

# MULTIPLE 275 KV TRANSMISSION LINE TRIPS AT MOUNT ENGLAND SUBSTATION IN QUEENSLAND, 13 FEBRUARY 2017

REVIEWABLE OPERATING INCIDENT REPORT UNDER THE  
NATIONAL ELECTRICITY RULES

Published: **26 July 2017**





## INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	0340 hrs Monday 13 February 2017
Region of incident	Queensland
Affected regions	Queensland
Event type	Transmission Equipment
Generation Impact	No generator was disconnected or limited as a result of the incident.
Customer Load Impact	Wivenhoe Power Station pumps tripped from ~240 MW per unit as a result of the incident.
Associated reports	<ul style="list-style-type: none"><li>• <a href="#">Fault at Torrens Island switchyard</a></li><li>• <a href="#">Trip of both 330kV lines supplying Ingleburn substation in NSW</a></li><li>• <a href="#">Black System in South Australia - Final Integrated Report</a></li></ul>

## ABBREVIATIONS

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	Circuit Breaker
CVT	Capacitor Voltage Transformer
kV	Kilovolt
Ms	millisecond
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

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# CONTENTS

<b>1. OVERVIEW</b>	<b>4</b>
<b>2. THE INCIDENT</b>	<b>4</b>
<b>3. PARTICIPANT INVESTIGATION</b>	<b>5</b>
3.1 Powerlink investigation	5
3.2 CS Energy investigation	6
<b>4. POWER SYSTEM SECURITY</b>	<b>6</b>
4.1 Reclassification	6
<b>5. CVT TYPE FAULTS</b>	<b>7</b>
<b>6. MARKET INFORMATION</b>	<b>8</b>
<b>7. CONCLUSIONS</b>	<b>9</b>
<b>8. PENDING ACTIONS</b>	<b>9</b>
<b>APPENDIX A. – POWER SYSTEM DIAGRAM</b>	<b>10</b>



## 1. OVERVIEW

This report relates to a reviewable operating incident<sup>1</sup> on 13 February 2017 at the Mount England substation in Queensland.

At 0340 hrs on 13 February 2017, the failure of a capacitor voltage transformer (CVT) on the Mt England–South Pine No.825 275 kV line (line 825) resulted in the outage of this line. This fault also resulted in the trips of the Mt England–Tarong No.8812 275 kV line (line 8812), and the Mt England–Wivenhoe PS No.823 and No.824 275 kV lines (lines 823 and 824).

This incident resulted in the loss of 475 MW of load at Wivenhoe Power Station<sup>2</sup>. There was no loss of generation.

As a reviewable operating incident, AEMO is required to assess power system security over the course of the 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.<sup>3</sup>

AEMO has concluded that:

1. The fault sequence was initiated by the failure of the capacitor voltage transformer on the Mt England–South Pine No.825 275 kV line.
2. The Wivenhoe Power Station control system was damaged due to the earth current, initiating the emergency shutdown of these units.
3. The simultaneous trip of both Wivenhoe Power Station units has been reclassified as a single credible contingency.
4. The provision and response of facilities and services were appropriate, and power system security was maintained over the course of the 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. THE INCIDENT

On Monday 13 February 2017 at 0340 hrs, there was a failure of the CVT associated with line 825 at Mount England substation resulting in the trip of this line. An auto reclose attempt was initiated five seconds later but failed due to the permanent fault on line 825. Approximately two seconds after the initial fault on line 825, line 8812 tripped and successfully auto reclosed.

Before the initiating fault, the Wivenhoe units were both in pumping mode, with loads of 239 MW and 236 MW for Pump 1 and Pump 2 respectively. Damage to the Wivenhoe Power Station Plant Control System resulted in the shutdown of these units and the trip of the 823 and 824 lines.

See Appendix A for a power system diagram illustrating the incident.

The reason for investigating and reporting on this incident is that the near simultaneous trip of lines 825, 8812, 823 and 824 is an unexpected event and is identified in power system security terms as a non-credible contingency<sup>4</sup>.

