

POWER SYSTEM OPERATING INCIDENT REPORT

VIOLATION OF THE FREQUENCY OPERATING STANDARDS IN TASMANIA ON 29 JULY 2011

PREPARED BY: Electricity System Operations Planning and Performance

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FINAL

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Purpose

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Abbreviations and Symbols

Abbreviation	Term
ACE	Area Control Error
AEMO	Australian Energy Market Operator Ltd
AGC	Automatic Generation Control
CB	Circuit Breaker
DI	Dispatch Interval
EST	Eastern Standard Time
EMS	Energy Management System
kV	kilovolt
FCAS	Frequency Control Ancillary Service
MASS	Market Ancillary Service Specification
MW	megawatt
NEM	National Electricity Market
NER	National Electricity Rules
XVPXSPT	AEMO's Setpoint Receiver Application

1 Introduction

On the 29 July 2011, a fault with AEMO's dispatch systems resulted in Basslink receiving incorrect dispatch targets on three separate occasions for the dispatch intervals (DIs) ending 0200 hrs to 0210 hrs, 0320 hrs to 0325 hrs and at 0455 hrs. This impacted the frequency control in Tasmania and resulted in the Tasmanian system frequency falling outside the normal operating frequency excursion band on all three occasions and failed to return to within the normal operating frequency band within 5 minutes.

The mainland system frequency remained within the normal operating frequency band during all three events.

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 AEMO and Basslink Pty Ltd. Data from AEMO's Energy Management System (EMS) have also been used in analysing the incident.

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

2 Pre-Contingent System Conditions

Thursday 28 July 2011

AEMO's Automatic Generation Control (AGC)¹ system at Mansfield control centre had been used without problem from the time the Energy Management System (EMS) database update was carried out at 1500 hrs on 20 July 2011 until the AGC function was transferred to the AGC system at Norwest control centre at 1026 hrs on 28 July 2011.

After the AGC transfer AEMO noted that Murraylink was no longer responding to its negative dispatch targets and remained dispatched at the last good dispatch target it received at 1020 hrs.

Subsequent investigations showed that the Setpoint Receiver (XVPXSPT²) application of the Norwest AGC system was failing to send correct dispatch targets to Murraylink because Murraylink was not correctly modelled as a bi-directional line. This incorrect modelling caused the blocking of negative dispatch targets (that is, power flow targets from South Australia to Victoria) from being sent to Murraylink. The Murraylink model was corrected and correct targets started reaching Murraylink at 1615 hrs.

After the Murraylink model used by the Norwest XVPXSPT application was corrected, the power transfer on Basslink was checked and found that it was receiving correct dispatch targets. However at the time the power flow on Basslink was in the positive direction (that is, from Tasmania to Victoria) so the check was inconclusive.

¹ The AGC system serves two purposes in the NEM. They are:

- Energy market dispatch: Generating units that are on remote control (on AGC) are ramped to their energy dispatch targets determined by NEMDE. In general any generating unit not enabled for regulation FCAS will be ramped to its energy dispatch target.
- Regulation FCAS dispatch: Actual frequency and time error values are compared to the desired frequency and time error to calculate the Area Control Error (ACE). This value is then used by the AGC to determine the desired MW outputs of the generating units enabled for regulation FCAS.

² Refer to Appendix A for a general description of AEMO's Setpoint Receiver application (XVPXSPT).

AEMO checked the Murraylink and Basslink models used by the Mansfield XVPXSPT application and found them to be correct. This was evidenced by the correct operation of the Mansfield XVPXSPT application for the period following the EMS database update on the 20 July 2011 at 1500 hrs until the AGC function was transferred to Norwest on the 28 July 2011 at 1026hrs.

The XVPXSPT application does not send dispatch targets to Directlink.

Following correction of the Murraylink model used by the Norwest XVPXSPT application, AGC remained operational from Norwest till approximately 0455 hrs on the 29 July 2011.

