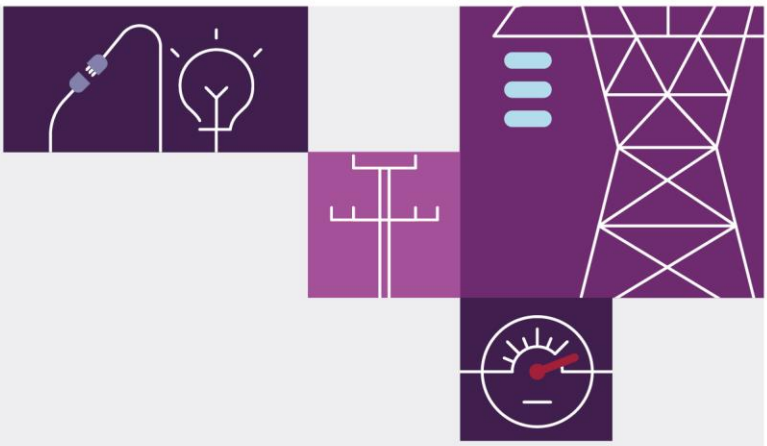
Preliminary Report – Trip of Liapootah – Palmerston 220 kV lines

October 2022

A preliminary operating incident report for the National Electricity Market – information as at 19/10/2022



Important notice

Purpose

AEMO has prepared this preliminary report as part of its review of the reviewable operating incident involving the non-credible trip of multiple transmission lines 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 performance of some equipment leading up to, during and after the event. 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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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.

Terms and abbreviations

This report uses terms that are defined in the National Electricity Rules, which have the same meanings. The following abbreviations are also used.

Abbreviation	Term
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
AUFLS2	Adaptive Under Frequency Load Shedding scheme 2
FCSPS	Frequency control system protection scheme
HVDC	High voltage direct current
MW	Megawatts
NEM	National Electricity Market
NER	National Electricity Rules
PMU	Phasor measurement unit
TNSP	Transmission Network Service Provider

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1 Overview

This preliminary report relates to a reviewable operating incident1 that occurred on 14 October 2022 in Tasmania. The incident involved the trip of a major double circuit 220 kilovolts (kV) line linking the north and south of the state. At approximately 0919 hrs, the following plant tripped:

- Both Liapootah – Waddamana – Palmerston 220 kV lines (No. 1 and No. 2 lines). This was caused by a landslide impacting the footings of a double circuit strain tower between Palmerston and Waddamana.
- Both Waddamana – Lindisfarne 220 kV lines (at the Waddamana end only).
- Basslink high voltage direct current (HVDC) interconnector, which was importing 425 megawatts (MW) to Tasmania at the time.
- Cattle Hill Wind Farm, Musselroe Wind Farm and Lemonthyme Power Station.
- Approximately 530 MW of electrical load (495 MW of this being industrial load)[2].

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 analysis or recommendations.

National Electricity Market 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 0915 hrs on 14 October 2022, just prior to the incident, is shown in Table 1.

Table 1 Tasmanian key system conditions at 0915 hrs, 14 October 2022

Quantity description	Value (MW)
Tasmanian operational demand	1,167
Tasmanian scheduled and semi scheduled generation	718
Basslink flow into Tasmania (George Town end)	446
North to South flow[3]	201

Table 2 provides a summary of Tasmanian generator dispatch at 0915 hrs on 14 October 2022.

[1] National Electricity Rules (NER) 4.8.15(a)(1)(i), as a non-credible contingency event on the transmission system, in accordance with the AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.

[2] The source of the decline in demand not accounted for by industrial load tripping is not presently known to AEMO. It will be investigated in the final report.

[3] Cut-set flow from Palmerston to Waddamana and Liapootah on both 220 kV double circuit and 110 kV lines.

