POWER SYSTEM OPERATING INCIDENT REPORT – POTENTIAL INSECURE POWER SYSTEM OPERATION IN TASMANIA DUE TO NCSPS OPERATION ON 18 APRIL 2012

PREPARED BY: System Capability

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FINAL

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Abbreviations and Symbols

Abbreviation	Term
CB	Circuit Breaker
DI	Dispatch Interval
FCAS	Frequency Control Ancillary Service
kV	Kilovolt
MW	Megawatt
NCSPS	Network Control System Protection Scheme
NEM	National Electricity Market

1 Introduction

At 1549 hrs on 18 April 2012 the Palmerston – Sheffield 220 kV transmission line in Tasmania was off-loaded following the unplanned trip of circuit breaker (CB) F152 at Sheffield substation during work to remove redundant cables.

Several seconds later the Tasmanian Network Control System Protection Scheme (NCSPS) unexpectedly operated, tripping the Reece 1 and Reece 2 generating units from a combined total output of 226 MW.

Transend identified deficiencies with the operation of the NCSPS while investigating this incident, and to ensure ongoing security of the Tasmanian power system the NCSPS was disabled on 1 May 2012.

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 Transend. Data from AEMO's Energy Management System (EMS) and Electricity Market Management System (EMMS) has also been used in analysing the incident.

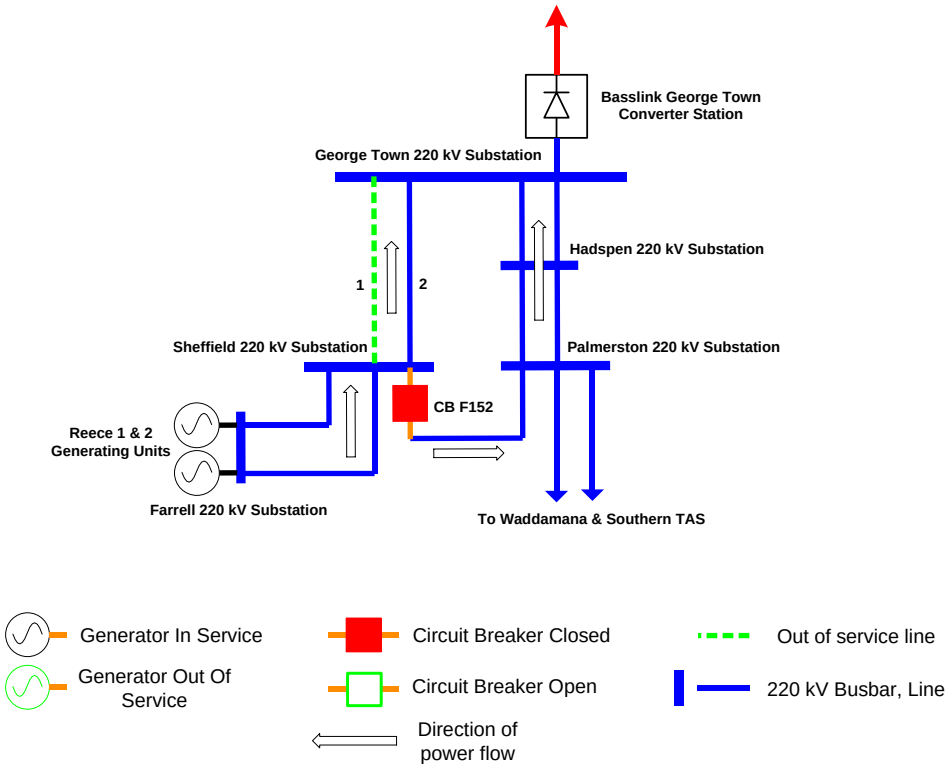
All references to time in this report are to National Electricity Market time (Australian Eastern Standard Time).

2 Pre-Contingent System Conditions

The status of the power system in northern Tasmania prior to the incident is shown in Figure 1. For clarity only the 220 kV network relevant to this incident has been included.

The Sheffield – George Town No. 1 220 kV line was out of service from 0311 hrs to 1833 hrs on 18 April 2012 due to planned work at George Town, and remained out of service throughout this incident. All other 220 kV transmission lines in Tasmania were in service prior to this incident. Basslink was transferring 360 MW from Tasmania to Victoria immediately prior to the incident.

