SIMULTANEOUS TRIP OF SOUTH EAST No.1 AND No.2 275 kV SVCs ON 31 JULY 2017

REVIEWABLE OPERATING INCIDENT REPORT UNDER THE NATIONAL ELECTRICITY RULES

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AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

INCIDENT CLASSIFICATIONS

Classification	Detail
Time and date of incident	0726 hrs and 1316 hrs Monday 31 July 2017
Region of incident	South Australia
Affected regions	South Australia
Event type	Transmission equipment failure
Generation impact	Nil
Customer load impact	Nil
Associated reports	Trip of both SVCs at South East substation on 23 April 2016

ABBREVIATIONS

Abbreviation	Term
AEMO	Australian Energy Market Operator
CB	circuit breaker
kV	kilovolt
MW	megawatt
NER	National Electricity Rules
SVC	Static VAR Compensator
TNSP	Transmission Network Service Provider
VAR	volt-ampere reactive

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 two reviewable operating incidents[1] that occurred on 31 July 2017 in south east South Australia.

These incidents both involved the simultaneous trip of the two static VAR compensators (SVC) at South East substation. Both trips were due to the loss of the low voltage supply to the cooling system for the SVCs after a voltage disturbance on the high voltage network.

No customer load or generation was lost as a result of these incidents.

As each was 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.[2]

AEMO has concluded that:

- The trip of the SVCs at South East was due to the loss of 415 volt (V) supply to the SVC cooling system following faults on the high voltage network in South Australia and Victoria.
- The loss of the 415 V supply to the SVC cooling system was due to the failure of the voltage sensing relays in the 415 V station supply system at South East substation.
- The power system remained in a secure operating state over the course 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 ElectraNet[3] and AusNet Services (AusNet)[4], and from AEMO's Energy Management Systems.

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

2. THE INCIDENTS

On Monday 31 July 2017 at 0726 hrs, both SVCs at South East substation tripped simultaneously, coincident with a network fault in the Mt Gambier 33 kilovolt (kV) network. The SVCs were returned to service at 0835 hrs.

Later on the same day, at 1316 hrs, both SVCs at South East substation again tripped simultaneously, this time coincident with a fault on the Heywood – Mortlake – Alcoa Portland No.2 500 kV line in Victoria. The SVCs were returned to service at 1421 hrs.

The reason for investigating these incidents is that the two SVCs failed simultaneously twice on the same day. Generally, the probability of two elements of transmission equipment tripping at the same time is very low, and is thereby an unexpected event, known in power system security terms as a non-credible contingency[5].

3. ELECTRANET INVESTIGATION

The following is based on information provided by ElectraNet, as South Australian TNSP and asset owner and operator of the South East SVCs.

