Hydro Tasmania
the renewable energy business

1 August 2008

Julian Eggleston
Reliability Panel
PO Box A2449
Sydney NSW 1235

By email: submission@aemc.gov.au

Dear Julian,

Review of Tasmanian Frequency Operating Standards – Supplementary Submission

Thank you for the opportunity to provide clarification on some parts of our presentations and submission.

Our submission consists of the following elements:

- Responses to specific queries which have been raised by the Panel. This response is attached to this letter.
- The slide pack which was presented to the Reliability Panel at their meeting on 30 July 2008
- A document which outlines Hydro Tasmania's proposed solution which entails:
  - Retaining the existing under frequency bands
  - Rationalising the over frequency bands
  - Incorporating Tamar Valley Power in the UFLSS to manage their non compliance area
  - Limiting the maximum contingency in Tasmania by including a limit in the Tasmanian Frequency Operating Standard
- A document which identifies a possible aero-derivative CCGT configuration which meets the existing Tasmanian frequency standard

- A confidential document on the costs of providing more R6 in Tasmania

We are looking forward to continuing to work with the Panel in finding a good solution to this issue. Our contact for this review is the undersigned on 03-62305775.

Yours sincerely,

D. Bowker

David Bowker
Manager Regulatory Affairs

Responses to Specific AEMC Queries by Hydro Tasmania

1. **The cost and availability of fast FCAS raise will be important in the assessment of a change to the Tasmanian frequency operating standards and the connection of the Alinta plant. The Panel needs to understand the true FCAS situation. Can Hydro Tasmania substantiate their:**

   - **estimate of the capital cost of additional fast raise of up to $1.2 million per MW;**

   Answer: See attached confidential paper. Further analysis has shown that the maximum price we would now expect to pay is $900,000 per MW if significant additional R6 is required then 20MW of initial capacity may be available at around $150,000/MW.

   - **claim that additional FCAS will significantly affect water usage, and wear and tear on hydro plant (page 5 of the submission);**

   Answer: The provision of R6 FCAS is typically in tight supply in Tasmania. A tightening of the frequency standard for generator events which raises R6 requirements will cause either a reduction in southward Basslink flow or require additional R6 to be sourced from within Tasmania to meet the requirement. Presently plant is run inefficiently at times to overcome the tight supply of this service.

   Typically, John Butters, a large Francis machine provides this service, and at low load output (~12 % of rated output) consumes around 35% more water for the same energy output as compared to its efficient operating range (~80% of rated output). Modelling with the 2007 year data indicates the cost impact associated with inefficient water usage (based on a value of $50/MWh) for low load running of a machine to provide the R6 service was $1.4million. This has not been recovered from the R6 market.

   These costs do not take into account the costs of any additional starts on the machine or additional vibration/cavitation on the machine turbine. A generator contingency scenario of 210MW/48 Hz increases the R6 requirement considerably and is expected to back off Basslink further or increase inefficient dispatch of more valuable water to provide R6.

   - **claim that existing FCAS supplies would decrease slightly (page 5 of the submission it is stated that "Existing FCAS supplies would decrease slightly as trapeziums would need to be recalculated and reregistered with regard to a new technical specification (estimated 5 per cent reduction"); and**

   Answer: The delivery of FCAS is specified in NEMMCO's Market Ancillary Services Specification v1.4. In particular, Raise 6s is verified according to the method in clause 2.6. This method, for proportional controllers (which are used in the raise FCAS market in Tasmania), verifies the response according to the raise reference frequency. This raise reference frequency is based on the containment frequency below 50 Hz for the generation events as given in the Tasmanian Frequency Operating Standards. Presently this figure is 47.5 Hz. Tightening the standard is expected to impact MASS, in which case a tighter test frequency is used for verification. The effect of a smaller test signal is expected to reduce the response of the machine's R6 capability. It will be a significant exercise to determine the revised machine response from governor models and/or actual machine response to calculate new trapeziums. This will require re-registration of trapeziums and significant reworking to incorporate in Hydro Tasmania's bidding systems.

Until the detailed work is undertaken, it is impossible to know the quantum of the decrease but it is clear that it will be a decrease.

- **claim that they can only recover local FCAS costs 10% of the time (Is this just the times when FCAS is supplied locally and monopolistically? Why discount the time when Tasmanian FCAS suppliers are competing with mainland FCAS suppliers?).**

Answer: The point which we were making is that Basslink is able to transport R6 from the mainland for about 90% of the time. If Hydro Tasmania were to invest in more R6 capability, this investment could only be recovered by charging realistic prices to achieve a return on this investment when Basslink is not able to transport R6. The price for R6 on the mainland is very low as there is an abundance of it. For 90% of the time Hydro Tasmania would be undercut by the cheap mainland R6. So whilst we could price below the mainland at these times, this would provide a negligible return compared to the cost of providing the additional service in Tasmania. We also highlighted the issue that generators pay for R6 so we would be paying ourselves in large part for the investment.

2. **What are the average hydrological inflows in Tasmania, 9,500 GWh p.a. or the OEPC figure of 9,000 GWh p.a.?**

Answer: Hydro Tasmania has recently reduced its inflow assumption from 9,500GWh to 9000GWh based on a statistically significant change over the last 11 years. Inflows for the last 2 financial years have actually been around 7000GWh so this is a conservative change.

