POWER SYSTEM INCIDENT REPORT

POWER SYSTEM SECURITY ISSUES IN SOUTH AUSTRALIA ON 27 NOVEMBER 2009

PREPARED BY: ESOPP

VERSION NO: 1.0

FINAL

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1. Introduction

On 27th November 2009 in South Australia (SA) region, due to concurrent planned outages of the Brinkworth to Davenport 275 kV line and the Waterloo to Hummocks 132 kV line, AEMO's real-time contingency analysis (RTCA) tool indicated post-contingent overloading on the Redhill to Brinkworth 132 kV line.

After 14:00 hrs, power system security in SA region worsened after the loss of both Para to Robertstown and Robertstown to Tungkillo 275 kV lines was declared as a credible contingency due to lightning reported in the vicinity. AEMO's RTCA continued to flag post-contingent violations on several network elements during this contingency reclassification event.

This report has been prepared under 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 and maintain power system security.

Information for this report has been obtained largely from AEMO's Market Management System (MMS) and Energy Management System (EMS).

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

2. Summary of events

On Friday 27th November 2009 in the SA region, there were planned outages of Brinkworth to Davenport 275 kV line and Waterloo to Hummocks 132 kV line with constraint sets S-BRDV and S-HUWT invoked in dispatch.

At 12:20 hrs, AEMO's RTCA commenced showing post-contingent overloading on the Redhill to Brinkworth 132 kV line (maximum rating of 150 MVA) on the loss of Bungama to Para 275 kV line.

At 14:00 hrs, Para to Robertstown and Robertstown to Tungkillo 275 kV lines were reclassified due to lightning and this condition prevailed till 16:55 hrs. Constraint set S-RBPA+RBTU_N-2 was invoked from 14:00 hrs to 16:55 hrs and Market Notice 29067 was issued at 14:19 hrs to inform participants of the reclassification. Due to unexpected high wind farm output, AEMO's RTCA continued to indicate overloading of Redhill to Brinkworth 132 kV line on the loss of Bungama to Para 275 kV line. ElectraNet was unable to confirm this condition.

AEMO's RTCA also revealed a potential power system security violation with regards to Robertstown 275/132 kV No. 1 transformer, had the reclassified lines tripped.

ElectraNet, in consultation with AEMO, recalled the Waterloo to Hummocks 132 kV line at 14:19 hrs, and it was returned to service at 15:50 hrs.

At 14:45 hrs, the Constraint Automation tool was used in an attempt to resolve the power system security issue with the Robertstown No. 1 transformer. Constraint set CA_BPS_3A21E435 was invoked from 14:45 hrs to 15:35 hrs.

Power system security did not improve and at 15:20 hrs, AEMO issued directions to AGL Hydro Partnership to reduce generation from Hallett wind farm (WF) to 25 MW and Hallett Hill WF to 25 MW. Market Notices 29068, 29069 and 29070 were issued. Due to the short duration of the directions, there was insufficient time to invoke constraints on Hallett WF and Hallett Hill WF.

At 15:25 hrs, the power system security violation with regards to Robertstown No. 1 transformer was cleared.

At 15:30 hrs, AEMO cancelled the directions on Hallett WF and Hallett Hill WF. Market Notices 29072 and 29073 were then issued.

At 16:55 hrs, the reclassification of Para to Robertstown and Robertstown to Tungkillo 275 kV lines was cancelled and Market Notice 29076 was issued.