3 Summary of Events

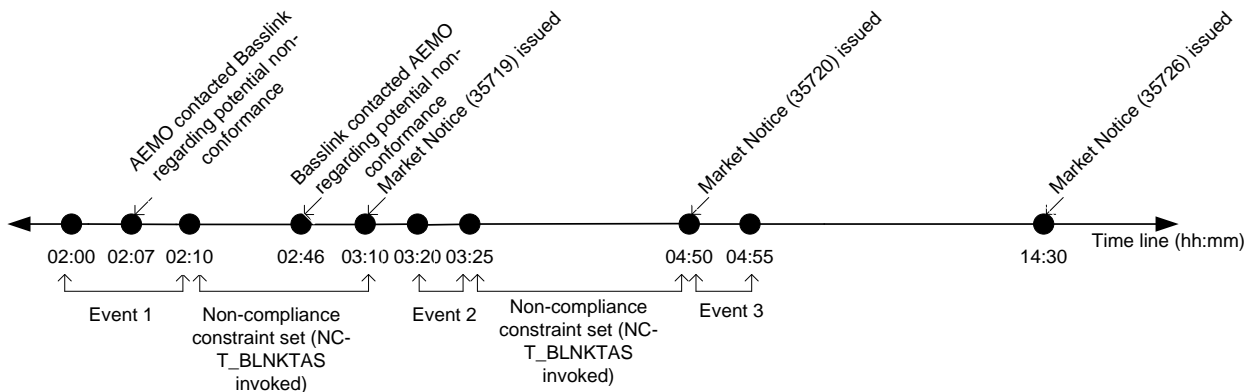


Figure 1: Time line summary of events on the 29 July 2011

3.1 Event 1: DIs ending 0200 hrs to 0210 hrs on 29 July 2011

Basslink was following its positive dispatch target (power flow from Tasmania to Victoria) of 52 MW for the DI ending 0155 hrs. For DIs ending 0200 hrs to 0210 hrs, negative dispatch targets of -94 MW, -155 MW and -154 MW respectively were determined by AEMO's dispatch systems but Basslink power transfer did not follow these targets and remained at around 47 MW. As shown in Figure 2 below, this caused the Tasmanian system frequency to fall to a minimum of 49.5 Hz at 0206 hrs. The Tasmanian system frequency was below 49.85 Hz for approximately 956 seconds as measured at the Chapel Street 220 kV substation.

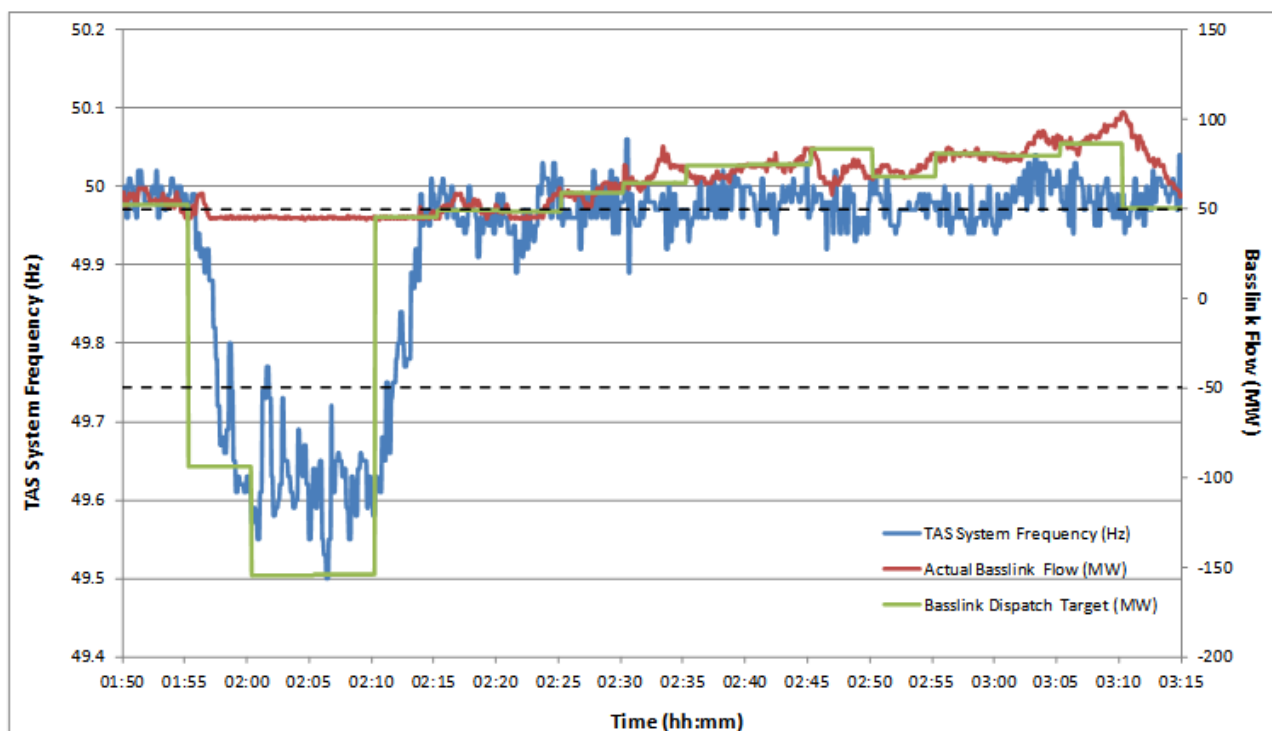


Figure 2: Event 1 – Basslink actual flow versus dispatch targets determined by AEMO’s dispatch systems

