
Trip of South East – Taillem Bend No. 1 275 kV Line and South East No. 1 Static Var Compensator on 26 and 27 April 2018

November 2018

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.

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INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	1114 hrs on 26 April 2018 and 1836 hrs on 27 April 2018
Region of incident	South Australia
Affected regions	South Australia
Event type	Protection mal-operation
Generation Impact	Nil
Customer load impact	Nil
Associated reports	Nil

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1. Overview

This report relates to a reviewable operating incident¹ that occurred on both 26 and 27 April 2018 in South Australia. Both incidents involved the simultaneous outage of the South East – Tailem Bend No. 1 275 kV line (No. 1 line) and the No. 1 Static Var Compensator (No. 1 SVC) at South East substation (SESS).

There was no loss of generation or customer load as a result of the incidents.

As both are reviewable operating incidents, AEMO is required to assess power system security over the course of the incidents, 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.

AEMO has concluded that:

1. The root cause of both incidents was a faulty micro-switch on the pressure relief device (PRD) protection for the No. 1 line reactor at SESS. The micro-switch was replaced along with those on similar reactors at SESS and Tailem Bend substation (TBSS).
2. The outage of the No. 1 SVC immediately following the No. 1 line outage was caused by the incorrect inclusion of an SVC current check in the CB Fail protection for CB 6606. The SVC current check elements in each CB Fail circuit at SESS have been disabled.
3. The power system was in a secure operating state prior to each incident and was returned to a secure operating state within 30 minutes of each 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 ElectraNet³ and from AEMO's Energy Management Systems.

National Electricity Market Time (Australian Eastern Standard Time) is used in this report. Local time in South Australia at the time of this incident is 30 minutes behind Market Time.

2. The incident

At 1114 hrs on Thursday 26 April 2018, the No. 1 line and No. 1 SVC tripped near simultaneously.

The No. 1 line was returned to service at 1447 hrs and the No. 1 SVC was returned to service at 1451 hrs on 26 April after a line reactor at SESS was isolated. Refer to Appendix A1 for a diagram of the relevant part of the power system before and immediately after the incident.

At 1836 hrs on Friday 27 April 2018, the No. 1 line and No. 1 SVC tripped again.

The No. 1 SVC was returned to service at 2007 hrs and the No. 1 line was returned to service at 2013 hrs on 27 April after protection outputs from the line reactor at SESS were isolated.

Refer to Appendix A2 for a detailed sequence of events.

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 See NER clause 4.8.15(b).

³ ElectraNet is transmission network service provider (TNSP) for the area in question.

As the simultaneous or near simultaneous trip of multiple transmission elements is not an expected event, this is a non-credible contingency and hence a reviewable operating incident. In accordance with clause 4.8.15 of the NER, AEMO is required to review and report on any reviewable operating incident.

3. Incident analysis

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

Both incidents were initiated by the No. 1 line reactor explosion vent protection⁴.

3.1 26 April 2018

At 1114 hrs on 26 April, the No. 1 line reactor PRD protection operated and tripped circuit breakers (CBs) 6604 and 6606 at SESS and CBs 6596 and 6536 at TBSS, resulting in the outage of the No. 1 line. This is an expected outcome for this type of protection. At the same time the PRD protection also correctly initiated the CB Fail Protection timer on CBs 6604 and 6606 at SESS. As CB 6604 had tripped correctly, the CB Fail timer timed out without further action.

The CB Fail protection for CB 6606 includes two current check features, a normal current check for current through CB 6606 and a second check for current in the No. 1 SVC reactor or capacitor. Even though CB 6606 had tripped correctly, the No. 1 SVC was in service with current flow within the SVC, causing the CB 6606 CB Fail protection to time out after 250 ms and trip CB 6610 resulting in the outage of the No. 1 SVC. This was not an expected outcome as CB 6606 had already opened correctly.

As a result of this incident, the No. 1 line reactor and CB 6606 were isolated pending further investigation.

The No. 1 line and No. 1 SVC were returned to service at 1447 hrs and 1451 hrs respectively on 26 April 2018.

3.2 27 April 2018

At 1836 hrs on 27 April 2018, the No. 1 line and No. 1 SVC tripped again due to operation of the No. 1 line reactor PRD protection. Even though the No. 1 reactor had been isolated, the secondary systems associated with the reactor were still in service. After this incident, the No. 1 line reactor auxiliary trip outputs and CB 6606 CB Fail circuits were isolated pending further investigation.

The No. 1 SVC and No. 1 line were returned to service at 2007 hrs and 2013 hrs respectively on 27 April 2018.

