

POWER SYSTEM OPERATING INCIDENT REPORT – INSECURE POWER SYSTEM OPERATION IN SOUTH AUSTRALIA ON 9 NOVEMBER 2011

PREPARED BY: Electricity System Operations Planning and Performance

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FINAL

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Abbreviations and Symbols

Abbreviation	Term
CB	Circuit Breaker
EMS	Energy Management System
kV	Kilovolt
MW	Megawatt
RTCA	AEMO real-time contingency analysis tool

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1 Introduction

On 9 November 2011 at 1450 hrs, the trip of Robertstown–Para and Robertstown–Tungkillo 275 kV lines were reclassified as a single credible contingency due to lightning activity in the vicinity of the lines¹. A short time after the reclassification, AEMO’s real-time contingency analysis (RTCA) tool indicated post-contingent overloading on Waterloo–Templers 132 kV line for the combined trip of the Robertstown–Para and Robertstown–Tungkillo lines.

At the time of the reclassification, the Brinkworth–Templers West 275 kV line was out of service for planned work, while the Bungama–Para 275 kV line in South Australia had tripped, auto-reclosed, tripped and locked out at both ends at 1426 hrs.

The RTCA violations were cleared when the Bungama–Para line returned to service at 1555 hrs. AEMO has determined the power system was insecure from 1450 hrs to 1555 hrs as the combined trip of the Robertstown–Para and Robertstown–Tungkillo lines would have overloaded the Waterloo–Templers line.

This report has been prepared under clause 4.8.15 (c) of the National Electricity Rules (NER) 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.

This report is largely based upon information provided by ElectraNet. Data from AEMO's Energy Management System and Electricity Market Management System has also been used in analysing the incident.

All references to time in this report are to National Electricity Market time (Eastern Standard Time).

2 Pre-Contingent System Conditions

The status of the power system prior to the incident is shown in Figure 1. For clarity, only equipment relevant to this incident has been included in the diagram. Note that prior to this event, there was a planned outage of the Brinkworth–Templers West line and an unplanned outage of the Bungama–Para line.

3 Summary of Events

Table 1 summarises the sequence of events during the incident.

Table 1: Sequence of events during the incident

Time (hrs)	Event or Action
1426	The Bungama–Para 275 kV line tripped, auto-reclosed, tripped and locked out at both ends. This resulted in the Bungama 275 kV East bus being de-energised.
1434	The Brinkworth–Clare North 132 kV line tripped.
1435	AEMO invoked constraint set S-BGPA for the unplanned outage of the Bungama–Para line.
1438	The Brinkworth–Clare North 132 kV line was returned to service.
1450	The trip of Robertstown–Para and Robertstown–Tungkillo 275 kV lines were reclassified as a single credible contingency due to lightning activity, and the relevant constraint set S-BGPA+RBPA+RBTU_N-2 was invoked.
1450	AEMO’s RTCA tool failed to solve for the trip of both Robertstown–Para and Robertstown–Tungkillo lines. The power system was considered to be insecure from this time.

¹ Refer to section 4.2.3 of the NER, which is available at:

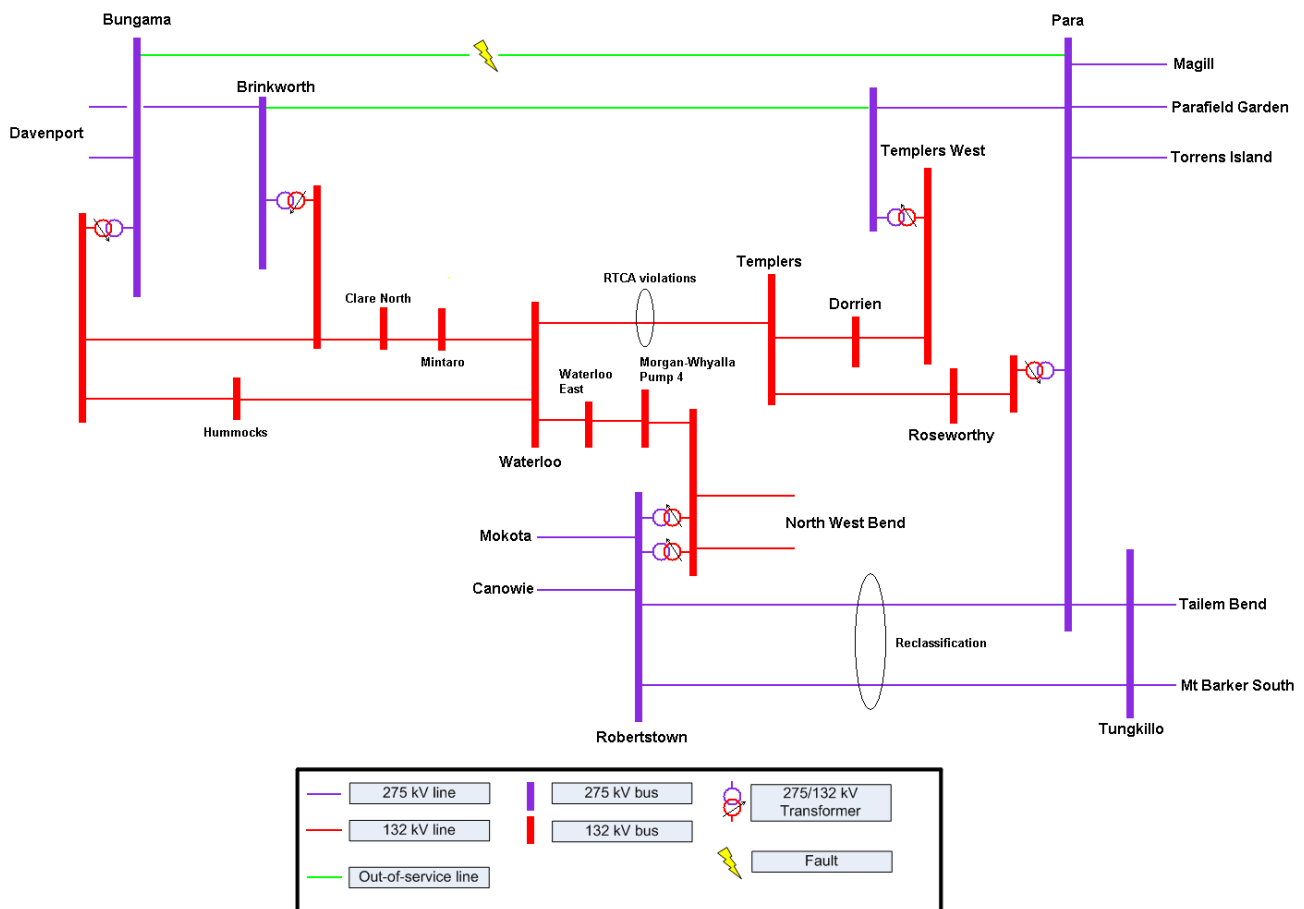
<http://www.aemc.gov.au/Electricity/National-Electricity-Rules/Current-Rules.html>.

1458	AEMO's RTCA tool began reporting violations on the Waterloo–Templers 132 kV line for the trip of both Robertstown–Para and Robertstown–Tungkillo lines.
1510	AEMO utilised the Constraint Automation tool ² to manage the RTCA violations on the Waterloo–Templers line. AEMO then invoked constraint set CA_MQS_3DCC97B9 generated by the tool.
1521	AEMO issued the Market Notice 36551 to advise participants of the reclassification of the Robertstown–Para and Robertstown–Tungkillo lines.
1530	AEMO revoked the constraint set CA_MQS_3DCC97B9 and invoked the constraint set CA_MQS_3DCC9BF2 generated using the Constraint Automation tool to better represent the power system conditions.
1532	AEMO issued the Market Notice 36552 to advise participants of the inter-regional transfer limit variation on Murraylink interconnector due to the unplanned outage of Bungama–Para line.
1536	AEMO advised ElectraNet that opening the Waterloo–Templers line would eliminate the RTCA violations. ElectraNet performed studies in regards to the proposed solution.
1538	AEMO issued the Market Notice 36553 to provide an update on the reclassification of the trip of Robertstown–Para and Robertstown–Tungkillo lines. It also advised that the Constraint Automation tool had been used, and constraint set CA_MQS_3DCC97B9 was invoked from 1510 hrs.
1541	ElectraNet was reluctant to open the Waterloo–Templers line as a network solution to resolve the RTCA violations, as Bungama–Para line was to be returned to service in approximately 5 minutes.
1546	AEMO issued the Market Notice 36555 to provide an update on the reclassification of the trip of Robertstown–Para and Robertstown–Tungkillo lines. It also advised that constraint set CA_MQS_3DCC97B9 was replaced by CA_MQS_3DCC9BF2 from 1530 hrs.
1548	AEMO advised ElectraNet that it was considering issuing an NER clause 4.8.9 instruction ³ for ElectraNet to open the Waterloo–Templers line if RTCA violations continued to be reported.
1551	The Clare North–Mintaro–Waterloo 132kV lines tripped and auto-reclosed.
1555	The Bungama–Para line returned to service. RTCA violations were cleared.
1610	AEMO revoked constraint sets CA_MQS_3DCC9BF2, S-BGPA and S-BGPA+RBPA+RBTU_N-2, and invoked constraint set S-BRTW_RBPA+RBTU_N-2 as the Brinkworth–Templers West line was still out of service for planned maintenance.
1619	AEMO issued the Market Notice 36558 to advise that the Bungama–Para line had returned to service.
1730	AEMO cancelled the reclassification of the Robertstown–Para and Robertstown–Tungkillo lines and revoked the constraint set S-BRTW_RBPA+RBTU_N-2.
1737	AEMO issued the Market Notice 36566 to advise participants of the cancellation of the reclassification of the Robertstown–Para and Robertstown–Tungkillo lines.