At 0207 hrs AEMO contacted the Basslink operator to notify that Basslink was not following its dispatch targets. The Basslink operator advised that it would take approximately one hour to investigate the cause.

In accordance with its procedures³, AEMO invoked the Basslink non-conformance constraint set NC-T_BLNKTAS for DIs ending 0215 hrs to 0310 hrs.

At 0246 hrs the Basslink operator contacted AEMO and informed that Basslink had not received dispatch targets from AEMO since DI ending 0200 hrs.

The Basslink operator investigated their control systems and correctly determined there were no faults with the Basslink systems and continued to work with AEMO and Transend to determine the root cause.

At 0308 hrs the Basslink non-conformance constraint set was revoked to see if the issue still existed.

At 0310 hrs AEMO issued Market Notice No.35719 to indicate that Basslink was non-conforming from 0210 hrs to 0310 hrs.

3.2 Event 2: DIs ending 0320 hrs to 0325 hrs on 29 July 2011

Basslink followed its positive dispatch target (power flow from Tasmania to Victoria) of 50 MW for DI ending 0315 hrs. However, for DIs ending 0320 hrs and 0325 hrs, negative dispatch targets of -53 MW and -156 MW respectively were determined by AEMO’s dispatch systems but the Basslink power transfer did not follow these targets and remained at around 50 MW. As shown in Figure 3 below, this resulted in the Tasmanian system frequency falling to a minimum of 49.16 Hz at 0326 hrs. The Tasmanian system frequency was below 49.85 Hz for approximately 584 seconds as measured at the Chapel Street 220 kV substation.

³ Refer to the “Power System Operating Procedure – Dispatch” available at:
<http://www.aemo.com.au/electricityops/3705.html>

