MULTIPLE LINE OUTAGES IN THE MOUNT ENGLAND – TARONG AREA IN QUEENSLAND, 13 FEBRUARY 2017

REVIEWABLE OPERATING INCIDENT REPORT UNDER THE NATIONAL ELECTRICITY RULES

Published: **3 August 2017**

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	1709 hrs Monday 13 February 2017
Region of incident	Queensland
Affected regions	Queensland
Event type	Environmental - lightning
Generation Impact	No generator was disconnected or limited as a result of the incident.
Customer Load Impact	No customer load was disconnected as a result of the incident.
Associated reports	Multiple 275 kV Transmission Line Trips at Mount England in Queensland, 13 February 2017

ABBREVIATIONS

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
kV	Kilovolt
MW	Megawatt
NER	National Electricity Rules
PS	Power Station
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.

Disclaimer

AEMO has made every effort to ensure the quality of the information in this report but cannot guarantee its accuracy or completeness. 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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1. OVERVIEW

This report relates to a reviewable operating incident[1] that occurred on 13 February 2017 at Mount England substation in Queensland. At 1709 hrs faults on the transmission system resulted in outages of multiple 275 kV transmission lines in the Mount England area, and the Mt England 275 kV No.1 busbar. There was extensive lightning activity in the area at the time. This was the second incident at the Mount England substation on this date; the other has been reported[2] separately.

No load or generation was lost as a result of this incident.

As a reviewable operating incident, AEMO is required to assess power system security over the course of each incident, and 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.[3]

AEMO has concluded that:

1. A lightning storm in the area resulted in faults on the following lines:
   - Mt England–Tarong No.837 275 kV line.
   - Blackwall–Tarong No.875 275 kV line.
2. These in turn, when combined with the pre-event plant configuration in place at Mount England substation, resulted in outages of the following:
   - Mt England–Wivenhoe No.823 275 kV line disconnected due to protection operation as a result of an overvoltage condition.
   - No.1 275 kV busbar at Mount England substation disconnected when line 837 was disconnected as a result of a persistent high voltage fault.
   - Mt England–Abermain No.8823 275 kV line disconnected when the de-energised line 837 experienced a high voltage fault, resulting in an external flashover across the tie breaker CB between line 837 and line 8823 in the substation.
3. Other than a brief period (approximately five seconds) in which an overvoltage condition was observed, the power system remained in a secure operating state over the course of the incident.
4. The provision and response of facilities and services were appropriate and all protection operated as designed and as expected.
5. There are no outstanding issues to resolve as a result of 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 Powerlink, CS Energy, and AEMO.

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

2. PRE-EVENT CONDITIONS

The Mt England–South Pine No.825 275 kV line (line 825) was out of service due to a previous fault, which has been separately reported, and is available on AEMO's website.

The Mt England–Tarong No.8812 275 kV line (line 8812) was out of service due to short notice planned work as part of repair works associated with the fault on line 825.

Refer to Appendix A for a diagram of the power system immediately prior to this incident.

[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] Multiple 275 kV transmission line trips at Mt England in QLD available: <http://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Multiple-275kV-line-outages-at-Mt-England_20170213_1_final.pdf>
[3] See NER clause 4.8.15(b).

3. INCIDENT

At approximately 1709 hrs on Monday 13 February 2017, an electrical storm passed through the Mount England and Tarong substation area, resulting in multiple faults on the following transmission lines:

- Mt England–Tarong No.837 275 kV line (line 837).
- Blackwall–Tarong No.875 275 kV line (line 875).

The faults and subsequent tripping of these lines, resulted in outages of the following:

- Mt England–Wivenhoe No.823 275 kV line (line 823).
- No.1 275 kV busbar at Mount England substation (Mt England No.1 busbar).

Wivenhoe Power Station Unit 1 was offline at the time, so no generation was lost with the loss of line 823. Wivenhoe Power Station Unit 2 was generating at 160 MW throughout the incident and was not impacted.

At approximately 1715 hrs, line 8812 was returned to service after remedial works were completed on that line. Seven seconds later, the Mt England – Abermain No 8823 275kV line (line 8823) tripped.

Refer to Appendix A for diagrams illustrating the power system as this incident progressed.

