



Trip of Mount England to Wivenhoe Power Station 275 kV Line and South Pine Static Var Compensator on 22 February 2021

July 2021

Reviewable Operating Incident Report under the
National Electricity Rules

INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of Incident	2120 hrs on 22 February 2021
Region of incident	Queensland
Affected regions	Queensland
Event type	Lightning and control system failure
Generation impact	Nil
Customer load impact	Approximately 500 MW of load shake off due to voltage reduction during fault
Associated reports	Nil

ABBREVIATIONS

Abbreviation	Term
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AEST	Australian Eastern Standard Time
NEM	National Electricity Market
NER	National Electricity Rules
TNSP	Transmission Network Service Provider

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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1. Overview

This report relates to a reviewable operating incident¹ that occurred on 22 February 2021 in Queensland. The incident involved a trip of the Mount England – Wivenhoe 275 kilovolt (kV) line (Line 824) and, approximately two seconds later, a trip of the South Pine No. 10 Static Var Compensator (South Pine SVC).

There was no loss of generation associated with this incident. However, AEMO noted that approximately 500 megawatt (MW) of load shake off² occurred in South Queensland during this event.

As this was a reviewable operating incident, 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 security³. AEMO has concluded that:

1. The trip of Line 824 was due to a high voltage fault that occurred on the transmission line due to lightning. All protection systems operated as designed and as expected cleared the fault.
2. The trip of South Pine SVC was due to operation of thyristor cooling system protection. Powerlink⁴ advised that the protection operation was due to a manufacturer design and setting issue with the SVC AC auxiliary supply automatic changeover function. Voltage fluctuations caused the automatic changeover function to fail and trip the SVC. Powerlink has developed a solution to address this issue and advised that this was implemented on 23 June 2021. At the time of writing this report, AEMO is reviewing the changes and the potential to amend the reclassification in place.
3. The transmission line and SVC were subsequently returned to service within around one hour after the tripping.
4. During the disturbance approximately 500 MW of temporary customer load shake off occurred in South Queensland.
5. The power system remained in a secure operating state throughout this incident and the Frequency Operating Standards⁵ were met.
6. As at the time of writing this report, AEMO has reclassified the simultaneous tripping of Mount England – Wivenhoe 275 kV line (Line 824) and South Pine SVC as a credible contingency event until further notice.

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 and AEMO.

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

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 An apparent loss of regional demand caused by customer equipment automatically disconnecting from the power system during voltage disturbances.

³ See NER clause 4.8.15(b).

⁴ Powerlink is the Transmission Network Service Provider (TNSP) for Queensland.

⁵ Frequency Operating Standard, effective 1 January 2020, available at <https://www.aemc.gov.au/media/87484>.

2. The incident

2.1 The incident

At 21:20:47 hrs on 22 February 2021, Line 824 tripped. Shortly after, at 21:20:49 hrs, the South Pine SVC also tripped.

The South Pine SVC was returned to service at 22:02:09 hrs on 22 February 2021 and Line 824 was returned to service at 22:14:43 hrs on 22 February 2021. Refer Appendix A1 of this report for the sequence of events.

2.2 Powerlink investigation

The following is based on information provided by Powerlink.

2.2.1 Trip of Transmission Line Feeder 824

At 21:20:47 hrs on 22 February 2021, Mount England – Wivenhoe 275 kV line (Line 824) tripped in response to protection system operation for a high voltage fault (two-phase to earth) on the feeder. The high voltage fault occurred at the time of an electrical storm (lightning) adjacent to Line 824. It was noted that the high voltage fault occurred immediately following a lightning strike as recorded by the Lightning Tracker System⁶. Flashed line insulators were found during post-event inspection near the location of the recorded lightning strike, consistent with high voltage fault phasing details as reported by the transmission line feeder protection systems.

The fault on Line 824 was cleared by tripping Line 824 due to operation of Line 824 protection system within 80 milliseconds (ms). Coincident with the trip of Line 824 at 21:20:47 hrs, there was approximately 500 MW of load shake off across South East Queensland, most likely due to voltage sensitive loads being unable to ride through the voltage transient associated with the high voltage fault. By 21:28:00 hrs on 22 February 2021, it was confirmed that most of the affected load had returned to service and no additional feeders were tripped either on Powerlink or Energex networks.

