

POWER SYSTEM INCIDENT REPORT

TRIPPING OF MULTIPLE 275 kV TRANSMISSION LINES NEAR BRINKWORTH SUBSTATION IN SOUTH AUSTRALIA ON 3 SEPTEMBER 2010

PREPARED BY: Electricity System Operations Planning and Performance

FINAL

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1. Introduction

At 1008 hrs on 3 September 2010, a high voltage power transmission network fault initiated the disconnection of multiple 275 kV transmission lines in the vicinity of Brinkworth 275 kV switching station in South Australia (SA). This incident took place at a time when severe lightning storm activity was experienced in SA and several unplanned power system equipment outages had taken place.

This report has been prepared in accordance with clause 4.8.15 of the National Electricity Rules 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 security in the power system incident described above.

ElectraNet has provided relevant information to AEMO for this power system incident investigation. Data from AEMO's Energy Management and Market Systems has also been used in investigating the event.

All references to time in this report refer to the Market time (Australian Eastern Standard Time).

2. Summary of Events

On 3 September 2010 from 0900 hrs South Australia experienced lightning storms causing several unplanned transmission line outages. At 1008 hrs, a high voltage power transmission network fault resulted in the disconnection of multiple 275 kV transmission lines in the vicinity of Brinkworth 275 kV switching station in South Australia.


Table 1 lists the sequence of relevant events causing the tripping of Para – Brinkworth and Davenport – Brinkworth 275 kV lines and the subsequent restoration of the lines.

Table 1: Sequence of events

Time	Event/Action	Impact on Transmission Network
0944 hrs	Para – Bungama 275 kV transmission line tripped during a lightning storm near the line. AEMO invoked the constraint set S-BGPA from 0950 hrs to maintain power system security with Para – Bungama line out of service.	Reduced the number of 275 kV transmission lines in service between Davenport, Para and Tungkillo to three, thereby increasing power flow on the remaining lines.
0946 hrs	AEMO reclassified the non-credible contingency loss of Robertstown – Para and Robertstown – Tungkillo 275 kV transmission lines as a credible contingency event because of lightning in the vicinity of this double circuit line, and invoked the constraint set S-RBPA+RBTU_N-2.	Reclassification reduced the allowable power transfer between Davenport, Para and Tungkillo as loss of two out of the remaining three 275 kV lines was declared a credible event.
1008hrs	A single phase fault occurred on phase V of the Para – Brinkworth 275 kV transmission line. Phase V of the line tripped at both ends by opening phase V of circuit breakers 6527 and 6528 at Brinkworth (see Figure 1) and 6517 and 6518 at Para (see Figure 3) after approximately 72 ms from the fault initiation.	The phase V of Para – Brinkworth 275 kV transmission line was correctly disconnected at both Para and Brinkworth substation ends.
1008hrs	Auto-reclose of the phase V was initiated at Brinkworth and Para. The initiation of auto-reclose at Brinkworth also triggered a "Three pole Trip" signal to be sent to line protections at Brinkworth. This took place before the line protections had been fully reset following the initial fault on the phase V and caused a three phase trip of	Three phase trip of Para – Brinkworth 275 kV transmission line at both ends. Davenport – Brinkworth 275 kV transmission line was disconnected at the Brinkworth end but remained

