POWER SYSTEM OPERATING INCIDENT REPORT – INSECURE POWER SYSTEM OPERATION IN TASMANIA UP TO OCTOBER 2011

PREPARED BY: Systems Capability

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FINAL

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Abbreviations and Symbols

Abbreviation	Term
FCAS	Frequency Control Ancillary Service
FOS	Frequency Operating Standard
kV	Kilovolt
NCSPS	Network Control System Protection Scheme

1 Introduction

The power system in Tasmania was not operated in a secure operating state during some periods of high power transfer from Tasmania to Victoria from 2006 until early October 2011. During this period there was a risk that the frequency in Tasmania would not meet the Tasmanian Frequency Operating Standards (FOS) following transmission contingencies that would trigger action by the Network Control System Protection Scheme (NCSPS).

Although a detailed analysis of all at-risk periods has not been undertaken, analysis by Transend has identified 12.8 hours in 2010 and 16.5 hours in 2011 where the power system was not secure.

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 or maintain power system security.

This report includes information provided by Transend. Data from AEMO's Energy Management System has also been used in analysing the incident.

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

2 Summary of Events

The NCSPS was installed in Tasmania as part of the establishment of the Basslink interconnector in 2006. The design of the NCSPS, discussed later in this report, can reduce generation in Tasmania following a transmission contingency. It can do this in one of two ways – fast NCSPS action and slow NCSPS action.

AEMO implemented constraint equations in Tasmania as part of establishing the NCSPS. In September 2011, Transend identified that the AEMO's constraint equations did not consider all generation tripped by fast NCSPS action.

As a result, under some operating conditions reduction in Basslink flow from Tasmania to Victoria may not be able to fully compensate for the generation tripped by fast NCSPS action, and the Tasmanian frequency could fall below the minimum levels required in the Tasmanian FOS.

Frequency Control Ancillary Services (FCAS) would normally be enabled to ensure the frequency would not breach the FOS. However, FCAS equations were not implemented to manage the generation tripping by fast NCSPS action in excess of the reduction in Basslink flow, so there may have been times when insufficient FCAS was enabled in Tasmania to assist in managing this contingency.

This could result in automatic under-frequency load shedding in Tasmania, most likely of large industrial customers. When these conditions occurred, the power system in Tasmania was not in a secure operating state.

Transend advised AEMO of this, and AEMO instructed Transend to disable the NCSPS from 3 October 2011. This was communicated in market notice 36240. Under some operating conditions, this instruction resulted in a significant reduction in the capability of the Tasmanian transmission network, and transfer capability from Tasmania to Victoria on Basslink.

3 Design of the NCSPS

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 under normal system conditions, prior to the occurrence of a transmission contingency.

These levels of loading are much higher than would be allowed without the NCSPS , and when the NCSPS is not in service, line loadings need to be kept well below this level, significantly reducing the power transfer capability of the Tasmanian transmission system.

Following a transmission contingency that increases loading on one of these selected lines up to its short time rating, the NCSPS rapidly reduces loading on the line to below its continuous rating by either tripping, or quickly 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 to rapidly reduce 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.

3.1 Fast and Slow NCSPS Action

The NCSPS can reduce generation following a transmission contingency in one of two ways - fast NCSPS action or slow NCSPS action.

- Fast NCSPS action is used when a transmission contingency results in post-contingency flows on transmission line terminal equipment that must be reduced within 10 seconds.
- Slow NCSPS action is used when a transmission contingency results only in the post-contingency flow exceeding the transmission line overhead conductor rating, but not the rating of the line terminal equipment. In this case the post-contingency flows only need to be reduced within several minutes.

As fast NCSPS action requires the post-contingency flow to be reduced within 10 seconds, as a safety precaution one additional generator is tripped beyond that actually required to remove the overload. This builds in a safety margin by allowing for one generator failing to trip when required to do so. For fast NCSPS action all generation is tripped simultaneously within 10 seconds of the contingency occurring.

Slow NCSPS action reduces generation in a much slower manner, over a period of up to a minute, reducing the disturbance to the power system in Tasmania. Due to the longer time available to reduce post-contingency flow, tripping of additional generation is not considered necessary, and only the required amount of generation reduction occurs for slow NCSPS action.

The risk of breaching the Tasmanian FOS is due to generation output being reduced beyond that actually required to manage the post-contingent flow, and therefore relates only to fast NCSPS action.

3.2 Basslink and the NCSPS

As described above, the design of the NCSPS relies on Basslink reducing transfer from Tasmania to Victoria following tripping of generation in Tasmania, to restore the supply-demand balance, and hence the frequency, in Tasmania. This reduction in Basslink power transfer occurs automatically through the action of the Basslink Frequency Controller.