² Constraint Automation tool is an application in AEMO's EMS that can generate constraint equations to manage power transfer on transmission lines to within thermal ratings following single contingency events and specific multiple contingencies events. More information can be found at:
<http://www.aemo.com.au/electricityops/0200-0017.html>.

³ Refer to section 4.8.9 of the NER from the Australian Energy Market Commission, which is available at:
<http://www.aemc.gov.au/Electricity/National-Electricity-Rules/Current-Rules.html>.

Figure 1 - Overview of the power system between Bungama and Para prior to the incident



4 Immediate Actions Taken

AEMO invoked a number of constraint sets, and also utilised the Constraint Automation tool in order to restore the power system to a secure operating state.

At the same time, AEMO and ElectraNet performed power system studies to evaluate options to remove the RTCA violations on the Waterloo–Templers line. Although recalling the Brinkworth–Templers West line would have been beneficial, it was not possible as it was undergoing an extended outage to replace line insulators and the estimated recall time was at least 8 hrs. Other options considered included opening the Waterloo–Templers line, and restoring the Bungama–Para line. Refer Table 1 for market notices issued advising participants of the event and the actions taken during this incident.

At 1555 hrs, ElectraNet returned the Bungama–Para line to service and the power system returned to a secure operating state.

5 Follow-up Actions

On 18 November 2011, ElectraNet informed AEMO that it considered directing relevant generating units to lower levels to reduce the post-contingency overload on the Waterloo–Templers line as the most appropriate solution.

AEMO advised ElectraNet that the level of estimated post-contingency overload on the Waterloo–Templers line was excessive; hence opening the line before taking action to reduce relevant generation was considered to be the most secure way of managing the situation.