3. **What is free governor mode?**

Answer "free governing" ensures that governors are not locked so that they won't respond to changes in frequency. The philosophy is based on the fact that nothing in the NER compels participants to participate in FCAS markets. Therefore, there is nothing stopping participants from locking their governors. If free governing was a condition of connection you would always get the benefit from the plant responding whether the participant was participating in the market or not. The effect of free governing is often referred to on the mainland as “free rider effect”.

The idea is that if large generators are governing then over frequency will not reach a point where OFGSS operates even if this protection begins at lower frequencies (i.e 51.6Hz)

Review of Tasmanian Frequency Standards

Hydro Tasmania
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Hydro Tasmania's Solution

Presentation to the Reliability Panel
30 July 2008

Outline

- The Case for Change
- Tamar Valley Power Non-Compliance
- R6 Issues
- Hydro Tasmania's Proposal
- Who Pays
- Summary

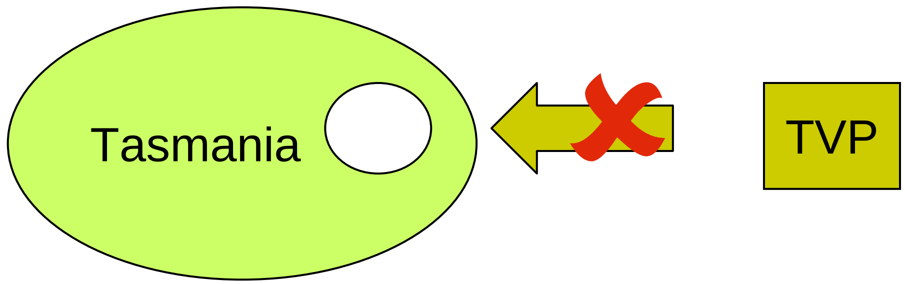
Case for change

Tamar Valley Power has <u>chosen</u> to build a CCGT that does not comply with the current frequency standards

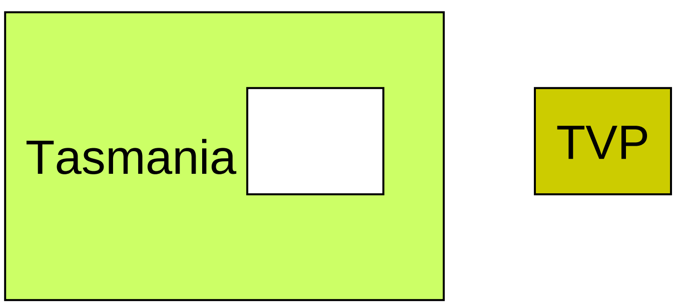
The Best Solution for Tasmania

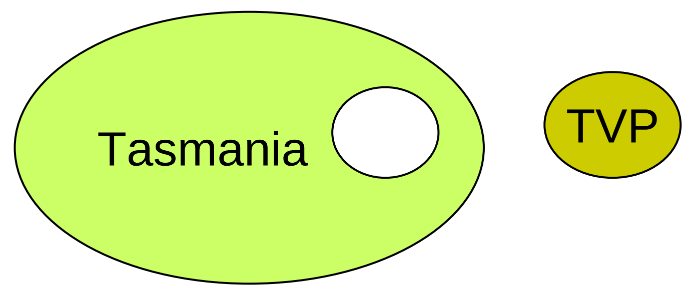
- Should meet the market objective – long term benefit for consumers
  - Best cost/benefit
  - Avoid risks associated with the significant uncertainty in costs and benefits of changing from current standards
- Maintain reliability and security of supply for customers (lowest risk)
- Preserve flexibility of future options

TVP – A square peg trying to fit into a round hole?



Two solutions – make the peg round or make the hole square





TVP Solution – change Tasmania

Hydro Tasmania Solution –TVP changes

NER Requirements for new Plant

- **Intent - new entrants should not impact existing participants**
- 5.3.5(d), requires NSP to: "*consult ……., if the Network Service Provider believes .... those connection agreements will be affected ….. and determine:*
  - (d) any possible material effect of this new connection on the network power transfer capability including that of other networks"
- S5.2.5.12 requires the Tamar Valley power station to meet certain requirements in relation to its impact on power transfer capability
- 5.4A(e) requires Transend … to provide the power transfer capability sought by the Connection Applicant ….. and considering:
  - (b) the potential augmentations or extensions required to affected networks to provide the level of power transfer capability required including taking into account the amount of transfer capability provided to other Registered Participants as part of transmission network and distribution network user access arrangements.

TVP non-compliance

Required capability based on Current Standard (Clause S5.2.5.3)		Combined cycle plant				Compliant Yes/No
Automatic	Minimum	Gas Turbine Generator (GTG)		Steam Turbine Generator (STG)	Combined Capability	
49 - 51 Hz indefinitely	49.85 – 50.15 indefinitely (a)(4)	47.5 – 52 Hz indefinitely		47 – 52.7 Hz indefinitely	47.5 – 52 Hz indefinitely	√ YES
47.5 – 49 Hz for 8 minutes	47.5 – 49.85 Hz for 8 minutes					√ YES
46 – 47.5 Hz for 2 minutes	46 – 47.5 Hz for 9 sec (a)(1)	47 – 47.5 Hz for 15 sec Trip ≤ 47 Hz with 2 sec delay. (GT load runs back to 20 MW as soon as the frequency falls to less than 47 Hz) Trip ≤ 46 Hz instantaneously		46.9 – 47 Hz (15 min accumulated). 46.8 -46.9 Hz (1 min accumulated). Trip setting data not provided Trip ≤ 46,8 Hz instantaneously	47 – 47.5 Hz for 15 sec Trip ≤ 47 Hz with 2 sec delay. (GT load runs back to 20 MW as soon as the frequency falls to less than 47 Hz) 46.9 – 47 Hz (15 min accumulated). 46.8 -46.9 Hz (1 min accumulated). Relay setting data not provided Trip ≤ 46,8 Hz instantaneously	X NO
53 – 51 Hz for 8 minutes	50.15 – 53 for 8 minutes (a)(5)	Trips > 52 Hz with 0.1 sec delay			Trips > 52 Hz with 0.1 sec delay	X NO
60 - 53 Hz for 2 minutes	55 - 53 Hz for 9 sec (a)(5)					