2.2.2 Trip of South Pine SVC

During this incident there were fluctuations in both cooling system auxiliary AC supplies associated with the South Pine SVC, caused by the fault on Line 824. These fluctuations caused the South Pine SVC thyristor cooling protection system to operate and trip the SVC at 21:20:49 hrs. As part of the incident review, Powerlink identified that the thyristor cooling protection system operated as a result of a manufacturer's design and setting issue with the SVC AC auxiliary supply automatic changeover function. This issue resulted in the SVC AC auxiliary supply function falsely detecting the loss of both the main and backup AC supplies, subsequently tripping the SVC. A solution to address the issue has been developed by Powerlink, which will make the AC auxiliary supply automatic changeover function resilient to external voltage fluctuations. Powerlink has advised that this solution was implemented on 23 June 2021. At the time of writing this report, AEMO is reviewing the changes and the potential to amend the reclassification (please see Section 3.3).

Powerlink has also noted that the cause of the South Pine SVC trip appears to be similar to the cause of tripping of the Strathmore SVC in January 2019 due to a similar manufacturer's design and setting issue. However, at that time, Powerlink did not consider South Pine SVC to be at risk, due to several differences in the AC auxiliary supply configuration and the higher fault levels at South Pine compared to Strathmore. Powerlink has completed an additional review of SVCs within their network and determined that there are no other SVCs at material risk of a similar occurrence. However, as the Greenbank SVC is almost identical to the

⁶ The system is based on <https://www.indjiwatch.com/>, with custom interface for identifying lightning strikes, used by Powerlink.

South Pine SVC (manufacturer and commissioning date), Powerlink plans to implement the same AC changeover design changes to that SVC also for consistency purposes.

2.2.3 Operation of Woolooga SVC

At 21:20:48 hrs on 22 February 2021, the Woolooga SVC briefly shut down its thyristor cooling system in response to the network voltage transient associated with the high voltage fault on Line 824. This action was expected and as per the design of the SVC. At 21:20:57 hrs, the Woolooga SVC blocked its automatic voltage regulation function as the cooling system had not returned to normal operation at this time.

When the SVC blocks its automatic voltage regulator function, the SVC reverts to the output of the standing direct connected harmonic filters, in this case approximately 70 megavolt-amperes reactive (MVAR) capacitive. At the instant immediately prior to the SVC blocking its automatic voltage regulator function, the SVC output was 110 MVAR inductive, hence this change resulted in a net output step change of 180 MVAR. This step change in MVAR output resulted in the Woolooga 275 kV bus voltage reaching a maximum of 304 kV (1.11 pu) for around 10 seconds based on two-second sampled SCADA data and was sustained at 295 kV (1.07 pu) for approximately a further 30 seconds⁷.

At 21:21:12 hrs on 22 February 2021, the SVC recommenced automatic voltage regulation after the thyristor cooling system returned to normal operation. The performance of the Woolooga SVC was as designed and expected for the conditions presented during this event.

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 NER⁸.

The power system was in a secure operating state throughout this incident and no action was required from AEMO apart from invoking the following constraints:

- Constraint set Q-SP_VC invoked at 2135 hrs and subsequently revoked at 2202 hrs.
- Constraint set Q-MEWW_824 invoked at 2210 hrs and subsequently revoked at 2220 hrs.