3.3 Investigation outcomes

3.3.1 Operation of PRD protection

Further investigation of the No. 1 line reactor determined that there had been no operation of the PRD as the explosion vent cover was still in place. Oil samples were taken for dissolved gas analysis with the results showing no evidence of an internal fault. The PRD protection is derived from a micro-switch contained in a sealed casing mounted on the reactor lid. This micro-switch was determined to be faulty and intermittently shorting out across the contacts. Internal inspection of the micro-switch revealed rust and corrosion and evidence of overheating.

⁴ The purpose of a transformer or reactor explosion vent is to release excessive pressure generated by internal faults.

The PRDs are maintained as part of the routine reactor plant maintenance. This includes an operational test of the micro-switch. This was last done in November 2015 with the test being successful.

The PRD micro-switch on the No. 1 line reactor was replaced before the reactor was returned to service on 3 May 2018.

Similar micro-switches are also installed on the other line reactors⁵ on the South East – Tailem Bend lines. Due to the condition of the PRD micro-switch on the No. 1 line reactor, a decision was made to replace the PRD micro-switches on the other reactors. This has been completed on the No. 2 line reactors at both SESS, TBSS, and the No. 1 line reactor at TBSS.

3.3.2 Operation of CB 6606 CB Fail protection

The trip of CB 6610 (and subsequent outage of the No. 1 SVC) due to the operation of the CB Fail protection on CB 6606 was not an expected outcome for the operation of the No. 1 line reactor PRD protection. As noted above, the CB Fail protection for CB 6606 includes two current check features, a normal current check for current through CB 6606, and a second check for current in the No. 1 SVC reactor or capacitor. Even if CB 6606 opens correctly, the No. 1 SVC will still be in service (via CB 6610) with current flow in the SVC components. Subsequent to this incident, the SVC current check element in the CB Fail protection for CB 6606 was isolated and the CB returned to service on 1 May 2018.

Investigations also showed that the CB Fail protection for CBs 6610, 6607, and 6611 at SESS also included a SVC current check element. These current check elements have also been disabled to prevent a recurrence of this type of incident.

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 NER⁶.

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 both of these incidents. Immediately after each incident the power system was in a satisfactory operating state but not a secure operating state. Following a contingency event AEMO is required to take all reasonable actions to restore the power system to a secure operating state within a maximum of 30 minutes⁷. To restore the power system to a secure operating state AEMO invoked the following constraint sets:

- S-TBSE_BC-2CP⁸.
- S-X_BC-2CP⁹.
- S-SE_VC1_BC-2CP¹⁰.

⁵ There are four line reactors in total on these lines.

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 Refer to NER clause 4.2.6(b).

⁸ Out = one South East – Tailem Bend 275 kV line with both Black Range series capacitors bypassed.

⁹ Out = both Black Range series capacitors bypassed.

¹⁰ Out = One South East SVC with both Black Range series capacitors bypassed.

The effect of these constraints was to reduce the power transfer into South Australia from Victoria. The power system was restored to a secure operating state by 1140 hrs on 26 April (26 minutes after the incident) and by 1855 hrs on 27 April (19 minutes after the incident).

No further action was required by AEMO to restore or maintain power system security.

4.1 Reclassification

After the No. 1 line and No. 1 SVC had been returned to service on 26 April, AEMO considered whether to reclassify the simultaneous loss of both transmission elements as a credible contingency. Based on advice from ElectraNet that the No. 1 line reactor and CB 6606 had been isolated and the incident was unlikely to re-occur, AEMO determined that reclassification was not required.

After the No. 1 line and No. 1 SVC had been returned to service on 27 April, AEMO again considered whether to reclassify the simultaneous loss of both of these transmission elements as a credible contingency. Based on advice from ElectraNet that the No. 1 line reactor and that the CB 6606 protection circuits had now also been isolated and the incident was unlikely to re-occur, AEMO determined that reclassification was not required.

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

1. A non-credible contingency event - notify within two hours of the event¹².
 - AEMO issued Market Notice 62496 at 1138 hrs on 26 April – 24 minutes after the event.
 - AEMO issued Market Notice 62595 at 1848 hrs on 27 April – 12 minutes after the event.
2. Any unplanned outage which requires the invoking of constraints with interconnector terms on the LHS¹³.
 - On 26 April, AEMO issued Market Notice 62568 at 1520 hrs to advise the market that the No. 1 line and No. 1 SVC had been returned to service and listed which constraints had been invoked during the outage. AEMO did not issue any Market Notice prior to this to advise the market that the constraints invoked for this outage would impact interconnector transfers.
 - On 27 April, AEMO issued Market Notice 62598 at 1858 hrs to advise the market that constraints had been invoked which would impact interconnector flows.
3. Reclassification, details, and cancelation of a non-credible contingency – notify as soon as practical¹⁴.
 - On 26 April, AEMO issued Market Notice 62568 at 1520 hrs to advise the market that the No. 1 line and No. 1 SVC had been returned to service and AEMO would not be reclassifying this events as a credible contingency event.