Table 3-1 Comparison of Alinta Generators Frequency Capability with AEMC Frequency Standard for Tasmania

Source: Alinta Submission

TVP Solution – Under Frequency

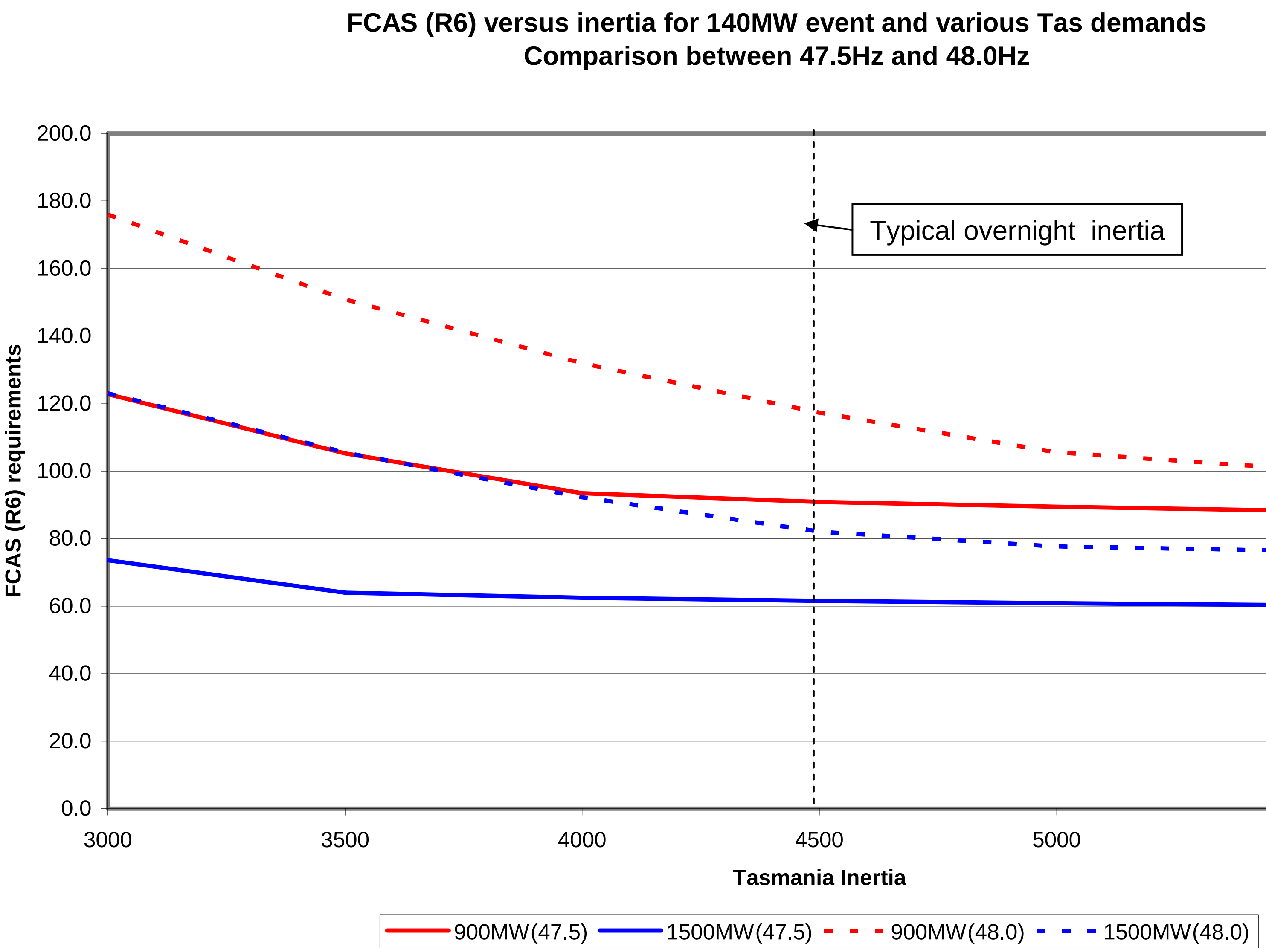
- Tightens credible contingency band by 0.5HZ and reduces non – credible band by 0.5Hz to alleviate their 46-47Hz non-compliance
- Creates the requirement for additional ancillary services to be enabled during dispatch (continuous)
- Increases risk of ineffective UFLSS operation
- Uses option of tightening standards before absolutely necessary

