AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

Trip of both Gordon – Chapel Street 220 kV lines and unexpected operation of AUFLS on 31 October 2020, and unexpected operation of AUFLS on 8 December 2020

April 2021

Reviewable Operating Incident Report under the National Electricity Rules

INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of Incident	1115 hrs on 31 October 2020 and 1318 hrs on 8 December 2020
Region of incident	Tasmania
Affected regions	Tasmania
Event type	Environmental – Bushfire and control scheme maloperation on 31 October 2020 Control scheme maloperation on 8 December 2020
Generation impact	125 MW of generation was lost as a result of the incident on 31 October 2020 There was no loss of generation as a result of the incident on 8 December 2020
Customer load impact	51 MW of contracted load was disconnected as a result of the incident on 31 October 2020 47 MW of contracted load was disconnected as a result of the incident on 8 December 2020
Associated reports	Nil

ABBREVIATIONS

Abbreviation	Term
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
AUFLS	Adaptive Under Frequency Load Shedding
FCAS	Frequency Control Ancillary Service
Hz	Hertz
kV	Kilovolt
MVA	Megavolt-ampere
MW	Megawatt
NEM	National Electricity Market
NER	National Electricity Rules
RoCoF	Rate of Change of Frequency
TNSP	Transmission Network Service Provider
VT	Voltage Transformer

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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Contents

Figures

1. Overview

This report relates to two incidents that resulted in the unexpected operation of the Adaptive Under Frequency Load Shedding scheme (AUFLS)[1] in Tasmania on 31 October 2020 and 8 December 2020. The incident on 31 October occurred during the near simultaneous (non-credible) trip of the Gordon – Chapel Street No. 1 and No. 2 220 kilovolt (kV) lines (GO-CS No. 1 and No. 2 lines), while the incident on 8 December did not involve a contingency on the power system.

As a result of the loss of the GO-CS lines on 31 October 2020, there was a loss of 125 megawatts (MW) of generation and 51 MW of customer load. The incident on 8 December resulted in the loss of 47 MW of customer load.

As these are reviewable operating incidents, 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 GO-CS lines on 31 October 2020 was due to a fault caused by either fire or dense smoke from a planned burn.
2. All protection operated correctly to clear the faults on the GO-CS lines.
3. For the incident on 31 October 2020, the AUFLS scheme operated incorrectly, disconnecting customer load before loss of generation had occurred.
4. For the incident on 8 December 2020, there was no fault or frequency disturbance on the power system and the AUFLS operated when it should not have. This was due to a combination of incorrect frequency calculations by the AUFLS relays and incorrect relay settings.
5. Modifications have been made to the AUFLS to minimise the risk of further inadvertent operation.
6. The power system remained in a secure operating state during both incidents.

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 TasNetworks[3] and AEMO.

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

2. The incidents

2.1 31 October 2020

The Tasmania Parks and Wildlife Service planned to conduct a hazard reduction burn in the Serpentine Gorge area to the west of the Gordon – Chapel Street lines near the Gordon Power Station.

TasNetworks attended the proposed burn area in September 2020 to survey the area and assess the vegetation to determine if any preliminary work was required to manage any risk posed by the planned burn. No additional vegetation management was identified as being required.

[1] Refer to Appendix 1 for a description of this scheme.

[2] See NER clause 4.8.15(b).

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

Refer to Appendix A2 for a diagram of the power system and associated hazard reduction burn information.

TasNetworks provided two suitably qualified staff to attend and supervise the planned burn. These staff attended the Parks and Wildlife Service's Fire Operations pre-burn briefing at approximately 0900 hrs on 31 October 2020. This briefing determined the weather was within the required parameters with a consistent light westerly wind forecast.

The burn started at 0945 hrs on 31 October 2020 to the west of the GO-CS lines, and based on forecast winds from the west was expected to progress slowly towards the east.

At approximately 1045 hrs on 31 October 2020, the wind direction began to change from a predominant westerly to a south westerly resulting in the fire front moving northwards towards the GO-CS lines. At approximately 1110 hrs on 31 October 2020, the fire entered an area of highly flammable tea-tree scrub around 1.5 metres tall underneath the GO-CS lines resulting in increased flame height and very dense smoke. At this stage the TasNetworks staff on site attempted to contact the TasNetworks control room via both satellite telephone and trunked mobile radio (TMR) to advise the control room of the developing situation. The on-site staff were not able to contact the control room.

At 1115 hrs on 31 October 2020, the GO-CS No. 1 line tripped due to a phase to phase fault. All protection operated correctly and as expected to clear the fault.

Two seconds later, the GO-CS No. 2 line tripped due to a phase to phase fault with all protection operating correctly and as expected to clear the fault. The loss of the GO-CS No. 2 line resulted in the disconnection of Gordon Power Station with the loss of 125 MW of generation.