¹¹ 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>.

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 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.

¹³ For short-term outages, AEMO is required to notify the Market of variances to interconnector transfer limits. AEMO, Power System Security Guidelines, Section 22.

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).

- On 27 April, AEMO issued Market Notice 62610 at 2029 hrs to advise the market that the cause of the incident had been identified and that it would not be reclassifying the event as a credible contingency event.

AEMO will review communications provided to the market for non-credible contingencies, and in what timeframe the advice is provided, to ensure advice is provided in a consistent and timely manner.

6. Conclusions

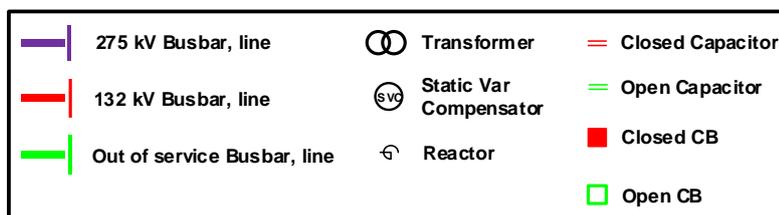
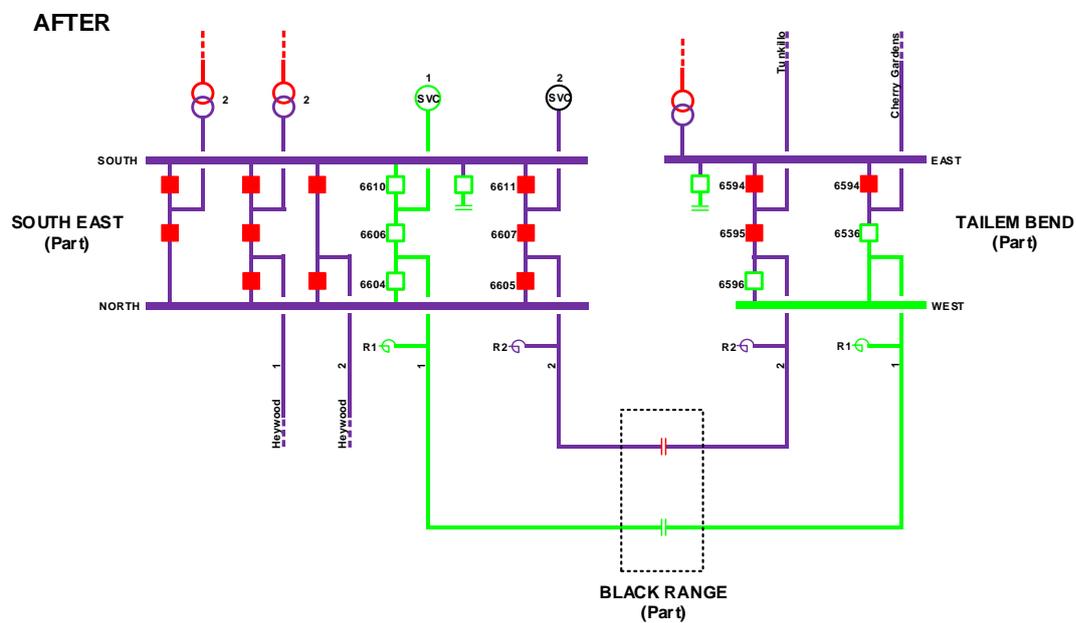
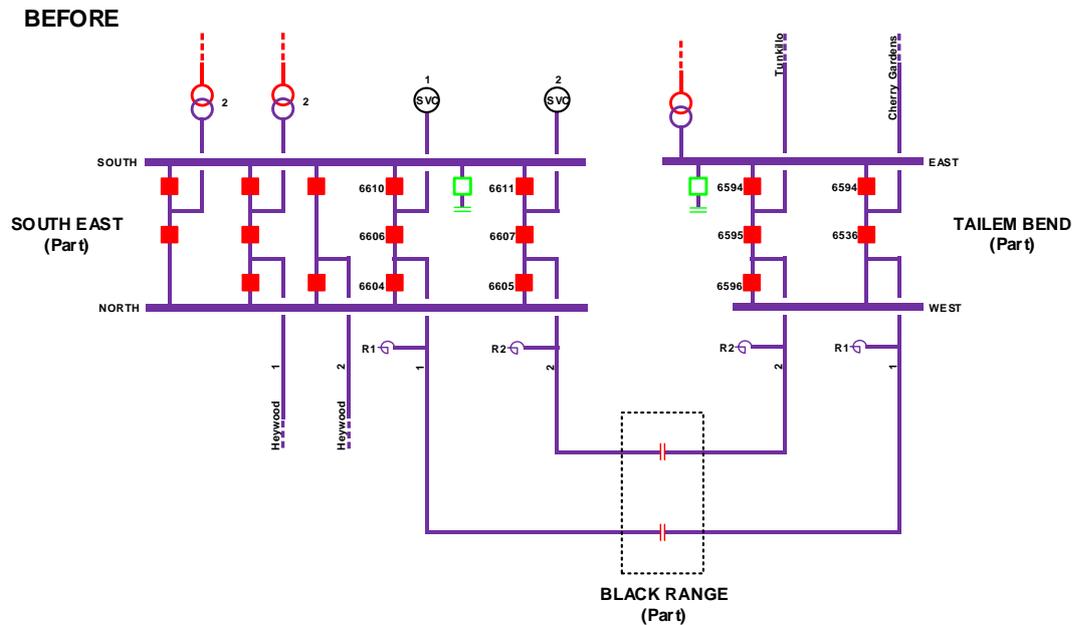
AEMO has assessed this incident in accordance with clause 4.8.15(b) of the NER. In particular, AEMO has assessed the adequacy of the provision and response of facilities or services, and the appropriateness of actions taken to restore or maintain power system security.