The Basslink Frequency Controller is a control system installed on the Basslink interconnector. When it detects the fall in Tasmanian frequency, such as resulting from the generation tripped by the NCSPS, it responds by automatically reducing transfers on Basslink from Tasmania to Victoria.

Due to the technical characteristics of Basslink, the Basslink Frequency Controller cannot reduce power transfer on Basslink from Tasmania to Victoria to lower than 50 MW. For this reason, power transfer on Basslink from Tasmania to Victoria must be maintained at a sufficient level to ensure that Basslink can fully compensate for the generation tripped by the NCSPS, allowing for this 50 MW minimum level.

Transfer on Basslink is controlled to the required levels using network constraint equations in AEMO's central dispatch process, based on limit advice provided by Transend.

4 Actions Taken to Date

In order to allow the NCSPS to be re-enabled, Transend developed and provided AEMO with limit advice in early October 2011 to ensure that the NCSPS would only undertake slow action, and that no fast NCSPS action would be possible. This limit advice was implemented progressively by AEMO, and was fully in place by 13 October 2011.

The lack of fast NCSPS action resulted in reductions in power transfer capability on some transmission corridors, particularly on the transfer of power towards George Town in northern Tasmania on the Sheffield - George Town 220 kV lines. High transfer of power on these lines into George Town is typically required during periods of high power transfers on Basslink from Tasmania to Victoria.

Even though the underlying capability of the Basslink interconnector itself was not changed, the lack of fast NCSPS action on the Sheffield - George Town 220 kV lines effectively restricted the ability to achieve high power transfers from Tasmania to Victoria on Basslink.

On 17 November 2011 Transend provided AEMO with limit advice to re-enable fast NCSPS action on the Sheffield - George Town 220 kV lines only. This advice conservatively ensured that Basslink could fully compensate for all generation tripped during fast NCSPS action following a contingency affecting loading on these transmission lines.

After undertaking due-diligence, AEMO implemented this limit advice on 12 December 2011, re-enabling fast NCSPS action on the Sheffield - George Town 220 kV lines only.

AEMO is satisfied that Transend has taken appropriate action to address power system security issues arising from fast NCSPS action.

5 Follow-up Actions

At the time of publication of this report, slow NCSPS action is fully enabled in Tasmania and fast NCSPS action is enabled for the Sheffield - George Town 220 kV lines only.

AEMO & Transend are working to jointly identify options to maximise the power transfer capability of the Tasmanian transmission network considering the action of the NCSPS. This may involve some combination of:

- New network or FCAS constraint equation arrangements for Tasmania.
- Modification to the NCSPS design.
- Upgrades to primary plant to remove the need for fast tripping.

6 Power System Security Assessment

6.1 Transend Analysis of Exposure

Transend undertook an investigation to identify the actual historical exposure to the risk of breaching the Tasmanian FOS, and hence insecure operation, due to fast NCSPS action. This was done by comparing periods where the NCSPS armed generation for fast NCSPS action against the available headroom on Basslink for reducing export to Victoria during these same periods.

This identified that the risk of breaching the Tasmania FOS existed for a total of approx 12.8 hrs in 2010 and 16.5 hrs in 2011. The exposure during earlier years has not been quantified.

Table 1 below shows the applicable FOS for Tasmania. The relevant standard in this case is the minimum frequency required during containment following a network event – i.e. 48 Hz.

Table 1 Tasmanian Frequency Operating Standards

Condition	Containment	Stabilisation	Recover
Accumulated time error	15 seconds		
No contingency event or load event	49.75 to 50.25 Hz, 49.84 to 50.15 Hz 99% of the time	49.85 to 50.15 Hz within 5 minutes	
Generation event, load event or network event	48 to 52 Hz	49.85 to 50.15 Hz within 10 minutes	
Separation event	47 to 55 Hz	48 to 52 Hz within 2 minutes	49.85 Hz to 50.15 Hz within 10 minutes
Multiple contingency event	47 to 55 Hz	48 to 52 Hz within 2 minutes	49.85 Hz to 50.15 Hz within 10 minutes