3. Power System Security

3.1 Operation of Redhill to Brinkworth 132 kV line

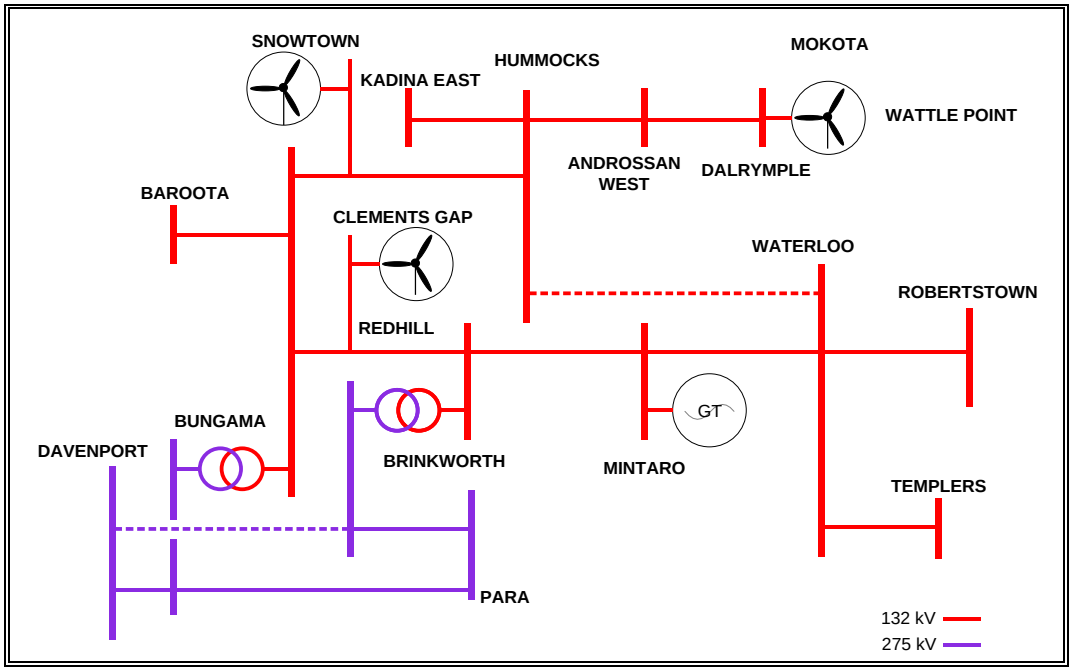

FIGURE 1. POWER SYSTEM IN THE VICINITY OF REDHILL TO BRINKWORTH 132 KV LINE

At 12:20 hrs, AEMO's RTCA highlighted a power system security violation where the post-contingent loading on the Redhill to Brinkworth 132 kV line would have exceeded its rating of 150 MVA had the Bungama to Para 275 kV line tripped (refer Figure 1). This condition existed from 12:20 hrs to 12:50 hrs (up to 104% of rating) and from 13:10 hrs to 15:20 hrs (up to 111% of rating); i.e. the power system was estimated to be insecure for 160 minutes.

3.2 Operation of Robertstown 275/132 kV No. 1 Transformer

At 14:00 hrs, the contingency reclassification event together with combined planned outages of the Brinkworth to Davenport 275 kV line and the Waterloo to Hummocks 132 kV line resulted in insecure operation of the Robertstown 275/132 kV No. 1 transformer. Figure 2 shows that loss of Para to Robertstown and Robertstown to Tungkillo 275 kV lines would have offloaded Robertstown No. 2 transformer.

