POWER SYSTEM INCIDENT REPORT: OPERATION OF TASMANIAN NETWORK CONTROL SPECIAL PROTECTION SYSTEM ON 10 NOVEMBER 2010

PREPARED BY: Electricity System Operations Planning and Performance

FINAL

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1 Introduction

At 1344 hrs on 10 November 2010 the Tasmanian Network Control Special Protection System (NCSPS) operated to trip Bastyan and Tribute Power Stations. Subsequent to the operation of the NCSPS the dispatch process reduced generation at Cethana and Mackintosh substantially.

Both Bastyan and Tribute were returned to service by 1350 hrs. No load was interrupted as a result of the incident.

The power system in Tasmania remained in a secure operating state throughout the incident.

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

Hydro Tasmania and Transend have 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.

2 Pre-Contingent System Conditions

The west Tasmanian power system is connected to the rest of the Tasmanian power system through the No.1 and No.2 Sheffield-George Town 220 kV lines and the Sheffield-Palmerston 220 kV line.

On 10 November 2010 the No.1 Sheffield-George Town 220 kV line was out of service for planned maintenance when this power system incident took place at 1344 hrs. Power flow from the west Tasmanian network to the east Tasmanian network was 344 MW at the time. The pre-contingent status of the network between the west and east networks of the Tasmanian power system at 1344 hrs can be seen in Figure 1.