Time	Event/Action	Impact on Transmission Network
	<p>Para – Brinkworth line.</p> <p>The circuit breaker 6528 at Brinkworth (refer Figure 1) was slow to open causing circuit breaker failure protection to operate tripping the circuit breakers 6530, 6527, 6528, 6093 and 6068 at Brinkworth (see Figure 2) and sending an inter-trip signal to open circuit breakers 6517 and 6518 at Para (see Figure 4).</p> <p>The circuit breakers 6517 and 6518 at Para single phase auto-reclosed but tripped again on the receipt of the inter-trip signal from Brinkworth.</p>	<p>energised from Davenport.</p> <p>Brinkworth 132/275 kV transformer (T3) was disconnected (Figure 2).</p> <p>The 275 kV transmission lines between Davenport, Para and Tungkillo reduced to Robertstown – Para and Robertstown – Tungkillo lines. Loss of these two lines had been declared as a credible contingency event at the time.</p>
10:11 hrs	<p>AEMO's Dynamic Security Assessment (DSA) application triggered an alarm indicating power system instability on contingent loss of Para – Robertstown and Robertstown – Tungkillo 275 kV lines.</p> <p>DSA alarm was reset when Para - Bungama line returned to service.</p>	See Note 1 for details.
1022 hrs	Para – Bungama 275 kV transmission line was returned to service.	Restoration of Para – Bungama 275 kV transmission line restored the 275 kV ring along Para, Bungama, Davenport, Robertson and Tungkillo.
1025 hrs	<p>From 1025 hrs to 1030 hrs AEMO invoked the constraint set #SA1_E_20100903 which limits the dispatch of North Brown Hill Wind Farm, Hallet Gas Turbine, Hallett 1 and 2 Wind Farms, Northern Power Station and Playford Power Station.</p> <p>This constraint set was revoked when Para - Bungama 275 kV transmission line was restored.</p>	Constraint set #SA1_E_20100903 reflected the power transfer capability with Para - Robertstown and Robertstown - Tungkillo lines out of service.
1030 hrs	<p>ElectraNet attempted to close circuit breaker 6530 at Brinkworth but was unsuccessful because manual resetting of trip relays was required before the circuit breaker would close.</p> <p>At 1035 hrs AEMO invoked the constraint set S-DVBR+BRPA (see Note 2) for the condition of prior outage of Davenport – Brinkworth and Brinkworth – Para 275 kV transmission lines.</p>	Davenport – Brinkworth was open at Brinkworth and Brinkworth – Para 275 kV transmission line was open at both ends.
1132 hrs	<p>Circuit breakers 6530, 6068 and 6093 at Brinkworth were closed.</p> <p>Constraint set S-DVBR+BRPA was revoked at 1140 hrs.</p>	Brinkworth – Davenport 275 kV transmission line was restored. Brinkworth 132/275 kV transformer (T3) was restored.
1344 hrs	Circuit breakers 6517 and 6518 at Para were closed.	Para – Brinkworth 275 kV transmission line energised from Para.
1350 hrs	Circuit breaker 6527 at Brinkworth was closed following a line patrol of Para – Brinkworth line.	Para – Brinkworth 275 kV transmission line restored.

Note 1 – AEMO performed transient stability simulation studies applying the system conditions at 1008 hrs to 1022 hrs (with Para – Bungama, Davenport – Brinkworth and Brinkworth – Para 275 kV transmission lines out of service). The studies indicated signs of transient instability in SA network for the loss of Para – Robertstown and Robertstown – Tungkillo 275 kV transmission lines (re-classified as a credible contingency at the time). However, simulations further showed that the NEM power system was stable for the loss of Para – Robertstown and Robertstown – Tungkillo 275 kV transmission lines with Para – Bungama 275 kV transmission line in service.



Note 2 - The constraint set S-DVBR+BRPA manages system security with Davenport – Brinkworth and Brinkworth – Para 275 kV transmission lines out of service. Figures 1 and 2 show the status of the relevant switchgear at Brinkworth 275 kV switching station before and after the incident. Figures 3 and 4 show the status of the relevant switchgear at Para 275 kV substation before and after the incident.

Figure 1: Single line diagram showing the status of important switchgear at Brinkworth 275 kV switching station just before the multiple 275 kV transmission line outages.