Table 2 Tasmania generation dispatch at 0915 hrs, 14 October 2022

Station name	Dispatched generation (MW)	Station name	Dispatched generation (MW)
Bastyan	0	**Lake Echo**	0
Bell Bay	0	**Mackintosh**	0
Cethana	79	**Meadowbank**	35
Cattle Hill Wind Farm	24	**Musselroe Wind Farm**	145
Devils Gate	58	**Poatina**	0
Fisher	46	**Reece**	0
Gordon	21	**Tarraleah**	55
Granville Harbour Wind Farm	36	**Trevallyn**	99
John Butters	0	**Tribute**	0
Lemonthyme/Wilmot	54	**Tungatinah**	7
Catagunya/Liapootah/Wayatinah	58	**Tamar Valley CCGT / OCGT**	0
Bluff Point Wind Farm	22	**Studland Bay Wind Farm**	21

2.2 Prior outages

There were no planned transmission outages in Tasmania at the time of the event on 14 October 2022.

Due to water ingress at Poatina Power Station, one day before the incident on 13 October 2022, Poatina – Palmerston 220 kV lines were de-energised at Hydro Tasmania's request.

2.3 Reclassifications

Prior to the event, an existing reclassification was in place for the coincident trip of Basslink with any transmission line in Tasmania, as advised in Market Notice 83081[4].

A reclassification was also in place for coincident trip of any 220 kV line from Waddamana with a quantity of load[5], as advised in Market Notice 68408.

2.4 Weather conditions and operational forecasts in Tasmania on 14 October 2022

A cold front and associated rain-bearing cloud band over Tasmania brought widespread heavy rainfall to the region on Thursday 13 and Friday 14 October 2022. The weather conditions relevant to this event can be summarised as follows:

- An overcast day on 14 October 2022, with mild temperatures and heavy rainfall. Operational demand in Tasmania was expected to peak at 1,326 MW at 0730 hrs, as per the day-ahead (1230 hrs) pre-dispatch forecast. Hobart recorded a minimum temperature of 11.0°C and a maximum temperature of 16.4°C.

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

[5] The load at risk of tripping with a 220 kV Waddamana line trip, was quantified as = (total Nystar load measured by SCADA – 25 MW of stable load) + 5 MW of Boyer load.

- Widespread daily rainfalls totalling 50 mm were observed in northern Tasmania, with localised 24-hour rainfall totals of more than 100 mm to 0900 hrs on 14 October 2022, making it Tasmania's wettest October day on record. Poatina observation station (approximately 10 km to the north-west of the impacted tower) recorded 125.8 mm of rainfall in the 48 hours to 0900 hrs on 14 October 2022. Severe weather warnings for intense rainfall and damaging winds were issued and current on 13 and 14 October 2022.
- Major flood warnings were current at 0900 hrs on 14 October 2022 for Macquarie River, Meander River, Mersey River, Forth River, River Derwent, North Esk River and South Esk River.
- High wind generation was forecast (up to approximately 75% of regional capacity), with wind generation expected to ease to moderate levels for a period in the afternoon.

3 Event

At approximately 0919 hrs on 14 October 2022, both Liapootah – Waddamana – Palmerston 220 kV lines tripped. It was later established that these line trips were caused by a landslide impacting the footings of a strain tower on this double circuit transmission line (as shown in Figure 1).

Figure 1 Double circuit strain tower damaged by landslide

Image supplied by TasNetworks.

This initiating event led to the subsequent trip of:

- Both Waddamana – Lindisfarne 220 kV lines, at the Waddamana end only.
- Basslink HVDC interconnector, which was importing 425 MW to Tasmania at the time.
- Cattle Hill Wind Farm, Musselroe Wind Farm, and Lemonthyme Power Station.
- Approximately 530 MW of load, 495 MW of which was industrial load tripped due to the operation of the Adaptive Under Frequency Load Shedding Scheme 2 (AUFLS2) and Frequency Control System Protection Scheme (FCSPS) remedial action schemes. These schemes operated in response to the event including subsequent trip of Basslink and Tasmanian generation.

The Liapootah – Waddamana – Palmerston 220 kV lines are two of the three lines that join North and South Tasmania. Following the trip of these 220 kV lines, North and South Tasmania remained connected only by the

remaining in service Waddamana – Palmerston 110 kV line. With the 220 kV lines out of service, any subsequent trip of this 110 kV line would split Tasmania into two separate electrical islands.

Table 3 below summarises the key events during the incident.