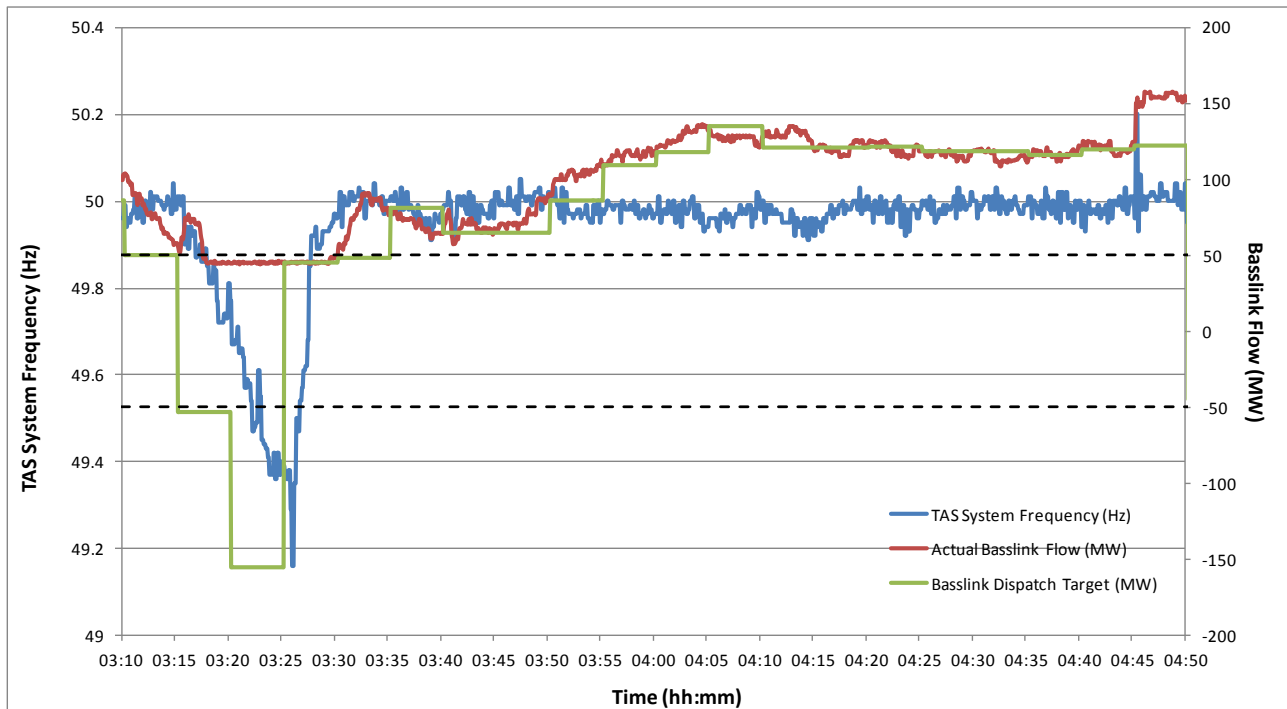


Figure 3: Event 2 – Basslink actual flow versus dispatch targets determined by AEMO’s dispatch systems

In accordance with its procedures⁴, AEMO invoked the Basslink non-conformance constraint set NC-T_BLNKTAS for DIs ending 0330 hrs to 0450 hrs.

At 0447 hrs the Basslink non-conformance constraint set was revoked to see if the issue still existed.

At 0450 hrs AEMO issued Market Notice No.35720 to indicate that Basslink was non-conforming from 0325 hrs to 0450 hrs

3.3 Event 3: DI ending 0455 hrs on 29 July 2011

Basslink followed its positive dispatch target (power flow from Tasmania to Victoria) of 122 MW for DI ending 0450 hrs. For DI ending 0455 hrs, AEMO’s dispatch systems determined a negative dispatch target of -45 MW but the Basslink power transfer was not consistent with this target. As shown in Figure 4 below, this resulted in the Tasmanian system frequency falling to a minimum of 49.62 Hz at 0455 hrs. Tasmanian system frequency was below 49.85 Hz for approximately 340 seconds as measured at the Chapel St 220 kV substation.

⁴ Refer to the “Power System Operating Procedure – Dispatch” available at:
<http://www.aemo.com.au/electricityops/3705.html>

