



PRELIMINARY REPORT – SOUTH AUSTRALIA SEPARATION EVENT 1 DECEMBER 2016.

A PRELIMINARY OPERATING INCIDENT REPORT FOR THE
NATIONAL ELECTRICITY MARKET – INFORMATION AS AT
9.00 AM, MONDAY 5 DECEMBER 2016

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IMPORTANT NOTICE

Purpose

AEMO has prepared this preliminary 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 been provided with preliminary data by Registered Participants as to the performance of some equipment leading up to, during, and after the separation event in accordance with clauses 3.14 and 4.8.15 of the Rules. In addition, AEMO has collated information from its own systems. The information provided by Registered Participants and collated from AEMO's own systems is preliminary information only. Any analysis and conclusions in these findings are also preliminary in nature.

While AEMO has made every effort to ensure the quality of the information in this report, its investigations are incomplete and the findings expressed in it may change as further information becomes available and further analysis is conducted. 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

At 0016 hrs (AEST) on 1 December 2016, a fault on the Moorabool to Tarrone 500kV transmission line in Victoria resulted in the South Australia (SA) electricity network being disconnected from Victoria.

At the time of the incident, SA was only connected to the Victorian network via one 500kV circuit, as the second circuit, which is normally connected, was out of service due to planned equipment maintenance arranged by AusNet Services. A second outage arranged by Alcoa Portland meant there was no redundant electricity supply to the Alcoa Portland Aluminium Smelter (APD) at the time of the incident.

The disconnection of the Moorabool to Tarrone 500kV transmission line resulted in the loss of approximately 230 MW of load in SA and the disconnection of all load at the APD.

No other load was lost in Victoria, although Portland wind farm (generating 3MW) and Macarthur wind farm (generating 4MW) were disconnected due to the incident.

All SA load was restored within 90 minutes (by 0145 hrs), and first supply was made available to APD in three hours and 14 minutes after its plant under maintenance was returned to service. Once APD were ready to restore load, AEMO gave permission 0447 hrs, four hours and 31 minutes after the event.

To stabilise the separated SA power system, AEMO Directed ElectraNet to reduce supply to BHP's Olympic Dam site to approximately 100 MW under a 2015 protocol agreed by AEMO and BHP for such events. Prior to the event, BHP's Olympic Dam site was consuming approximately 170 MW. The duration of this reduction was for three hours and seven minutes.

This event is not related to the SA black system event that occurred on 28 September 2016.

2. PRE-EVENT CONDITIONS

Immediately prior to the incident there were two planned outages:

- Outage of the Heywood No.2 500kV busbar: The request for this outage was submitted by AusNet Services via AEMO's public Network Outage Schedule on 22 August 2016. It commenced at 0600 hrs on 30 November 2016 with an eight-hour recall time. Further information on this outage was provided by Market Notice on 31 October 2016¹.
- Outage of the Heywood – APD No.2 500kV transmission line: The request for this outage was submitted by APD² via AEMO's public Network Outage Schedule on 7 November 2016. The outage commenced at 0630 hrs on 28 November 2016 with a two-hour recall time.

