POWER SYSTEM OPERATING INCIDENT REPORT
TRIP OF NO.2 EILDON GENERATING UNIT ON 18 AUGUST 2011

PREPARED BY: Electricity System Operations Planning and Performance

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FINAL

Disclaimer

Purpose

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Abbreviations and Symbols

Abbreviation	Term
AEMO	Australian Energy Market Operator Ltd
CB	Circuit Breaker
EPS	Eildon Power Station
EST	Eastern Standard Time
kV	Kilovolt
MBTS	Mount Beauty Terminal Station
MW	Megawatt
MVAr	Megavolt amperes reactive
NEM	National Electricity Market
NER	National Electricity Rules
TTS	Thomastown Terminal Station

1 Introduction

At 0851 hrs on 18 August 2011, the No. 2 generating unit at Eildon power station in Victoria tripped out of service when the No. 2 Eildon Power Station (EPS) - Mt Beauty Terminal Station (MBTS) 220 kV line was closed at MBTS. The EPS - Thomastown Terminal Station (TTS) 220 kV line was out of service for planned work at the time. The Eildon No.2 generating unit was operating in synchronous condenser mode when the incident occurred.

This report has been prepared under clause 4.8.15 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 AGL. Data from AEMO's Energy Management System has also been used in analysing the incident.

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

2 Pre-Contingent System Conditions

The EPS–TTS line had been switched out of service for a planned outage and the No. 1 Eildon generating unit was operating in synchronous condenser mode to manage the voltage at EPS when this incident took place.

At 0614 hrs, the voltage at EPS terminal station increased to marginally above 240 kV[1]. The No. 1 Eildon unit was absorbing approximately 32 MVAr at the time[2]. In accordance with the agreed procedures, the No.2 EPS – MBTS 220 kV line was switched out of service to manage voltage levels at EPS in accordance with agreed procedures and the constraint set V-EPMB was invoked at 0620 hrs.

At 0850 hrs, SP AusNet advised AEMO that the No.2 EPS – MBTS 220 kV line could be returned to service as the second Eildon generating unit was available for voltage control. The second EPS unit was brought into service and the unit 1 and the unit 2 were absorbing 16.6 MVAr and 16.3 MVAr.

The status of EPS and connections to MBTS prior to the incident are shown in Figure 1[3]. Only the equipment relevant to this incident has been included in the diagram for clarity.

[1] 240 kV is the continuous voltage rating of Eildon bus.

[2] Previous experience has been that approximately 30 MVAr from Eildon generating unit(s) is required to manage voltage levels at EPS when EPS-TTS line is out of service. However, this was not sufficient on the day as the EPS voltage increased to above the continuous voltage rating at 0614 hrs while No.1 Eildon unit was absorbing 32 MVAr.

[3] Note that AEMO's operating diagrams and SP AusNet's operating diagrams are different from AGL's operating diagrams in transmission line numbering. Diagrams in this report are based on AGL's diagrams.