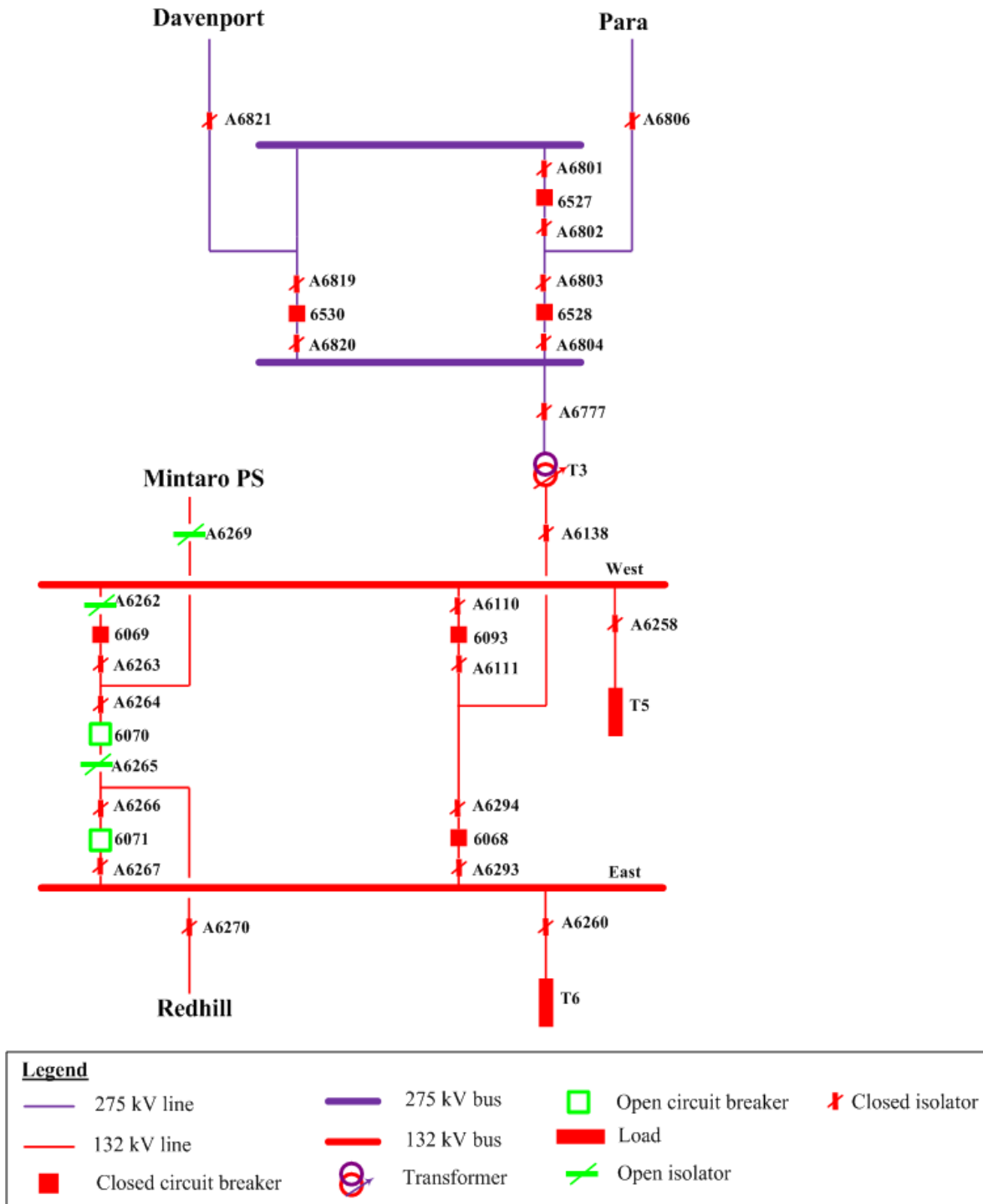


Figure 2: Single line diagram showing the status of important switchgear at Brinkworth 275 kV switching station just after the multiple 275 kV transmission line outages.