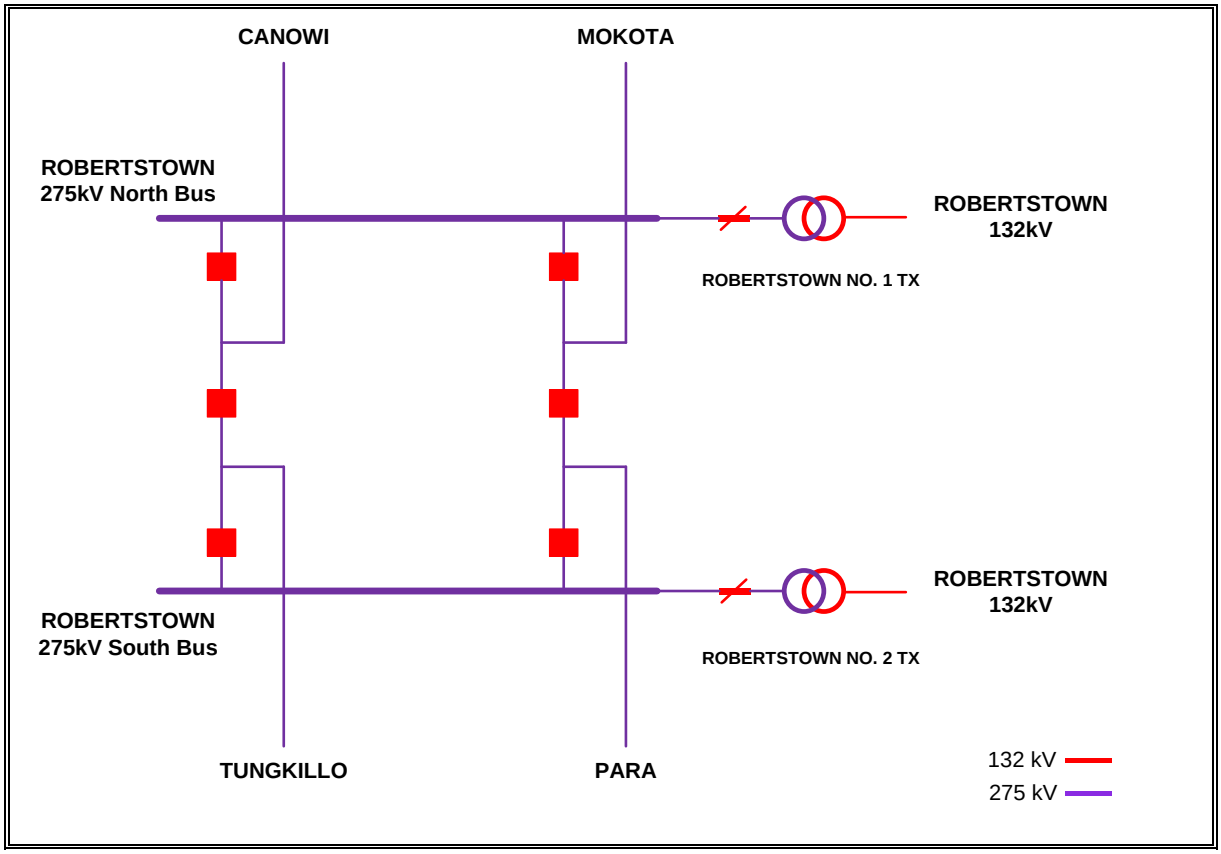

FIGURE 2. ROBERTSTOWN 275 KV SUBSTATION

AEMO's RTCA indicated that the post-contingent loading on the Robertstown No. 1 transformer would have exceeded its maximum rating of 160 MVA by up to 38% (after adjusting for the enablement of the Murraylink interconnector to runback its flow) if the Para to Robertstown and Robertstown to Tungkillo lines had tripped (refer Figure 3).

For this contingency, the effect of the Murraylink runback scheme was not considered in AEMO's RTCA, hence it was indicating higher post-contingent flows on the transformer than what would have been the case had the contingency occurred. Even so, the insecure operation of the Robertstown No. 1 transformer lasted for an estimated duration of 80 minutes (with Murraylink interconnector enabled for runback).