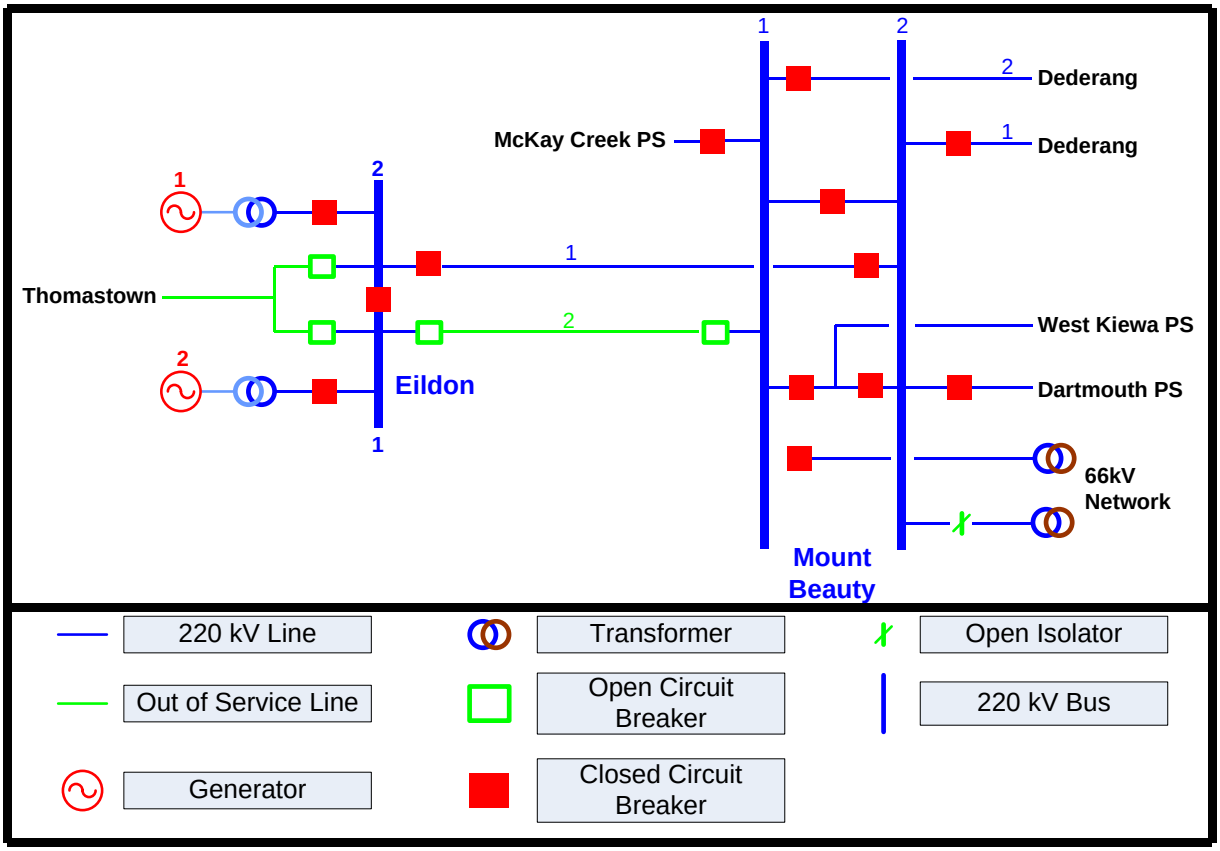

Figure 1 – Status of Eildon terminal station and connections to Mount Beauty prior to the incident

3 Summary of Events

At 0851 hrs, No.2 Eildon generating unit tripped out of service on closing of the No.2 EPS – MBTS 220 kV line circuit breaker (CB) at MBTS end. No.1 Eildon generating unit remained in service.

The status of EPS and connections to MBTS immediately after the incident are shown in Figure 2.

