
Trip of the Rowville No. 2 500 kV
Busbar and A2 500/220 kV
Transformer on 18 January 2018

March 2019

Reviewable operating incident report under the
National Electricity Rules

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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INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	1519 hrs on Thursday 18 January 2018
Region of incident	Victoria
Affected regions	Victoria
Event type	Transmission equipment failure / Protection mal-operation
Generation Impact	Nil
Customer load impact	Approximately 600 MW of load was lost. The loss of load occurred in the distribution networks and no bulk supply points were disconnected from the transmission network. AEMO did not instruct any load shedding.
Associated reports	Nil

Contents

1.	Overview	4
2.	The incident	6
2.1	Demand reduction	6
3.	AusNet investigation	7
3.1	Trip of Rowville busbar and A2 transformer	7
3.2	Trip of the Rowville – South Morang No. 3 line	7
4.	Trip of Loy Yang B generating unit	8
5.	Power system security	8
5.1	Overview	8
5.2	Satisfactory operating state	9
5.3	Reclassification	9
6.	Market information	10
7.	Conclusions	11
8.	Pending actions	11
A1.	Power system diagram	12

1. Overview

This report relates to a reviewable operating incident¹ that occurred on 18 January 2018 in Victoria. This incident involved the outage of the Rowville (ROTS) No. 2 500 kV busbar, ROTs A2 500/220 kV transformer, and the Rowville – South Morang No. 3 500 kV transmission line (ROTS–SMTS line) at South Morang (SMTS). Around nine minutes after the trip of the transmission equipment, the Loy Yang B No. 1 generating unit tripped from 530 MW.

Approximately 600 MW of load was lost during this incident. The loss of load occurred in the distribution networks and no bulk supply points were disconnected from the transmission network. AEMO did not instruct any load shedding.

The disconnection of multiple transmission elements is considered a non-credible contingency event under the National Electricity Rules (NER), and accordingly this was a reviewable operating incident. AEMO is required to assess power system security over the course of this 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 security².

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 AusNet Services³ and Alinta Energy (Alinta)⁴, and from AEMO Energy Management Systems.

AEMO has concluded that:

1. The root cause of the disconnection of the busbar and transformer at ROTs was a faulty current transformer (CT) at ROTs, which was not isolated by AusNet Services in a timely manner.
2. The trip of the ROTs–SMTS line occurred due to incorrect protection settings at SMTS. The protection settings have been corrected.
3. Analysis performed subsequent to the conclusion of the incident indicated that, as a result of network switching requested by AEMO in response to this incident, the power system was not in a satisfactory operating state between 18 January and 1 February 2018.
4. The trip of the Loy Yang B1 generating unit was caused by a generator governor issue and was not directly related to the issues at ROTs or SMTS.
5. AEMO did not reclassify the loss of the ROTs–SMTS line for any fault at ROTs as a credible contingency in a timely manner.
6. AEMO did not advise the market that constraints with interconnector terms on the LHS had been invoked during this incident.

National Electricity Market (NEM) time (Australian Eastern Standard Time) is used in this report. Local time in Victoria at the time of this incident is AEST plus one hour.

¹ See National Electricity Rules (NER) clause 4.8.15(a)(1)(i) and the AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents, 1 April 2013.

² See NER clause 4.8.15(b).

³ AusNet Services is the primary declared transmission system operator for the Victoria region and provides network capability services to AEMO in its capacity as a Transmission Network Service Provider (TNSP). Note that Information provided by AusNet Services has been provided on a without prejudice basis and nothing in this report is intended to constitute, or may be taken by any person as constituting, an admission of fault, liability, wrongdoing, negligence, bad faith or the like on behalf of AusNet Services (or its respective associated companies, businesses, partners, directors, officers or employees).

⁴ Alinta Energy is the operator of Loy Yang B power station.

2. The incident

At 1519 hrs on Thursday 18 January 2018, the ROTS No. 2 500 kV busbar, the ROTS A2 500/220 kV transformer, and the ROTS–SMTS line at SMTS tripped simultaneously. The ROTS end of the ROTS–SMTS line did not trip. Appendix A1 provides a diagram of the relevant part of the power system immediately after the incident.

At 1528 hrs, on Thursday 18 January the Loy Yang B No. 1 generating unit tripped from 530 MW.