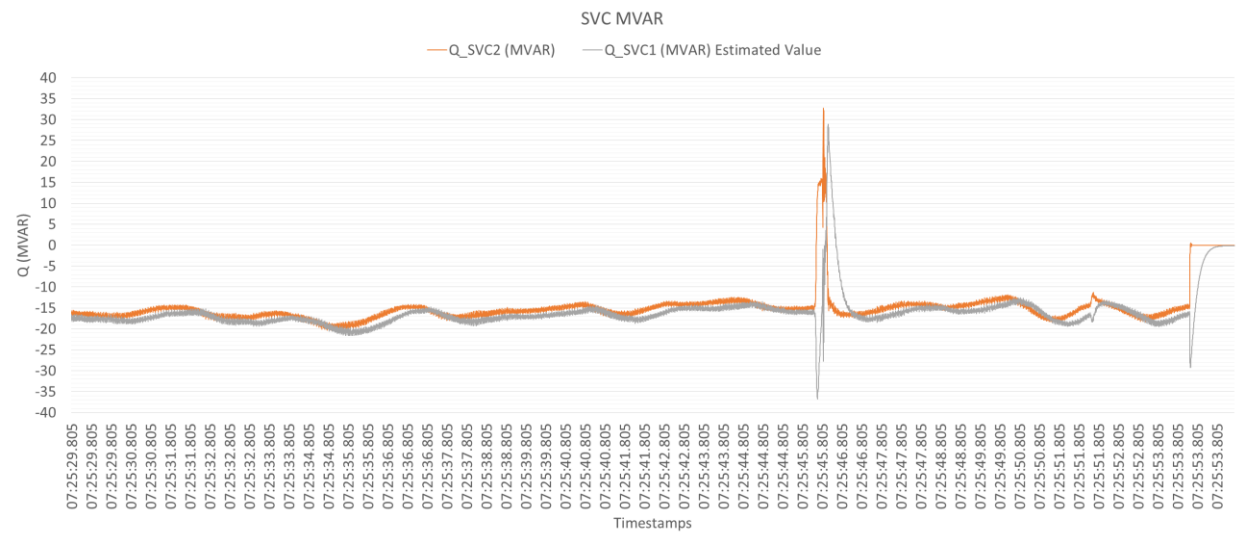
[1] See NER clause 4.8.15(a)(1)(i), as the event relates to a non-credible contingency event; and the AEMC Reliability Panel Guidelines for Identifying Reviewable Operating Incidents.
[2] See NER clause 4.8.15(b).
[3] ElectraNet is the Transmission Network Service Provider (TNSP) in the South Australia region.
[4] AusNet is the TNSP in the Victorian region.
[5] See NER Clause 4.2.3 – Credible and non-credible contingency events, and *AEMO Power System Security Guidelines,* Section 10 – Definition of a non-credible contingency event, available at: http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Security-and-reliability/Power-system-operation.

The trip of the SVCs on each occasion was due to the failure of auxiliary power supplies to the SVCs' cooling systems. If the auxiliary supply to the cooling system is lost for greater than approximately six seconds, the SVC will trip automatically.

The SVCs' cooling system relies on a 415 V power supply. This 415 V supply is provided via either a main, standby, or emergency diesel 415 V power supply. If the main supply is unavailable, an automatic changeover occurs to the standby station supply. If the standby supply is unavailable, a separate automatic changeover occurs to the emergency diesel supply. A diagram and a more detailed description of the SVC auxiliary supply are provided in Appendix C.

At 0726 hrs on 31 July 2017, a fault on the 33 kV network at Mount Gambier resulted in a voltage disturbance on the 275 kV network at South East and subsequent tripping of the SVCs about eight seconds later. The change in SVC output due to the 33 kV fault and subsequent tripping of the SVCs is shown in Figure 1.

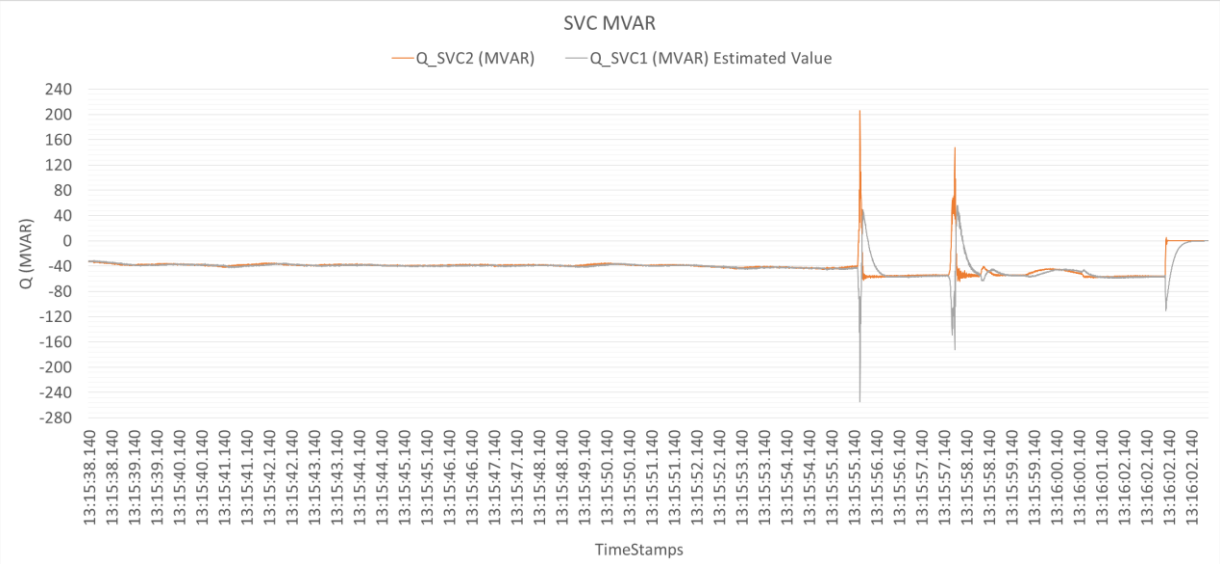
Figure 1 SVC output at 0726 hrs on 31 July 2017