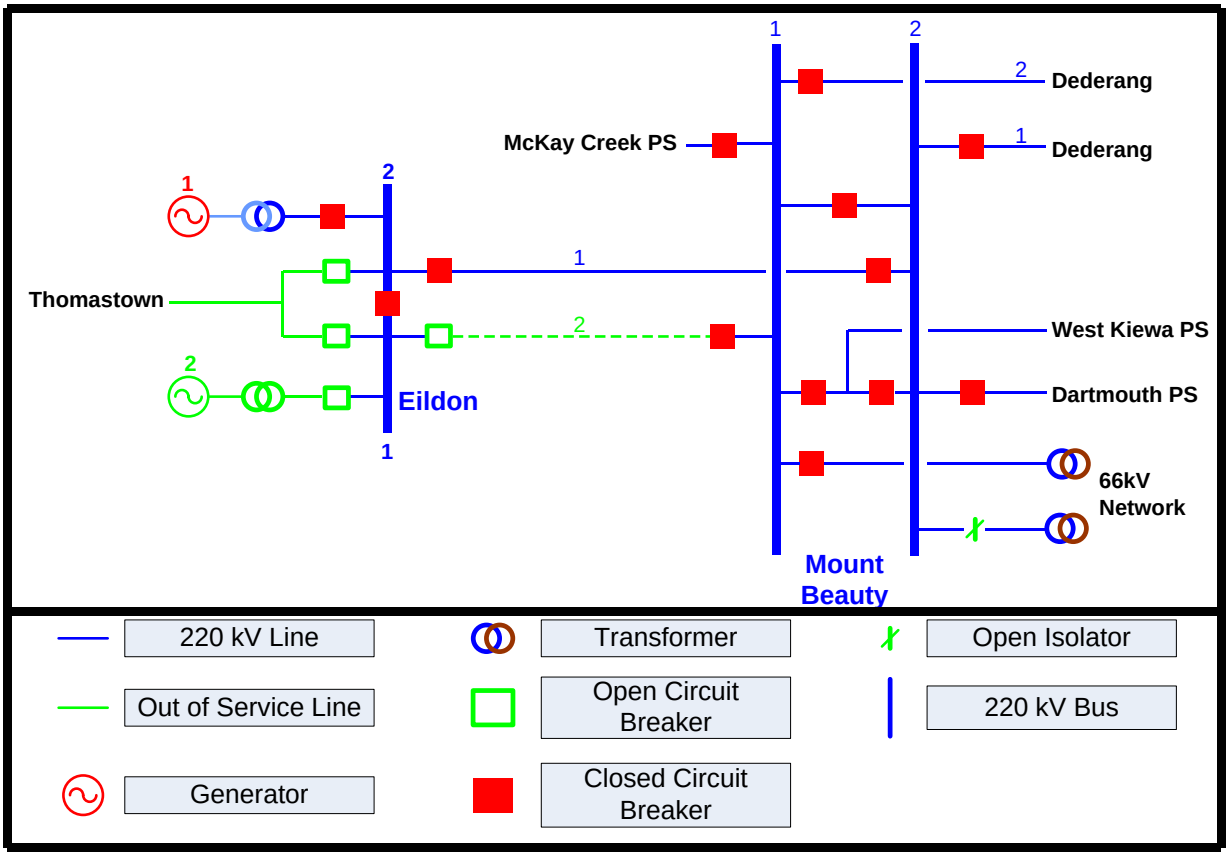

Figure 2 - Status of Eildon terminal station and connections to Mount Beauty immediately after the incident

At 0857 hrs the No.2 EPS – MBTS line was taken out of service again to manage voltage at EPS.

Initial investigations did not find the cause of trip of the No.2 Eildon generating unit and AGL, in coordination with SP AusNet, arranged to repeat the previous switching sequence under similar system conditions to those that existed at the time of the incident to identify the cause of the generator trip.

The EPS No.2 unit was brought back to service and at 1044 hrs, the CB of No.2 EPS – MBTS 220 kV line at MBTS was closed. On this occasion both No. 1 and No. 2 generating units tripped out of service.

The status of EPS and connections to MBTS immediately after the test are shown in Figure 3.