Line 824 was returned to service at 0606 hrs, and line 823 was returned to service at 0638 hrs on 13 February 2017.

<sup>1</sup> 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.

<sup>2</sup> Both Wivenhoe Power station units were in pump mode at the time of this incident.

<sup>3</sup> See NER clause 4.8.15(b).

<sup>4</sup> NER Clause 4.2.3 - Credible and non-credible contingency events; *AEMO Power System Security Guidelines*, Section 10 - Definition of a non-credible contingency events

Line 825 was returned to service at 2153 hrs on 13 February 2017 after repairs to the failed plant. The power system remained in a secure state for the duration of the event.

## 3. PARTICIPANT INVESTIGATION

### 3.1 Powerlink investigation

Powerlink investigated this incident and provided the following information.

On Monday 13 February 2017 at 0340 hrs, there was an explosive failure of the 275 kV CVT associated with line 825 at Mount England. The original single-phase fault ('A' phase to ground) developed into a multiphase fault, resulting in the line tripping on all three phases. Although an auto reclose attempt was initiated this failed due to a permanent fault on the conductors.

The failure of the CVT on line 825 also generated a multiphase fault on line 8812, resulting in the trip of this line. This fault was a result of the arc flash generated by the CVT failure on line 825. This line was successfully reclosed 10 seconds after it tripped.

Lines 823 and 824 tripped 362 and 382 ms respectively after the initial fault, as a result of an intertrip signal received from Wivenhoe Power Station. See Section 3.2 for details regarding the trip of Wivenhoe Power Station.

All faults were cleared within mandated clearance times<sup>5</sup>.

Table 1 provides a detailed sequence of events.

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

Time (hrs)	Event
03:40:31.807	Line 825 single phase trip due to single phase fault (phase 'A' to ground)
03:40:32.061	Line 825 three phase trip as the single phase fault develops into a multiphase fault
03:40:32.169	Line 823 trip due to intertrip received from Wivenhoe Power Station
03:40:32.189	Line 824 trip due to intertrip received from Wivenhoe Power Station
03:40:33.737	Line 8812 trip due to a multiphase fault (phase 'A' and 'C' to ground)
03:40:37.076	Line 825 auto reclose attempt and trip
03:40:44.448	Line 8812 auto reclose successful

Line 824 was returned to service at 0606 hrs, and line 823 was returned to service at 0638 hrs on 13 February 2017.

Line 825 was returned to service at 2153 hrs on 13 February 2017 after repairs to the failed plant.

<sup>5</sup> NER Schedule 5.1a System Standards Clause S5.1a.8.





## 3.2 CS Energy investigation

CS Energy, operator of Wivenhoe Power Station<sup>6</sup>, investigated this event and provided the following information.

Prior to the event, Wivenhoe Power Station Units 1 and 2 were in pumping mode at 239 MW and 236 MW respectively. The faults at Mount England substation produced a voltage rise on the station earth grid with the resulting earth currents impacting the plant control systems, burning input cards and signal fuses. This triggered an electrical fault shutdown in both units, initiating emergency stop and intertrip signals to Mount England on both lines.

The damaged cards and blown fuses were replaced, and the shutdown relays were reset, prior to the transformers being re-energised from the grid.

The trip of Wivenhoe Power Station was not expected for the type and location of fault. No grid protection systems operated to trip the station.

CS Energy has scheduled an audit and testing of the Wivenhoe earthing system. This is expected to highlight any further rectification actions required to prevent a similar type of event from tripping the units again.

There is also evidence the 24 VDC redundant battery supply to the station control system was adversely impacted by earth current resulting from the grid fault due to the configuration of the DC supply connections. The DC supply connections also have to be investigated, with the removal of any non-complying connections.

## 4. 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.<sup>7</sup>

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

AEMO invoked constraint set Q-SPME\_825<sup>8</sup> approximately 20 minutes after the CVT failure on line 825. This constraint was revoked at 2205 hrs on 13 February 2017 approximately 12 minutes after the line was returned to service.