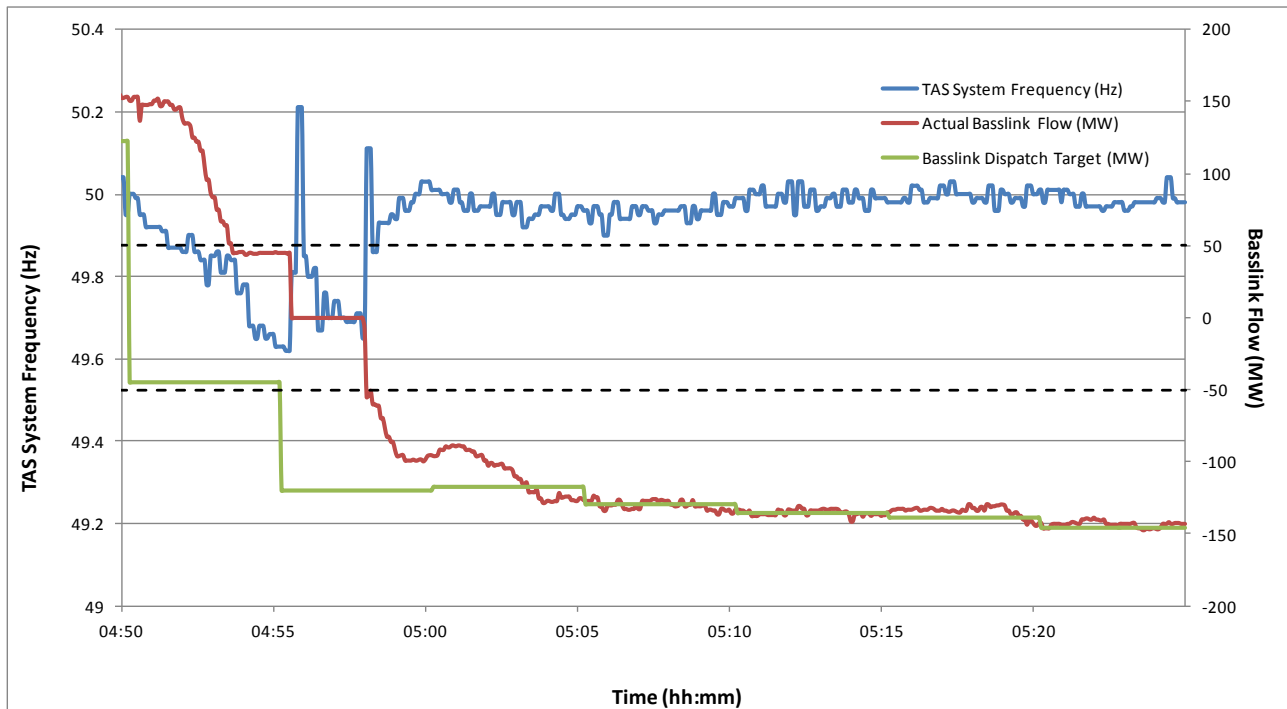


Figure 4: Event 3 – Basslink actual flow versus dispatch targets determined by AEMO's dispatch systems

4 Immediate Actions Taken

4.1 Immediate actions taken by AEMO

Some of the immediate actions taken (such as invoking and revoking of constraint sets, issuing of market notices) are summarised in section 3.

When Basslink did not follow its dispatch targets for DIs ending 0200 hrs to 0210 hrs and 0320 hrs to 0325 hrs, AEMO subsequently invoked the Basslink non-conformance constraint set NC-T_BLNKTAS. This constraint set ensured that the Basslink dispatch target calculated by AEMO's dispatch systems was set to the actual Basslink flow at the beginning of the dispatch interval and that the Basslink flow remained in the positive direction (power transfer from Tasmania to Victoria).

At 0246 hrs the Basslink operator reported that Basslink was not receiving negative dispatch targets. At 0440 hrs AEMO determined that its XVPXSPT application was not sending negative dispatch targets correctly to Basslink..

Given this, at 1430 hrs later that day AEMO issued the Market Notice No.35726 withdrawing the Basslink non-conformances previously declared in Market Notices Nos.35719 and 35720.

At 0450 hrs, AEMO revoked the non-conformance constraint set NC-T_BLNKTAS. The dispatch target for DI ending 0455 hrs was -45 MW. However, Basslink power transfer was not consistent with its dispatch target. At 0453 hrs AEMO transferred the AGC function from the Norwest control centre to the Mansfield control centre, at which point consistency of the Basslink power transfer and its negative dispatch targets was observed.

4.2 Immediate actions taken by Basslink Operator

The Basslink operator indicated that for DIs ending 0200 hrs to 0210 hrs, 0320 hrs to 0325 hrs and 0455 hrs, when the dispatch targets for Basslink were negative, Basslink systems at the George Town converter station received target values of 4095 from AEMO's XVPXSPT application, which

were reset to the default value of +600 as designed⁵. There were no power transfer targets received at the Basslink systems at the Loy Yang converter station. By design AEMO sends dispatch targets to both the Loy Yang and Georgetown converter stations.

Appendix B shows a graph – taken from Basslink’s Human Machine Interface⁶ at George Town – of power target setpoints determined by the Basslink systems and actual power transfers. The following observations can be made from that graph for each of the three events:

- Although Basslink systems limited the dispatch target value of 4095 to +600, which in turn retransmitted a target setpoint of 594 MW to Basslink’s Station & Pole Control systems⁷, as a result, the actual Basslink flow remained just above the “no-go zone”⁸. This is because the Basslink frequency controller prevented the interconnector from achieving the target setpoint (the red trace) of 594 MW.
- A change in Tasmanian system frequency (the green trace) is observed in each of the three events as the Basslink frequency control action prevented the interconnector from achieving the dispatch targets (the red trace) of 594 MW, thus preventing the Tasmanian system frequency from falling any lower than what was actually observed.
- After each of the three events, Basslink interconnector correctly followed dispatch targets (the red trace).

5 Follow-up Actions

After the AGC function was transferred to the Mansfield control centre at 0453 hrs on 29 July 2011, log records of Norwest AGC were checked for evidence of manual changes applied to the XVPXSPT database since the previous database update on 20 July 2011, but it was not possible to find records of such changes. Due to the time between the previous database upload and this incident, such evidence had been overwritten by more recent log records.

As in the case of Murraylink not receiving negative dispatch targets on 28 July 2011, subsequent investigations showed that the XVPXSPT application was sending incorrect dispatch targets because it had not modelled Basslink as a bi-directional line, thus blocking negative dispatch targets from being sent.