The transmission equipment was returned to service at the following times on 18 January 2018:

- The ROTS–SMTS line was returned to service at 1520 hrs.
- The ROTS No. 2 500 kV busbar was returned to service at 1552 hrs.
- The ROTS A2 500/220 kV transformer was returned to service via the 1 bus 500 kV circuit breaker (CB) at 1836 hrs, after a faulty CT was isolated.

The Loy Yang B No.1 generating unit was returned to service at 1711 hrs on 18 January 2018.

The failed CT at ROTS was replaced and returned to service along with the A2 transformer 2 bus 500 kV CB on 6 February 2018.

In accordance with clause 4.8.15 of the NER, AEMO is required to review and report on any reviewable operating incident, which includes the simultaneous non-credible disconnection of multiple transmission elements.

2.1 Demand reduction

There was a reduction of around 600 MW in the Victoria region demand coincident with this incident. This reduction in demand occurred within the distribution networks and was caused by the voltage disturbance on the power system as a result of the fault at ROTS. The demand returned to pre-fault levels within 20 minutes, as shown in Figure 1. No bulk supply points were disconnected from the transmission network and AEMO did not instruct any load shedding.

Figure 1 Victoria region demand (MW)



3. AusNet investigation

The following is based on information provided by AusNet Services (AusNet) as transmission network service provider (TNSP) of the area in question.

3.1 Trip of Rowville busbar and A2 transformer

The ROTS No. 2 500 kV busbar and A2 transformer tripped as a result of a failed 500 kV current transformer (CT) associated with the A2 transformer. Given the location of this CT on the bus side of transformer circuit breaker, the trip of the busbar and transformer is an expected outcome of the failure.

At 1453 hrs, AusNet received a 'SF6⁵ Low alarm' and a 'SF6 Critical alarm' associated with the ROTS A2 transformer CT. The alarms were received around 100 ms apart. Field staff were requested to attend the site, rather than remotely isolating the CT from the control room. The CT failed 26 minutes later at 1519 hrs, resulting in a high voltage fault on the power system before staff reached ROTS.

Subsequent investigations revealed that the pressure relief device (PRD) on the red phase CT had operated, resulting in a loss of SF6 pressure. This loss of SF6 pressure led to an internal phase to ground fault in the CT.

The fault in the CT was detected by the A2 Transformer 'X' Differential Protection relay and the A2 Transformer 'Y' 500kV Zone Protection relay which initiated trips to all four circuit breakers (CBs) on the A2 Transformer within ~68ms. As the failed CT was on the 500 kV busbar side of the transformer the CB tripping of the transformer did not clear the fault. The A2 Transformer No. 2 Busbar 500 kV CB 'X' CB Fail protection operated to trip all 500 kV CBs on the No. 2 busbar, to clear the fault within ~140ms.

AusNet has advised that all protection operated correctly, according to design and within the required timeframes⁶.

3.1.1 Follow-up

AusNet has a policy in place for SF6 insulated switchgear, where if both the SF6 Low alarm and the SF6 Critical alarm are received near simultaneously, implying a sudden SF6 pressure loss, the CT should be isolated as soon as possible by opening the adjacent CBs. If this policy had been followed, it is unlikely the fault on the power system would have occurred. However, at the time of this incident this advice was not in Operating Procedures used by the AusNet Control Room operators, and the CT was not isolated prior to the fault. AusNet has advised AEMO that the required procedures have now been developed and made available to the AusNet Control Room operators. AusNet has also confirmed that there are no other operating policies that have not been included in Operating Procedures.

3.2 Trip of the Rowville – South Morang No. 3 line

Coincident with the fault at ROTS, the ROTS–SMTS No. 3 500 kV line tripped at the South Morang end only. This was not an expected outcome for the fault at ROTS. Investigations by AusNet identified an erroneous logic configuration file in the line 'Y' Protection relay at SMTS. A setting change to correct the relay logic was implemented on 24 January 2018.

Although it is believed this was a one-off issue, AusNet has instigated a review of similar protection relays to determine if the problem exists elsewhere in the Victoria transmission network. AusNet will provide a copy of the results of the review to AEMO by 30 June 2019.

⁵ Sulphur hexafluoride (SF6) is the insulating material commonly used in high voltage switchgear.

⁶ According to clause S5.1a.8 of the National Electricity Rules.

4. Trip of Loy Yang B generating unit

The Loy Yang B No. 1 generating unit tripped from 530 MW at 1528 hrs, nine minutes after the fault at ROTS. Alinta, as the operator of Loy Yang B, provided the following information.