At 1316 hrs on 31 July 2017, a fault and subsequent automatic reclose attempt on the Heywood – Mortlake – Alcoa Portland No.2 500 kV line in Victoria resulted in two voltage disturbances on the 275 kV network at South East and tripping of the SVCs about 7.5 seconds after the initial disturbance.

The change in SVC output due to the 500 kV fault and subsequent tripping of the SVCs is shown in Figure 2.

Figure 2 SVC output at 1316 hrs on 31 July 2017



Investigation revealed the loss of the 415 V supply to the SVC cooling system was caused by the failure of the voltage sensing relays in the substation changeover board. One voltage sensing relay is used to measure the integrity of the 415 V supply from the auxiliary transformers, the other is used to measure the integrity of the supply from the station transformer. If the auxiliary supply fails, the relay initiates a changeover to the station transformer, and if the station supply fails, the second relay initiates a changeover to the station back-up diesel supply.

In this case, an internal component failure in both of the voltage sensing relays resulted in increased sensitivity of the relays to momentary dips in voltage. As a result of this increased sensitivity, the momentary voltage disturbances caused by the high voltage system faults resulted in both relays initiating changeover. However, the diesel generator takes approximately 12 seconds to start, which is not quick enough to prevent tripping of the SVCs after supply to the cooling system is lost to prevent overheating.

Following the second trip event on 31 July 2017, ElectraNet de-sensitised the voltage sensing relays by applying a 2.5 second delay, until the relays were replaced on 3 August 2017.

Given the same relays had also failed on 23 April 2016[6], ElectraNet intends to replace the relays with more reliable technology, and has scheduled an outage to do so on 21 September 2017.

4. AUSNET SERVICES INVESTIGATION

The following is based on information provided by AusNet Services, as TNSP of the Victorian region.

At 1316 hrs on 31 July 2017, the Heywood – Mortlake – Alcoa Portland No.2 500 kV line tripped via protection.

The fault was identified as being associated with a polymeric insulator failure on the blue phase resulting in the conductor falling to the ground.

The fault was cleared within 47 ms, which is within mandated clearance times.[7] The auto-reclose attempt was unsuccessful, as the fault remained on the line.

[6] This was also the subject of an incident report by AEMO, *Trip of South East Substation No. 1 and No. 2 275 kV SVCs on 23 April 2016*, published July 2016 and available at: http://aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events/Power-System-Operating-Incident-Reports.

[7] NER Schedule 5.1a System Standards Clause S5.1a.8.

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.[8]

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

Following the initial trip of the SVCs at 0726 hrs on 31 July 2017, AEMO invoked constraint set S-X_SE_SVC[9] from 0735 hrs, approximately nine minutes later. Constraint set S-X_SE_SVC was revoked at 0850 hrs, approximately 15 minutes after the SVCs were returned to service.

Following the trip of the Heywood – Mortlake – Alcoa Portland No.2 500 kV line and the South East SVCs at 1316 hrs, the following constraints were invoked from 1325 hrs:

- F-V-HYMO.[10]
- S-X_BC_CP.[11]
- V-HYMO.[12]
- S-X_SE_SVC_BC-2CP.[13]

AEMO also requested ElectraNet to bypass the Black Range series capacitor banks due to the outage of the Heywood – Mortlake – Alcoa Portland No.2 500 kV line, and the constraints invoked are consistent with these being out of service.