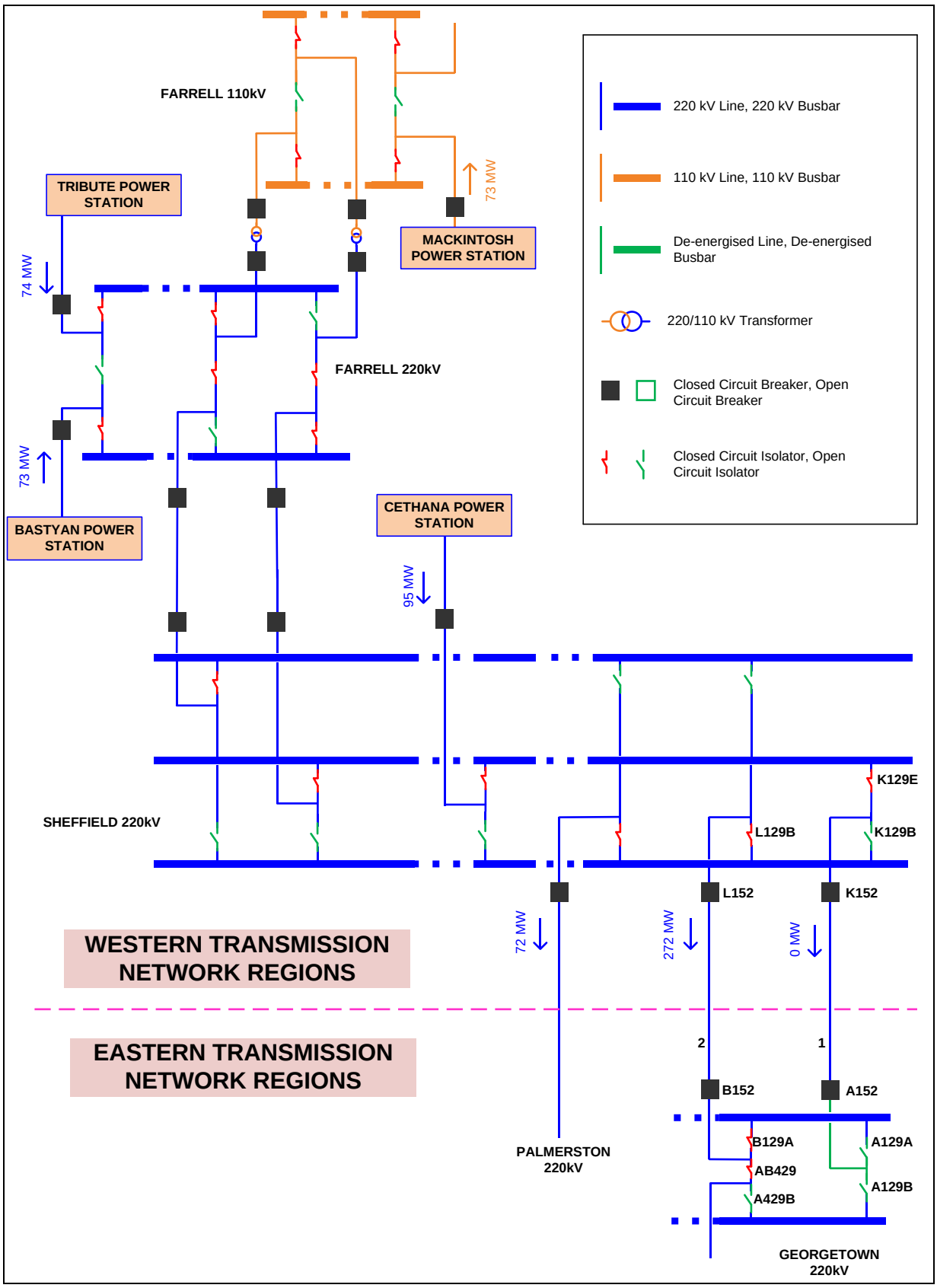

Figure 1 – Power System Prior to the Operation of the NCSPS

3 Summary of Events

At 1344 hrs on 10 November 2010, as part of the scheduled maintenance work on No.1 Sheffield-George Town 220 kV line, circuit breakers A152 and K152 were closed. As isolators A129A and A129B at the George Town 220 kV substation were open there was no power flow through the line after the circuit breakers were closed.

The circuit breaker K152 was closed at Sheffield and when the circuit breaker A152 was closed at George Town the Tasmanian NCSPS operated to trip the Bastyan Power Station (Bastyan) and the Tribute Power Station (Tribute). At the time of the incident Bastyan was generating 73 MW and Tribute 74 MW.

The status of the connection between the west and east Tasmanian power system immediately following the tripping of Bastyan and Tribute can be seen in Figure 2.

At the beginning of dispatch interval 13:50 (1345 hrs) Cethana received a dispatch target of 3 MW from an initial generation level of 97 MW and Mackintosh received a dispatch target of 25 MW from an initial generation level of 81 MW. By the end of dispatch interval 1350 (1350 hrs) Cethana and Mackintosh had achieved their dispatch targets.

Tribute and Bastyan returned to service at 1349 hrs and 1350 hrs respectively.