The transmission fault at ROTS and subsequent voltage disturbance caused a governor system minor fault on the 'A' governor system, due to a MW transducer out of range issue. When the operator reset the alarm, this caused a transfer to the 'B' governor system. It appears there was an incorrect setting on the 'B' governor. This then shut the control valves on the generating unit.

The Loy Yang B No. 1 generating unit was returned to service at 1711 hrs on 18 January 2018.

Alinta has advised AEMO that the governor controls of the No. 2 generating unit at Loy Yang B have been checked and confirmed as operational.

AEMO has determined that the trip of the generating unit was not directly related to the transmission fault and did not involve any non-compliance with the applicable generator performance standards⁷.

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 NEM 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.

5.1 Overview

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

The power system was in a secure operating state prior to this incident. AEMO took the following actions to restore and maintain power system security when the incident occurred:

- To manage the outage of the ROTS transformer, AEMO invoked constraint set V-ROTX_R⁹ at 1530 hrs on 18 January 2018.
- From 1532 hrs on 18 January 2018, AEMO's contingency analysis applications indicated overloads would occur on the Brunswick–Richmond 220 kV transmission line (BTS–RTS line) if the Cranbourne 500/220 kV transformer tripped. To manage this situation, AEMO requested AusNet to parallel the 1/2 and 3/4 220 kV busbars at ROTS via the normally open Richmond No. 4 line 4 bus 220 kV CB at ROTS. This was completed at 1552 hrs on 18 January 2018 and all contingency analysis violations ceased. The maximum violation during this period was a potential for a six percent overload on the BTS–RTS line.

⁷ In accordance with clause S5.2.5.8 of the NER generating units must not trip in response to power system disturbances.

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.

⁹ Out—a single Rowville 'A' transformer.

- No action was required in relation to the outage of the ROTS–SMTS line as the line was returned to service by AusNet within one minute.

On 1 February 2018, AEMO conducted further analysis of the power system with the ROTS 1/2 and 3/4 220 kV busbars tied. Analysis using PSS/e simulation tools showed that with the busbars tied, the fault level capability of the 220 kV switchgear at ROTS would be exceeded for a single phase fault close to ROTS. Based on this analysis, AEMO asked AusNet to de-couple the 1/2 and 3/4 220 kV busbars at ROTS on 1 February 2018.

AEMO has contingency analysis applications in place to determine the potential fault current on the power system and compare these results to equipment capability in real time. These applications did not identify the fault level issues at ROTS, and no preferred or normal network configuration for ROTS had been identified.

On that basis AEMO did not request AusNet to reverse the earlier action taken to parallel the busbars at ROTS at the time the transformer was returned to service via the 1 bus 500 kV circuit breaker (CB) at 1836 hrs on 18 January.

After requesting de-coupling of the 1/2 and 3/4 busbars on 1 February 2018, AEMO reviewed the contingency analysis applications and identified that some of the ROTS switchgear was not accurately reflected in the models. This impacted how fault levels were calculated. AEMO requested that the 1/2 and 3/4 220 kV busbars at ROTS were not to be tied until this modelling was corrected. This was completed on 22 March 2018.

The modelling issue identified was specific to substations such as ROTS where there are no loads. AEMO has since reviewed the modelling for similar types of substations in Victoria and found no power system security issues in relation to fault levels. In the other NEM regions the relevant TNSPs monitor fault level conditions and advise AEMO if a problem is identified.

AEMO has updated its operating procedures to ensure that preferred or normal network configurations are identified and documented.

5.2 Satisfactory operating state

The National Electricity Rules¹⁰ state that the power system is in a satisfactory operating state when, among other things:

‘the configuration of the power system is such that the severity of any potential fault is within the capability of circuit breakers to disconnect the faulted circuit or equipment’.

Because AEMO’s 1 February 2018 analysis showed that the fault level capability of the 220 kV switchgear at ROTS would be exceeded for a single phase fault close to ROTS the power system was by definition not in a satisfactory operating state between 18 January and 1 February 2018.

A fault on the 220 kV network in the ROTS area during this time may have resulted in damage to switchgear at ROTS. I

5.3 Reclassification¹¹

As part of a reviewable operating incident review for a non-credible contingency event, AEMO must report on how it assessed and applied the reclassification criteria published under the NER.