Constraint set S-X_SE_SVC_BC-2CP was revoked at 1430 hrs after the SVCs were returned to service, and constraint sets F-V-HYMO, S-X_BC_CP, and V-HYMO were revoked at 1530 hrs when the Heywood – Mortlake segment of the 500 kV line was returned to service.

No further action was required to maintain power system security. Power system frequency[14] and voltage[15] remained within limits and faults were cleared within required timeframes.[16]

5.1 Reclassification

When the SVCs were returned to service at 0835 hrs, AEMO assessed whether or not to reclassify the event as a credible contingency.[17] For this incident, AEMO was not satisfied that the incident was unlikely to reoccur. AEMO issued Market Notice 58894 at 0835 hrs to notify the market that the simultaneous trip of the South East SVCs would be reclassified as a credible contingency.

Following the second trip of the SVCs at 1316 hrs, AEMO revised the reclassification from 1421 hrs on 31 July 2017, such that the simultaneous trip of South East 275 kV No.1 SVC and No.2 SVC was reclassified as a credible contingency event ‘for a disturbance on the Power System in the vicinity of the South East substation'. AEMO issued Market Notice 58915 at 1606 hrs to notify the market of this update. Constraint set S-X_SE_SVC was invoked from 1650 hrs to manage this reclassification.

AEMO cancelled the reclassification (Market Notice 58930) and revoked constraint set S-X_SE_SVC on 3 August 2017 from 1245 hrs after the failed voltage sensing relays had been replaced.

For this incident, the power system remained in a secure operating state over the course of the incident. AEMO correctly assessed the incident and reclassified the incident as a credible contingency until the relays were replaced, and appropriate notifications were issued.

[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= Both South East SVC1 & SVC 2 O/S. (Note: with both Black Range series caps I/S).
[10] Out= Heywood to Mortlake (HYTS–MOPS) 500 kV line – FCAS Requirements.
[11] Out = both Black Range series capacitors bypassed.
[12] Out= Heywood to Mortlake (HYTS–MOPS) No.2 500 kV line.
[13] Out= Both South East SVC1 & SVC 2 O/S. (Note: with both Black Range series caps O/S).
[14] Operating Frequency Tolerance Band specified in AEMC Reliability Panel Frequency Operating Standards.
[15] NER Schedule 5.1a System Standards Clause S5.1a.4 - Power frequency voltage.
[16] NER Schedule 5.1a System Standards Clause S5.1a.8 – Fault clearance times.
[17] 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 whether the condition that caused the non-credible contingency event has been resolved.

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[18] 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.[19]
2. Updates to the non-credible contingency event – as information becomes available.[20]
3. Constraints invoked with interconnector terms on the left hand side (LHS).[21]
4. Reclassification, details, and cancellation of a non-credible contingency – notify as soon as practical.[22]

Over the course of this incident, AEMO issued appropriate, timely, and sufficiently detailed market information, as detailed in the following table.

Table 1 Market information

Market notice	Time issued	Regarding	Time between event and notification being issued	Ref*
58892	31/7/2017 0746 hrs	Constraint set S-X_SE_SVC invoked at 0735 hrs after the unplanned outage of SVC1 and SVC2 at 0726 hrs. S-X_SE_SVC contains equations with the Heywood interconnector on the LHS.	9 minutes	3
58893	0754 hrs	Non-credible contingency event – at 0726 hrs the South East 275 kV SVC1 and SVC2 tripped.	28 minutes	1
58894	0902 hrs	AEMO reclassified the simultaneous trip of South East 275 kV SVC1 and SVC2 as credible from 0835 hrs until further notice.	7 minutes	4
58895	0906	S-X_SE_SVC revoked from 0850 hrs.	16 minutes	3
58900	1328 hrs	Non-credible contingency event – at 1316 hrs there was an unplanned outage of: • HYTS – MOPS – APD No.2 500 kV line • APD Potline 1 and Potline 2 • SVC1 and SVC2	12 minutes	1
58906	1353 hrs	Following constraint sets invoked at 1325 hrs after the unplanned outage of the HYTS – MOPS – APD No.2 500 kV line: • F-V-HYMO • S-X_BC_CP • V-HYMO • S-X_SE_SVC_BC-2CP which contain equations with the following interconnectors on the LHS: • Queensland to New South Wales Interconnector • Victoria to New South Wales • Heywood interconnector • Murraylink • Basslink	18 minutes	3
58914	1534 hrs	Following constraint sets revoked at 1530 hrs: F-V-HYMO S-X_BC_CP V-HYMO	4 minutes	3