AEMO has concluded that:

1. The root cause of both incidents was a faulty micro-switch on the PRD protection for the No. 1 line reactor at SESS. The micro-switch was replaced along with those on similar reactors at SESS and TBSS.
2. The outage of the No. 1 SVC immediately following the No. 1 line trip was caused by the incorrect inclusion of an SVC current check in the CB Fail protection for CB 6606. The SVC current check elements in each CB Fail circuit at SESS have been isolated and disabled.
3. The power system was in a secure operating state prior to each incident and was returned to a secure operating state within 30 minutes of each incident.

A1. Power system diagram

The diagrams below show the power system before and immediately after the incident on 26 April 2018.



A2. Sequence of events

Date/time	Event
26/04/2018	
1114 hrs	Black Range No. 1 Series capacitor bypassed.
1121 hrs	Black Range No.2 Series capacitor bypassed.
1125 hrs	Constraint sets S-TBSE_BC-2CP, S-X_BC-2CP and S-SE_VC1 invoked.
1138 hrs	Market Notice 62496 issued.
1145 hrs	Constraint set S-SE_VC1 revoked and S-SE_VC1BC-2CP invoked.
1226 hrs	275 kV West busbar at TBSS returned to service.
1304 hrs	CB 6066 at SESS isolated.
1426 hrs	No. 1 line reactor at SESS isolated.
1447 hrs	No. 1 line returned to service.
1451 hrs	No. 1 SVC returned to service.
1455 hrs	Black Range No. 1 and No. 2 series capacitors returned to service.
1510 hrs	Constraint sets S-TBSE_BC-2CP, S-X_BC-2CP and SE_VC1BC-2CP revoked.
1520 hrs	Market Notice 62568 issued.
27/04/2018	
1836 hrs	Trip of No. 1 line and No. 1 SVC. CBs 6604 and 6610 open at SESS. CBs 6536 and 6596 open at TBSS.
1836 hrs	Black Range No. 1 Series capacitor bypassed.
1845 hrs	Constraint sets S-TBSE_BC-2CP, S-X_BC-2CP and SE_VC1BC-2CP invoked.
1847 hrs	Black Range No.2 Series capacitor bypassed.
1848 hrs	Market Notice 62595 issued.
1858 hrs	Market Notice 62598 issued.
1920 hrs	No. 1 line reactor (at SESS) protection isolated.
2000 hrs	SESS CB 6066 CB Fail protection isolated.
2006 hrs	No. 1 SVC returned to service.
2012 hrs	No. 1 line returned to service.
2012 hrs	Black Range No. 1 and No. 2 series capacitors returned to service.
2015 hrs	Constraint set SE_VC1BC-2CP revoked.
2020 hrs	Constraint sets S-TBSE_BC-2CP and S-X_BC-2CP revoked.
2029 hrs	Market Notice 62610 issued.

Date/time	Event
01/05/2018	
0917 hrs	CB 6606 at SESS returned to service.
03/05/2018	
1611 hrs	No. 1 line switched out of service to restore No. 1 line reactor.
1628 hrs	No. 1 line and No. 1 line reactor returned to service.