AEMO subsequently rebuilt the XVPXSPT database at the Norwest control centre with the correct Basslink model and implemented increased logging in EMS systems to maintain records of manual changes to the XVPXSPT database. At 1051 hrs on 29 July 2011 the AGC function was subsequently transferred to the Norwest control centre.

⁵ Basslink systems are designed such that when setpoint values of 4095 are received from AEMO’s dispatch systems, the Basslink setpoint is capped to +/- 600 and retransmitted to Basslink’s Station & Pole Control systems. These setpoints correspond to power transfer targets of 594 MW and -478 MW respectively.

⁶ The Human Machine Interface provides a sequence of event recorder information with all control actions and events time stamped to an accuracy level of milliseconds.

⁷ The red trace represents Basslink dispatch targets received, as capped where values of 4095 are received.

⁸ Basslink is unable to transfer FCAS while the power flow through Basslink is within the “no-go zone”. Basslink is considered operating within the “no-go zone” if either the dispatch target in the previous dispatch interval or the measured Basslink flow (MW) at the start of the current dispatch interval is on or within +/- 50 MW.

6 Power System Security Assessment

6.1 Power system security assessment for the mainland regions

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

There were no disconnections of generation or load interruptions in the mainland power system as a result of this incident.

6.2 Power system security assessment for the Tasmania region

The Tasmanian and mainland regions remained interconnected during the three events, hence the applicable frequency operating standards⁹ are for the “Normal Condition” specified in the Tasmanian frequency operating standards – interconnected system. The “Normal Condition” requires that the frequency be contained within 49.75 – 50.25 Hz, be stabilised and restored to within 49.85 Hz – 50.15 Hz within 5 minutes and should not be outside 49.85 Hz – 50.15 Hz for more than 1% of the time in a 30 day period. However, during the three events the frequency fell to below 49.75 Hz and took approximately 956 seconds, 584 seconds and 340 seconds respectively to recover to within 49.85 Hz – 50.15 Hz.

The frequency operating standard was therefore not met in the Tasmanian power system for the containment, stabilisation and recovery¹⁰ phases of the three events.

The constraint set F-I_NIL is invoked in AEMO’s dispatch systems at all times. This constraint set contains constraint equations that ensure sufficient Frequency Control Ancillary Services (FCAS) are enabled in the NEM for regulation and contingency requirements, on the basis that the Basslink power transfer would be consistent with its dispatch targets.

AEMO’s evaluation of the delivery of enabled FCAS services within the Tasmanian power system is as follows:

- AEMO was not able to verify the amount of Fast Raise FCAS delivered because high speed data was not available for verification. This was because the conditions required to trigger the event data recorders¹¹ were not met during any of the three events.
- AEMO was not able to verify the amount of Slow Raise FCAS¹² delivered because Fast Raise FCAS information was not available (refer previous dot point).
- The amount of Delayed Raise FCAS delivered by most generating units was 0 MW. This is because the trigger settings for the delivery of Delayed Raise FCAS were not reached for most of the generating units enabled for this service. Note that all of the generating units enabled for Delayed Raise FCAS in Tasmania during these events use switching controllers to trigger service delivery.

⁹ The frequency operating standards for the mainland and Tasmania regions are available at:
<http://www.aemc.gov.au/Panels-and-Committees/Reliability-Panel/Guidelines-and-standards.html>.

¹⁰ Definition of the terms “containment”, “stabilisation” and “recovery” are outlined in the frequency operating standards for the mainland and Tasmania regions.

¹¹ Section 2.5(ix) of the Market Ancillary Service Specification (MASS) states that the event data recorders in Tasmania are triggered when the system frequency deviation is 0.8 Hz and at a minimum rate of change of 0.15 Hz per second.

¹² When a unit is enabled for more than one contingency FCAS, the verification of Fast, Slow and Delayed services are inter-related, and both high speed data and 4 second data are required to carry out the verification of the enabled FCAS as outlined in the MASS.

- All generating units enabled for Regulation Raise FCAS responded correctly. In most cases the response would have been due to governor action rather than responses to AGC.

There was no disconnection of generation or load interruptions in Tasmania as a result of this incident.

6.3 Assessment of Operation of Basslink Interconnector

The immediate actions taken by Basslink Pty Ltd have been outlined in section 4 of this report.

Basslink operated as designed during the three events on 29 July 2011.

Subsequent discussions between AEMO and Basslink Pty Ltd revealed that Basslink was not aware of the interpretation of the dispatch target of 4095 sent by AEMO dispatch systems¹³. AEMO is currently addressing this issue.