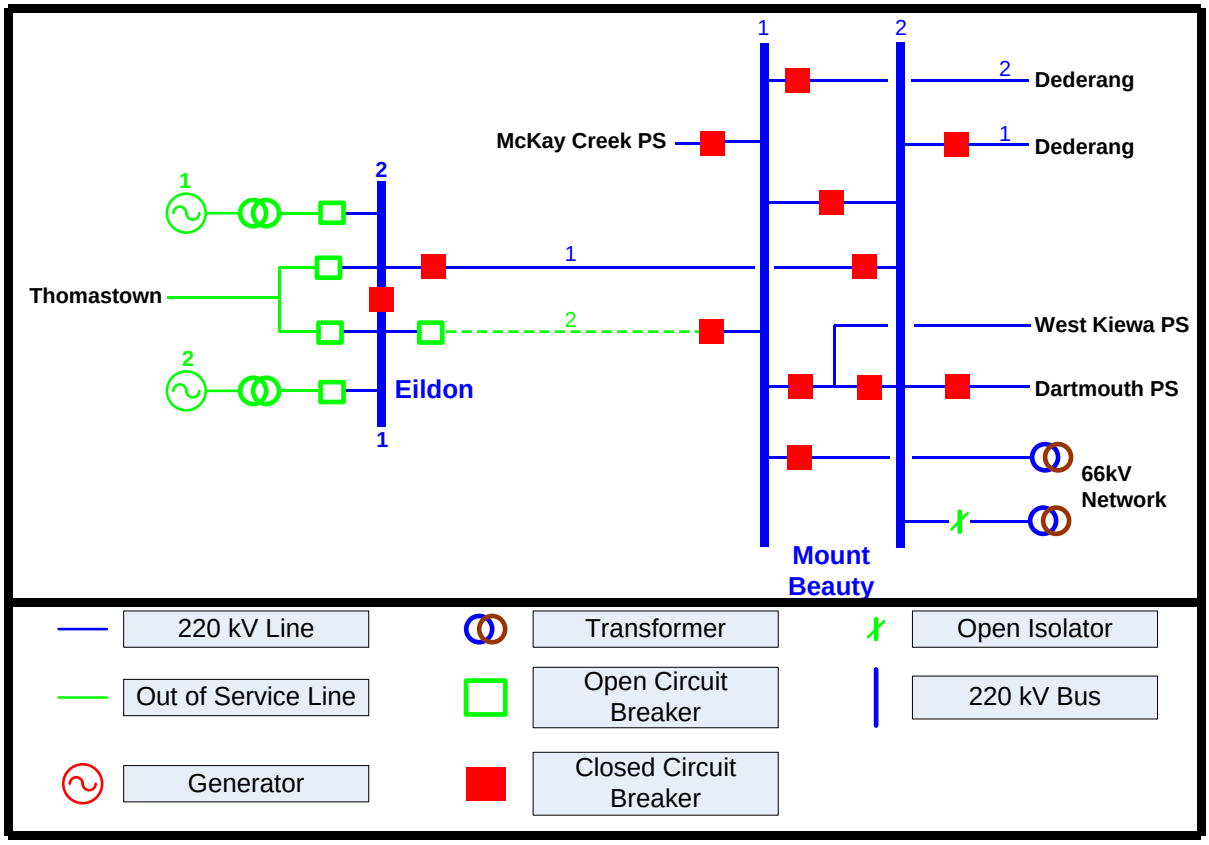

Figure 3 - Status of Eildon terminal station and connections to Mount Beauty immediately after the test

Onsite investigations showed that the trip of the 220 kV generator CBs at EPS were initiated by the operation of generator transformer protection relays. However, the exact reason for operation of these relays was not clear at this time.

The voltage at EPS terminal station was marginally above 240 kV till 1102 hrs. The voltage then reduced to below 240 kV when the Eildon generating units returned to service in synchronous condenser mode at approximately 1104 hrs.

At 1203 hrs, the power system was restored with both EPS – MBTS 220 kV lines in service and both Eildon generating units on synchronous condenser mode. The constraint set V-EPMB was revoked.

4 Follow-up Actions

Further investigations by AGL revealed that the generating unit's governor system had sent a trip signal to the generator transformer protection relay 150 ms after a line voltage disturbance caused by the closing of CB at MBTS end.

The governor electrical over-speed protection of EPS generating units had been set to operate instantaneously at the time. The speed measurement used by the governor electrical over-speed protection is derived using the voltage waveform of 220 kV voltage at the EPS switchyard. AGL determined that whenever a significant level of harmonics was present in this high voltage measurement, the governor electrical over-speed would operate.

During this power system incident and during the subsequent testing, closing of the EPS–MBTS line CB at MBTS resulted in a voltage disturbance which operated the governor electrical over-speed protection. The governor electrical over-speed protection then sent a trip signal to the generator transformer protection relay, resulting in the Eildon generating units tripping out of service. The testing conducted by AGL also confirmed that the generator transformer protection relay operated as designed during the incident.

Figure 4 shows the voltage disturbance that occurred as a result of the closure of CB at MBTS end at 1044 hrs on 18 August 2011.