Figure 1 - Status of the power system prior to the incident



3 Summary of Events

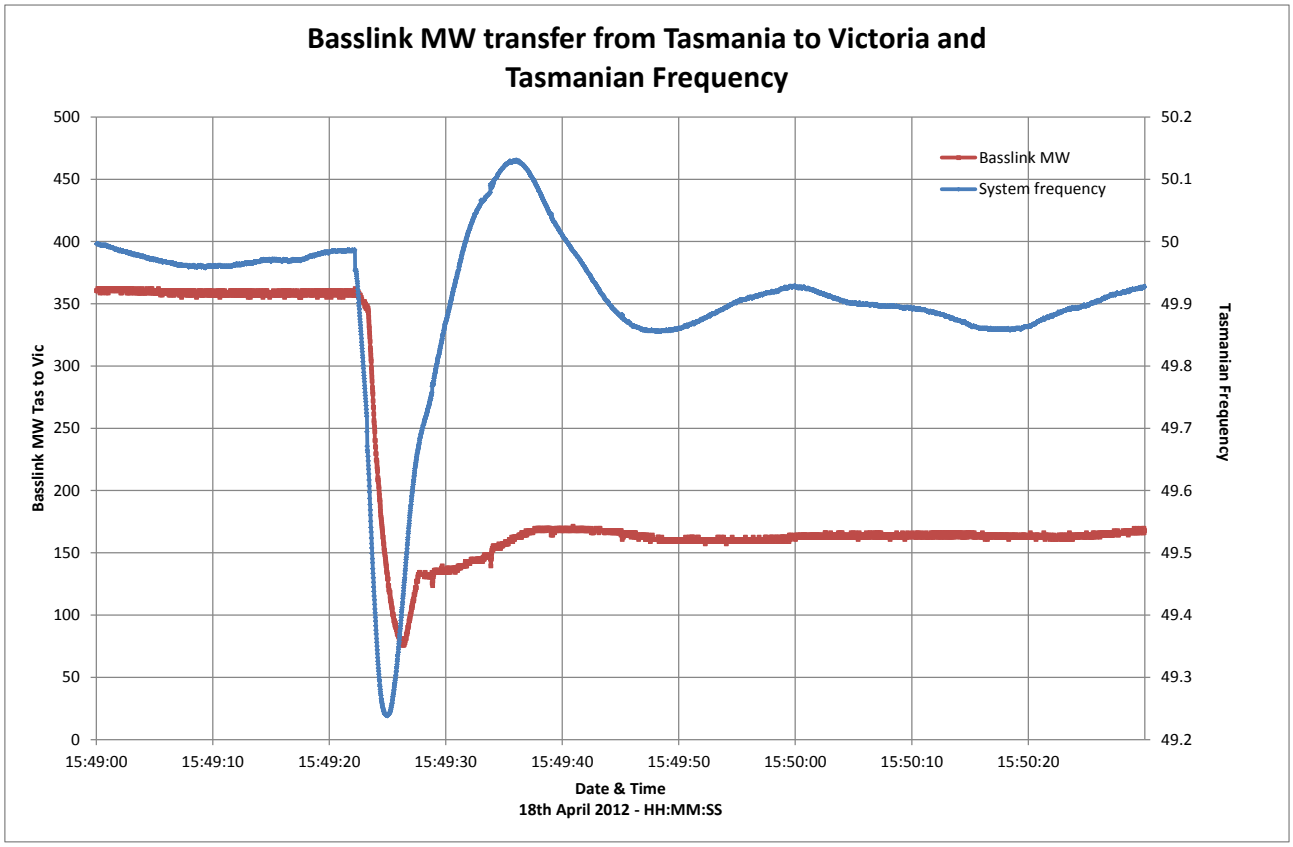
3.1 Initial Event

At 1549 hrs the 220 kV CB F152 at Sheffield substation opened, which off-loaded the Palmerston – Sheffield 220 kV line. The line opened at the Sheffield end only and remained energised from Palmerston throughout this event. The reason for CB F152 opening was identified as work to remove redundant control cables at Sheffield substation. 5 to 6 seconds after CB F152 opened, the NCSPS acted to trip Reece 1 and Reece 2 generating units from a combined output of 227 MW.