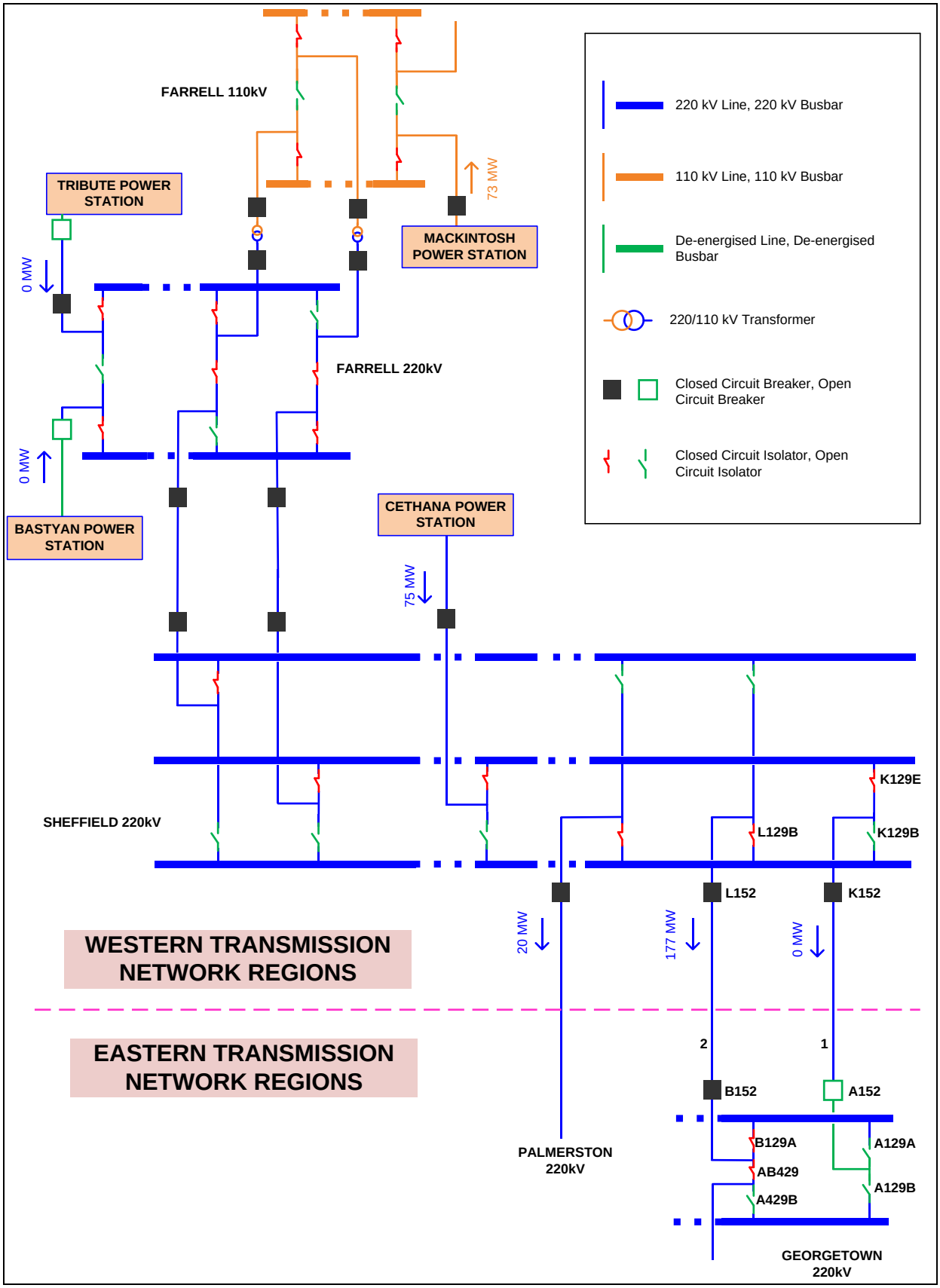

Figure 2 – Power System Immediately following the operation of the NCSPS

4 Management of Power System Security

The NCSPS is designed to prevent damage due to overload of specific power system elements within the Tasmanian power system. Protected elements include the No.1 and No.2 Sheffield-George Town 220 kV lines.

The NCSPS protects a power system element by estimating the power flow through that element. The estimation is based on the monitoring of circuit breakers on parallel flow paths to the protected element[1]. If the estimated power flow through the element exceeds the equipment's rated limit (rating) then the NCSPS will operate to reduce the power flow through the element.

The NCSPS uses two types of ratings for each element protected: the terminal rating, and the continuous rating. If the terminal rating is exceeded then the power flow across the element must be reduced very quickly (within seconds) to prevent damage to the equipment. If the continuous rating is exceeded but not the terminal limit then the power flow across the element can be reduced relatively slowly (within minutes).

The manner in which the NCSPS reduces power flow depends on the rating that has been violated. If the terminal limits are exceeded then the NCSPS initiates the fast tripping of selected generating units. If the continuous rating is exceeded but not the terminal limit then the NCSPS initiates delayed tripping of selected generating units[2].

Prior to the commencement of the scheduled maintenance on the No.1 Sheffield-George Town 220 kV line on 10 November 2011, the NCSPS was configured so that the protection logic associated with the No.1 and the No.2 Sheffield-George Town 220 kV lines was deactivated. This is as per Transend's operating procedures and was done to prevent the unintentional operation of NCSPS.

In preparation for the scheduled maintenance on the No.1 Sheffield-George Town 220 kV line isolators A129A and A129B at George Town were opened. With these isolators open no power flow was possible through the line.