AEMO also invoked constraint sets:

- Q-ME WV\_823<sup>9</sup>
- Q-ME WV\_824<sup>10</sup>

approximately 25 minutes after lines 823 and 824 tripped. These constraints were revoked at 0620 hrs.

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

### 4.1 Reclassification

AEMO assessed whether or not to reclassify the event of the loss of these multiple lines as a credible contingency<sup>11</sup>. For this incident, AEMO was not satisfied that the cause had been identified and that the incident was unlikely to reoccur. As such, AEMO issued Market Notice 57485 at 0702 hrs on 13 February 2017 to notify the market that the simultaneous trip of the following transmission lines would be reclassified as a credible contingency:

<sup>6</sup> Wivenhoe Power Station consists of two 250 MW hydro pump/generating units.

<sup>7</sup> 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

<sup>8</sup> Out= 825 H12 Mt England to H2 South Pine 275 kV feeder

<sup>9</sup> Out= Mt England to Wivenhoe (823) line

<sup>10</sup> Out= Mt England to Wivenhoe (824) line

<sup>11</sup> 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.



- Mt England–Wivenhoe PS No.823 275 kV Line.
- Mt England–Wivenhoe PS No.824 275 kV Line.
- Mt England–Tarong No.8812 275 kV Line.

At 0745hrs on 13 February 2017, AEMO received further information from Powerlink that the cause of the fault had been identified and isolated. AEMO issued Market Notice 57487 at 0758 hrs to notify the market of the cancellation of the reclassification from 0745 hrs.

Following further advice received from CS Energy on 15 May 2017, AEMO has reclassified the loss of both Wivenhoe units as a credible contingency. Based on advice from CS Energy, a similar credible fault on the grid could result in similar damage to the Plant Control System, initiating the emergency shutdown of both units simultaneously. The reclassification applies to all modes of unit operation; generator, pump and synchronous compensator.

AEMO issued Market Notice 58584 at 1800 hrs on 16 May 2017 to notify the market of this reclassification from 1800 hrs on 16 May 2017 until further notice. This notice also details the constraint sets invoked:

- Q-WIV\_N-2<sup>12</sup>
- F-Q\_WIV\_N-2<sup>13</sup>

For this incident, the power system remained in a secure operating state over the course of the incident. Power system frequency<sup>14</sup> and voltage<sup>15</sup> remained within limits and the fault was cleared within required timeframes<sup>16</sup>. AEMO correctly assessed the incident and reclassified the incident as a credible contingency, and appropriate notifications were issued.

## 5. CVT TYPE FAULTS

There have been three CVT failures on the grid resulting in line losses in 2017:

- This incident on 13 February 2017 at the Mount England substation, where Powerlink has identified the component that failed to be the capacitor stack in the CVT.
- On 3 March 2017, a CVT failed at the Torrens Island Switchyard<sup>17</sup> in South Australia, and resulted in the loss of multiple generating units<sup>18</sup>. In this case, ElectraNet suspects the cause of the CVT failure at Torrens Island to be the internal failure of the primary capacity voltage divider.
- On 18 April 2017, a CVT partially failed on the Moorabool–Mortlake No.2 500 kV line at the Moorabool Terminal Station. In this incident, the CVT failed in one of its capacitor sections affecting the value of the voltage dividing capacitance in the CVT, resulting in overvoltage, and corresponding protection operation to open only the MLTS end of the line. While this incident is not considered a reviewable incident, AEMO notes the root cause in the failure of a CVT.