Specification of a CCGT which meets the Current Standard

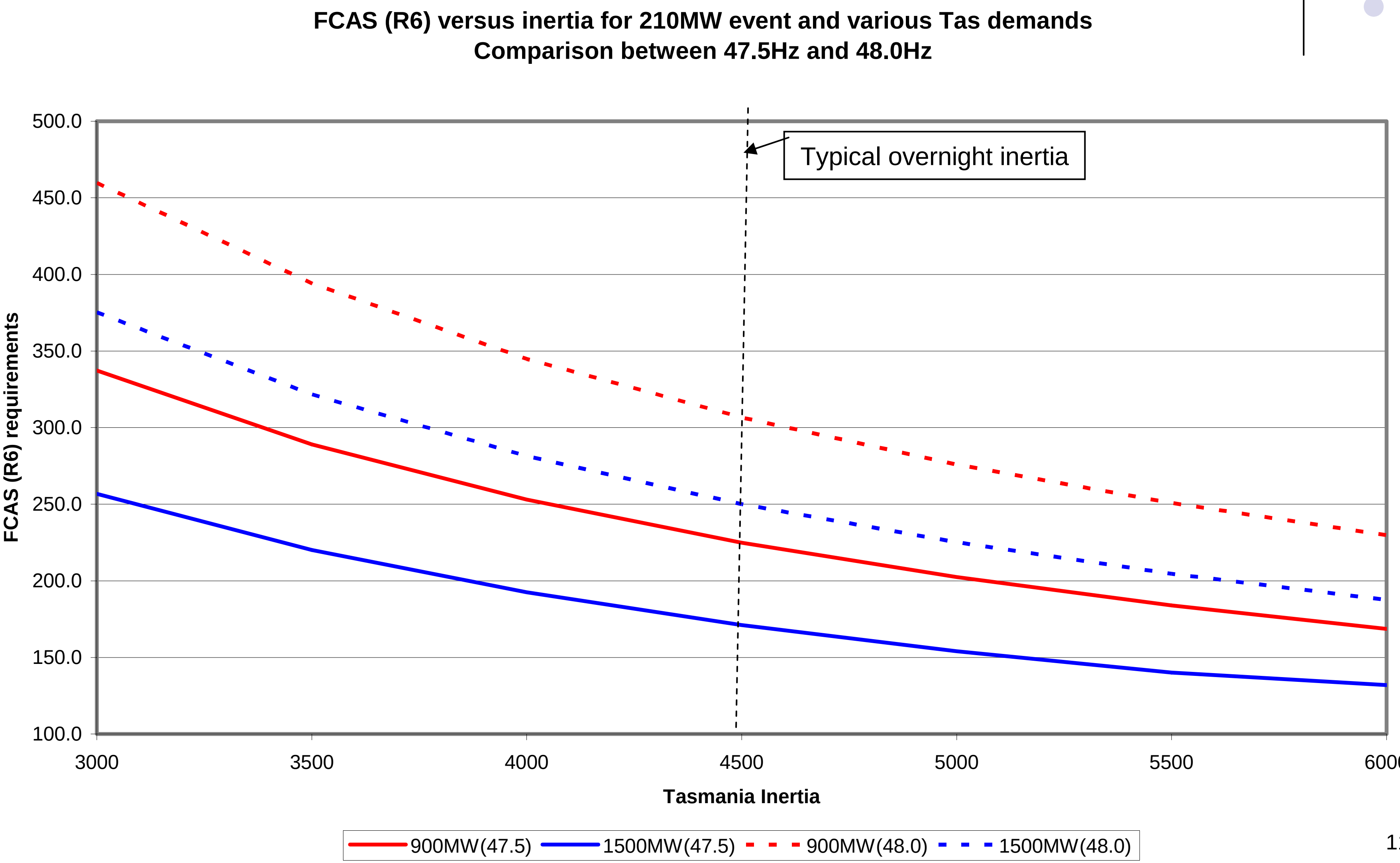
- It is possible to build CCGT plant which will meet the current frequency standard
- One example:
  - 2 CCGT units of 90MW each
    - 50MW Trent GT
    - 40MW steam
- Indicative Cost comparison to TVP Plant
  - Capital cost +12%
  - SRMC +3%

See Hydro Tasmania’s Supplementary Submission for details

R6 at 140MW Contingency



R6 at 210MW Contingency



R6 issues summary

- Increased contingency is completely incompatible with small Tasmanian system
- R6 in short supply in Tasmania
- Full costs not recoverable in FCAS raise markets, so will increase energy prices for customers
- Additional sources of R6 are expensive
- More cost effective to avoid more R6