The equipment was returned to service as follows:

- Line 875 successfully auto-reclosed both times it tripped.
- Mt England No.1 busbar was returned to service at 1751 hrs on 13 February 2017.
- Line 8823 was returned to service at 1858 hrs on 13 February 2017.
- Line 837 was returned to service at 1745 hrs on 14 February 2017 after repairs to plant.
- Line 823 was returned to service at 1623 hrs on 20 February 2017.

The power system was in a secure state for the duration of the incident, other than a brief period (approximately five seconds) when a high voltage condition was observed on the Mount England No.1 275 kV busbar and connecting lines.

As this was a multiple contingency event, AEMO is required to review it in accordance with the National Electricity Rules (NER)[4].

4. PARTICIPANT INVESTIGATION

4.1 Powerlink investigation

The following section is based on information provided by Powerlink. Between 1709 hrs and 1715 hrs on 13 February 2017, multiple 275 kV transmission lines in the Mount England substation tripped. The electrical storm resulted in five separate high voltage faults on the transmission network over six minutes.

All faults were cleared within mandated clearance times.[5]

Table 1 details the sequence of events and further commentary regarding the high voltage faults that occurred in this period. A more detailed sequence of events, including circuit breaker (CB) operation is included in Appendix B.

[4] NER Clause 4.8.15
[5] NER Schedule 5.1a System Standards Clause S5.1a.8

Table 1: Detailed sequence of events, as provided by Powerlink

Time (hrs)	Event	Comment
Pre-event	Lines 825 and 8812 out of service.	Lines out of service for rectification activities after the incident earlier in the day.
17:09:03.300	Line 837 single phase trip due to single phase fault (phase 'A' to ground).	Mount England No.1 busbar and line 823 connected to the transmission network via the two in service phases of line 837 only after the single phase trip.
17:09:08.029	Mount England substation 275 kV No.1 capacitor (Mt England No.1 capacitor) closed.	Emergency Voltage Regulation systems operated to close the capacitor as a result of a low voltage condition on the Mount England No.1 busbar. The low voltage condition was a result of the phase imbalance, given the bus was connected via only two phases following the trip of line 837.
17:09:08.219	Line 823 trip due to intertrip signal received from Wivenhoe Power Station.	See Section 4.2 for details.
17:09:08.510	Auto-reclose attempt on line 837 to re-energise the out of service phase. Immediately on energising, protection systems operated to trip the line from service on all 3 phases due to the re-occurrence of the high voltage fault.	After the trip of line 837, the Mt England No.1 busbar and line 823 were disconnected from the network on all phases, and de-energised.
17:09:12.885	Mt England No.1 capacitor tripped due to a 'No Volt' condition on the Mt England No.1 busbar.	The busbar had been de-energised with the trip of line 837 at 17:09:08.510.
17:15:35.056	Line 8812 returned to service from previous event.	Mt England No.1 busbar remained de-energised.
17:15:42.644	Line 8823 trip due to operation of Circuit Breaker fail protection associated with CB 5042. (5042 is the tie breaker CB between line 8823 and line 837 at Mt England substation). This circuit breaker was already open due to the trip of line 837 at 17:09:08.510.	Protection operated due to occurrence of a high voltage fault on the circuit breaker as a result of a further lightning strike on the out of service 837 line causing an external flashover across the open CB 5042.

During this event, line 875 (from Tarong to Blackwall) also tripped twice and auto-reclosed each time. This had no impact on the events at Mt England. The first trip at 17:09:03.411 was single phase (phase 'A' to ground), and the second trip at 17:09:48.903 was multi-phase (phase 'A' to ground and phase 'C' to ground).

The Mt England No.1 Busbar was re-energised via CB 88122 (line 8812) at 1751 hrs on 13 February 2017.

Line 8823 was returned to service at 1858 hrs on 13 February 2017. CB 5042 remained out of service until Powerlink could complete further investigations.

Line 837 was returned to service at 1745 hrs on 14 February 2017 after repairs to plant.

Line 823 was returned to service at 1623 hrs on 20 February 2017.

All protection operated as designed and as expected.

4.2 CS Energy investigation

CS Energy investigated this incident and found the protection on Unit 1 at Wivenhoe Power Station operated as expected. Immediately prior to the incident, Wivenhoe Power Station Unit 1 was offline.

At 17:09:08 hrs the Unit 1 Main Transformer differential protection operated and correctly sent an intertrip signal to open the 8232 CB at Mt England and disconnect the transformer. The differential protection operated due to a sudden increase in the 3rd and 5th harmonic currents as a result of over-fluxing of the transformer core. This over-fluxing was the result of abnormally high voltages in one phase of the transformer when the No1 bus 275kV capacitor at Mt England was closed into service. Refer to Section 5.1 for more detail.