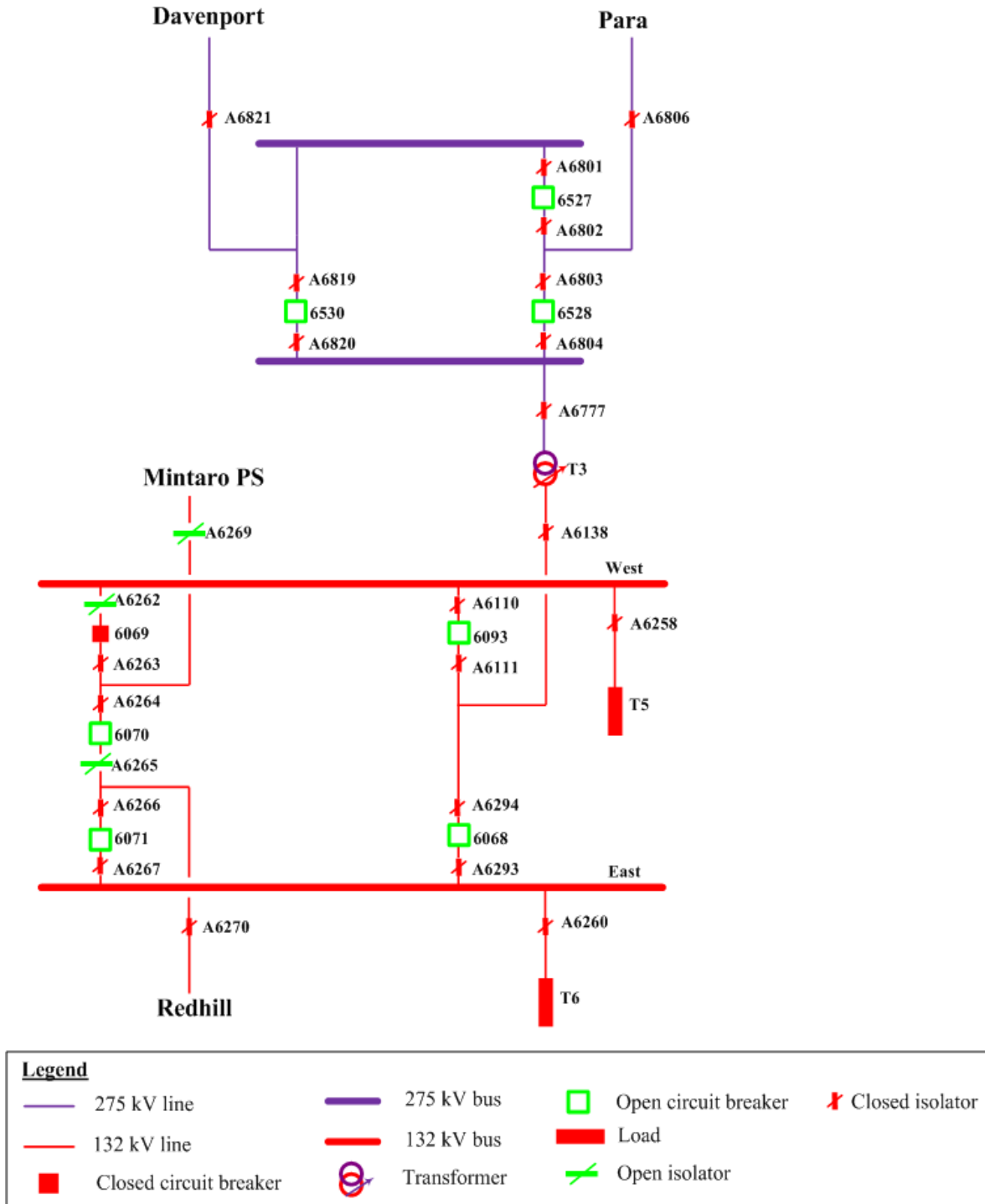


Figure 3: Single line diagram showing the status of the important switchgear at Para 275 kV switching station just before the multiple 275 kV transmission line outages.