[18] AEMO generally informs the market about operating incidents as the progress by issuing Market Notices – see AEMO website at: http://www.aemo.com.au/Electricity/National-Electricity-Market-NEM/Market-notices-and-events.
[19] 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.
[20] AEMO is required to notify the Market as it becomes aware of new and material information – NER Clause 4.2.3A(d).
[21] For a short-term outage, AEMO is required to notify the market of variances to interconnector transfer limits – AEMO, *Power System Security Guidelines,* Section 22.
[22] 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).

Market notice	Time issued	Regarding	Time between event and notification being issued	Ref*
58915	1606 hrs	AEMO revised reclassification of the SVCs to: • For a disturbance on the Power System in the vicinity of the South East substation, the simultaneous trip of South East 275 kV SVC1 and SVC2 is reclassified as a credible contingency event from 1421 hrs 31/07/17 until further notice.	105 minutes	2 & 4
58916	1657 hrs	Constraint set S-X_SE_SVC invoked at 1650 hrs, which contains equations with the Heywood interconnector on the LHS, to manage power system security for the reclassification of the SVCs.	7 minutes	3
58930	3/8/2017 1301 hrs	AEMO cancelled the reclassification (Market Notice 58915), and revoked constraint set S-X_SE_SVC at 1245 hrs, as AEMO had been advised by the TNSP that the problem associated with the SVCs had been rectified.	16 minutes	2 & 4

* Refers to the category of market information for which AEMO was required to publish a market notice, as described in the list above the table.

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:

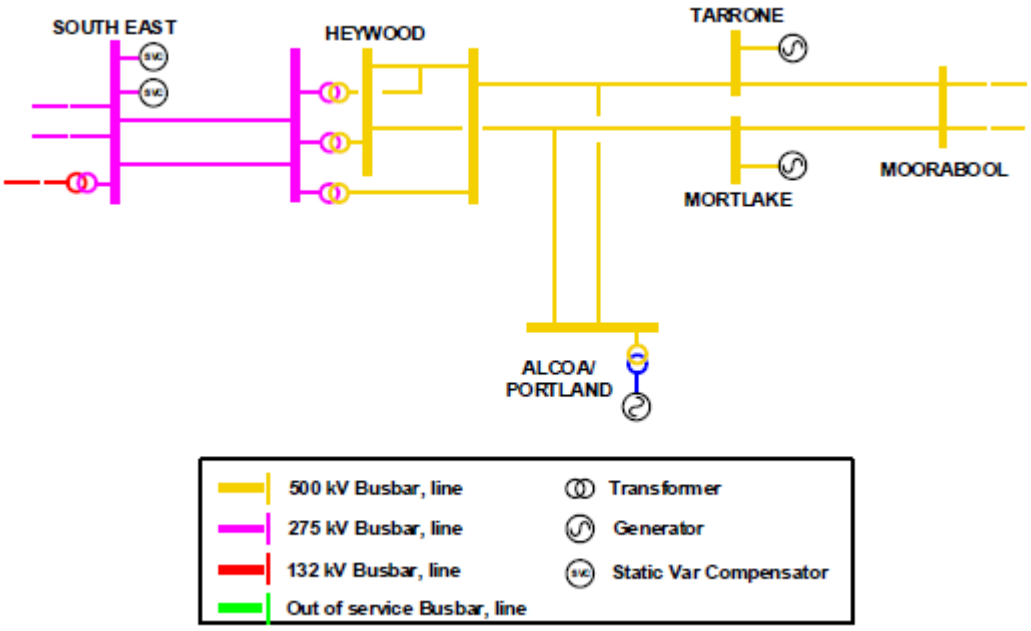
- The trip of the SVCs at South East was due to the loss of 415 V supply to the SVC cooling system during faults on the high voltage network in South Australia and Victoria.
- The loss of the 415 V supply to the SVC cooling system was due to the failure of the voltage sensing relays in the 415 V station supply system at South East substation.
- The power system remained in a secure operating state over the course of each incident.