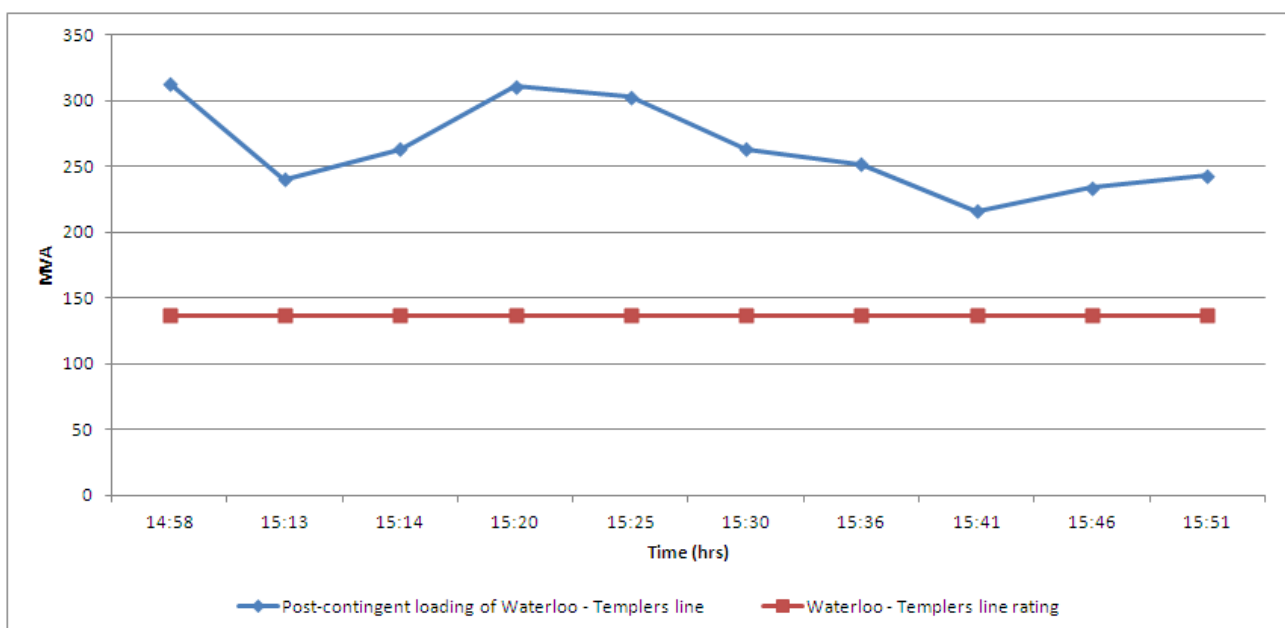
6 Power System Security Assessment

The power system voltages and frequencies remained within the normal operating bands throughout the incident.

AEMO determined that the power system was not in a secure operating state for a period of 65 minutes between 1450 hrs and 1555 hrs. During this period, the combined trip of the Robertstown–Para and Robertstown–Tungkillo lines would have resulted in a severe thermal overload of the Waterloo–Templers line. Figure 2 shows the estimated post-contingency loading on the Waterloo–Templers line recorded by the RTCA tool.

The power system returned to a secure operating state when ElectraNet restored Bungama–Para line to service. The responses of AEMO and ElectraNet were adequate to restore the power system security within 65 minutes.

Figure 2 - Post-contingent loading of the Waterloo–Templers line recorded by AEMO’s RTCA tool



6.1 Performance of constraint sets

During the incident, AEMO invoked several constraint sets to restore power system security. However, the constraint sets invoked were ineffective in reducing the post-contingent loading of Waterloo–Templers line. RTCA violations were cleared only after the Bungama–Para line returned to service at 1555 hrs.

The constraint sets were not effective in removing the RTCA violations because:

- There was no applicable constraint set available for power system conditions whereby the Robertstown–Para and Robertstown–Tungkillo lines were reclassified as a single credible contingency with both the Brinkworth–Templers West and Bungama–Para lines out-of-service.
- The Constraint Automation tool is not effective when used for multiple contingencies that will result in a bus split or with additional equipment off-loaded. In this case, the Robertstown No. 2 275/132 kV transformer would have been off-loaded if the Robertstown–Para and Robertstown–Tungkillo lines had tripped. Referring to Figure 3, opening CBs 6571, 6572, 6574 and 6575 would off-load the No. 2 transformer.