The scheduled maintenance included opening and closing circuit breakers K152 at Sheffield and A152 at George Town. When both the circuit breakers were closed the NCSPS automatically reactivated the protection logic associated with the No.1 and the No.2 Sheffield-George Town 220 kV lines.

The NCSPS incorrectly identified the subsequent reopening of circuit breaker A152 as a trip of the No.1 Sheffield-George Town 220 kV line.

The terminal rating of the No.2 Sheffield-George Town 220 kV line is 1250 Amps. At the time of protection operation flow on the line was 659 Amps. However the NCSPS uses a calculation to determine post-contingency flows on the remaining line. The calculation used to determine the flow on the No.2 Sheffield-George Town 220 kV line following the trip of the No.1 Sheffield-George Town 220 kV line is:

[1] If circuit breakers on parallel flow paths to the protected element open then the amount of power flowing through the protected element will increase. The NCSPS uses a calculation to estimate the increase in power flow on the protected element.

[2] The delay action allows for the re-dispatch of units to relieve the overload. If the overload can be relieved through re-dispatch then tripping generating units can be avoided.

$$Post\ Trip\ Line\ Flow = 1.95 \times Pre\ Trip\ Line\ Flow$$

Using this calculation the NCSPS determined the post trip line flow to be 1285 Amps.

As the terminal limit was exceeded the NCSPS initiated the fast tripping of Bastyan and Tribute power stations.

Immediately prior to tripping the Bastyan was generating 73 MW and the Tribute 74 MW. In automatically selecting units to trip the NCSPS calculates how many generating units are required to be tripped to alleviate the overload. In case there is a failure to trip of one of the selected units, the NCSPS also selects for tripping one more unit than is necessary to alleviate the overload. To alleviate the suspected overload on the No.2 Sheffield-George Town 220 kV line the NCSPS selected Bastyan to trip[3]. Tribute was selected as the redundant unit.

At the beginning of the 1350 hr dispatch interval (1345 hrs) Cethana Power Station (Cethana) received a dispatch target of 3 MW from an initial generation level of 97 MW and Mackintosh Power Station (Mackintosh) received a dispatch target of 25 MW from an initial generation level of 81 MW. The reason for the large change in dispatch target was due to the action of constraint equation T>T_GTSH_220_1.

Prior to the outage of the No.1 Sheffield-George Town 220 kV line constraint set T-GTSH_BL was invoked by AEMO. Constraint T>T_GTSH_220_1 is a part of the constraint set T-GTSH_BL and is designed to prevent overloading of the No.1 Sheffield-Palmerston 220 kV line following the trip of No.2 Sheffield-George Town 220 kV line. This is done by constraining the output of generating units in west Tasmania.

The form of constraint equation T>T_GTSH_220_1 is:

$$\begin{aligned} &Dispatched\ Generation\ in\ Western\ Tasmania \\ &\quad < 0.95 \times (Rating\ of\ Sheffield - Palmerston\ 220\ kV\ line) \\ &\quad - 1.0 \times (Flow\ on\ Sheffield - Palmerston\ 220\ kV\ line) \\ &\quad - 1.095 \times (Flow\ on\ Remaining\ Sheffield - George\ Town\ 220\ kV\ line\ ) \\ &\quad + \ (Measured\ Generation\ in\ Western\ Tasmania) \end{aligned}$$

The calculated value of the right hand side of constraint equation T>T_GTSH_220_1 for dispatch interval 1345 was 458 MW and 318 MW for dispatch interval 1350. The change was largely due to the change in the "Measured Generation in Western Tasmania" term. The "Measured Generation in Western Tasmania" term was 147 MW lower at the beginning of the dispatch interval 1350 than at the beginning of dispatch interval 1345 due to the loss of Bastyan and Tribute Power Stations.

Even though the "Measured Generation in Western Tasmania" was correctly used in the dispatch process, the "Flow on Sheffield-Palmerston 220 kV line" and "Flow on Remaining Sheffield-George Town 220 kV line" measurements had not been updated. Hence at the time of commencing dispatch calculation for the dispatch interval 1350 the line flow measurements represented their higher pre-incident levels[4]. To satisfy the reduced right hand side of this equation for dispatch

[3] The NCSPS selects units from a prioritised list. At the time of the incident, the two power stations that had highest priority for tripping, and were available, were respectively Bastyan and Tribute.