Prior to 2017, there have been no significant failures of CVTs<sup>19</sup> of which AEMO is aware. AEMO notes there was a failure of a current transformer (CT) associated with a circuit breaker (CB) at the Ingleburn substation in New South Wales on 20 November 2015<sup>20</sup>. TransGrid identified that that type of CT has an increased risk of failure as a small number have failed previously. TransGrid has an asset

<sup>12</sup> Out=Nil, loss of both Wivenhoe units (generating/pumping) declared credible, QNI limits

<sup>13</sup> Out=Nil, loss of both Wivenhoe units (generating/pumping) declared credible, FCAS Requirements

<sup>14</sup> Operating Frequency Tolerance Band specified in AEMC Reliability Panel Frequency Operating Standards

<sup>15</sup> NER Schedule 5.1a System Standards Clause S5.1a.4 - Power frequency voltage

<sup>16</sup> NER Schedule 5.1a System Standards Clause S5.1a.8 – Fault clearance times

<sup>17</sup> Note, a substation, switchyard and terminal station all refer to the grid interconnecting point between two different voltages. Different states use different terminology to describe this grid component.

<sup>18</sup> Fault at Torrens Island Switchyard and Loss of Multiple Generating Units on 3 March 2017, published 10 March 2017, <[http://aemo.com.au/-/media/Files/Electricity/NEM/Market\\_Notices\\_and\\_Events/Power\\_System\\_Incident\\_Reports/2017/Report-SA-on-3-March-2017.pdf](http://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Report-SA-on-3-March-2017.pdf)>

<sup>19</sup> That resulted in non-credible or multiple contingencies

<sup>20</sup> Trip of both 330 kV Transmission Lines Supplying Ingleburn Substation: 20 November 2015, published August 2016, <[http://aemo.com.au/-/media/Files/Electricity/NEM/Market\\_Notices\\_and\\_Events/Power\\_System\\_Incident\\_Reports/2016/Trip-of-two-330-kV-TLs-at-Ingleburn-on-Friday-20-November-2015.pdf](http://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2016/Trip-of-two-330-kV-TLs-at-Ingleburn-on-Friday-20-November-2015.pdf)>





management strategy in place to monitor the condition of CTs of this type in service, and replace these as required.

As AEMO noted as a recommendation in the report regarding the fault at Torrens Island Switchyard on 3 March 2017, AEMO is working with Transmission Network Service Providers (TNSPs) to promote information sharing on asset failures. This matter was discussed at the Power System Security Working Group meeting on 18 July 2017, and AEMO and the TNSPs agreed to progress methods for better information sharing on asset failures.

Similarly, Recommendation 5 from the final report on the Black System in South Australia on 28 September 2017<sup>21</sup>, is for AEMO to consider developing a new reclassification process to manage 'type' risk, including how information of potential risks will be sought, and the most appropriate methods to manage power system security during such a reclassification, by December 2017. Information sharing between TNSPs will also assist this process, and inform AEMO's consideration of a reclassification process.

## 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<sup>22</sup> 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.<sup>23</sup>

AEMO issued Market Notice 57481 at 0421 hrs – 41 minutes after the event. Market Notice 57482 was issued at 0427 hrs to correct the date of the original notice.

2. Constraints invoked with interconnector terms on the LHS.<sup>24</sup>

AEMO issued Market Notice 58584 at 1800 hrs on 16 May 2017 to notify the market of the reclassification of the loss of both Wivenhoe units simultaneously as a credible contingency from 1800 hrs 16/05/17 until further notice. The constraints invoked for this reclassification include interconnector terms on the LHS.

AEMO did not issue a market notice when constraint set Q-SPME\_825 was invoked at 0400 hrs on 13 February 2017 due to the fault on line 825 at 0340 hrs. This set contains constraint equations with interconnector terms on the left hand side. In this case, there was no market impact as the constraint did not bind. AEMO has reminded operational staff to follow standard procedures and this will be specifically covered in upcoming skills maintenance and simulator training.

3. Reclassification, details, and cancelation of a non-credible contingency – notify as soon as practical.<sup>25</sup>

AEMO issued Market Notice 57485 at 0702 hrs on 13 February 2017 to notify the market of the reclassification of the simultaneous trip of line 823, line 824 and line 8812 from 0608hrs (54 minutes after the reclassification).

AEMO issued Market Notice 57487 at 0758 hrs to cancel this reclassification from 0745 hrs given the cause has been identified and is unlikely to reoccur.