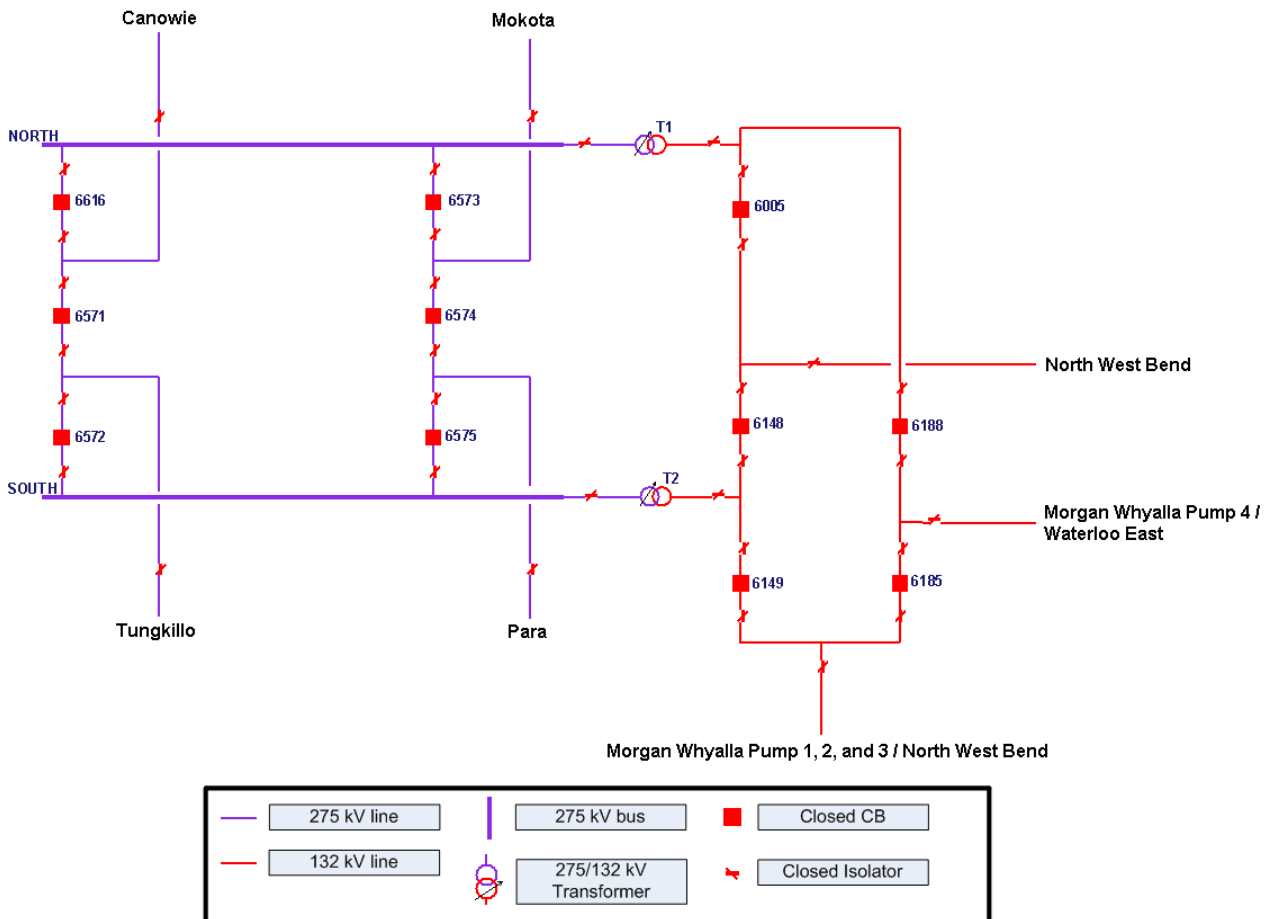
- Some of the generating units in South Australia failed to follow their dispatch targets diligently. This issue is covered in more detail in the next section of this report.

Table 2 summarises the constraint sets that were invoked by AEMO to manage power system security during the incident.

Table 2: Constraint sets invoked during the incident

Constraint set	Invoke Time (hrs)	Revoke Time (hrs)	Comments
S-BGPA	1435	1610	Constraint set applicable for Bungama–Para line out-of-service.
S-BGPA+RBPA+RBTU_N-2	1450	1610	Constraint set applicable for Bungama–Para line out-of-service with the N-2 reclassification of Robertstown–Para and Robertstown–Tungkillo lines.
CA_MQS_3DCC97B9	1510	1530	Constraint set generated by Constraint Automation tool for use under specific system conditions at that time.
CA_MQS_3DCC9BF2	1530	1610	Constraint set generated by Constraint Automation tool for use under specific system conditions at that time.
S-BRTW_RBPA+RBTU_N-2	1610	1730	Constraint set applicable for Brinkworth–Templers West line out-of-service with the N-2 reclassification of Robertstown–Para and Robertstown–Tungkillo lines.