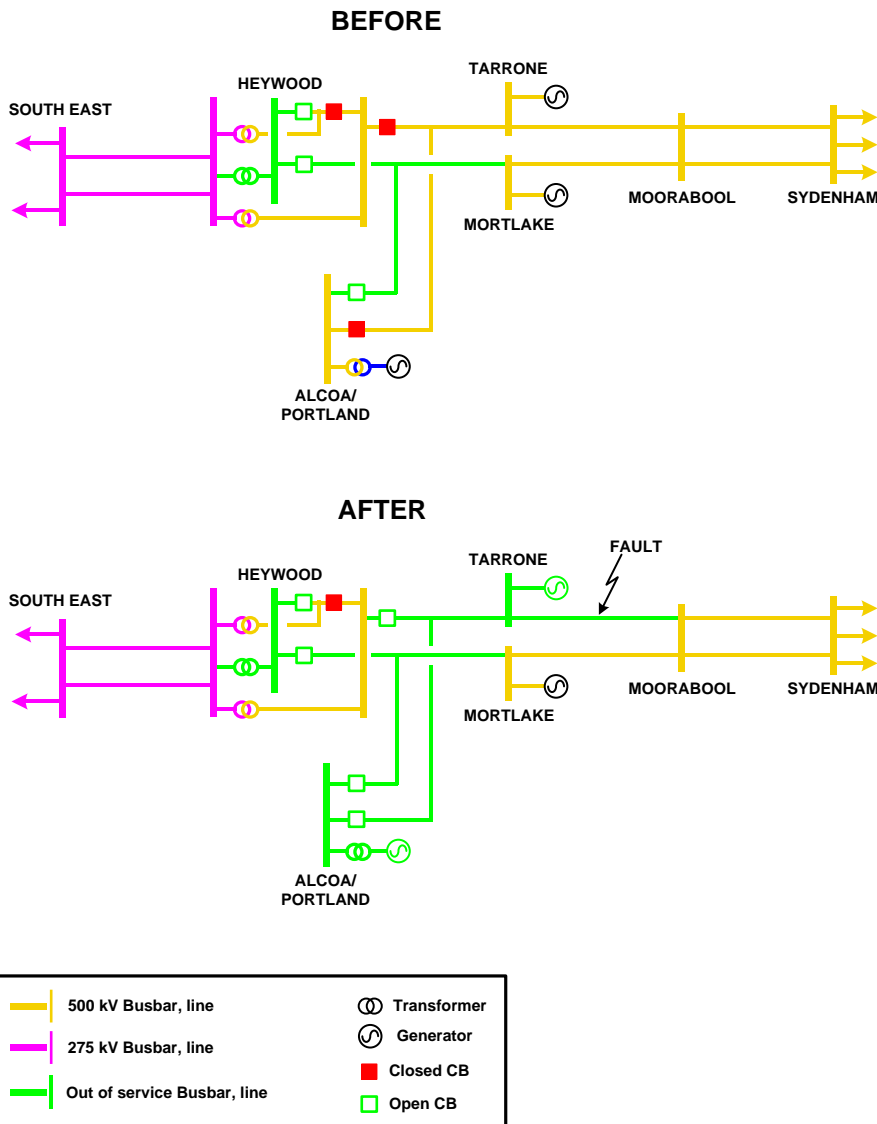
Both outages were due to be completed by 1600 hrs on 1 December 2016. Refer to Appendix A for a diagram of the power system prior to the incident.

The diagrams below show the relevant section of the Victorian 500kV transmission network both before and immediately after the incident. Note that circuit breaker information in substations east of Heywood has been omitted for clarity.

There are circuit breakers at the T connection of the APD connection.

¹ Refer to Market Notices 55515.

² The outage was submitted by AusNet Services on behalf of APD.



The two outages in combination de-loaded the Mortlake to Heywood 500kV line. Either outage independently would not require the de-loading of this line. AEMO de-energised the Moorabool to Mortlake to Heywood 500kV line to control voltages. The effect of the two outages in combination was that the APD supply was at a single-contingency risk. From 0600 hrs on 30 November 2016, there was only a single transmission line supplying the APD load and connecting Victoria to SA as part of the Heywood interconnector. The Murraylink interconnector was in service and operating normally.

To maintain the power system in a secure operating state during these outages, AEMO took the following steps:

- Invoked constraint sets to limit flow on the Heywood Interconnector to ensure the rate of change of frequency (RoCoF) in SA after a credible separation would not exceed 1 Hz/sec.
- Invoked constraint sets to limit generation at Mortlake to 0 MW.
- Invoked constraints sets to ensure 35MW of raise and lower regulation frequency control ancillary service (FCAS) was enabled in SA.

The power system was in a secure operating state immediately prior to the incident.

The Operational Demand in SA was 1386 MW and was supplied by a combination of 875 MW of thermal generation, 85 MW of wind generation and 463 MW of import from Victoria (240 MW via Heywood and 223 MW on Murraylink). The online inertia in SA prior to the event was 7,785 MW.s.

Table 1 shows the contingency raise Frequency Control Ancillary Services (FCAS) enabled in SA just prior to the event. These contingency raise services were not specifically enabled to meet any requirement in SA, but were part of the overall NEM requirement to cover the loss of the largest single operating generating unit in the National Electricity Market (NEM).

Table 1: Contingency FCAS in SA

Service	Amount enabled (MW)
Fast raise	52
Slow raise	85
Delayed raise	39

The Jurisdictional System Security Coordinator for SA has previously advised AEMO to amend the Separation Event Frequency Standard for SA to 47–52 Hz. On that basis, AEMO has determined that no contingency raise FCAS is required for the credible loss of the Heywood Interconnector if flow is towards SA, as frequency will be maintained above 47 Hz by the operation of under frequency load shedding (UFLS) and the 1 Hz per second RoCoF limit applied under credible contingency conditions.