<sup>21</sup> Black System South Australia 28 September 2016 – Final Integrated Report, published March 2017 <[http://aemo.com.au/-/media/Files/Electricity/NEM/Market\\_Notices\\_and\\_Events/Power\\_System\\_Incident\\_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf](http://aemo.com.au/-/media/Files/Electricity/NEM/Market_Notices_and_Events/Power_System_Incident_Reports/2017/Integrated-Final-Report-SA-Black-System-28-September-2016.pdf)>

<sup>22</sup> AEMO generally informs the market about operating incidents as the progress by issuing Market Notices – see AEMO website

<sup>23</sup> 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

<sup>24</sup> For short term outage AEMO is required to notify the Market of variances to interconnector transfer limits AEMO, *Power System Security Guidelines*, Section 22

<sup>25</sup> 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)



AEMO issued Market Notice 58584 at 1800 hrs on 16 May 2017 to notify the market of the reclassification of the loss of both Wivenhoe units simultaneously as a credible contingency from 1800 hrs 16/05/17 until further notice, as described in section 4.1.

## 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. The fault sequence was initiated by the failure of the capacitor voltage transformer on the Mt England–South Pine No.825 275 kV line.
2. The Wivenhoe Power Station control system was damaged due to the earth current, initiating the emergency shutdown of these units.
3. The simultaneous trip of both Wivenhoe Power Station units has been reclassified as a single credible contingency.
4. The provision and response of facilities and services were appropriate and power system security was maintained over the course of the incident.

## 8. PENDING ACTIONS

CS Energy to complete the following actions by 31 October 2017:

- Undertake an earthing audit and implement any rectification actions to address the potential for damage to the control system, and
- Investigate the 24 VDC power supplies and implement any rectification actions.

When this work is complete, AEMO will review the reclassification of the credible loss of both units.

## APPENDIX A. – POWER SYSTEM DIAGRAM

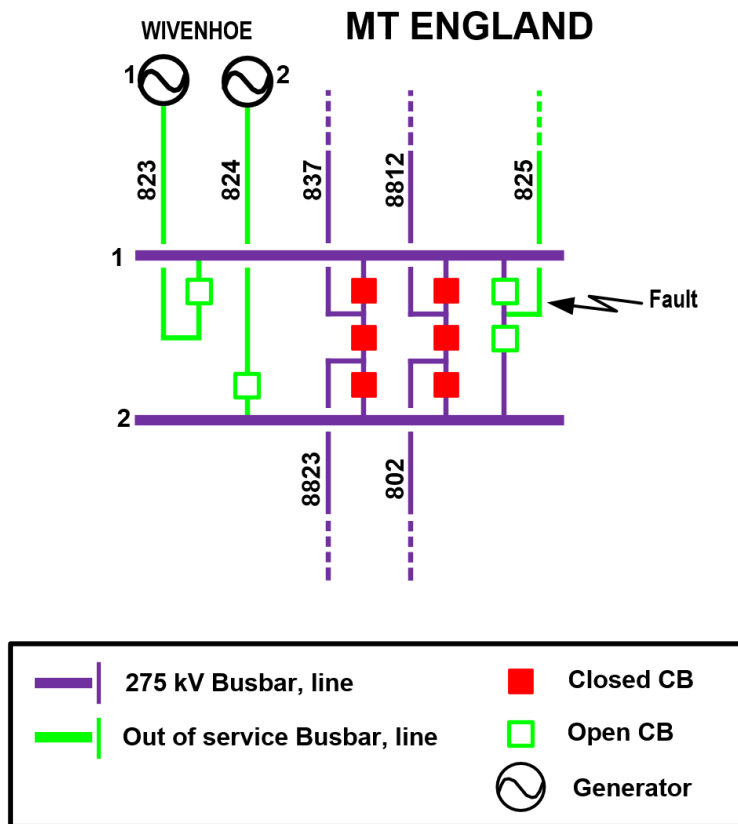


Figure 1: The power system immediately after the incident