[4] The dispatch process uses real time SCADA data inputs that are captured from AEMO's energy management system (EMS) database. These SCADA inputs are typically based on updated measurements obtained from participants' operational metering systems. The complete set of SCADA data inputs that are captured by the dispatch process may not always present an internally

interval 1350 the dispatch process issued reduced dispatch targets for Mackintosh and Cethana to 3 MW and 25 MW respectively.

Following their tripping, the offered availability of Bastyan and Tribute to the Electricity Market was not changed[5]. Hence at the start of the 1350 dispatch interval (1345 hrs) Bastyan and Tribute were still seen by the dispatch process as being available for generation. Hence for the dispatch interval 1350, Bastyan and Tribute were issued dispatch targets of 73 MW[6] and 74 MW respectively. This further resulted in reduced generation in the power system. For dispatch interval 1355 Bastyan was issued a dispatch target of 5 MW reflecting a reduction of its ramp rate from 30 MW/min to 1 MW/min for that dispatch interval only while it was disconnected from the system.

At 1349 hrs Tribute returned to service and began ramping up generation to meet its dispatch target. At 1357 hrs Tribute met its dispatch target of 74 MW.

At 1350 hrs Bastyan returned to service and began ramping up generation to meet its dispatch target. At 1352 hrs Bastyan met its dispatch target of 5 MW.

The combination of reduced generation at Cethana and Mackintosh along with the allocation of non-zero dispatch targets to Bastyan and Tribute whilst they were unavailable resulted in a net deficit of 191 MW of generation in Tasmania during dispatch interval 13:55, as shown in Figure 3.

consistent view of the power system owing to, for example, different refresh rates of individual SCADA items.

For dispatch interval 1350 SCADA data inputs were capture shortly after the operation of the NCSPS, with the “Measured Generation in Western Tasmania” measurement already updated to reflect the trip of the Bastyan and Tribute units but the “Flow on Sheffield-Palmerston 220 kV line” and “Flow on Remaining Sheffield-George Town 220 kV line” measurements had not yet been updated to reflect the off-loading of these lines as a result of the unit trips.

[5] The offered availability of a generating unit is specified in a unit’s energy market offer. A generating unit may change the amount of offered availability by submitting a revised energy market offer. Following the tripping of Bastyan and Tribute revised energy offers were not received by the dispatch process.

[6] In order to satisfy the reduced right hand side of constraint equation T>T_GTSH_220_1 in dispatch interval 1350 Bastyan also received a much reduced dispatch target.