3.2 System response immediately following event

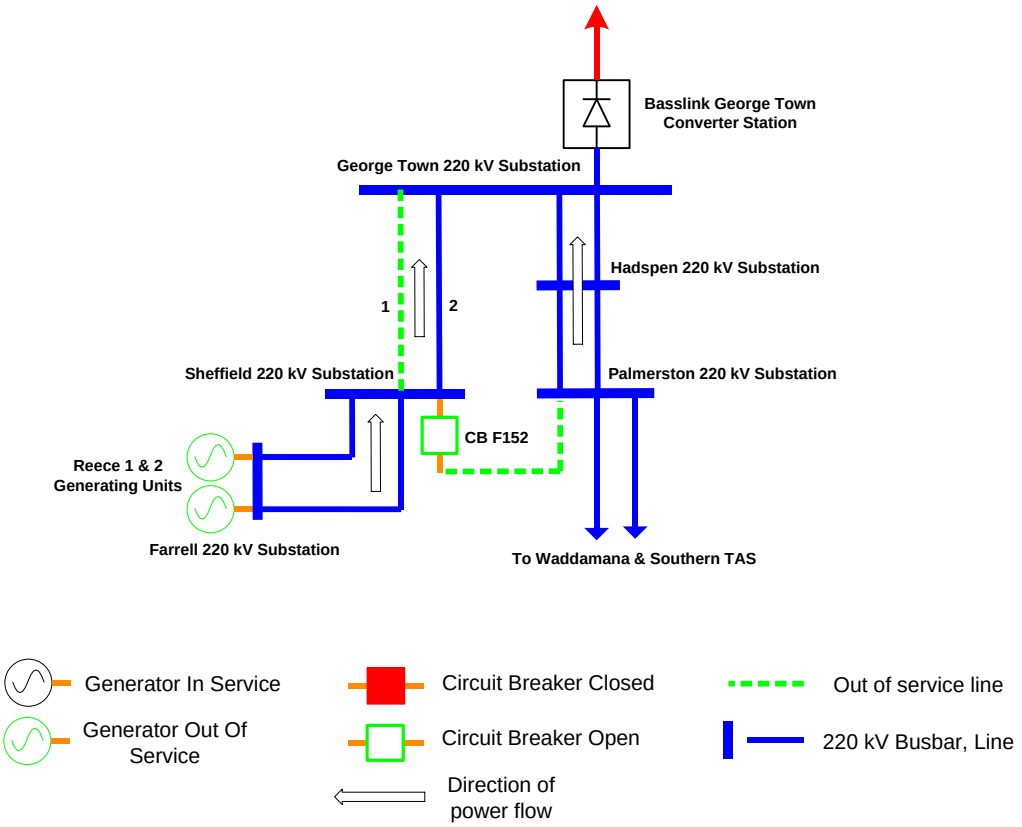
After the Reece 1 and Reece 2 generating units were tripped the Tasmanian frequency fell to a minimum of 49.24 Hz. In response to the fall in Tasmanian frequency, Basslink rapidly reduced transfer from Tasmania to Victoria from an initial transfer of 360 MW to a minimum of 85 MW, before stabilising again at 170 MW. Basslink MW and Tasmanian frequency are shown below in figure 2.

Figure 2 – Basslink MW transfers and Tasmanian frequency



The status of the power system immediately after the incident is shown in Figure 3.

Figure 3 - Status of the power system immediately after the incident



4 Immediate Actions Taken

Table 1 - Summary of immediate actions taken to ensure the security of the power system

Time on 18 April 2012	Action taken
1556 hrs	AEMO invoked constraint sets 'T-PMSH' and 'T-X_PMSH+GTSH' for the unplanned outage of the Palmerston – Sheffield 220 kV line, effective from dispatch interval (DI) ending 1605 hrs
1607 hrs	Reece 2 generating unit was returned to service
1610 hrs	Sheffield – Palmerston 220 kV line was returned to service.
1612 hrs	AEMO revoked the constraint sets 'T-PMSH' and 'T-X_PMSH+GTSH' for the outage of the Palmerston – Sheffield 220 kV line
1615 hrs	Reece 1 generating unit was returned to service

No further actions were taken at this time in response to this incident.

4.1 Market Impact

For the period that the constraint sets 'T-PMSH' and 'T-X_PMSH+GTSH' were invoked in central dispatch, a constraint equation within the first and second set was binding and violated, respectively.

The combined effect of these two constraints was to reduce output from most Tasmanian generation and to constrain Basslink flow to Victoria. This constraint action resulted in very high

Tasmanian energy prices of $12,500, $5,735.28 and $11,243.89 per MWh for the DI ending 1605, 1610 and 1615 hrs respectively, and high Tasmanian fast raise FCAS price of $1,358.40 per MWh for DI ending 1605 hrs. AEMO has published a separate pricing event report covering this outcome[1].