High Speed Monitoring (HSM) and Phasor Monitoring Unit (PMU) data is still in the process of being collated and analysed to confirm the exact sequence of events. In the final report, the order of events could change from those presented in Table 3.

Table 3 Sequence of incident events (14 October 2022)

Event sequence (hrs)	Description	Notes
0919	Trip of both Liapootah – Waddamana – Palmerston 220 kV lines	Caused by a landslide damaging a transmission line tower.
	Trip of both Waddamana – Lindisfarne 220 kV lines	Lines opened at the Waddamana end only. To isolate the Liapootah – Waddamana – Palmerston 220 kV lines from Waddamana substation, Waddamana 220 kV circuit breakers opened that also connect the Waddamana – Lindisfarne 220 kV lines to the substation.
	Basslink tripped while transferring 425 MW to Tasmania	Extended commutation failure.
0919 **(relative sequence not yet confirmed for these events)**	Approximately 530 MW of load tripped (495 MW being industrial load)	Industrial load tripped associated with operation of FCSPS and AUFLS2.
	Musselroe Wind Farm tripped while generating 148 MW	Cause of trip to be confirmed.
	Cattle Hill Wind Farm tripped while generating 32 MW	Cattle Hill Wind Farm was islanded from the network following trip of the four Waddamana 220 kV lines.
	Lemonthyme Power Station tripped while generating 54 MW	Cause of trip to be confirmed.
0938 – 1044	Tripped industrial load restored[6]	-
0949	Basslink re-energised at George Town	-
0959	Basslink tripped while transferring 0 MW	Trip due high voltage at George Town.
1015	Basslink returned to service	Constraint set I-VT_000 which limits Tasmanian import to 0 MW remained in place to maintain system security.
1200	Basslink returned to service	Constraint set I-VT_000 revoked at 1200. Transfer to Tasmania restored by 1201.

Figure 2 below shows Tasmanian frequency during the event. It shows that measured frequencies were closely aligned across the island, as expected given that North and South Tasmania remained electrically connected throughout the incident. Frequency declined to a minimum of approximately 48.3 hertz (Hz) before recovering. Mainland National Electricity Market (NEM) measured frequency remained within the normal operating frequency band during the incident.

[6] The source of the decline in demand not accounted for by industrial load tripping is not presently known to AEMO. It will be investigated in the final report.

Figure 2 Tasmanian frequency during the incident (PMU recordings)