In response to the line trips and loss of Gordon generation, the AUFLS scheme operated, which resulted in the disconnection of 51 MW of contracted customer load. The customer load restored to service at 1120 hrs on the same day.

Both GO-CS lines were returned to service at 1216 hrs on 31 October 2020 after the fire had cleared the area under the lines.

Refer to Section 2.3 for discussion of the AUFLS operation.

Communications issues

TasNetworks advised that at the time of the incident, the satellite telephone provided to the on-site staff was able to make to calls to mobile telephone numbers only and could therefore not contact the pre-programmed control room landline number. The failure of the TMR was due to poor radio coverage in the area. TasNetworks has advised AEMO that all satellite telephones have been modified to be able to contact landline numbers and that a pre-burn communications check has been implemented.

Pre-burn assessment

Although an assessment of vegetation around the planned burn was conducted, neither TasNetworks or the Parks and Wildlife Service Fire Operations identified the potential risk posed by the highly flammable tea-tree scrub located in a valley under the GO-CS lines.

To improve pre-burn assessments and manage any planned and unplanned fires, TasNetworks, Tasmania Parks and Wildlife Service, and the Tasmania Fire Services are developing an agreement to implement a framework for the coordination and management of planned fuel reduction burns and bushfire mitigation.

2.2 8 December 2020

At approximately 1318 hrs on 8 December 2020, the AUFLS scheme unexpectedly operated at the same time as switching was being carried out on the 110 kV busbar at Chapel Street substation. This switching involved a changeover of voltage transformer supplies. The operation of the AUFLS resulted in the loss of 47 MW of contracted customer load, although there was no fault or frequency disturbance on the power system.

AEMO provided clearance to restore the contracted customer load at 1325 hrs on 8 December 2020, while the AUFLS scheme remained temporarily disabled to allow TasNetworks to complete restoration switching at Chapel Street 110 kV substation. This was completed by 1435 hrs on the same day.

2.3 Unexpected operation of the AUFLS scheme

Refer to Appendix A1 for a description of the AUFLS scheme.

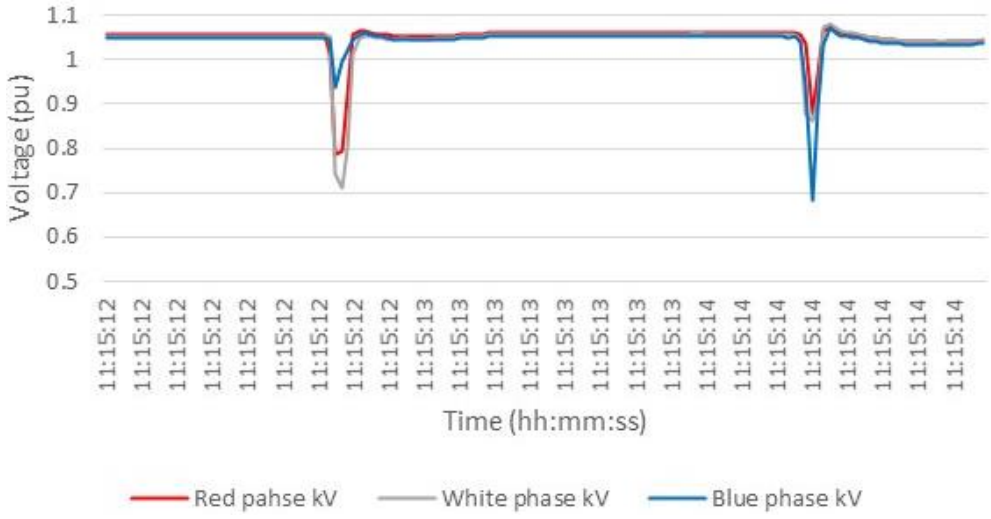
31 October 2020

Although it was initially thought the AUFLS had operated correctly in response to the loss of the Gordon generation, subsequent analysis by TasNetworks determined the AUFLS operated after the trip of the GO-CS No. 1 line and prior to the loss of the Gordon generation. This was not an expected outcome, as there was no loss of generation and consequently no significant frequency disturbance.

Investigation by TasNetworks showed that the frequency measurement unit of the AUFLS scheme provided an erroneous input to the control algorithm with a minimum frequency of approximately 47.75 hertz (Hz), which met the first of the trigger requirements of the AUFLS. The frequency measurement unit uses a zero crossing detection method to calculate frequency based on the voltage. Any distortion of the voltage waveform, which commonly occurs during a fault on the power system, can lead to incorrect frequency calculations.