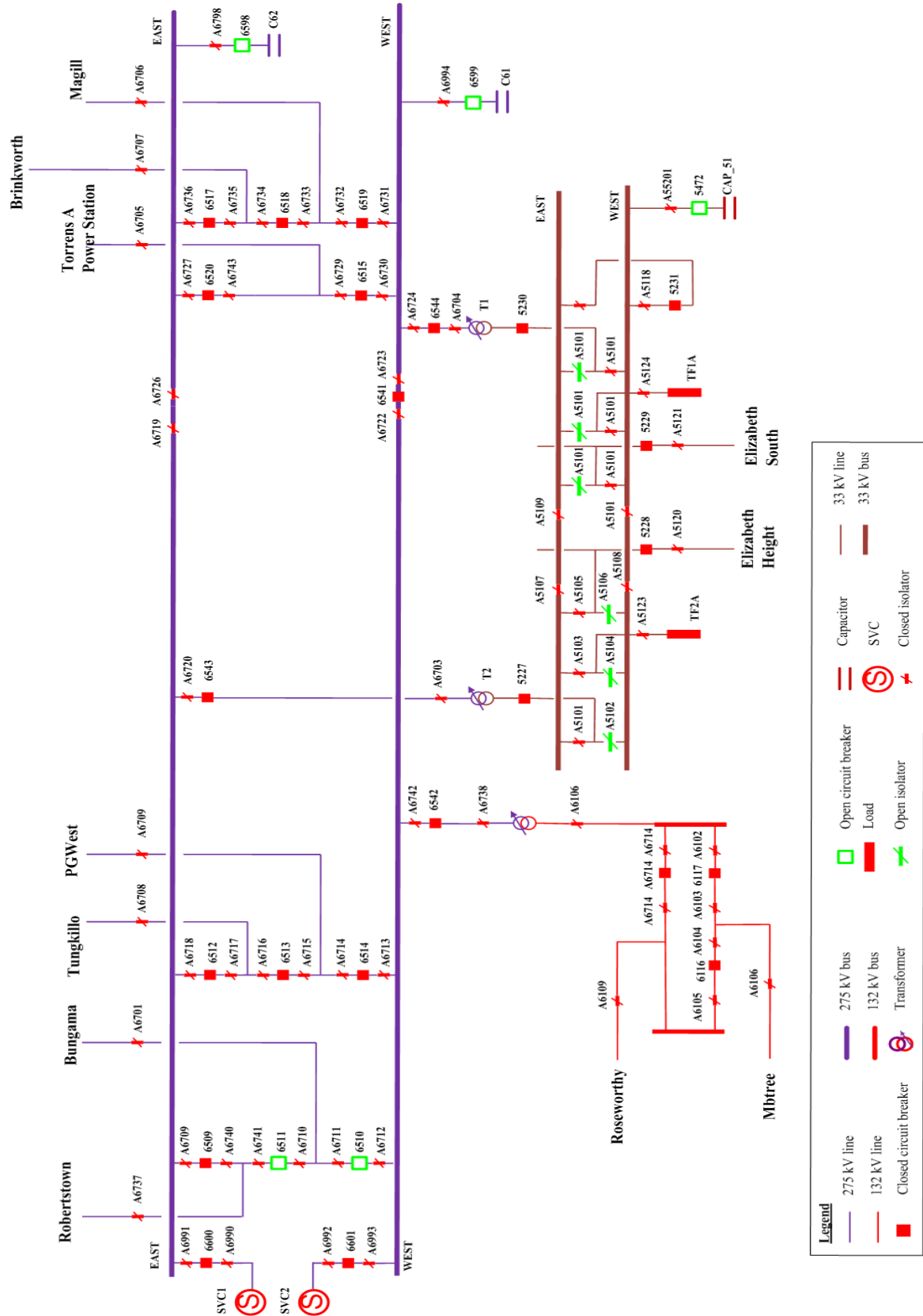
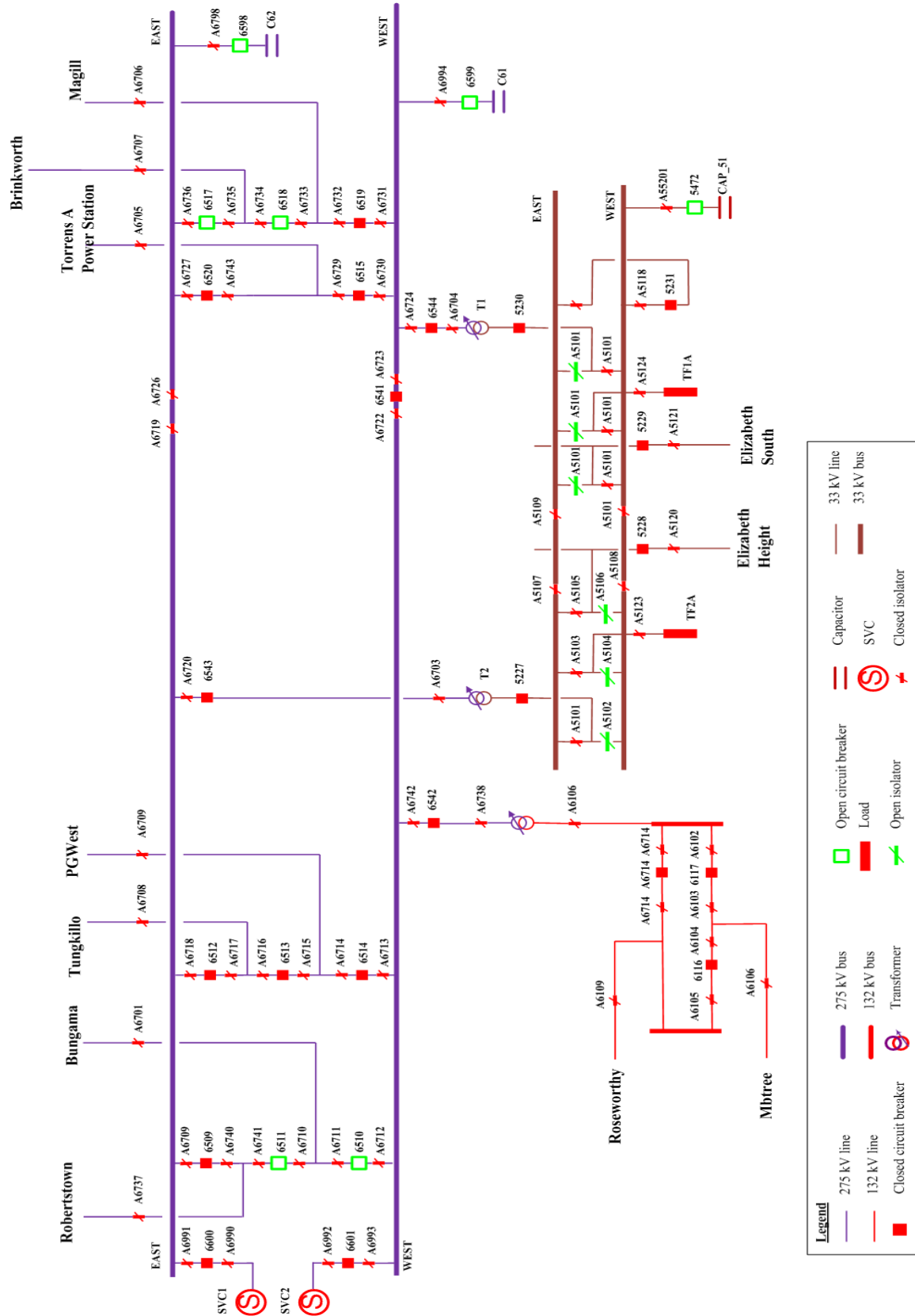