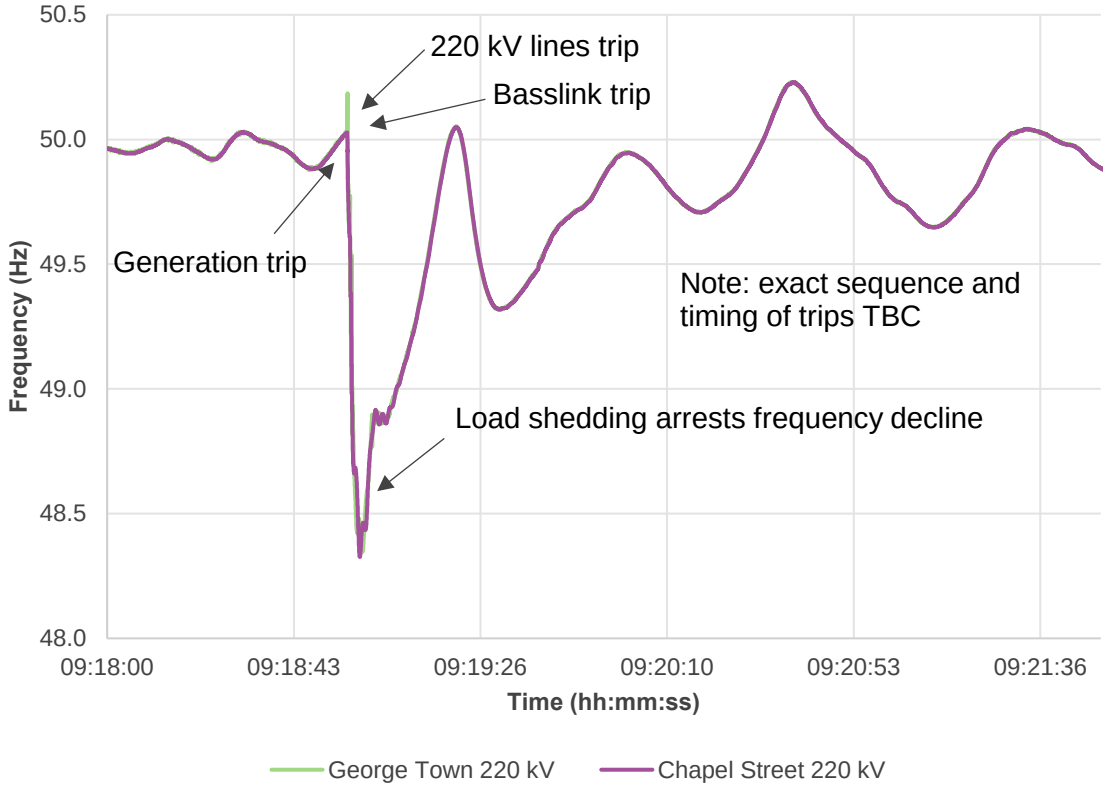


Figure 3 shows voltages at various locations across Tasmania during the incident. It indicates there were some post fault voltage oscillations that damped out over approximately 10 seconds.

Figure 3 Voltages during the incident (PMU recordings)