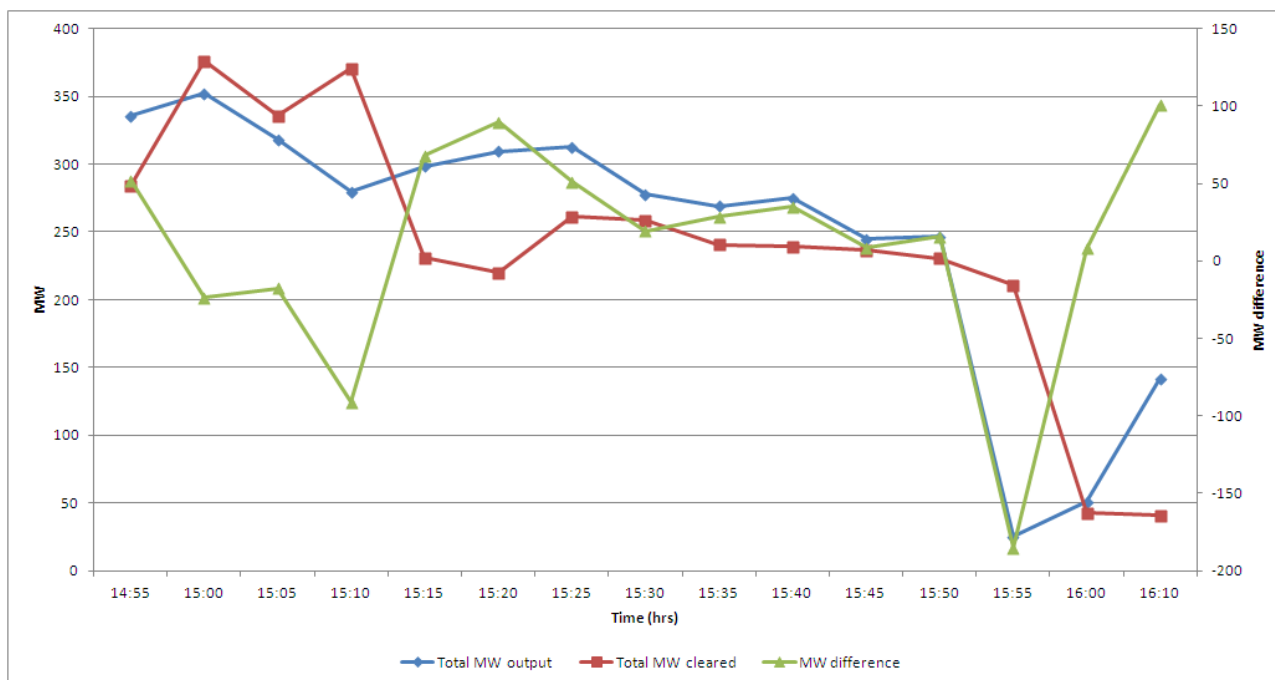
Figure 3 - Robertstown substation during the incident



6.2 Generation responses

During this event, some semi-scheduled wind generation in South Australia failed to follow their dispatch targets diligently. There were significant differences between the aggregated dispatch targets and MW outputs for a number of wind farms. However, no generators were declared non-conforming during this period. Figure 4 illustrates these differences.

Figure 4 - Wind farms' cumulative MW outputs and dispatch targets



7 Conclusions

From 1450 hrs to 1555 hrs on 9 November 2011, the power system was not in a secure operating state because of a combination of:

- Planned outage of a transmission line
- Unplanned outage of a transmission line
- Reclassification of the trip of two transmission lines as a credible contingency

AEMO determined the use of the Constraint Automation tool as the best available option to remove the RTCA violations on that day. However, subsequent investigations revealed that an NER clause 4.8.9 direction⁴ to constrain off relevant generation could have been a better option.

The power system was returned to a secure operating state after ElectraNet returned the transmission line that was out of service due to an unplanned outage to service.

AEMO is satisfied with its actions and the actions undertaken by ElectraNet to restore power system security.

AEMO correctly applied the criteria published in section 12 of its Power System Security Guidelines in assessing that the circumstances of this incident did not warrant reclassifying similar incidents as a credible contingency event.

⁴ Refer to section 4.8.9 of the NER from the Australian Energy Market Commission, which is available at: <http://www.aemc.gov.au/Electricity/National-Electricity-Rules/Current-Rules.html>.

8 Recommendations

AEMO has reviewed and concluded that current operational procedures are adequate to manage power system security in similar situations. However, a need has been identified to provide scenario simulation training to control room operators. This will improve their situational awareness and responses when exposed to similar scenarios in future. This will be completed by the end of May 2012.