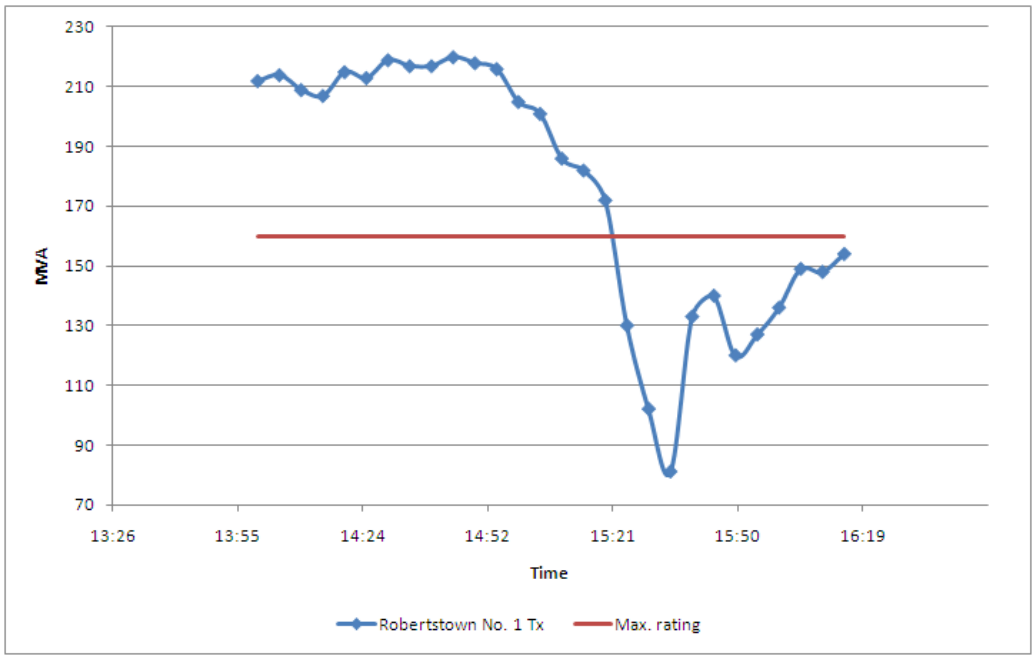

FIGURE 3. 5-MINUTE RTCA POST-CONTINGENT FLOW ON ROBERTSTOWN NO. 1 TRANSFORMER (WITH MURRAYLINK ENABLED FOR RUNBACK)

3.3 Operation of Contingency Reclassification Constraint Set

During the reclassification of the Para to Robertstown and Robertstown to Tungkillo circuits, constraint set S-RBPA+RBTU_N-2 was invoked from 14:00 hrs to 16:55 hrs. Constraint equation V>>S_RBTU_N-2_MW4WT, which was part of the set, was binding from 14:50 hrs to 15:35 hrs (refer Figure 4).

Although constraint equation V>>S_RBTU_N-2_MW4WT was primarily designed to manage post-contingent thermal overload on the Robertstown to Waterloo 132 kV line, it would have also helped to relieve part of the post-contingent violation on the Robertstown 275/132 kV No. 1 transformer.

Constraint set S-RBPA+RBTU_N-2 was developed for the combined loss of Para to Robertstown and Robertstown to Tungkillo 275 kV lines with all other network elements in service. Due to the concurrent planned outages of Brinkworth to Davenport 275 kV line and Waterloo to Hummocks 132 kV line, this constraint set was ineffective during this event.