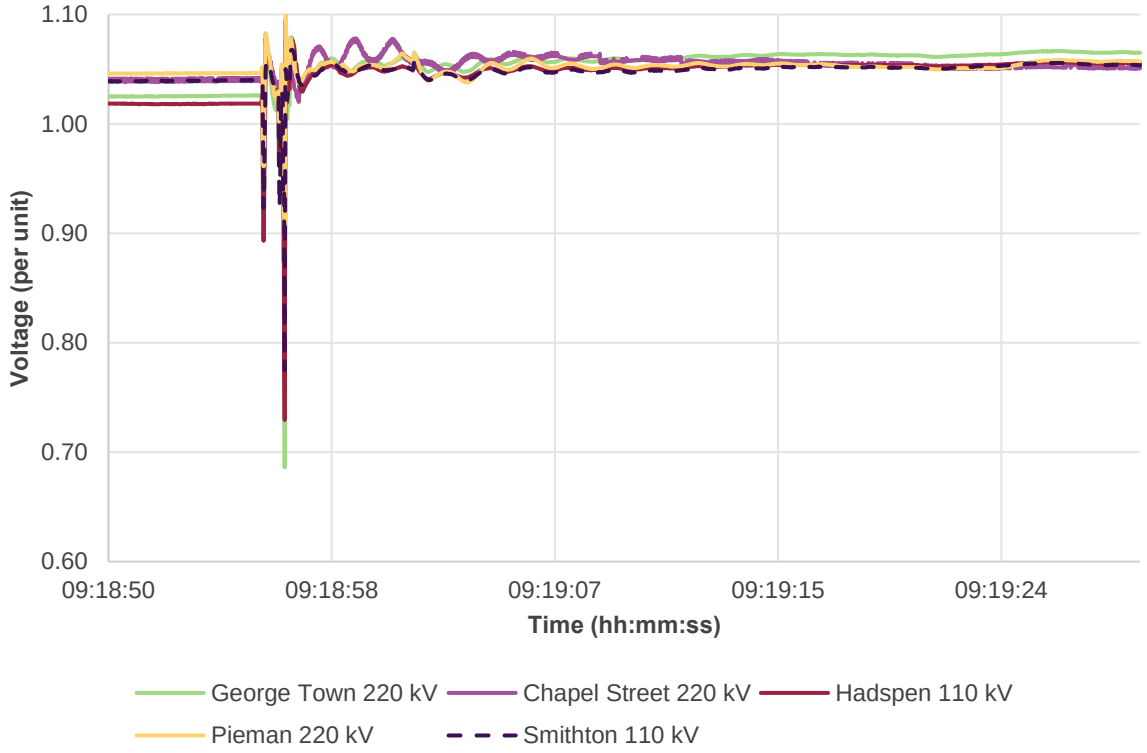
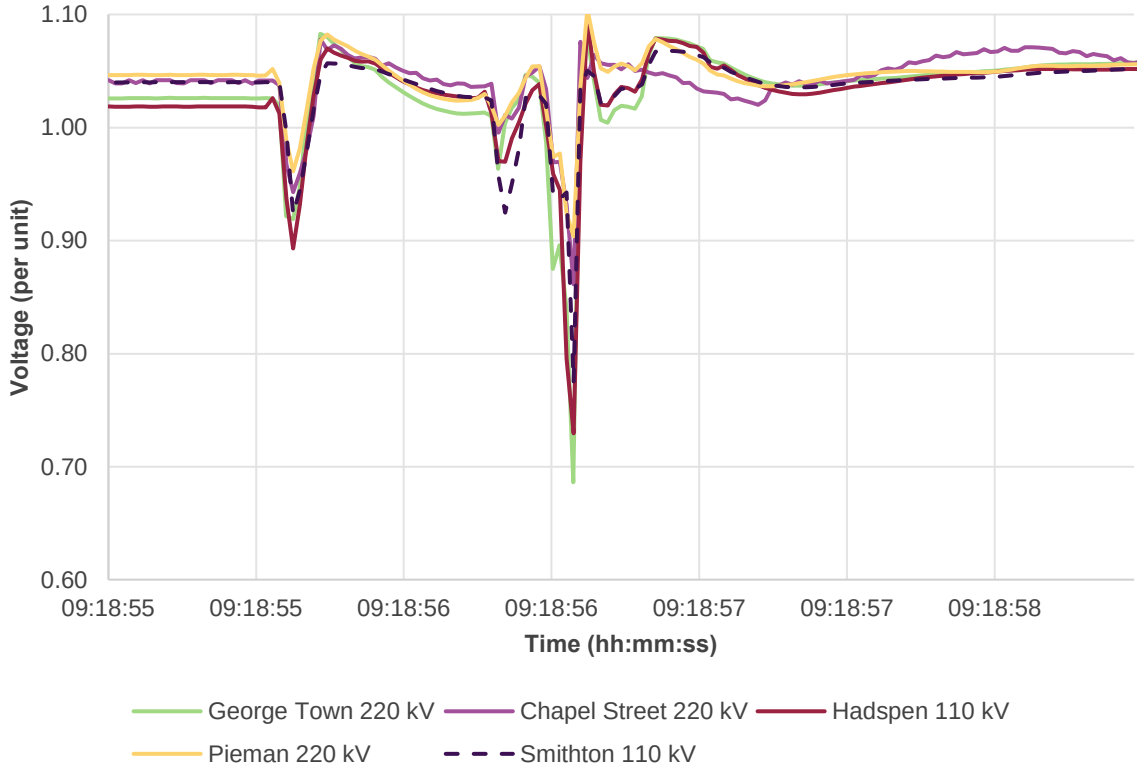


Figure 4 shows the same voltages, but zoomed in on the initial voltage disturbances. It shows a shallow voltage disturbance at first, followed by a deeper disturbance approximately one second later.

Figure 4 Voltages during incident (PMU) zoomed in on initial voltage disturbances



4 Reclassification

No reclassifications were made during this incident on 14 October, as the Liapootah – Waddamana – Palmerston 220 kV lines were not returned to service.

Subsequently, on 18 October, AEMO updated an existing reclassification (referred to in section 2.3) to cover the loss of any 220 kV or 110 kV line in Southern Tasmania in conjunction with a quantity of load[7] as a credible contingency event until further notice. This reclassification was put in place because AEMO considered simultaneous trip of any Southern Tasmanian 220 kV or 110 kV circuit[8] and the respective load to be reasonably possible.

This reclassification update was applied at 1535 hrs on 18 October, and applies until further notice, as documented in market notice 102360.

5 Constraints

The constraint sets that were invoked on 14 October to manage the incident are recorded in Table 4 below.