Hydro Tasmania Proposal

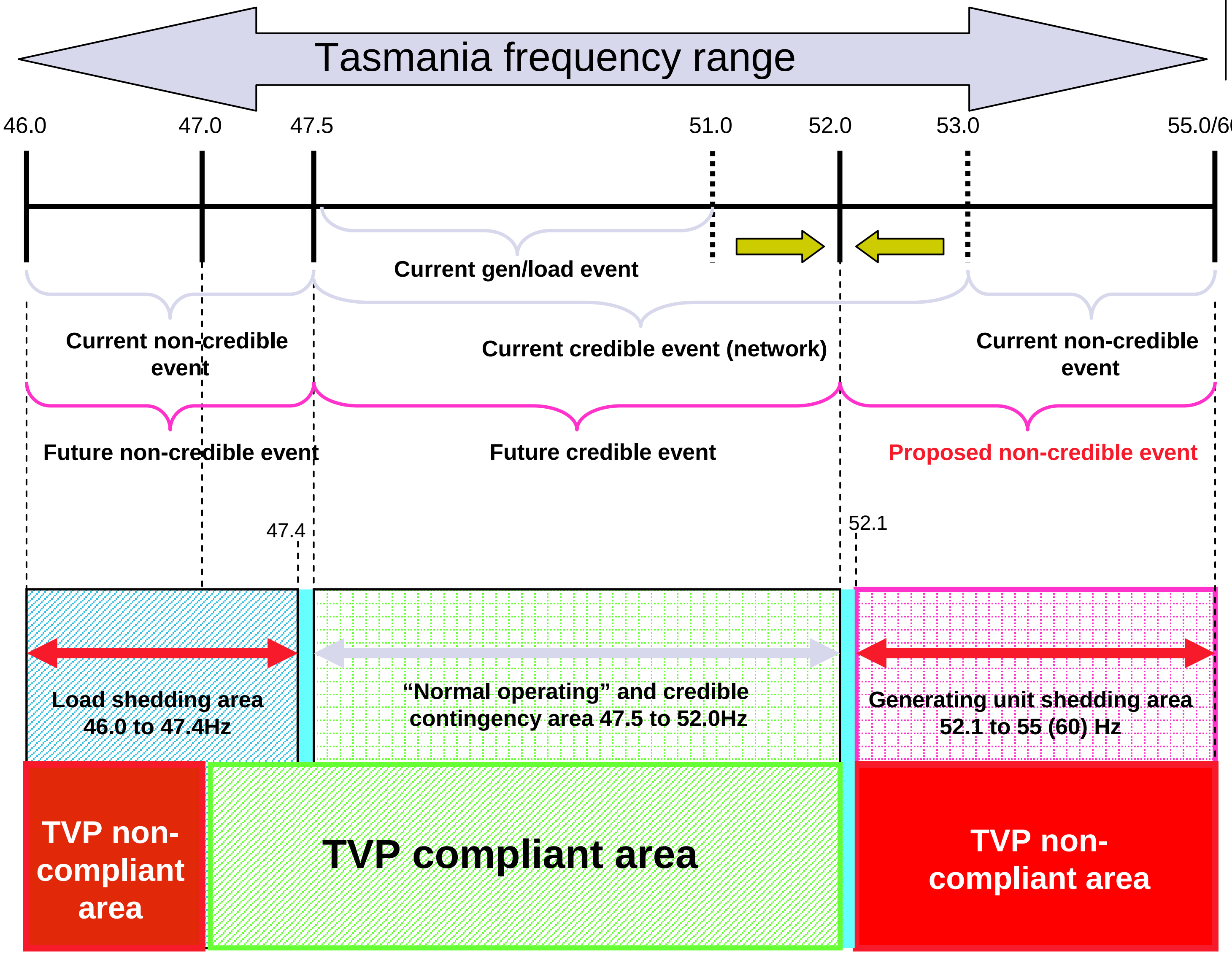
- Retain existing **under frequency standards** and include TVP in UFLSS
  - Addresses areas of non-compliance without creating additional complications in dispatch
  - Connects TVP at lowest cost
  - Attributes costs to the causer
- Modify/simplify **over frequency bands**
  - Reduce costs to generators with no impact on customers
- Limit **contingency size** to 144MW
  - By including contingency limit in Frequency Standard
  - Basslink reduced its contingency from 480MW to 144MW
  - Some ways that TVP can meet this :
    - Secure 70MW external dedicated load tripping
    - Split GT and steam contingency

See Hydro Tasmania's Supplementary Submission for details

Alternative Solutions

- Inter-trip full TVP output
- Plant modifications to meet minimum access standards (9 secs)
- Change plant to aero-derivative GT's
- R6 provided as connection agreement condition to offset cost of new standard

Managing TVP non-compliance with minor frequency standard and UFLSS changes



Cost Allocation – Who Pays?

TVP Proposal

Basslink	AS	Consumers	TVP
Lower BL flows HT Rev loss Tas water loss	AS Costs HT invests Costs recovered In energy	Consumer Reliability down AS costs passed thru	TVP No costs

HT Proposal

Basslink	AS	Consumers	TVP
BL flows Unchanged No HT loss No water loss	No AS cost increase	Consumer Reliability unchanged	TVP pay their compliance costs

Benefits of Hydro Tasmania's proposal

- Best cost benefit for the market
- Lowest risk to security and reliability of supply
- Provides TVP access to the market thereby increasing competition
- Proposal addresses structure and does not rely on commercial arrangements
- Compliance costs are allocated to the beneficiary
- Focussed on non-compliance area of TVP
- Maintains the option to tighten in future years if and when appropriate

Summary

- Current under frequency standard and contingency best for a system the size of Tasmania
- Tighter standard requires more R6
- Need to explore all options under current standard before changing
- New plant should not impact existing participants and should bear cost of connection
- Increased R6 means higher energy prices for customers

Hydro Tasmania Proposal to address TVP Frequency Standard Non-compliance

1 Introduction

The large TVP CCGT proposed for connection at Bell Bay has areas of technical capability not totally compliant with current Tasmanian frequency standards and information available (Attachment 1) indicates that protection settings will trip the plant in violation of NER performance standard requirements. Frequency standard changes are currently being considered, particularly in respect of the lower frequency limits for both generating unit and multiple contingency events. The proposed changes suggest that the generating unit event lower frequency limit be raised from the present 47.5Hz to 48.0Hz and the multiple-contingency lower frequency be raised from the present 46.0Hz to 47.0Hz.

Attachment 1 (an extract of Reference 1[1]) summarises the various TVP CCGT element non-compliance issues, there clearly being no compliance concern above 47.5Hz but an escalating issue as the frequency falls below 47.0Hz. Note that the current frequency standards (and hence NER performance standards) would require stable operation down to 46.0Hz for a limited time (during a system multiple contingency). The abovementioned frequency standard changes as proposed in Reference 1 have been determined to provide a safe operating margin for the plant capability as shown in Attachment 1.