The maximum voltage reached during the event was approximately 238kV phase-to-ground with a steady state value of around 228kV phase-to-ground (394kV to 412kV line voltage).

Line 823 was returned to service at 1623 hrs on 20 February 2017, once CS Energy had tested and confirmed the transformer had not been damaged by the over-fluxing it experienced.

5. POWER SYSTEM SECURITY

AEMO is responsible for power system security in the National Electricity Market (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.[6]

This section assesses how AEMO managed power system security over the course of this incident.

AEMO invoked constraint set Q-MEWV_823[7] at 1720 hrs, approximately 11 minutes after line 823 tripped. This constraint was revoked at 0150 hrs on 15 February 2017.

AEMO had already invoked constraint set Q-TRME at 1210 hrs on 13 February 2017, to manage the short notice planned works outage of line 8812, and Q-SPME_825 to manage the trip of this line earlier in the day.

5.1 Voltage Fluctuations

The power system was not in a satisfactory state (and thus not secure) for a brief period (approximately five seconds) when voltage levels at Mt England and Wivenhoe Power Station exceeded the overvoltage limit set in the NER[8]. The high voltage occurred as a result of the single phase disconnection of line 837, which resulted in a low voltage condition on the Mt England No.1 busbar and subsequent automatic switching into service of the Mt England No.1 capacitor.

The low voltage condition was observed on the Mt England No.1 busbar when phase ‘A’ was disconnected following the trip of line 837 at 17:09:03.300. The No.1 busbar and line 823 were then only connected to the rest of the grid by the remaining ‘B’ and ‘C’ phases, and the resulting phase imbalance produced the low voltage condition.

At 17:09:08.029 Emergency Voltage Regulation systems operated correctly to close the Mt England No.1 capacitor bank and increase the voltage. As phase ‘A’ was disconnected from the grid, and thus had minimal impedance, this phase experienced a particularly large voltage increase when the capacitor bank was switched in. The maximum line voltage on line 823 was measured to be approximately 412 kV, with a steady state of 394 kV. This is 43-50% greater than the rated line voltage of 275 kV, and thus exceeded the maximum permissible short time over-voltage of 130%.

Protection systems operated correctly on the Unit 1 transformer at Wivenhoe Power System to trip line 823 at 17:09:08.219. Line 837 was disconnected on all three phases at 17:09:08.510 after an unsuccessful auto-reclose attempt, and the Mt England No.1 busbar was de-energised. At this point,

[6] 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
[7] Out= Mt England to Wivenhoe (823) line
[8] NER Schedule 5.1a System Standards Clause S5.1a.4 - Power frequency voltage. The maximum permissible short time over-voltage is 130%.

the power system returned to secure operating state. The capacitor banks automatically switched back out at 17:09:12.885 as a result of the 'No volt' condition.

No further action was required to maintain power system security over the course of the incident.

5.2 Reclassification

Prior to the incident, AEMO was aware of lightning in the area. AEMO did not reclassify the simultaneous trip of any of the lines in the area as a single credible contingency as there was no reason to as these lines are not listed as vulnerable in the *Power System Security Guidelines*[9].

After the event, AEMO assessed whether or not to reclassify the event as a credible contingency[10]. Based on information provided by Powerlink for this incident, AEMO was satisfied that the cause had been identified and that the incident was unlikely to reoccur. AEMO issued Market Notice 57518 at 0151 hrs on 14 February 2017 to notify the market that the incident would not be reclassified as a credible contingency. In the time between the event and confirming that the incident would not be reclassified, line 837 remained out of service.

Other than the short period in which voltage fluctuations were observed, the power system remained in a secure operating state over the course of the incident. Power system frequency[11] remained within limits and all faults were cleared within required timeframes[12]. AEMO correctly assessed the incident and did not reclassify it as a credible contingency, and appropriate notifications were issued.