Despite the frequency trigger being met, the AUFLS should not have operated, as the voltage had not recovered to above 0.7 pu for a least 20 ms after the fault. Voltage measurements from Palmerston substation, as shown in Figure 1, show the voltage on 'W' phase falling to 0.71 pu. The AUFLS relay gets its voltage measurement from the Chapel Street substation which is much closer to the fault location so the voltage would likely have fallen below the 0.7 pu requirement.

Figure 1 Voltage at Palmerston 220 kV bus



Analysis by TasNetworks noted an error in the undervoltage masking logic, where a 5 ms delay was programmed instead of the required 20 ms delay. Therefore, the combination of a low frequency input and an insufficient delay to allow the voltage to recover sufficiently resulted in the AUFLS operating when it should not have.

8 December 2020

In the incident on 8 December 2020, there was no corresponding high voltage fault or frequency disturbance to trigger operation of the AUFLS scheme. At the time of this incident, TasNetworks was carrying out

switching on the 110 kV busbars at Chapel Street substation. When the 110 kV 'A' busbar was energised, this resulted in an automatic changeover of voltage transformer (VT) supplies to the AUFLS relay. This changeover of VT supplies resulted in a single cycle of 0.0 pu voltage being supplied to the AUFLS relay. This 0.0 pu voltage input resulted in an inaccurate frequency calculation of less than 48.8 Hz, which satisfied the frequency trigger requirement of the AUFLS scheme. However, operation should have been blocked, as the voltage had not recovered to above 0.7 pu for at least 20 ms. Similar to the event on 31 October 2020, the combination of a low frequency input and an insufficient delay to allow the voltage to recover sufficiently resulted in the AUFLS operating when it should not have.

2.3.1 Corrective measures

In response to these events, TasNetworks made the following changes to the AUFLS. These changes are expected to prevent further inadvertent operation of the AUFLS.

1. Added hard limits of 48 Hz to 52 Hz added to the raw frequency measurement.
2. Added an 80 ms first order low pass filter to smooth the input frequency measurement.
3. Increased the undervoltage detection threshold from 0.7 pu. to 0.88 pu.
4. Increased the undervoltage detection time delay from 5 ms to 100 ms.

On 2 February 2021, Schweitzer Engineering Laboratories (SEL) issued a Service Bulletin identifying potential issues with the frequency estimation algorithm on certain SEL protection system relays, as used in the AUFLS scheme, and provided information on firmware upgrades to resolve these issues. TasNetworks has advised it will review this information with a view to implementing the changes and reversing some of the previously implemented corrective measures.

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[4].

The power system was in a secure operating state prior to the events of 31 October 2020. The loss of the Gordon Power Station generation resulted in the calculated post-contingent[5] fault level at Burnie substation falling to approximately 590 megavolt amperes (MVA), as shown in Figure 2. Based on information available at the time, a post-contingent fault level below 600 MVA indicated that the power system may not be in a secure operating state.

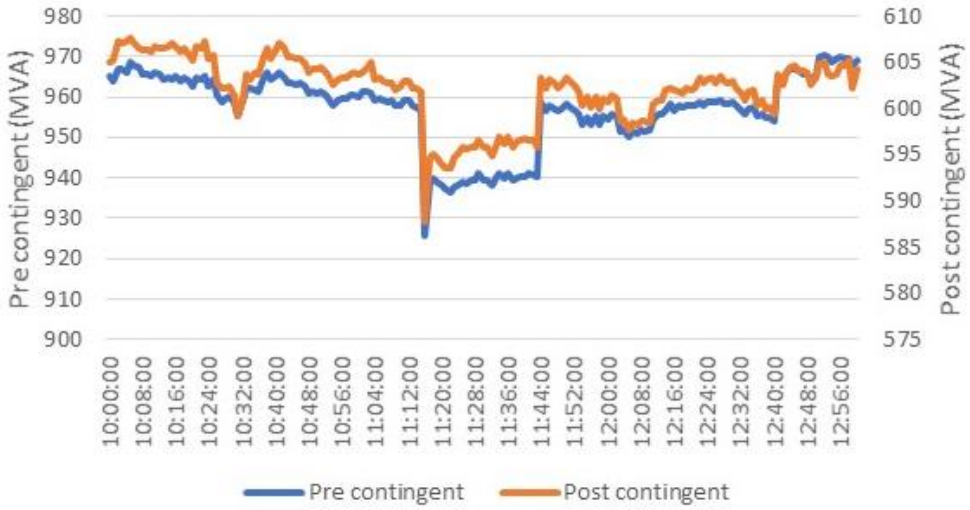
At 1139 hrs on 31 October 2020, AEMO enabled a generating unit at Poatina Power Station in accordance with contractual arrangements between TasNetworks and Hydro Tasmania to increase the post-contingent fault level at Burnie substation to above the 600 MVA limit to ensure the power system was in a secure operating state. Subsequent studies conducted by AEMO using updated system models have shown the power system would remain in a secure operating state for post contingent fault levels down to 560 MVA[6] at Burnie.