The proposed Tasmanian frequency standard changes will have a significant adverse impact upon the market, primarily due to substantially increased demand for Fast Raise FCAS (R6) when there is already a shortfall in local supply. This paper suggest a less “invasive” solution to the TVP non-compliance issue in that only minor frequency standard changes are proposed together with a combination of supplementary load tripping and enhancement of the UFLSS. This solution would in the first instance require acceptance by key stakeholders such as Transend and NEMMCO followed by some Rule changes/amendments. This proposal is based on the principle that a new generator entrant has the obligation of not impacting other participants and imposing costs on them arising out of system changes such as frequency standards.

2 Discussion of the issue

Alinta Power is in the process of negotiating a connection agreement with Transend and this process has highlighted that the proposed CCGT plant fails to comply with the Tasmanian frequency standards. The changes proposed by Alinta to the frequency standards result in substantial changes to the amounts of R6 required for generating unit event in Tasmania the issue being exacerbated by the size of contingency increasing from the current 144MW to a new maximum of 210MW (which is expected to be a base load quantity). The diagrams below illustrate the extent of impact of the proposed frequency standard changes with Figure 1 based upon the contingency size being contained to 140MW and Figure 2 illustrating the impact of the larger contingency (210MW).

[1] Frequency standard development – Final report to Alinta Power (Transend/Hill Michael)