6. 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 was required to inform the market on the following matters:

1. A non-credible contingency event - notify within two hours of the event.[14]
    - AEMO issued Market Notice 57509 at 1736 hrs – 27 minutes after the initial outage, to notify the market of a non-credible contingency event.
2. Reclassification, details, and cancelation of a non-credible contingency – notify as soon as practical.[15]
    - AEMO issued Market Notice 57518 at 0151 hrs – 6 hours, 42 minutes after the event,to notify the market that AEMO does not intend to reclassify the event as a credible contingency. This is based on information received from the TNSP that the cause of the events at 1709 hrs has been identified and is unlikely to re-occur. AEMO delayed publication of this market notice until sufficient information had been received from the TNSP regarding the event, given line 837 remained out of service

Over the course of this incident, AEMO issued appropriate and sufficiently detailed market information.

[9] As per the *Power System Security Guidelines*, vulnerable transmission lines are double circuit transmission lines which fall into the categories for Probable or Proven. A double circuit transmission line in this category is eligible to be reclassified as a credible contingency event during a lightning storm if a cloud to ground lightning strike is detected within a specified distance of the vulnerable lines.
[10] AEMO is required to assess whether or not to reclassify a non credible contingency event as a credible contingency - NER Clause 4.2.3A (c) - and to report how re-classification criteria were applied - NER Clause 4.8.15 (ca). AEMO has to determine if the condition that caused the non-credible contingency event has been resolved.
[11] Operating Frequency Tolerance Band specified in AEMC Reliability Panel Frequency Operating Standards
[12] NER Schedule 5.1a System Standards Clause S5.1a.8 – Fault clearance times
[13] AEMO generally informs the market about operating incidents as the progress by issuing Market Notices – see AEMO website
[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
[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)

7. CONCLUSIONS

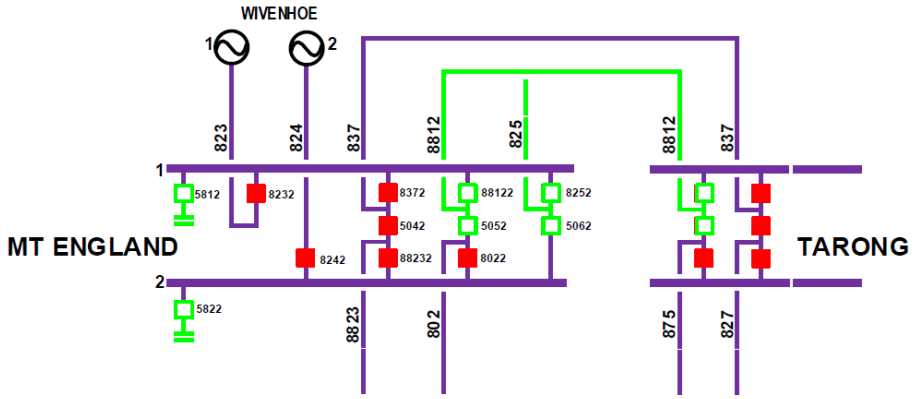
AEMO has assessed this incident in accordance with clause 4.8.15(b) of the NER. In particular, AEMO has assessed the adequacy of the provision and response of facilities or services, and the appropriateness of actions taken to restore or maintain power system security.

AEMO has concluded that:

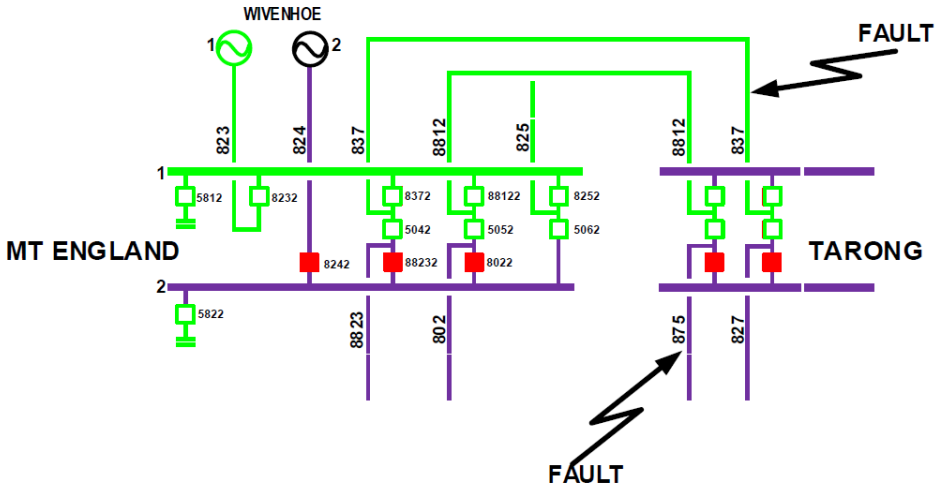
1. A lightning storm in the area resulted in faults on the following lines:
   - Mt England–Tarong No.837 275 kV line.
   - Blackwall–Tarong No.875 275 kV line.
2. These in turn, when combined with the pre-event plant configuration in place at Mount England substation, resulted in outages of the following:
   - Mt England–Wivenhoe No.823 275 kV line disconnected due to protection operation as a result of an overvoltage condition.
   - No.1 275 kV busbar at Mount England substation, disconnected when line 837 was disconnected as a result of a persistent high voltage fault.
   - Mt England–Abermain No.8823 275 kV line, disconnected when the de-energised line 837 experienced a high voltage fault, resulting in an external flashover across the tie breaker CB.
3. Other than a brief period (approximately five seconds) in which an overvoltage condition was observed, the power system remained in a secure operating state over the course of the incident.
4. The provision and response of facilities and services were appropriate and all protection operated as designed and as expected.
5. There are no outstanding issues to resolve as a result of this incident.