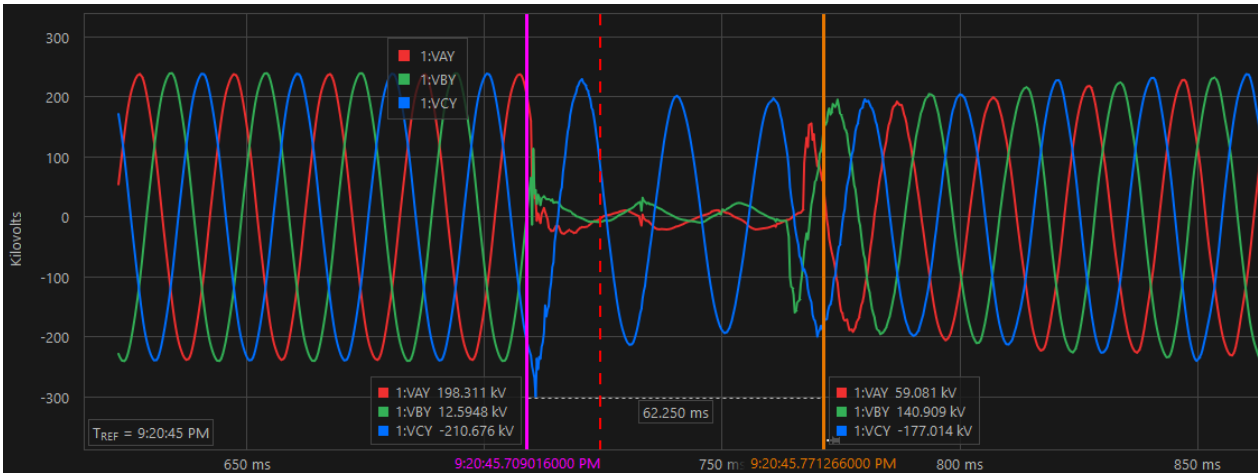
3.1 Voltage

Figure 1 shows the transient voltage dip obtained from high-resolution three-phase fault record data at Mount England 275 kV bus. The recording shows that the primarily impacted phase A and phase B voltage waveforms lasted for approximately 62 ms until the fault was cleared. The disturbance was sufficient to cause voltage sensitive loads in the region to shake off temporarily.

⁷ Figure S5.1a.1 of NER version 164 requires voltage to not exceed 1.1 pu for more than 0.9 seconds for credible contingency events. However, this event was re-classified as non-credible contingency, hence the brief voltage excursion above 1.1 pu for 10 seconds does not violate the NER clause S5.1a.4.

⁸ 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.

Figure 1 Mount England 275 kV three-phase bus voltage at 21:20:47 hrs on 22 February 2021

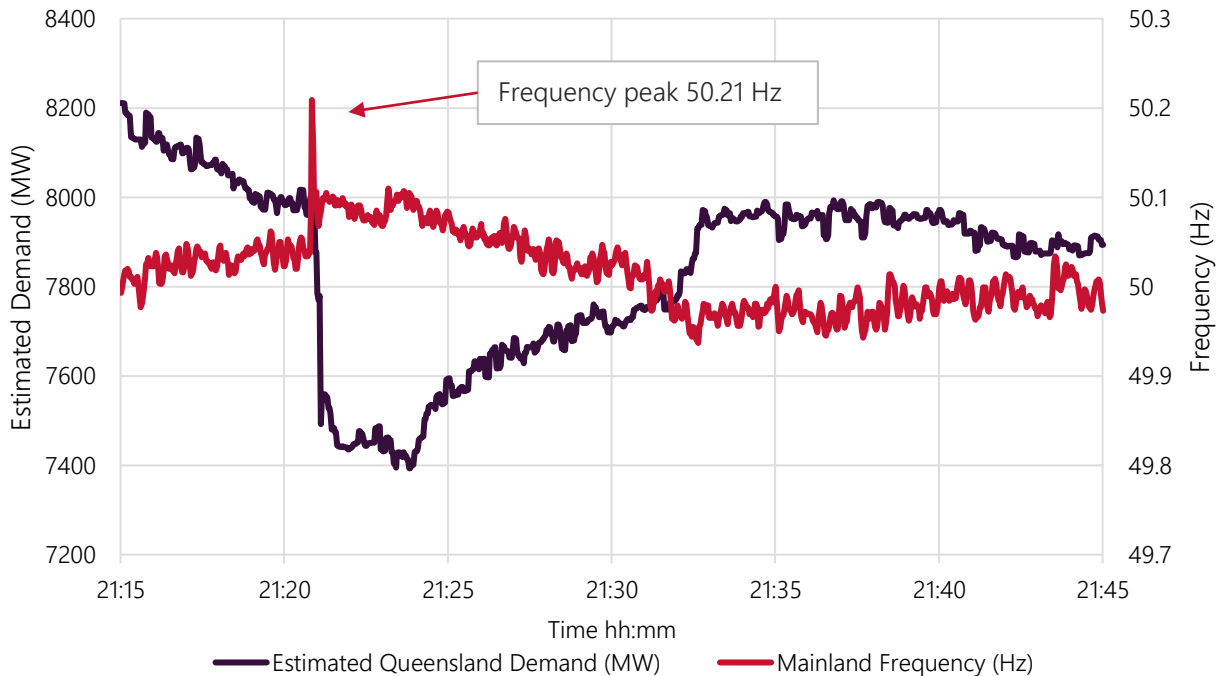


3.2 Frequency

During this incident the NEM mainland frequency reached a maximum of around 50.2 hertz (Hz) at 21:21 hrs on 22 February 2021, as shown in Figure 2, coincident with the reduction in estimated Queensland megawatt demand of approximately 500 MW (based on real-time SCADA data).

The over-frequency lasted for a brief period of less than four seconds, following which the frequency returned to within the normal operating frequency band (49.85 Hz – 50.15 Hz) within five minutes, as specified in Table A.2 of the AEMC Frequency Operating Standard⁹.