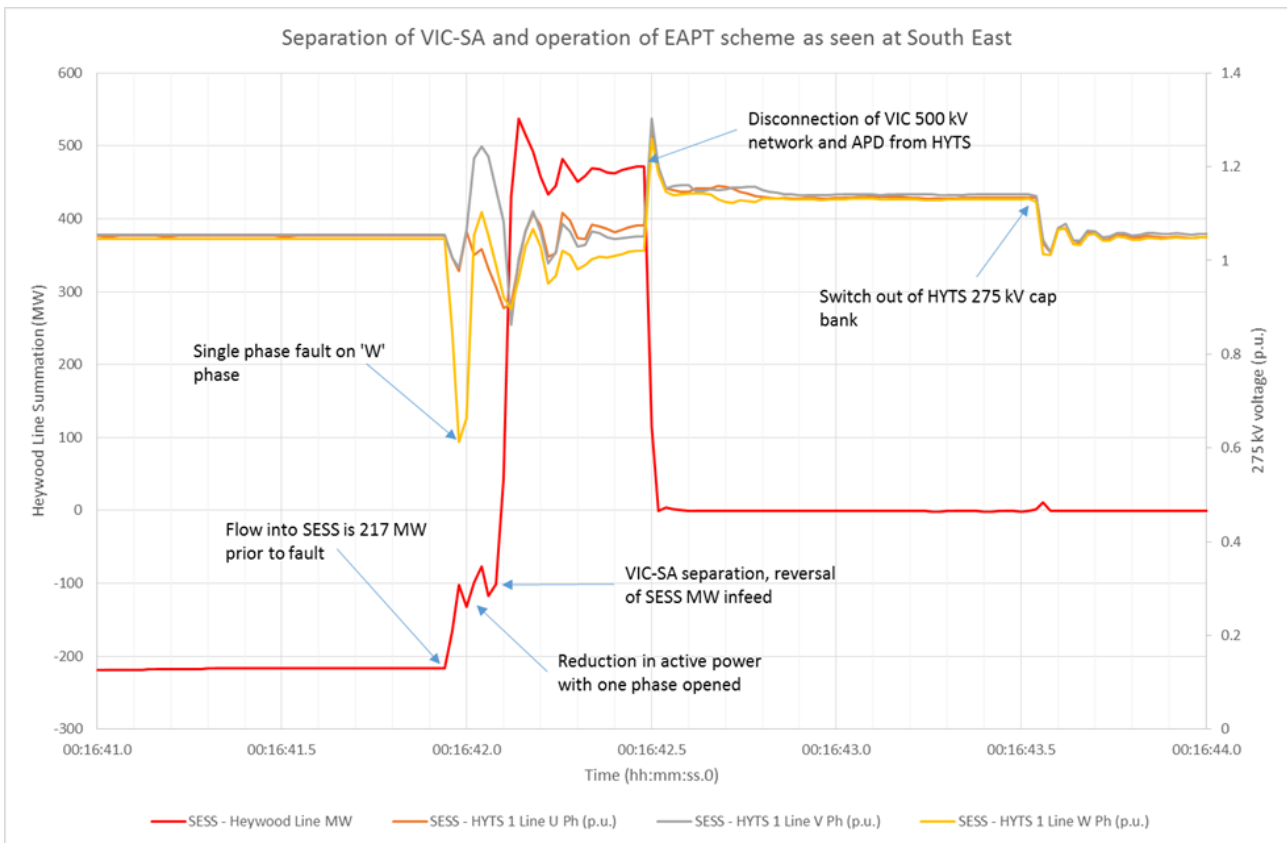
3. EVENT

At 0016 hrs, a single phase to earth fault occurred on the Moorabool – Tarrone 500kV transmission line causing the line to trip out of service. A broken conductor cable on the transmission line was observed when the line was patrolled by helicopter. It is believed the line tripped as a normal response to this type of fault. AEMO is not yet aware of the cause of the fallen conductor cable.

The trip of this line severed the interconnection to SA via the Heywood Interconnector and left the load at APD connected to the SA network. A control scheme then operated to disconnect the APD load from South Australia, resulting in a loss of all supply to APD.

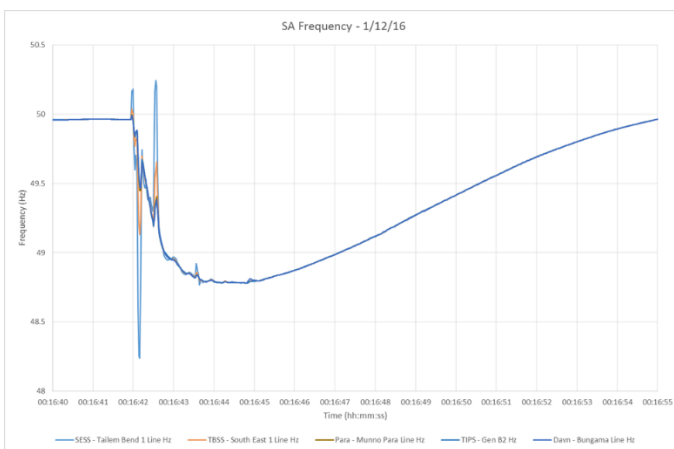
The fault sequence is shown in Figure 2. The power flow on the Heywood Interconnector was initially 217 MW towards SA. Immediately after the faulted line tripped, the power flow reversed with 480 MW flow from SA to supply the load at APD. After approximately 400ms, AEMO's Emergency APD Potline Tripping (EAPT) control scheme operated to disconnect the load at APD and the flow from SA reduced to zero.