APPENDIX A. – POWER SYSTEM DIAGRAM

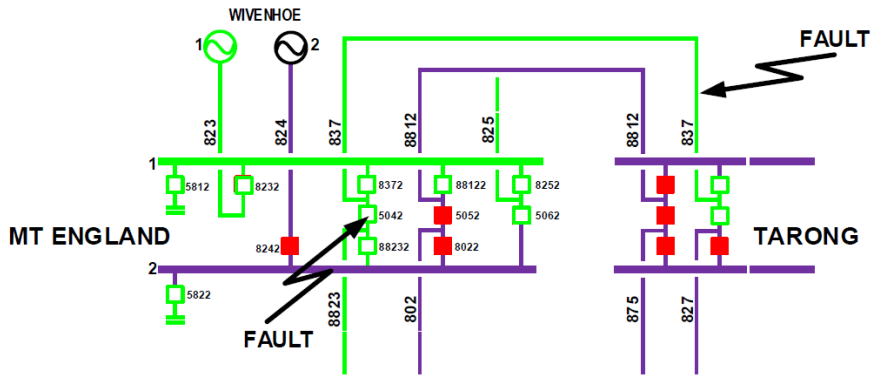
The power system in the area immediately before the incident

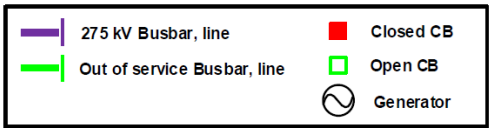


The power system after the initial set of events at 1709 hrs.



The power system after the next set of events at 1715 hrs.





APPENDIX B – INCIDENT LOG

Time and Date	Event
Monday 13 February 2017 17:09:03.300	Line 837 single phase trip, Mt England substation CB 8372 and 5042 opened on phase A*.
17:09:03.411	Line 875 trip.
17:09:08.029	Mt England No.1 capacitor closed (Mt England CB 5812 closed).
17:09:08.219	Line 823 trip due to Wivenhoe Power Station unit 1 transformer protection operation (Mt England CB 8232 opened)
17:09:08.510	Line 837 trip (Mt England CB 8372 and 5042 opened on all 3 phases).
17:09:08.547	Line 875 auto-reclosed.
17:09:12.885	Mt England No.1 capacitor trip (Mt England CB 5812 opened).
17:09:48.903	Line 875 trip.
17:09:59.023	Line 875 auto-reclosed.
17:15:35.056	Line 8812 returned to service (Mt England CB 5052 closed). Line 8812 was out of service due to rectification activities from a previous event.
17:15:42.644	Line 8823 trip (Mt England CB 88232 opened).
17:20	Q-MEWV_823 invoked.
17:36	Market Notice 57509 issued – advising of non-credible contingency event.
17:51	Re-energisation of No.1 busbar (Mt England CB 88122 closed)
18:58	Line 8823 returned to service (Mt England CB 88232 closed)
Tuesday 14 February 2017 01:51	Market notice 57518 issued – advising that the non-credible contingency event will not be reclassified.
17:45	Line 837 returned to service.
Wednesday 15 February 2017 01:50	Q-MEWV_823 revoked.
18:50	Q-TRME revoked.
Monday 20 February 2017 16:23	Line 823 returned to service (Mt England CB 8232 closed).

* Only Mt England CB operations have been listed, unless otherwise specified, all 3 phases are opened or closed.