6.4 Assessment of AEMO Actions

Actions Taken by AEMO on 28 July 2011

Section 2 of this report outlines the actions taken by AEMO to address the XVPXSTPT issue with Murraylink on the 28 July 2011.

Following this incident, the Basslink model for the Norwest XVPXSPT application should have also been checked to see if negative dispatch targets could be sent.

Actions Taken by AEMO on 29 July 2011

Sections 4 and 5 of this report outline the actions taken by AEMO following the three Basslink events that occurred on the 29 July 2011.

All actions taken by AEMO to restore the integrity of the Norwest XVPXSPT application were adequate. AEMO could have resolved such issues more promptly if AEMO had visibility of the dispatch targets sent from the XVPXSPT application, and procedures to check the validity of those dispatch targets.

Similar event on 15 December 2011

On the 15 December 2011, during investigations for this report, AEMO's dispatch systems again sent dispatch targets of 4095 to Basslink. Again, incorrect modelling of Basslink as a generator instead of a line occurred following a database upload, thus preventing the XVPXSPT application from sending negative dispatch targets to Basslink. Further investigation revealed the root cause was that the Basslink and Murraylink models were reverting to the default model of a generator following a database upload. This resulted in the incorrect modelling of Basslink and Murraylink in the Norwest XVPXSPT application. AEMO has subsequently updated its procedures on database updates of the XVPXSPT application to minimise the possibility of incorrect modelling of Murraylink and Basslink in the XVPXSPT application. AEMO has also issued a temporary operating advice to its control room staff to manage this situation. This temporary operating advice will be active until AEMO rectifies the problem associated with the modelling of Basslink and Murraylink in the Norwest XVPXSPT application.

7 Conclusions

A fault with AEMO's Setpoint Receiver (XVPXSPT) application resulted in AEMO's dispatch systems sending incorrect dispatch targets to Basslink on three separate occasions on the 29 July 2011. This led to the Tasmanian system frequency falling below 49.75 Hz during all three events.

¹³ As described in Appendix A

Tasmanian frequency did not stabilise and recover to within the normal operating frequency band of 49.85 Hz – 50.15 Hz within 5 minutes.

Following the 29 July 2011 incident, AEMO improved logging in its EMS system to ensure manual changes made to its XVPXSPT application can be tracked.

Following the repeat of this incident on 15 December 2011, AEMO has updated its procedures on database updates of the XVPXSPT application to minimise the possibility of incorrect modelling of Murraylink and Basslink.

AEMO is satisfied that it has taken suitable measures to minimise the risk of sending incorrect dispatch targets for Basslink and Murraylink following database updates of the XVPXSPT application. AEMO has issued a temporary operating advice to its on-control room staff to manage this situation. This temporary operating advice will remain active until AEMO is satisfied that the problem with the modelling of Basslink and Murraylink in the Norwest XVPXSPT application will not reoccur. Hence the reliability issues associated XVPXSPT application experienced during the three events investigated no longer exist.

AEMO is satisfied that Basslink operated as designed during the three events on the 29 July 2011.

AEMO correctly applied the criteria published in sections 6 and 7 of its “Operating Procedure – SO_OP3708A Frequency Control Ancillary Services” in the scheduling and dispatch of FCAS.