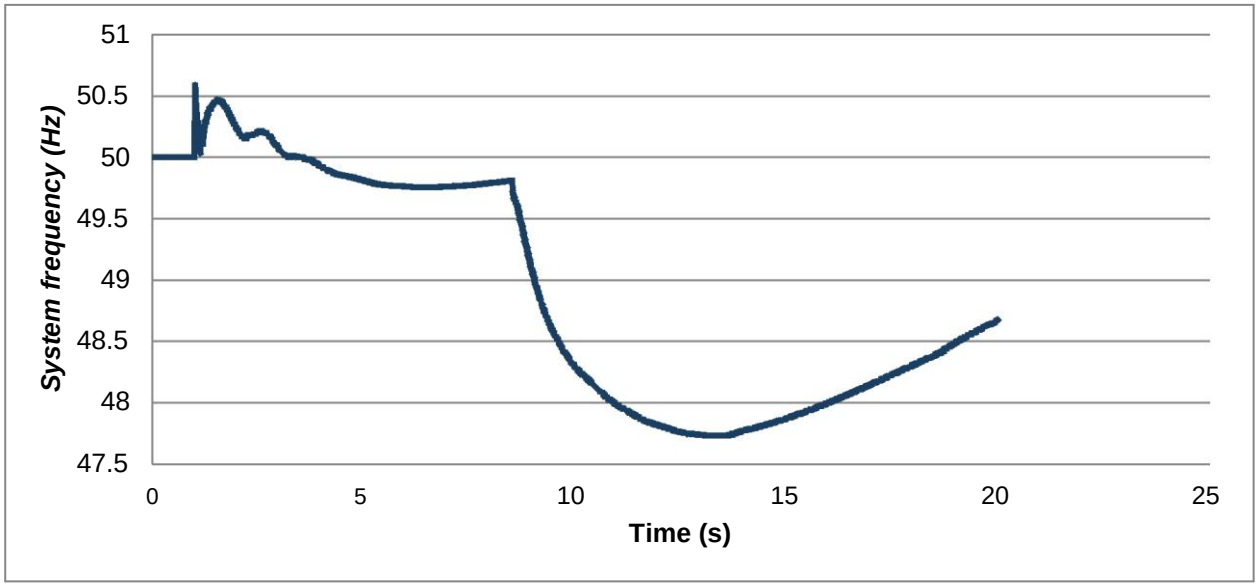
To confirm the risk of breaching the Tasmanian FOS, Transend simulated the Tasmanian frequency response following fast NCSPS action based on historical system operating conditions.

Figure 1 below shows a simulation by Transend of Tasmanian frequency using power system conditions on 12 July 2011 at 05:44 hrs (AEST). A fault and trip of a Sheffield - George Town 220 kV line was simulated, with fast NCSPS action tripping 511 MW of generation, 7.5 seconds later to remove the overload on the terminal equipment of the remaining parallel Sheffield - George Town 220 kV line.

At this time Basslink was transferring 432 MW from Tasmania to Victoria, so could only compensate for 382 MW of this generation loss. The minimum frequency in the simulation was 47.72 Hz.

Under-frequency load shedding would be expected to operate in Tasmania once the frequency fell below 48.0 Hz.

Figure 1 Simulated Tasmanian Frequency



6.2 Tasmania Inertia and NCSPS Action

During its investigations, Transend identified an additional risk to power system security due to fast NCSPS action.

NCSPS action can remove significant amounts of generation from the Tasmanian system, reducing the inertia of on-line generation in Tasmania. All other things being equal, Tasmanian frequency will fall more rapidly under the lower inertia conditions following tripping of generation by the NCSPS.

Under some conditions following fast NCSPS action, the resulting low inertia conditions mean that the frequency in Tasmania will fall so fast that the action of the Basslink Frequency Controller may not be able to arrest it before it reaches the minimum 48.0 Hz level as required under the Tasmanian FOS, even though the Basslink Frequency Controller can ultimately fully compensate for the tripped generation.

To address this issue, the limit advice provided by Transend allowing the NCSPS to be re-enabled for fast action on the Sheffield - George Town 220 kV lines includes thresholds for post-contingent system inertia in Tasmania which must be exceeded before fast NCSPS action is permitted.

This inertia issue can only arise with fast NCSPS action, as slow NCSPS action does not disconnect generation from the system, but instead reduces generation output by tripping governor solenoid valves, which leaves the units connected to the power system and still providing system inertia.

This inertia issue will need to be considered as part of any overall solution to NCSPS issues in Tasmania.

7 Conclusions

Prior to October 2011, the power system in Tasmania was not in a secure operating state on a limited number of occasions, and at risk of breaching the Tasmanian FOS following a single credible transmission contingency, due to the action of the NCSPS.

Transend has assessed that this risk existed for approximately 30 hours in total in calendar years 2010 and 2011 combined. At no time were the Tasmanian FOS actually breached due to NCSPS action.

In October 2011, AEMO implemented new constraint arrangements which removed this risk. Under some power system operating conditions these new constraint arrangements reduce the power transfer capability of the Tasmanian transmission network.

Work is continuing between Transend to AEMO to identify options to maximise the power transfer capability of the Tasmanian transmission network.

8 Recommendations

1. AEMO and Transend will jointly identify options to maximise the power transfer capability of the Tasmanian transmission network considering the action of the NCSPS. This action will be completed by the end of December 2012.
2. AEMO will review and collate existing documentation on the design and operation of the NCSPS. This action will be completed by the end of June 2012.
3. AEMO staff will undertake refresher training on the design and operation of the NCSPS. This action will be completed by the end of June 2012.