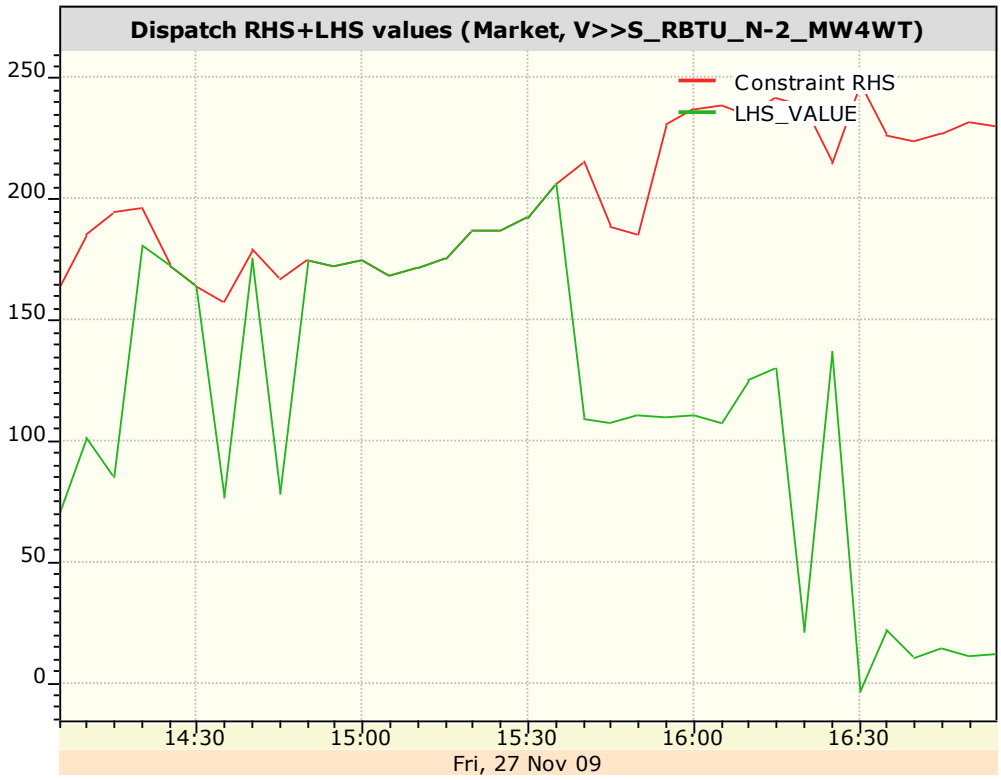

FIGURE 4. BINDING CONSTRAINT EQUATION V>>S_RBTU_N-2_MW4WT DURING THE CONTINGENCY RECLASSIFICATION

3.4 Use of the Constraint Automation tool

At 14:45 hrs, an attempt was made to use AEMO's Constraint Automation tool to resolve the power system security violation of the Robertstown No. 1 transformer. Constraint set CA_BPS_3A21E435 was invoked but constraint equation CA_BPS_3A21E435_01 violated from 14:45 hrs to 15:35 hrs (refer Figure 5). This constraint equation was unable to remove RTCA violations on the Robertstown No. 1 transformer. AEMO's investigations revealed that the Constraint Automation tool is ineffective for multiple contingencies that will result in a bus split or cause additional equipment to be offloaded. An internal Short-Term Operating Procedure (STOP) was subsequently issued on 3 December 2009 to ensure AEMO staff is aware of this limitation of the Constraint Automation tool.

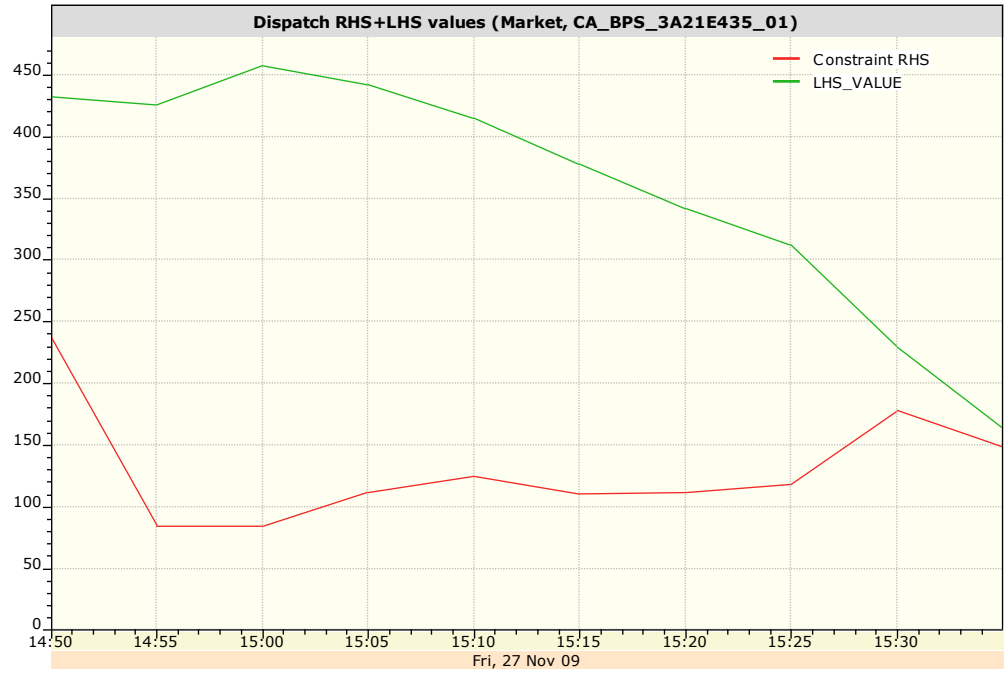

FIGURE 5. CONSTRAINT EQUATION (CA_BPS_3A21E435_01) VIOLATED DURING THE CONTINGENCY RECLASSIFICATION EVENT

3.5 Non-responsiveness of generation

During this contingency reclassification event, some of the generators in SA region failed to follow their dispatch targets diligently. While the level of non-responsiveness of individual units did not lead to the declaration of non-conformances, the sum of all non-responsiveness was sufficient to cause power system security issues. At 14:20 hrs, AEMO requested those generating units to follow their dispatch targets.