8 Recommendations

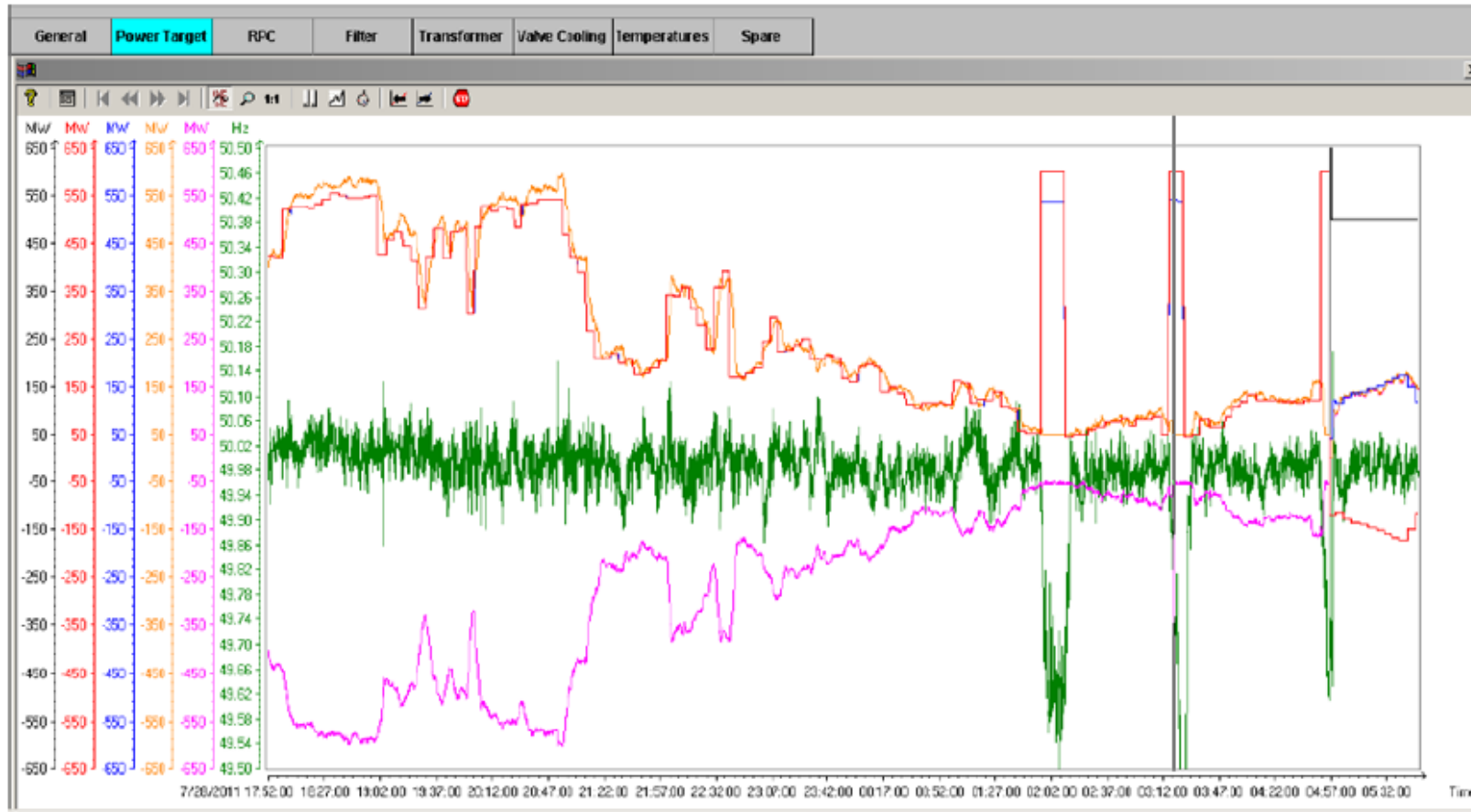
1. AEMO will send Basslink Pty Ltd a copy of the specification of XVPXSPT application to explain its functionality. AEMO will complete this action by 31 January 2012.
2. AEMO, Transend, Basslink Pty Ltd and SP AusNet will assess and determine a suitable solution and agree on an implementation plan to resolve Basslink systems receiving two different target values at the George Town and Loy Yang converter stations on rare occasions. This action will be completed by 30 April 2012.

Appendix A - General description of the AEMO Setpoint rReceiver application (XVPXSPT)

The XVPXSPT application sends 5 minute dispatch targets to Victorian power stations, Murraylink and Basslink. XVPXSPT sends 5 minute dispatch targets to Victorian power stations for manual dispatch of generating units whenever they are not dispatched by the AGC system.

The XVPXSPT monitors the MW dispatch target, the MW bid availability and the AGC status for each record in its database and issues the appropriate target value on receipt of the NEMDE solver trigger for each dispatch interval. Changes to a generating unit's AGC status will cause the target value of the generating unit to be sent immediately. If the unit is on AGC control or is not available for dispatch, the target value of 4095 is sent out. If a generating unit then switches to local control, AGC ceases issuing controls and XVPXSPT issues its current dispatch target immediately. From this point in time onwards while the unit remains off AGC, XVPXSPT will send its target values.

Appendix B - Power targets generated by Basslink systems as observed at the George Town human machine interface (Sourced from Basslink Pty Ltd)



Legend

---- DC Pole Power Capability - - - - DC Power Target Setpoint¹⁴ - - - - DC Power Setpoint - - - - Line Active Power - - - - Pole DC Power - - - - System Frequency

¹⁴ The red trace represents the NEMDE targets and the Basslink capped targets for dispatch intervals where setpoint values of 4095 were received.