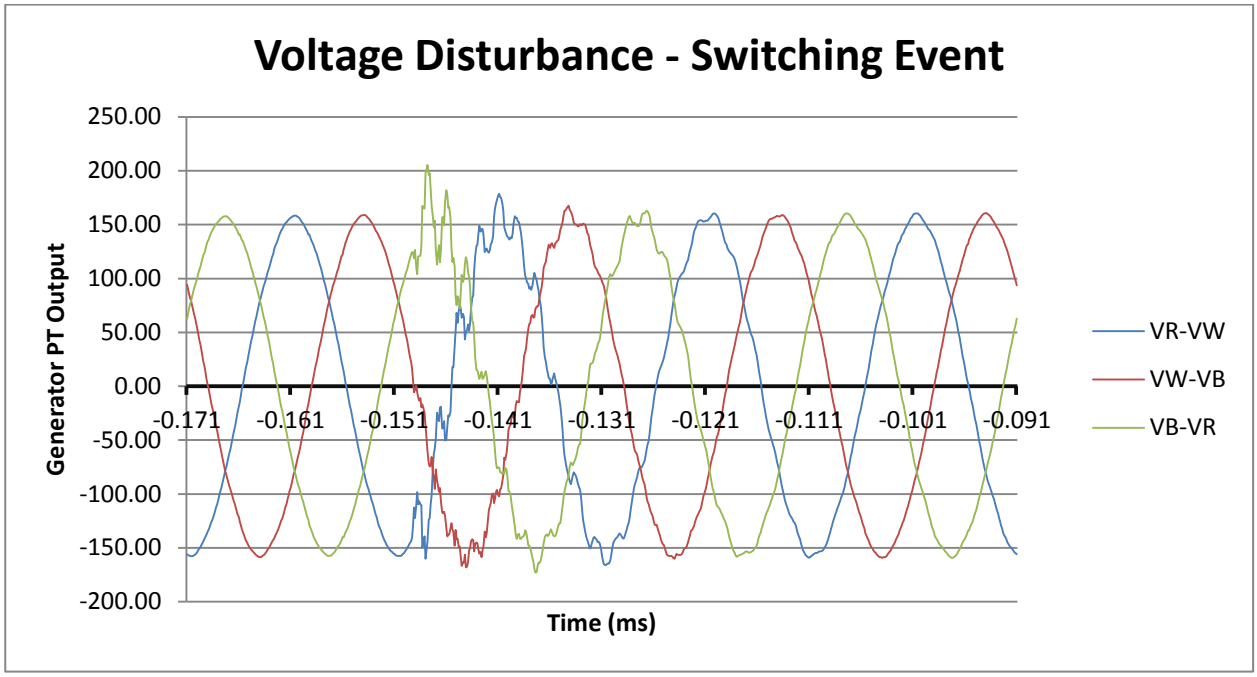

Figure 4 – Voltage disturbance during switching event of No.2 EPS – MBTS 220 kV line (Source: AGL)[4]

Initially, AGL inhibited the electrical over-speed protection as a temporary measure until a permanent solution could be implemented. Note that generator over-speed protection is also provided by two other independent protection systems.

Subsequently, AGL placed the governor electrical over-speed protection in service after introducing a time delay setting of 0.5 seconds. The new protection setting was tested and found to operate satisfactorily.

During this investigation AEMO noted some inconsistency in numbering of transmission lines connected to EPS in AEMO and AGL operating diagrams and SCADA displays.

5 Power System Security Assessment

Both Eildon generating units were operating in synchronous condenser mode there was no loss of generation as a result of the event. The power system frequency remained within the normal operating bands throughout the incident. The voltage at EPS was marginally above the normal operating limit for approximately 15 minutes during the incident.

6 Conclusions

AEMO concludes:

- The trip of No.2 EPS generating unit on closing of the No.2 EPS – MBTS 220 kV line at MBTS was caused by the operation of governor electrical over-speed protection of the generating unit.
- The presence of a significant level of harmonics in the voltage waveform used in the electrical over-speed protection of the generating unit caused the operation of governor electrical over-speed protection. This protection was disabled as a temporary measure.

[4] Time on x-axis was measured in reference to the point when both Eildon generating units tripped out of service.

- AGL modified the settings of governor over-speed protection to ensure operation only for genuine faults. The new protection setting was tested and found to operate satisfactory.

7 Recommendations

1. AEMO and SP AusNet will liaise with AGL to resolve inconsistent line numbering in their respective operating diagrams and SCADA displays with a view to resolve this by end of February 2012.
2. AEMO and SP AusNet will check whether both EPS generating units should be online for reactive power absorption before taking EPS–TTS line out of service for planned outages. If this is required AEMO and SP AusNet will update their respective outage planning procedures. AEMO and SP AusNet will complete this action by the end of February 2012.