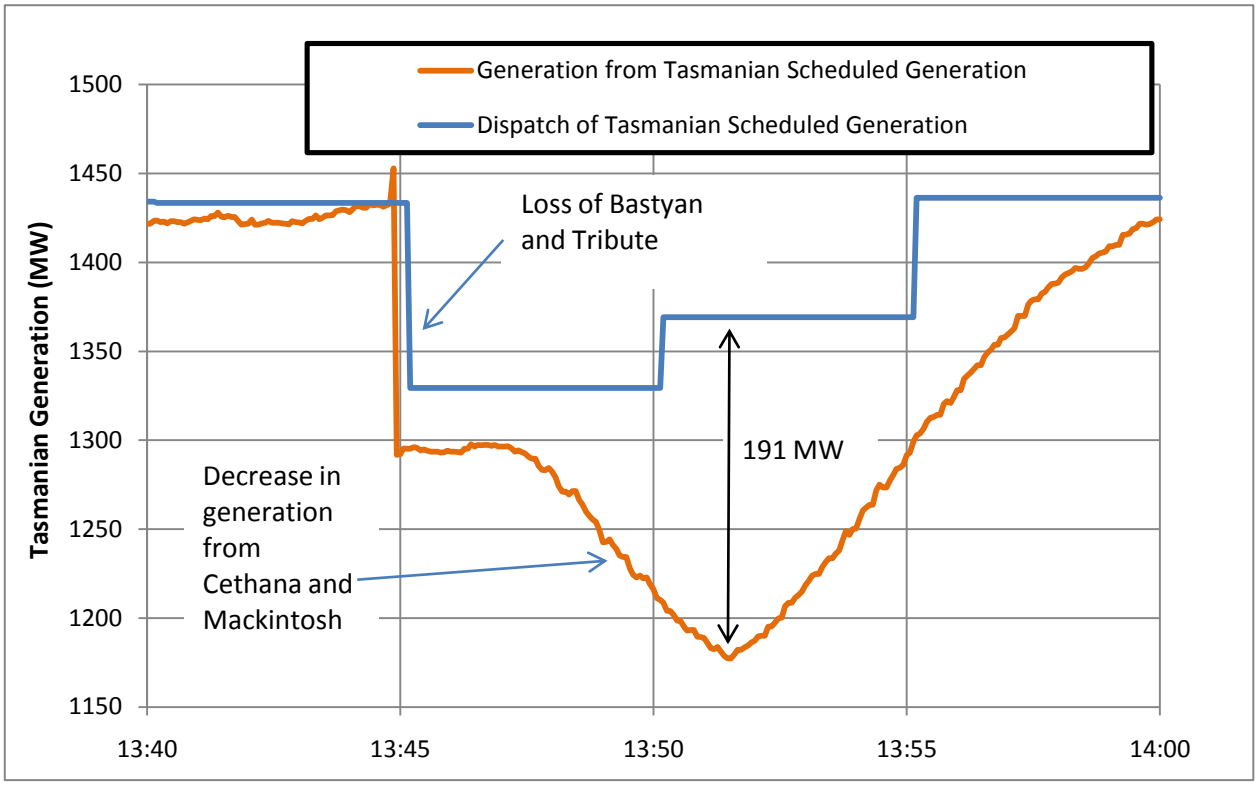

Figure 3 – Generation in Tasmania following the loss of Bastyan and Tribute Power Stations

Following the trip of Bastyan and Tribute the power system frequency in Tasmania fell to a minimum of 49.74 Hz. Power system frequency recovered to within the normal operating frequency band within four seconds, see Figure 4. This is within the requirements of the Tasmanian Frequency Operating Standards.

During the period when Bastyan and Tribute were being sent dispatch targets whilst they were unavailable the Tasmanian power system frequency declined below the normal operating frequency band twice for a total of 12 seconds.

The major controlling influence on the Tasmanian power system frequency was the Basslink frequency controller, see Figure 4. The Basslink frequency controller alters the MW flow on the Basslink interconnector in response to changes in power system frequency.

When Bastyan and Tribute tripped Basslink flow was 330 MW from the Tasmania to the mainland regions. Immediately following the trip of the two Power Stations, Basslink reduced its flow to the mainland regions from 330 MW to approximately 200 MW. During the period when Bastyan and Tribute were dispatched whilst they were unavailable Basslink further reduced its flow to the mainland regions from 200 MW to 96 MW in order to manage Tasmanian power system frequency, see Figure 4.