3.6 Impact of generation at Clements Gap WF

Figure 6 shows the wind generation at Clements Gap WF on 27 November 2009, which increased significantly from around 11:20 hrs due to unexpected high winds and contributed to increased levels of security violations. Clements Gap is a semi-scheduled wind generator, which would have been dispatched to acceptable levels of generation provided suitable constraint equations were employed in the dispatch system. However, the requirement for a constraint set covering the combined outage of the Brinkworth to Davenport 275 kV line and Waterloo to Hummocks 132 kV line was not identified during outage assessment and suitable constraint equations were, therefore, not available for invocation during the outage period.

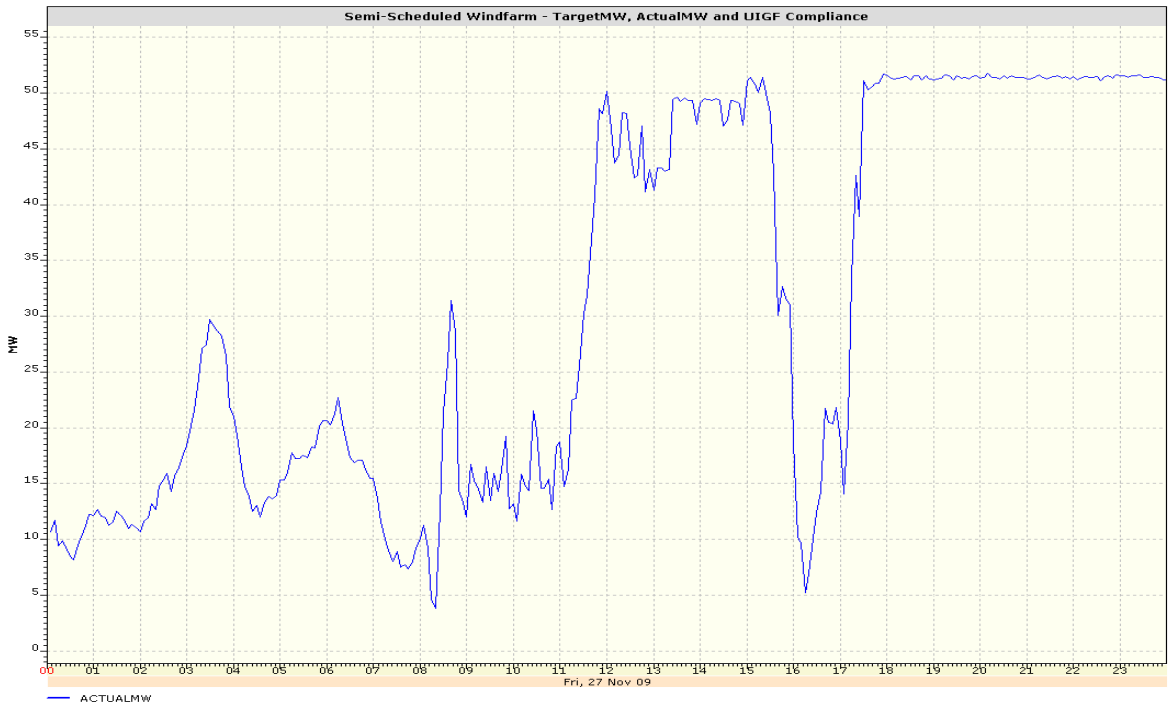

FIGURE 6. WIND GENERATION OF CLEMENTS GAP

3.7 Operational and power system security issues

After investigating the two main power system security events that occurred on 27 November 2009, the following operational and system security issues have been identified:

Operational issues:

1. The concurrent planned outages of the Brinkworth to Davenport 275 kV line and Waterloo to Hummocks 132 kV line had been assessed separately and AEMO had given permission to proceed based on the current AEMO outage assessment procedures. The unexpected increase in wind generation at Clements Gap WF from around 11:20 hrs on this day contributed to the increased levels of security violations during these outages. See Recommendation 1.