Figure 2: 500kV transmission line - Moorabool to Tarrone conductor fault 1 December 2016.



The sudden loss of supply to SA resulted in the frequency falling below 49 Hz. ElectraNet’s under frequency load shedding (UFLS) scheme operated to shed around 190 MW of load in SA. There was also an additional reduction of around 40 MW that was not associated with the UFLS scheme. Figure 3 shows the frequency in SA in response to this incident. Although further analysis is required, information to date is that the UFLS operated as expected.

Figure 3: SA frequency



No generation in SA tripped or reduced output as a result of the separation event.

4. RESTORATION

Immediately after the incident, AEMO's efforts were directed towards stabilising the islanded SA network and restoring the lost SA and APD loads as fast as possible. The restoration sequence is shown in Table 2.

Table 2: Restoration sequence

Time	Action
0054 hrs	AEMO gave permission to restore all load in SA.
0131 hrs	The planned outages of the Mortlake – Heywood - APD 500kV line and the Heywood busbar were confirmed as recalled.
0145 hrs	All load restored in SA.
0330 hrs	Connection restored to APD via the Mortlake – Heywood - APD 500kV line. APD advised AEMO it was not ready to restore load. Auxiliary supply made available to APD.
0357 hrs	Heywood No2 500kV busbar returned to service via the Mortlake – Heywood - APD 500kV line
0407 hrs	AEMO gave permission to re-synchronise Victoria and SA via the Heywood interconnector
0420 hrs	AusNet Services advised AEMO that synchronism had been delayed due to a switchgear problem at HYTS.
0441 hrs	Victoria and SA successfully synchronised. Heywood Interconnector in service via the Mortlake – Heywood - APD 500kV line.
0447 hrs	APD advised AEMO they were ready to restore load. AEMO gave permission to APD to restore all load. Due to internal issues at APD a series of attempts to restore load between 0447 hrs and 0549 hrs are requested from APD to AEMO. AEMO gave permission on all occasions.
0453 hrs	Direction to generator 1 was cancelled.
0456 hrs	Direction to reduce supply to BHP's Olympic Dam site was cancelled.
0459 hrs	Direction to generator 2 was cancelled.
1018 hrs	Heywood – Tarrone - APD 500kV line returned to service.
2132 hrs	The faulted Moorabool - Tarrone 500kV line was repaired and returned to service. Both connections to the Heywood interconnector in service.

5. OPERATION OF SA WHEN ISLANDED

SA was able to be operated successfully as an electrical island with no synchronous connection to the NEM grid. During this time the direct current (DC) non-synchronous connection through Murraylink remained connected and supplying power to SA.

When SA was islanded from Victoria, AEMO invoked constraint sets to enable contingency FCAS in SA at 0025 hrs. Contingency FCAS when operating SA as an electrical island is required to maintain the frequency operating standards within the region, and to prevent further load shedding.

From 0030 hrs, constraints associated with the provision of six second raise (R6) and six second lower (L6) FCAS violated indicating a shortage of these services.

To manage the shortage of R6 FCAS, AEMO issued a Direction to a generating unit in SA to increase the supply of R6 FCAS. AEMO also issued a Direction to a generating unit to reduce its output to reduce the size of contingency risk, and hence reduce the requirement for R6 FCAS. This is in accordance with AEMO's normal operating procedures.

The requirement for contingency lower FCAS is determined by the size of the largest load that could be lost as a result of a single credible contingency. To manage the shortage of L6 FCAS, AEMO Directed Electranet to reduce the largest industrial load in SA. This reduced the requirement for L6 FCAS and was in accordance with an agreed protocol between AEMO and BHP. All Directions were cancelled as soon as the interconnection to Victoria was restored. These Directions will be covered in detail in a Directions report to be published at a later date.

The 35 MW of raise and lower regulation FCAS was enabled in SA prior to the incident as part of the outage planning process. This amount of regulation FCAS was sufficient to manage frequency in the islanded SA power system. There were no material issues with frequency control in SA while operating as an island.

6. NEXT STEPS

AEMO will conduct an investigation into how each component of the electricity system responded under these circumstances. A full report will be published in 2017 after AEMO has collected and analysed all available data.