5 Follow-up Actions

Table 2 - Summary of follow-up actions taken

Date and Time of AEMO Market Notice	Action taken	Market Notice
19 April 1738 hrs	Following an initial investigation by Transend which raised concerns as to the action of the NCSPS during this incident, the NCSPS was disabled from 1800 hrs	38692
20 April 1416 hrs	NCSPS was re-enabled from 1430 hrs for all lines except the Sheffield – George Town and Sheffield – Palmerston 220 kV lines. The initial investigation by Transend into the action of the NCSPS only identified concerns related to action on these lines	38698
23 April 1610 hrs	Update on the investigation into the NCSPS. No change to the operation of the NCSPS at this time.	38743
27 April 1257 hrs	Further update on the investigation into the NCSPS. No change to the operation of the NCSPS at this time.	38759
1 May 1745 hrs	Following further investigation by Transend which identified more widespread problems with the NCSPS, the scheme was disabled for all lines at 1744 hrs	38776

Further information on the problems identified with the NCSPS is provided below.

5.1 Design of the NCSPS

The NCSPS is a control scheme installed in Tasmania as part of the establishment of the Basslink interconnector in 2006. The NCSPS facilitates higher power transfers on Basslink towards Victoria by allowing selected transmission lines in Tasmania to transfer power up to 95% of their continuous ratings, prior to the occurrence of a transmission contingency.

Following a transmission contingency that increases loading on one of the selected transmission lines above its continuous rating, the NCSPS is designed to rapidly reduce loading on the line to below its continuous rating by either tripping or rapidly reducing the output of generating units which impact on the loading of the line.

To compensate for this sudden reduction in generation in Tasmania, the NCSPS then relies on Basslink rapidly reducing power transfer from Tasmania to Victoria to restore the supply-demand balance, and hence the frequency, in Tasmania. As a result, NCSPS action is only enabled when Basslink is transferring power from Tasmania to Victoria.

The NCSPS allows significantly higher transmission line loadings in Tasmania than would otherwise be possible, and when the NCSPS is not in service there may be a significant reduction in the capability of the Tasmanian transmission system.

[1] http://www.aemo.com.au/en/Electricity/Market-and-Power-Systems/NEM-Reports/Pricing-Event-Reports-April-2012

5.1.1 NCSPS generation arming

The NCSPS operates on a continuous 4 second calculation cycle. Every 4 seconds it measures the current flow on selected transmission lines, and then calculates what the current flow would be on that transmission line following selected critical transmission contingencies.

If this flow would be above the continuous rating of the line, the NCSPS then calculates what generation would need to be tripped or off-loaded to reduce loading on the transmission line to below its continuous rating following this critical contingency. This list of generation to be tripped or off-loaded following selected contingencies is then stored by the NCSPS until the next 4 second calculation cycle.

If the NCSPS then detects that a critical transmission line is open at the start of the next 4 second calculation cycle, the NCSPS will then trip or off-load the generation it has previously determined for that particular transmission contingency, in order to reduce the transmission line loading to below the continuous rating.

5.2 Incorrect NCSPS action on 18 April 2012

Analysis by Transend of the action of the NCSPS on 18 April 2012 determined:

- The NCSPS tripped the Reece 1 and 2 generating units following the opening of the Palmerston – Sheffield 220 kV line in order to remove what it assessed was an overload on the Sheffield – George Town No. 2 220 kV line.
- The current loading on the Sheffield – George Town No. 2 220 kV line was 589 Amperes immediately before, and 767 Amperes immediately after the opening of the Palmerston – Sheffield 220 kV line, well below the 1,250 Ampere continuous rating of the Sheffield – George Town No. 2 line.
- It was not necessary for the NCSPS to trip the Reece units, as the loading on the Sheffield – George Town No. 2 220 kV line did not exceed 95% of its continuous rating following the opening of the Palmerston – Sheffield 220 kV line.
- The NCSPS acted in accordance with its design, based on the SCADA inputs it received during this event.

Investigation by Transend determined that the SCADA inputs used by the NCSPS for line circuit breaker status and for line loading were inconsistent, due to problems with data latency and synchronisation.

These SCADA inputs are used by the NCSPS to determine the need for generation tripping, and as a trigger to initiate generation tripping,

The NCSPS initially only detected the increase in the line current on the Sheffield – George Town No. 2 220 kV line, and used this increased current to calculate the required amount of generation to arm for tripping following various contingencies.