2. The two constraint sets S-BRDV and S-HUWT were invoked to reflect the concurrent outages of the Brinkworth to Davenport 275 kV line and Waterloo to Hummocks 132 kV line. Investigations revealed that these constraint sets suitably reflect the power transfer limits for individual outages but are not suitable to manage power system security when both lines are out of service concurrently. This is the reason for the security violations from 12:20 hrs on this day.

At 14:00 hrs, after the loss of the Para to Robertstown and Robertstown to Tungkillo 275 kV lines was declared a credible contingency, constraint set S-RBPA+RBTU_N-2 was invoked. The investigations revealed that this constraint set is suitable for the contingency reclassification when all other network elements in the vicinity are in service. However, on this day two other significant transmission lines were already out of service, which resulted in the constraint set invoked being ineffective. See Recommendation 2.

3. AEMO's RTCA application showed overloading on the Redhill to Brinkworth 132 kV line on the loss of the Bungama to Para 275 kV line from 12:20 hrs to 12:50 hrs and 13:10 hrs to 15:20 hrs. AEMO analysed the situation to determine the most suitable corrective action to remove the power system security violation. RTCA flagged post-contingency overloading on the Robertstown No. 1 275/132 kV transformer commencing from 14:05 hrs. AEMO requested generating units to follow their targets since this was aggravating the power system security violation at the time.

   At 14:40 hrs, AEMO invoked a constraint equation generated using the Constraint Automation tool to alleviate the power system security violation. However, this equation proved to be ineffective due to limitations in the Constraint Automation tool. AEMO subsequently issued an internal procedure on 3 Dec 2009 explaining the applicability of the Constraint Automation tool to cover multiple contingencies.

   AEMO has reviewed its operating procedures to check the adequacy of coverage for managing situations similar to the ones experienced on 27 November 2009 and found them to be adequate.

4. The following issues were noted in the AEMO systems used to manage power system security on 27 November 2009:

   (a) Murraylink runback scheme had not been implemented in RTCA at the time.
   (b) Hallett Hill WF was yet to be implemented in the Constraint Automation tool.
   (c) Ratings of Redhill to Brinkworth 132 kV line had not been implemented in the Constraint Automation tool. Hence, it was not possible to generate constraint equations using the Constraint Automation tool to manage power system security for this event.
   (d) Murraylink runback scheme had not been implemented in the Constraint Automation tool at the time.
   (e) Constraint Automation tool is ineffective for multiple contingencies that will result in a bus split or cause additional equipment to be offloaded.

AEMO has since addressed all the above issues and updated its systems. See Recommendation 3 and 4.

4. Conclusions

The power system was not in a secure operating state with regards to the operation of Redhill to Brinkworth 132 kV line from 12:20 hrs to 12:50 hrs and 13:10 hrs to 15:20 hrs on 27 November 2009.

The power system was not in a secure operating state with regards to the operation of No. 1 275/132 kV transformer at Robertstown from 14:00 hrs to 15:20 hrs on 27 November 2009.

Considering both issues it is considered that the power system was operated insecurely for 160 minutes during this event.

This report includes further recommendations to address issues identified in the investigation of this power system incident.

5. Recommendations

Recommendation 1:

AEMO is to review its outage assessment procedures in light of the observations from this power system incident. This recommendation should be completed by the end of April 2010.

Recommendation 2:

AEMO is to review its guidelines on the application of constraint equations during concurrent outages and improve the guidelines so as to identify situations where new constraint sets for concurrent outages will be required. This recommendation should be completed by the end of May 2010.

Recommendation 3:

AEMO is to audit the contingency definitions used in RTCA to ensure all control schemes employed in the transmission networks are modelled in RTCA. This action has already been implemented for the Murraylink runback scheme. This recommendation should be completed for other control schemes by the end of June 2010.

Recommendation 4:

AEMO will improve the 6-monthly audit process for the Constraint Automation database to ensure all relevant power system elements and their associated parameters are included in the database. This recommendation should be completed by the end of June 2010.