[7] The load at risk of tripping with a 220 kV or 110 kV Southern Tasmanian line trip, is quantified as = (total Nystar load measured by SCADA – 25 MW of stable load) + 5 MW of Boyer load.

[8] The previous reclassification was for trip of any 220 kV line from Waddamana, and the same load.

Table 4 Constraints set invoked on 14 October 2022 to manage incident

Set name	Time invoked (hrs)	Time revoked* (hrs)	Description
I-BL_ZERO	0930	0955	Limit Basslink to zero in either direction, because it was out of service.
T-X_LIPM_WACB	0935	1045	Set to manage outage of both Liapootah – Waddamana – Palmerston 220 kV lines, with associated 220 kV circuit breaker at Waddamana out of service.
T-WIND_100	1005	N/A	Discretionary 100 MW upper limit on Tas Wind Generation, applied based on limit advice for operating Tasmania at credible risk of separation between North and South.
T-LIPM_PMWA_N-3	1005	1600	Set to manage loss of both Liapootah – Waddamana – Palmerston 220 kV lines and the Palmerston - Waddamana 110 kV line as a credible contingency.
F-TAS_NTH_STH_ISLE	1005	1915	Frequency control ancillary services (FCAS) constraint set to manage North/South separation between Palmerston and Liapootah/Waddamana.
I-BL_ZERO	1005	1015	Limit Basslink to zero in either direction, because it was out of service.
I-TV_150	1005	15/10/2022 0815	Tas to Vic on Basslink upper limit of 150 MW based on limit advice for operating Tasmania as separated between North and South.
I-VT_000	1005	1200	Vic to Tas on Basslink upper limit of 0 MW. Level of constraint based on load blocks available for FCSPS.
I-VT_050	1200	1240	Vic to Tas on Basslink upper limit of 50 MW. Level of constraint based on load blocks available for FCSPS.
I-VT_100	1240	1510	Vic to Tas on Basslink upper limit of 100 MW. Level of constraint based on load blocks available for FCSPS.
T-X_LIPM_WACB	1600	N/A	Set to manage outage of both Liapootah – Waddamana – Palmerston 220 kV lines, with associated 220 kV circuit breaker at Waddamana out of service.
F-TAS_NTH_STH_RISK	1900	N/A	FCAS constraint to manage credible risk of Tasmania North/South separation between Palmerston and Liapootah/Waddamana. Ensures a distribution of Tasmania dispatched FCAS between North and South Tasmania.

* All revocations were on 14 October 2022, unless otherwise specified.

6 Market notices

The Market Notices listed below were issued on 14 October 2022 as a consequence of the event[9]:

- At 0942 hrs on 14 October 2022, AEMO issued MN 102213 to advise of a non-credible contingency event involving trip of the Liapootah – Waddamana – Palmerston 220 kV lines, Basslink and approximately 530 MW of electrical load.
- At 1027 hrs on 14 October 2022, AEMO issued MN 102234 to advise that the constraint set I-BL_zero had been applied from 0930 hrs to 1015 hrs. This constraint set limits Basslink to zero in either direction.
- At 1153 hrs on 14 October 2022, AEMO issued MN 102263 to advise that AEMO had issued a direction to a participant in the Tasmania region.

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

- At 1222 hrs on 14 October 2022, AEMO issued MN 102266 to advise that Basslink had returned to service, that the Liapootah – Waddamana – Palmerston 220 kV lines remained out of service, and noted the constraint sets invoked to manage the outage.
- At 1222 hrs on 14 October 2022, AEMO issued MN 102285 to declare an LOR1 condition for Tasmania from 0630 hrs to 0800 hrs on 17 October 2022. The forecast capacity reserve requirement was 723 MW. The minimum capacity reserve available was 692 MW.

7 Operation of Tasmania

While both Liapootah – Waddamana – Palmerston 220 kV lines are out of service, North and South Tasmania are connected via only the Palmerston – Waddamana 110 kV line. Therefore separation of North and South Tasmania into separate synchronous islands is considered a credible contingency.