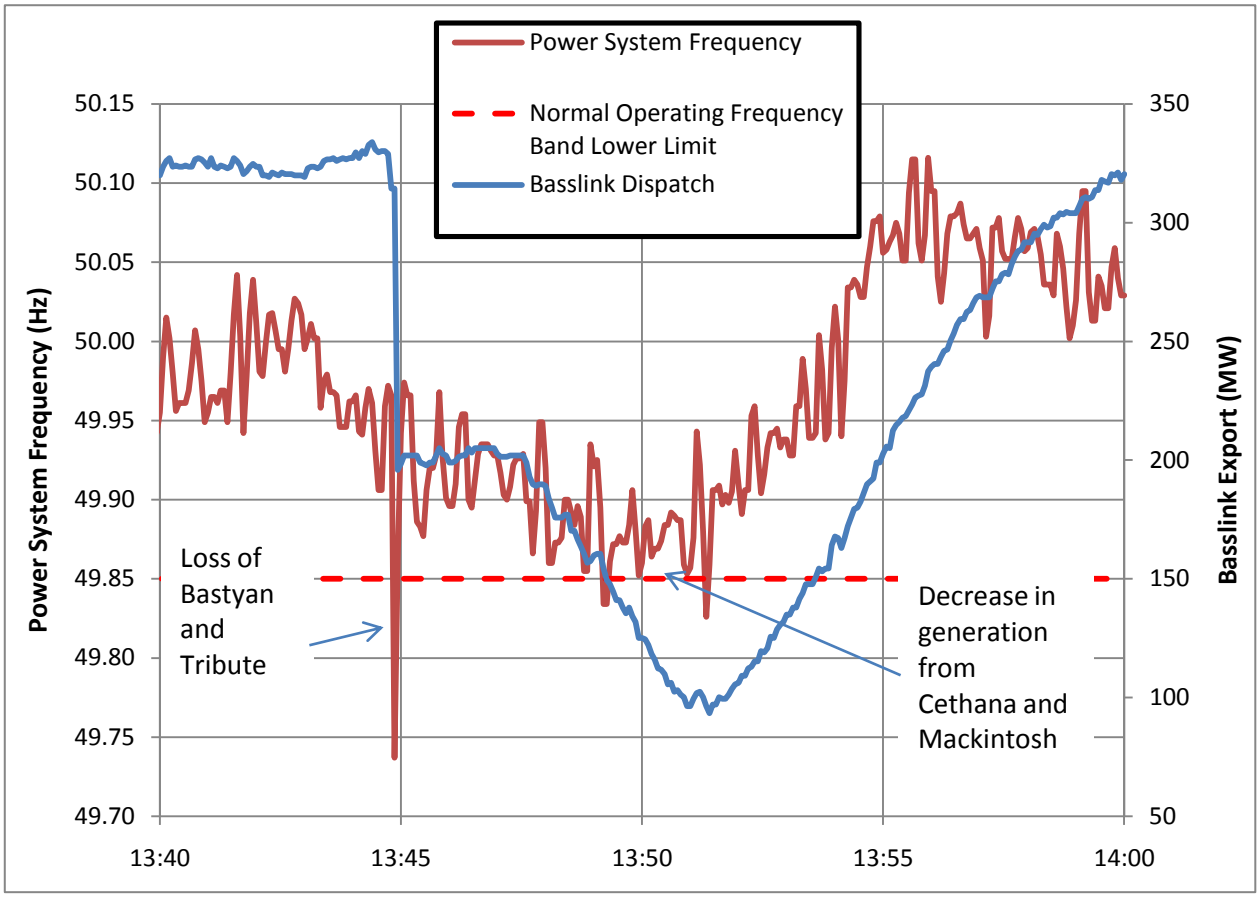

Figure 4 – Power System Frequency and Basslink Export following the loss of Bastyan and Tribute Power Stations

The power system remained in a secure operating state for the duration of the incident.

5 Follow-up Actions

To prevent future inadvertent operation of the NCSPS during planned outages, Transend have made the following changes to their operational procedures:

- Before commencing outages of NCSPS monitored lines, the monitoring will be deactivated and the monitoring should be reactivated only after the lines have returned to service.
- During the outages of NCSPS monitored lines, the line circuit breaker statuses will be hand-dressed to open state for the duration of the outage.

Transend are considering changes to the NCSPS to make the reactivation of NCSPS protection logic a manual rather than automatic process.

6 Conclusions

- Power system security was maintained throughout the incident
- The NCSPS worked as designed, however the incident has highlighted a deficiency in the logic used for the automatic reactivation of the NCSPS
- Transend have made changes to their operating procedures to prevent the unintentional reactivation of the NCSPS

- The NEM dispatch processes worked as designed, however the incident highlights a known and accepted issue with the impact of delays in the refreshing of SCADA data inputs to the dispatch process when a power system incident occurs shortly before initiating a dispatch process run

7 Recommendations

Transend will inform AEMO of the progress of its investigation into making the reactivation of NCSPS protection logic a manual process, by the end of June 2011.