8. PENDING ACTIONS

ElectraNet to replace the voltage sensing relays in the 415 V station supply system at South East substation. This work is expected to be completed by 21 September 2017.

APPENDIX A. POWER SYSTEM DIAGRAM

Figure 3 Power system in the area



APPENDIX B. INCIDENT EVENT LOG

Table 2 Chronological log of incident

Time and date	Event
0726 hrs Mon 31 Jul 2017	South East SVC1 and 2 tripped due to loss of 415 V AC auxiliary supply coinciding 33 kV fault at Mount Gambier
0735 hrs	Constraint set S-X_SE_SVC invoked
0746 hrs	Market Notice 58892 published – inter-regional transfer limit variation.
0754 hrs	Market Notice 58893 published – non-credible contingency event.
0835 hrs	South East SVC1 and 2 returned to service.
0835 hrs	Market notice 58894 published – reclassification of a non-credible contingency.
0850 hrs	Constraint set S-X_SE_SVC revoked
1316 hrs	South East SVC1 and 2 tripped due to loss of 415 V AC auxiliary supply coinciding 33 kV fault at Mount Gambier coinciding with fault on HYTS – MOPS – APD 500 kV No2 line.
1325 hrs	Constraint sets F-V-HYMO, S-X_BC_CP, V-HYMO, S-X_SE_SVC_BC-2CP invoked
1328 hrs	Market Notice 58900 published – non-credible contingency.
1353 hrs	Market Notice 58906 published – inter-regional transfer limit variation.
1421 hrs	South East SVC1 and 2 returned to service with new 2.5 second delay to the relays. Reclassification revised.
1430 hrs	Constraint set S-X_SE_SVC_BC-2CP revoked
1520 hrs	HYTS – MOPS No.2 500 kV line segment returned to service. APD segment remains out of service to repair fallen conductor.
1530 hrs	Constraint sets F-V-HYMO, S-X_BC_CP, V-HYMO, revoked
1534 hrs	Market Notice 58914 published – update to inter-regional transfer limit variation.
1606 hrs	Market Notice 58915 published – update to reclassification of South East SVCs.
1650 hrs	Constraint set S-X_SE_SVC invoked
1657 hrs	Market Notice 58916 published – inter-regional transfer limit variation.
1707 hrs Tues 1 Aug 2017	HYTS – APD No.2 500 kV line returned to service.
1055 hrs Thurs 3 Aug 2017	Voltage sensing failure relays of the SVCs were replaced with ones of the same type.
1245 hrs	Reclassification cancelled. Constraint set S-X_SE_SVC revoked.
1301 hrs	Market Notice 58930 published – cancel reclassification.

APPENDIX C. SVC 415 V AUXILIARY SUPPLIES

South East substation No.1 and No.2 SVCs require a 415 V supply to maintain water cooling to the thyristor valves. If the 415 V supply to the cooling system pumps is interrupted for greater than six seconds, the SVCs are tripped.

The 415 V supply to each SVC is provided via a number of changeover switches, as shown in Figure 4. A main supply is derived from either TF1 or TF2 auxiliary transformers, via switch 89AC. If this main supply fails, an auto changeover, operated via switch C/O 1, operates to switch the 415 V source to the site Station Transformer supply. If normal and standby supplies fail, a standby generator is started automatically, and this will maintain essential 415 V supplies to site, via changeover switch C/O 2.

Each SVC has a main and standby 415 V supply and an automatic changeover switch. If the main 415 V supply to the SVCs fails, the SVCs should automatically switch to their standby supply via switches C/O 3 and C/O 4.

Figure 4 South East Substation 415 V supply