AEMO’s initial assessment on 18 January 2018 determined that, as the initiating fault had been identified and isolated, there was no reason to reclassify the simultaneous loss of the ROTS A2 transformer, the ROTS No. 2 500 kV busbar, and the ROTS–SMTS line as a credible contingency event. AEMO issued Market Notice 60803 to advise the market that reclassification was not required.

However, this analysis did not adequately consider the possible trip of the ROTS–SMTS line at one end (independent of the original fault). Further analysis conducted on 23 January 2018 concluded that although the cause of the line trip had been identified, the relevant corrective actions had not yet been implemented.

¹⁰ NER clause 4.2.2(e).

¹¹ See NER clause 4.8.15(ca).

As such, it remained reasonably possible that the ROTS–SMTS line could trip at the SMTS end for any fault at ROTS. AEMO therefore reclassified this event as credible (opening of a line at one end only is not normally considered credible) and issued Market Notice 60921 on 23 January 2018 to advise the market. AEMO cancelled this reclassification (Market Notice 60932) on 24 January 2018 after revised protection relay settings were implemented by AusNet at SMTS.

While AEMO did not initially reclassify the disconnection of the ROTS–SMTS line as credible, this had no impact on power system security as reclassification would not have required any constraints to be invoked.

Following this incident, all AEMO control room staff have undertaken additional targeted skills maintenance and simulator training on non-credible contingencies, including reclassifications and market communication.

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 market¹² 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 event¹³.
 - AEMO issued Market Notice 60797 at 1620 hrs on 18 January 2018, 61 minutes after the incident.
1. Constraints invoked with interconnector terms on left hand side¹⁴.
 - AEMO invoked constraint set V-ROTX_R from 1530 hrs to 1840 hrs on 18 January 2018. This constraint set contains constraint equations with interconnector terms on the LHS. AEMO did not advise the market when the constraint was invoked¹⁵.
2. Updates to the non-credible contingency event – as information becomes available¹⁶.
 - AEMO issued Market Notice 60803 at 1920 hrs on 18 January 2018 to advise the market that plant had been returned to service and reclassification was not required.
3. Advice of reclassification – notify as soon as is practicable¹⁷.
 - AEMO issued Market Notice 60921 at 0707 hrs on 23 January 2018 to advise of the reclassification involving the ROTS–SMTS line.
 - AEMO issued Market Notice 60932 at 1425 hrs on 24 January 2018 to advise the reclassification involving the ROTS–SMTS line had been cancelled.

¹² AEMO generally informs the market about operating incidents as the progress by issuing Market Notices – see AEMO website at <http://www.aemo.com.au/Market-Notices>.

¹³ 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. Available at: https://www.aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Power_System_Ops/Procedures/SO_OP_3715--Power-System-Security-Guidelines.pdf.

¹⁴ For short term outages AEMO is required to notify the Market of variances to interconnector transfer limits as per section 22 of AEMOs Power System Security Guidelines.

¹⁵ Refer to comment in Section 5.2 in relation to skills maintenance and training.

¹⁶ AEMO is required to notify the market as it becomes aware of new and material information – NER clause 4.2.3A(d).

¹⁷ AEMO Power System Security Guidelines, Section 11.1.

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 and how the reclassification criteria were assessed and applied.

AEMO has concluded that:

4. The root cause of the fault at ROTS was a faulty current transformer at ROTS, which was not isolated by AusNet in a timely manner.
5. The trip of the ROTS–SMTS line occurred due to incorrect protection settings at SMTS. The protection settings have been corrected.
6. Analysis performed subsequent to the conclusion of the incident indicated that, as a result of network switching requested by AEMO in response to this incident, the power system was not in a satisfactory operating state for extended periods between 18 January and 1 February 2018.
7. The trip of the Loy Yang B1 generating unit was caused by a generator governor issue and was not directly related to the issues at ROTS or SMTS.
8. AEMO did not reclassify the loss of the ROTS–SMTS line for any fault at ROTS as a credible contingency in a timely manner.
9. AEMO did not advise the market that constraints with interconnector terms on the LHS had been invoked during this incident.

8. Pending actions

- AusNet has indicated that it is completing a review of protection relays similar to those on the ROTS–SMTS line, with the results of this review to be provided to AEMO by 30 June 2019.

A1. Power system diagram

The diagram below shows the relevant part of the power system immediately after the incident.

SOUTH MORANG (SMTS)