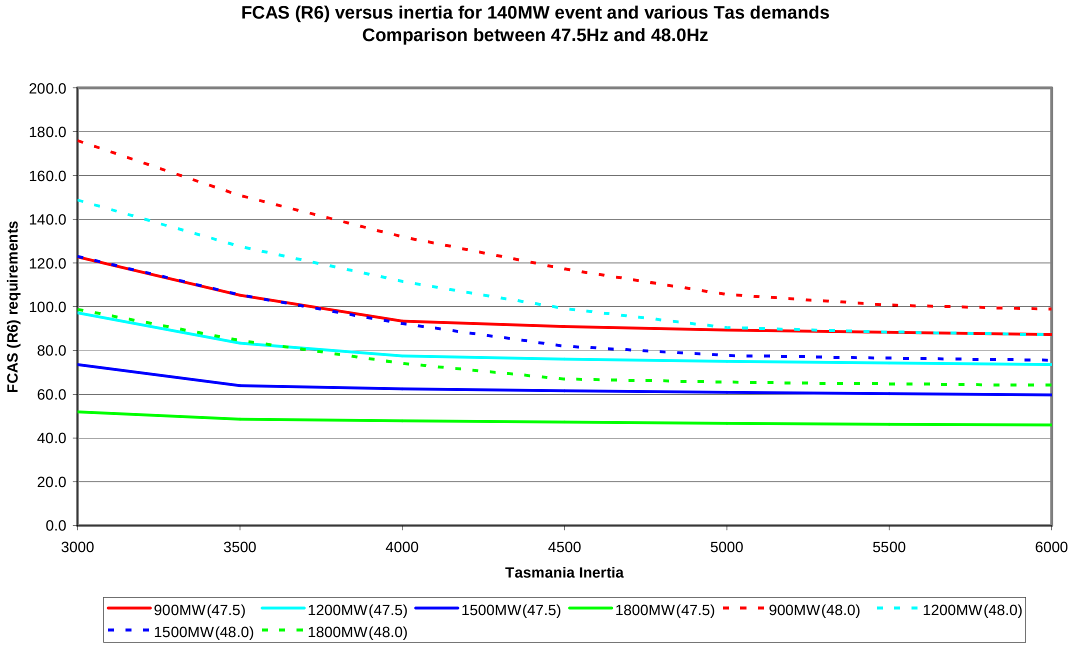


Figure 1: 140MW contingency in current and new frequency standards

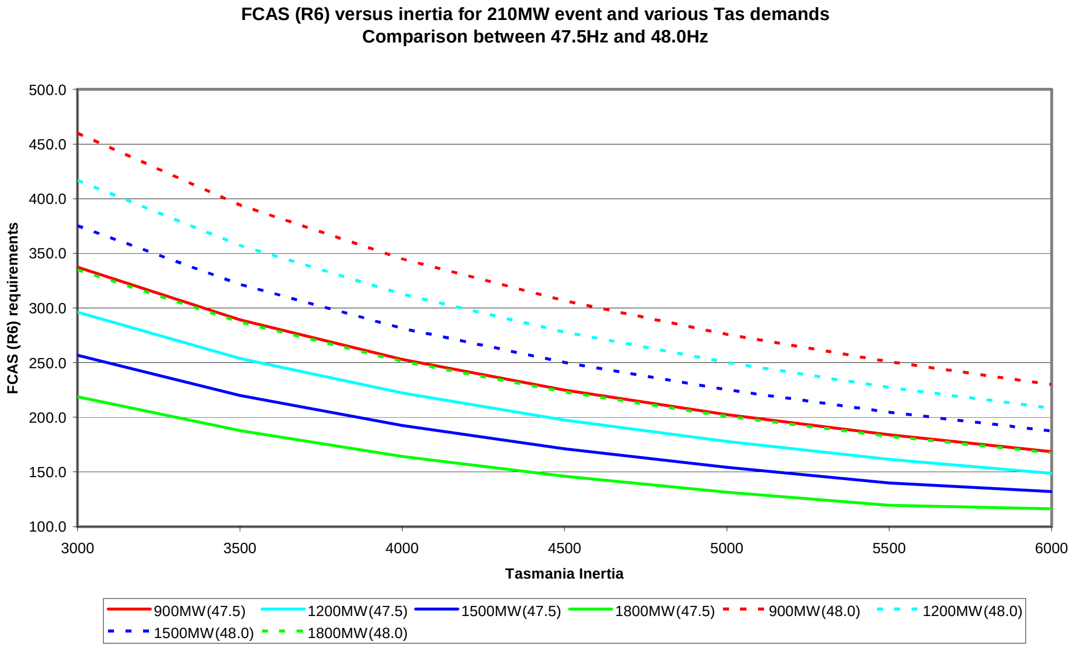


Figure 2: 210MW contingency in current and new frequency standards

2.1 Discussion of graphs:

If we use the 1200MW system (pale blue curves) and use an average low inertia reference point of 4500MW, compare the R6 values required for a 144MW contingency (Figure 1) versus a 210MW contingency (Figure 2). Rough scaling gives the following values:

Frequency std	140MW contingency	210MW contingency
47.5Hz	75	190
48.0Hz	100	275

This data for the scenario, which is certainly not a worst case scenario, shows an overall increase of 200MW of R6 from the current situation (275-75). Such quantities of R6 are simply not available from dispatched plant and would result in Basslink constrained around the no-go zone and substantially constrained on import, particularly during overnight low inertia periods. (For more detailed discussion on the FCAS issues see Reference 2).

If we assume that the frequency standard changes but not the contingency size, then referring to the table above the change is 100 - 75 = 25MW. The maximum difference according to Figure 1 (900MW system) would be around 50MW change for the lowest inertia cases.

Although the above change suggests only a 50% increase of R6 on current maxima, in reality the change is much greater as Hydro Tasmania has always managed the generating unit contingency size to significantly less than 144MW under these low inertia scenarios such that the maximum R6 requirement would typically be limited to between 60MW and 70MW. A new base load 144MW contingency with a 48.0Hz frequency actually represents a step change in R6 of around 100MW (from a notional 60MW or so for a 110MW contingency size). The sourcing of 160MW of R6 under high Basslink imports, (i.e. with few hydro machines dispatched), is virtually impossible and would result in Basslink imports being constrained to allow global R6 to supply the shortfall in the dispatch. The contingency size increase on its own therefore already represents an adverse market outcome.

3 FCAS R6 availability in Tasmania

The majority of Hydro Tasmania machines are registered FCAS providers, the exceptions mainly being the non-scheduled machines. As required by NER, Hydro Tasmania has derived trapeziums for each FCAS service, these trapeziums being a compliant representation of machine governor capability taking into account aggregation combinations, lake level (head) effects and machine upgrades. Hydro Tasmania bids energy and FCAS to maximise efficient water usage and the market dispatches in accordance with NEMDE co-optimisation formulation.

3.1 How much R6 could Hydro Tasmania deliver under emergency conditions?

Figure 2 indicates that for a **1600MW** system, a 210MW contingency at the proposed 48.0Hz would require around 180MW of R6. Analysis undertaken with current R6 capability has shown that with all 2200MW of Hydro Tasmania machines dispatched such that all R6 machines are dispatched at reduced levels (upper break points) to maximise their R6 capability and all other machines dispatched at full output, a gross amount of 173MW of R6 could be delivered in conjunction with the required **1600MW** delivered energy. (Almost 600MW of energy reduction required to deliver the 173MW of R6). This scenario implies that other generating units (e.g. TVP, wind generation) would have to be available and included in the Tasmanian Reserve margin requirements.

This analysis therefore concludes that, only if directed under emergency conditions and all plant is available on the day, it could be conceivable (at very high cost and given time to plan), to deliver 173MW of R6 in a 1600MW system. It should be evident that Hydro Tasmania R6 resources are substantially inadequate to deliver the amounts of R6 determined for the scenarios in Figures 1 and 2 which are far more onerous than the 1600MW example analysed.

Hydro Tasmania believes that it is in the best interests of the market and all participants to explore an alternative to changing the frequency standard and to limit the maximum contingency size in Tasmania to the present 144MW.

4 Hydro Tasmania Proposal to mitigate TVP non-compliance

Hydro Tasmania's proposal is that TVP should be included in the UFLSS. It is able to operate for the required 9 seconds down to 47Hz so it would be tripped at 47Hz. At the same time, an equivalent load block would be tripped.

In perusing Attachment 1 it is clear that the TVP plant displays large areas of compliance with the current frequency standards and really only has difficulty in meeting the standards at frequencies below 47.0Hz and above 52.0Hz. Hydro Tasmania believes that it should be possible to exploit, as far as possible, the capability as displayed by the performance data to operate robustly within most of the current credible event frequency band. Figure 3 has been developed to illustrate the compliance/non-compliance issues and to explain a concept of adapting the plant to the current frequency standards (with minor changes) and suggested methods to mitigate the residual areas of non-compliance.

This diagram should also be studied in the context that events below 47.5 are rare. Since Basslink has been in production, the frequency has only been below 48Hz once for less than a minute when it went down to 47.7. Control changes since then mean that the same event today would probably result in a smaller excursion.