The NCSPS only detected the opening of CB F152 at Sheffield, which caused the increased line current, 5 to 6 seconds after CB F152 opened. This delay meant that the NCSPS incorrectly assessed that the increase in line current was pre-contingent, rather than post-contingent.

Upon detecting the opening of CB F152, the NCSPS immediately tripped the generation it had previously calculated and armed for this particular contingency, in this case the Reece 1 and 2 generating units.

The data synchronisation and latency issues relate to the performance of Transend's SCADA system, which is used by the NCSPS to detect line currents and the status of circuit breakers.

These issues are important for two reasons:

1. The NCSPS was designed on the assumption that a change in CB status would always be detected by the NCSPS before, or at the same time as, the change in line current

measurement resulting from that CB status change. This synchronised measurement of changed conditions did not occur during this incident.

This assumption is key to the correct calculation of the amount of generation that needs to be tripped or off-loaded by the NCSPS to remove a line overload, as the NCSPS will not otherwise be aware of the correct configuration of the transmission system when making the calculation.

2. The 5 to 6 second delay in detecting a change of CB status significantly exceeded a 3 second latency design requirement specified for the NCSPS. This 3 second maximum latency requirement allows for correct coordination between the primary NCSPS and a backup NCSPS control scheme.

   Lack of coordination between the primary and backup NCSPS could potentially result in un-coordinated over-tripping of generation, and a breach of the Tasmanian frequency operating standards for a credible network contingency resulting in NCSPS action.

Further investigation by Transend found that similar data latency and synchronisation issues may occur at a number of other switchyards in Tasmania, and that the issues might not be entirely predictable.

As a result, Transend determined that there was an ongoing risk of similar incidents occurring where the NCSPS may operate inappropriately.

On 1 May 2012 Transend disabled the NCSPS for all lines in Tasmania, and it remains disabled at the time of writing.

5.3 NCSPS action on 14 April 2012

At around 2112 hrs on 14 April 2012, several days before the incident described in this report, the NCSPS acted to trip generation following the planned opening of a circuit breaker at the George Town 220 kV switchyard. In this incident, the Reece 2 and Bastyan generating units were tripped from a combined total output of 179 MW.

Investigation by Transend of this incident determined that the NCSPS operated in accordance with its design. On this occasion, the tripping of generation occurred because the Sheffield – George Town No. 1 220 kV line should have been, but was not, disabled in the NCSPS prior to opening the circuit breaker at George Town. Had this line been disabled in the NCSPS it would not have tripped generation on this occasion.

6 Power System Security Assessment

During the incident on 18 April 2012, all power system voltages remained within the normal operating bands and the Tasmanian frequency remained within the band required for a load or generation event specified in the Tasmanian Frequency Operating Standards.

Subsequent investigation of this incident by Transend determined that the Tasmanian power system may have been operated insecurely on a number of previous occasions due to the potential action of the NCSPS tripping more generation than could be compensated for by either Basslink or generation within Tasmania.

It is not possible at this time to directly determine the amount of time the Tasmanian power system may have been operated insecurely, due to the unpredictable nature of the SCADA data latency and synchronisation issues.

The NCSPS was disabled by Transend on 1 May 2012, and will remain disabled until the underlying problems with the implementation and design of the NCSPS can be addressed. With the NCSPS disabled existing constraint and operating arrangements in Tasmania will ensure the ongoing secure operation of the Tasmanian power system.

7 Conclusions

On 18 April 2012, the NCSPS unexpectedly tripped 227 MW of generation following the opening of a circuit breaker at Sheffield substation.While the NCSPS acted in accordance with its design, it was not necessary for the NCSPS to trip generation to manage transmission line loadings on this occasion.

Investigation by Transend determined that the generation tripping occurred due to issues with the synchronisation and latency of measurements of line current and circuit breaker status used by the NCSPS. These issues ultimately related to the performance of Transend's SCADA system. Similar issues were subsequently detected at other switchyards in Tasmania.

On 1 May 2012, Transend disabled the NCSPS to ensure the ongoing security of the Tasmanian power system, and the scheme remains disabled at this time.

8 Recommendations

Transend to modify the implementation or design of the NCSPS to ensure security of the Tasmanian power system.

Transend to advise AEMO of any changes made to the implementation or design of the NCSPS prior to it returning to service, to allow AEMO to confirm the security of the Tasmanian power system.

It is expected that these recommendations will be completed by the end of September 2012.