Figure 2 Queensland estimated megawatt demand and frequency on 22 February 2021



⁹ Frequency Operating Standard, effective 1 January 2020, available at <https://www.aemc.gov.au/media/87484>.

3.3 Reclassification

AEMO assessed whether to reclassify this incident as a credible contingency event¹⁰. It was confirmed at 22:11 hrs on 22 February 2021 that a lightning strike on the Mount England – Wivenhoe 275 kV Line 824 also resulted in tripping the South Pine SVC due to AC changeover failure. Powerlink was unable to confirm that this event was not likely to re-occur.

Line 824 returned to service at 22:14:43 hrs on 22 February 2021 and AEMO correctly reclassified this event as a credible contingency at 22:25:25 hrs on 22 February 2021, until further notice. Powerlink has developed a solution to address the issue with the South Pine SVC tripping due to the auxiliary supply automatic changeover function and advised that this was implemented on 23 June 2021. At the time of writing this report, AEMO is reviewing the changes and the potential to amend the reclassification in place.

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 market¹¹ 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 event¹².
 - AEMO issued Market Notice 82958 at 2142 hrs on 22 February 2021, 22 minutes after the event, to advise of the non-credible contingency event.
 - This Market Notice also advised that constraint set Q-SP_VC had been invoked, which contains equations with interconnectors constraints on the LHS, N-Q-MSNP1 and NSW1-QLD¹³.
2. Reclassification, details, and cancellation of a non-credible contingency – notify as soon as practical¹⁴.
 - AEMO issued Market Notice 82959 at 2225 hrs on 22 February 2021 to advise that AEMO has reclassified the incident as a credible contingency.

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:

¹⁰ 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).

¹¹ AEMO generally informs the market about operating incidents as they progress by issuing Market Notices – see <https://www.aemo.com.au/Market-Notices>.

¹² 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.

¹³ For short notice outages, AEMO is required to notify the Market of variances to interconnector transfer limits as per section 22 of AEMO's Power System Security Guidelines.

¹⁴ 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).

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2. The trip of South Pine SVC was due to operation of thyristor cooling system protection. Powerlink advised that the protection operation was due to a manufacturer design and setting issue with the SVC AC auxiliary supply automatic changeover function. Voltage fluctuations caused the automatic changeover function to fail and trip the SVC. Powerlink has developed a solution to address this issue and advised that this was implemented on 23 June 2021. At the time of writing this report, AEMO is reviewing the changes and the potential to amend the reclassification in place.
3. The transmission line and SVC were subsequently returned to service within around one hour after the tripping.
4. During the disturbance approximately 500 MW of temporary customer load shake off occurred in South Queensland.
5. The power system remained in a secure operating state throughout this incident and the Frequency Operating Standards were met.
6. As at the time of writing this report, AEMO has reclassified the simultaneous tripping of Mount England – Wivenhoe 275 kV line (Line 824) and South Pine SVC as a credible contingency event until further notice.

6. Recommendations

It is recommended that TNSPs perform a review of the SVC cooling system auxiliary AC supply configurations and any automatic changeover function settings to prevent similar tripping incidents of SVCs during fault induced transients.

AEMO plans to discuss the findings of this and other incidents at the upcoming Operational Planning Working Group and Power System Security Working Group meetings in late 2021.

A1. Sequence of events

Table 1 Sequence of events on 22 February 2021

Time hh:mm:ss	Events/Comments
21:20:47	Mount England – Wivenhoe 275 kV transmission line (Line 824) tripped
21:20:49	South Pine SVC tripped
21:20:57	Automatic voltage regulation function of Woolooga SVC blocked automatically
21:21:12	Automatic voltage regulation function of Woolooga SVC restored automatically
21:28:00	Powerlink confirmed that no feeder trips on their or Energex's networks. Confirmation that almost all load dropped off had returned.
21:35:00	Constraint set Q-SP_VC invoked
21:42:00	Market Notice 82958 inter-regional transfer limit variation – South Pine 275 kV SVC issued
21:58:00	Powerlink indicated that fault cause was direct lightning strike on the Mount England – Wivenhoe 275 kV line (Line 824)
22:02:09	South Pine SVC returned to service
22:10:00	Constraint set Q-SP_VC revoked
22:14:43	Mount England – Wivenhoe 275 kV line (Line 824) returned to service
22:15:00	Constraint set Q-MEWW_824 invoked
22:20:00	Constraint set Q-MEWW_824 revoked
22:25:25	Market Notice 82959 – Non credible contingency event – Queensland region issued reclassifying the trip of Mount England – Wivenhoe 275 kV transmission line (Line 824) and the South Pine SVC as a credible contingency