To ensure system security can be maintained during this network configuration, the following operational measures were implemented as at the time of preparing this report:

1. Active power flow on the Palmerston – Waddamana 110 kV line was constrained below 15 MW in both directions.
2. Constraints invoked included an equation that constrained South Tasmania generation to less than (or equal to) South Tasmania demand. This constraint ensures the published pre-dispatch (PD) and short-term (ST) projected assessment of system adequacy (PASA) reserves for Tasmania reflect reserves in North Tasmania where the regional reference node is located.
3. Additional reporting tools were developed to assess system reliability for South Tasmania. AEMO is closely monitoring the power system in South Tasmania, given the abnormal network configuration prior to one of the failed 220 kV lines being returned to service.
4. AEMO discussed a planned outage of the Gordon 432 MW hydro power station with Hydro Tasmania and this particular outage was subsequently cancelled to maximise available generation and frequency control ancillary services (FCAS) in South Tasmania.

8 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.
- Assessment of performance of any remedial action schemes which operated during incident.
- The cause of the Basslink trip.
- Confirmation of the cause of the Liapootah – Waddamana – Palmerston 1 and 2 and the Waddamana – Lindisfarne 1 and 2 220 kV line trips.
- Identification of the cause of all load loss during incident, if possible.
- Further assessment of system security throughout the event.

- A review of generator performance during this incident (including assessment of Musselroe, Cattle Hill and Lemonthyme's performance during the incident).
- Investigation of frequency performance of the power system.
- Post incident operation of the Tasmanian power system.
- Key findings and recommendations arising from AEMO's investigation.

A1. System diagrams

Figure 5 Network configuration before the event (EMS 09:15:22, 14 October 2022)