Figure 4: Single line diagram showing the status of important switchgear at Para 275 kV switching station just after the multiple 275 kV transmission line outages.



3. Management of Power System Security

There was no loss of load or generation during this event. Power system frequency remained within the normal operating frequency band.

AEMO and ElectraNet took action to securely operate the power system when severe lightning storms were experienced in the area on this day. In accordance with its procedures, AEMO reclassified the loss of Para – Robertstown and Robertstown – Tungkillo 275 kV transmission line as a credible contingency event at 0946 hrs and invoked the appropriate constraint equations.

With the Para – Bungama , Davenport – Brinkworth and Brinkworth – Para 275 kV transmission lines out of service, DSA indicated potential instability for the contingent loss of Para – Robertstown and Robertstown – Tungkillo 275 kV transmission lines. AEMO invoked the constraint set #SA1_E_20100903 which limits generation at North Brown Hill Wind Farm, Hallet Gas Turbine Station, Hallett 1 and 2 Wind Farms, Northern Power Station and Playford Power Station to address the stability issue. AEMO revoked this constraint at 1030 hrs when Para – Bungama 275 kV transmission line was returned to service. Subsequent analysis (see note 1 in Section 2) indicated this constraint set adequately addressed the stability issue.

4. Follow up actions

ElectraNet investigated the performance of the protection systems at Brinkworth. The investigation established that the protection relays at Brinkworth correctly operated to clear the initial single phase fault by single phase tripping and auto-reclosing of circuit breakers 6517 and 6518 at Para and 6527 and 6528 at Brinkworth¹.

However, the subsequent operation of protection relays at Brinkworth caused an incorrect three-phase trip of Brinkworth – Para line. This was attributed to logic programmed into protection and auto-reclosing relays at Brinkworth.

The investigation further revealed that circuit breaker 6528 at Brinkworth failed to operate for the three phase trip signal triggering the operation of backup protection systems at Brinkworth.

ElectraNet rectified the auto-reclosing logic at Brinkworth on 1 November 2010 and confirmed that this control logic deficiency was site specific to Brinkworth.

On 30 November 2010 ElectraNet completed additional maintenance on circuit breakers 6527, 6528 and 6530 at Brinkworth as an interim measure until these circuit breakers are replaced. These circuit breakers are scheduled to be replaced by the end of December 2011.

¹ Transient, single phase faults constitute the majority of faults on high voltage transmission lines. It is common practice to employ single phase trip and auto-reclose functionality on high voltage transmission lines to minimise the impact of these faults on power system security.

5. Conclusions

AEMO has verified that sufficient constraint equations were invoked to securely operate the power system during the incident. ElectraNet has established the cause of the incorrect operation of protections at Brinkworth. ElectraNet has undertaken the following measures to address the issues highlighted in this power system incident.

- Logic errors in programming of auto-reclosing relays were corrected on 1 November 2010.
- Additional maintenance of circuit breakers 6527, 6528 and 6530 at Brinkworth was completed on 30 November 2010.
- Replacement of circuit breakers 6527, 6528 and 6530 at Brinkworth has been scheduled to be completed by the end of December 2011.

6. Recommendations

ElectraNet will inform AEMO the progress of replacing circuit breakers 6527, 6528 and 6530 at Brinkworth by the end of December 2011.