[4] 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.

[5] Loss of either the Sheffield – Burnie 220 kV line or the Burnie 220/110 kV transformer.

[6] Refer to the 2020 System Strength and Inertia Report, at https://www.aemo.com.au/-/media/files/electricity/nem/planning_and_forecasting/Operability/2020/2020-System-Strength-and-Inertia-Report.

Figure 2 Burnie 110 kV fault level



Additionally, AEMO invoked constraint sets T-GO_ZERO[7] and F-T_GORDON_ZERO[8] after the incident on 31 October 2020.

No action was required in relation to power system security for the 8 December 2020 event.

3.1 Frequency

In the incident on 31 October 2020, immediately after the trip of GO-CS No. 1 line the frequency in Tasmania dropped to a minimum value of approximately 49.33 Hz due to power system transient performance.

Following the trip of GO-CS No. 2 line and loss of 125 MW of generation from the Gordon Power Station, the frequency dropped to a minimum value of 49.26 Hz and returned to above 49.85 Hz within 5 minutes. The frequency operating standard was met in relation to this incident.

In the incident on 8 December 2020, there was no fault or significant frequency disturbance in the Tasmanian power system.

3.2 Reclassification

AEMO assessed whether to reclassify each of these incidents as a credible contingency event[9].

Prior to the incident on 31 October 2020, AEMO was not advised of any increased risk of tripping of the GO-CS lines and AEMO correctly did not reclassify the loss of both GO-CS lines as a credible contingency event.

After the incident on 31 October 2020, TasNetworks advised AEMO that the cause of the trip of GO-CS lines had been identified and the fire around the transmission lines was under control before the lines were returned to service. Based on this advice, AEMO determined the incident was unlikely to recur and therefore correctly determined that reclassification of the loss of both GO-CS line as a credible contingency event was not required.

At the time of incident on 31 October 2020, it was believed by AEMO and TasNetworks that the AUFLS had operated correctly in response to the loss of both the GO-CS lines and therefore any reclassification involving the operation of the AUFLS was not considered.

[7] Zero MW upper limit on Gordon generation

[8] Gordon FCAS <= 0 MW

[9] 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).

The incorrect operation of the AUFLS was identified by TasNetworks as part of its post-event analysis. As part of this analysis, TasNetworks implemented a number of changes to the AUFLS to prevent further incorrect operation, negating any need to further consider reclassification.

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[10] 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[11].
    - AEMO issued Market Notice 79496 at 1229 hrs on 31 October 2020, 74 minutes after the event, to advise of the non-credible contingency event. AEMO also advised at the same Market Notice that the cause of the trip of GO-CS lines had been identified and AEMO determined the incident was unlikely to recur and reclassification as a credible contingency event was not required.

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 GO-CS lines on 31 October 2020 was due to a fault caused by either fire or dense smoke from a planned burn.
2. All protection operated correctly to clear the faults on the GO-CS lines.
3. For the incident on 31 October 2020, the AUFLS scheme operated incorrectly, disconnecting customer load before loss of generation had occurred.
4. For the incident on 8 December 2020, there was no fault or frequency disturbance on the power system and the AUFLS operated when it should not have. This was due to a combination of incorrect frequency calculations by the AUFLS relays and incorrect relay settings.
5. Modifications have been made to the AUFLS to minimise the risk of further inadvertent operation.
6. The power system remained in a secure operating state during both incidents.

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

[11] 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.

A1. The AUFLS scheme

The AUFLS scheme is a normally enabled control scheme designed to reduce the Fast Raise Frequency Control Ancillary Services (FCAS) requirement in the Tasmania region by shedding contracted load when frequency in Tasmania falls below 48.8 Hz.

The scheme continually monitors the system frequency, and if the frequency falls below 48.8 Hz up to four blocks of contracted industrial load will be tripped within 150 ms. The amount of load tripped is dependent on the rate of change of frequency (RoCoF) and the system inertia.

To prevent unintended operation during power system faults, the scheme incorporates a voltage check function where the voltage must be above 0.7 pu for at least 20 ms[12].

That is, for the scheme to operate, the following conditions must be met:

- Tasmania region frequency below 48.8 Hz, and
- Voltage level above 0.7 pu for at least 20 ms.

[12] These values have been updated to 0.88 pu and 100 ms respectively in response to the events described in this report.

A2. Geographic overview

Figure 3 provides the geographic overview of relevant areas of the power system and the planned burn boundary.

Figure 3 Overview of part of the power system including planned burn boundary area