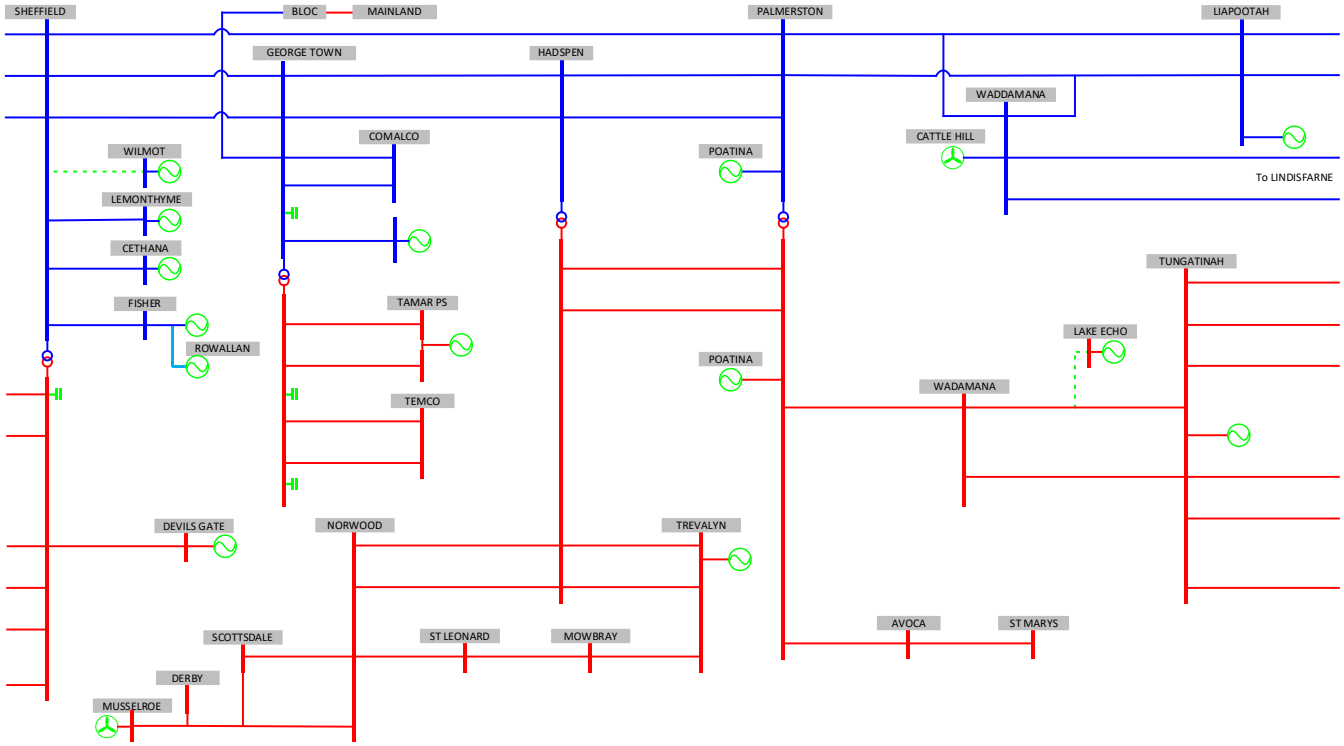


Figure 6 Network configuration after the event (EMS 09:20:22, 14 October 2022)

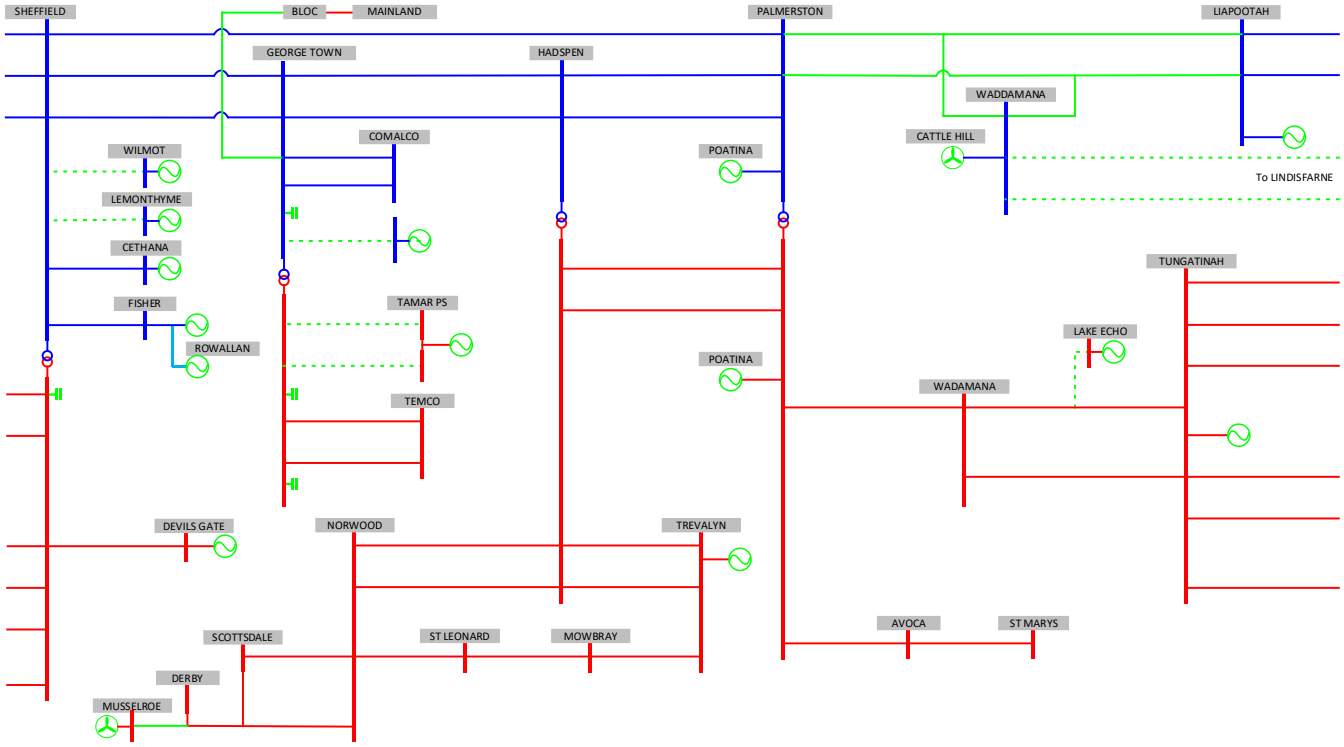


Figure 7 WA – LI and WA – LF transmission lines restored. Network configuration at 2030 hrs 19 October 2022