Managing TVP non-compliance
with minor frequency standard and UFLSS changes

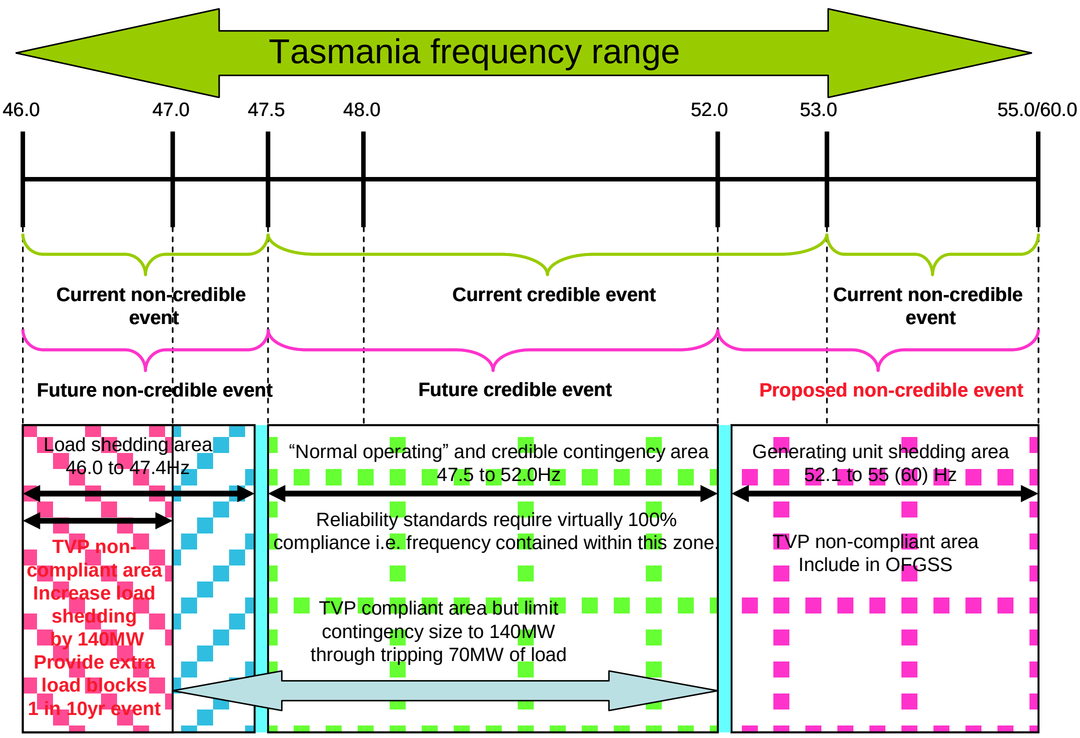


Figure 3: Illustration of compliance/non-compliance areas of TVP plant

4.1 *Discussion of Figure 3*

The diagram shows the frequency ranges for credible and non-credible events in Tasmania and proposes a minor change to the divide between the credible and non-credible upper frequency bands, i.e. creating the divide at 52.0Hz instead of 53.0Hz (the present standard).

Using the data from Attachment 1 and Reference 1, the blocks on the lower section of Figure 1 have been developed. The shaded blocks are discussed below:

4.1.1 Middle green shaded area

This block represents the Hydro Tasmania proposed future credible event band (47.5Hz to 52.0Hz). Note that the TVP plant is fully compliant in this band but as previously discussed and seen in Figure 1, the large contingency 210MW would result in large R6 increases particularly at low inertia (high Basslink import), i.e. create adverse market outcomes. To mitigate this FCAS outcome, the use of supplementary (direct) tripping of around 70MW of contracted load will reduce the contingency to 140MW maximum and ensure no excessive R6 increases. The requirement here is for TVP to send a direct intertrip to a contracted load for any protection or manual trip signal. This will ensure that the plant represent no more that 140MW of contingency to the Tasmania system. (Figure 4, to be discussed later, shows the protection tripping logic proposed).

4.1.2 Upper pink shaded area

As TVP plant is robust up to 52.0Hz, it is recommended that TVP protection be robust up to and including 52.0Hz, i.e. trip at say 52.1Hz and be included in the generating unit shedding scheme that would have to be re-designed to accommodate the frequency changes. Various other changes will be required to ensure that all network events are managed within the tighter upper frequency band. These include:

- Increased FCAS (mainly L6) if same amount of generating unit tripping is retained. Indications are that the L6 amounts would be approximately double present values (40MW to 80MW). Such increase could be accommodated with current L6 resources.
- Alternatively change FCSPS to increase amount of generating unit tripping. A proposal has already been considered by Transend to eliminate the need for FCAS through increased generating unit tripping albeit for a different objective (reducing possible L6 constraints). This concept could be applied and extended to a tighter frequency band.
- Increased FCAS for the Network event (load tripping). This increase is not expected to be substantial and could result in this value being on par or slightly above the L6 required for a Tasmania load event (which is not affected by the 53.0 to 52.0Hz change). The net market outcome should be almost zero as the largest L6 constraint dominates and sets the requirement in dispatch.

For other generating units such as TVP to be eligible to bid FCAS lower services they would have to be capable of operating up to 52.0Hz and not tripping at or below 52.0Hz.

4.1.3 Lower blue shaded area

This area, together with the green area, (as indicated), is the total robust operating zone of the TVP plant. It is interesting to note that the plant is robust for part (0.4Hz) of the under frequency load shedding area. This is an important observation as it translates into a substantial case for maintaining the current lower frequency standard (as shown in the diagram) and providing mitigation for the rare frequency excursions below 47.0Hz.

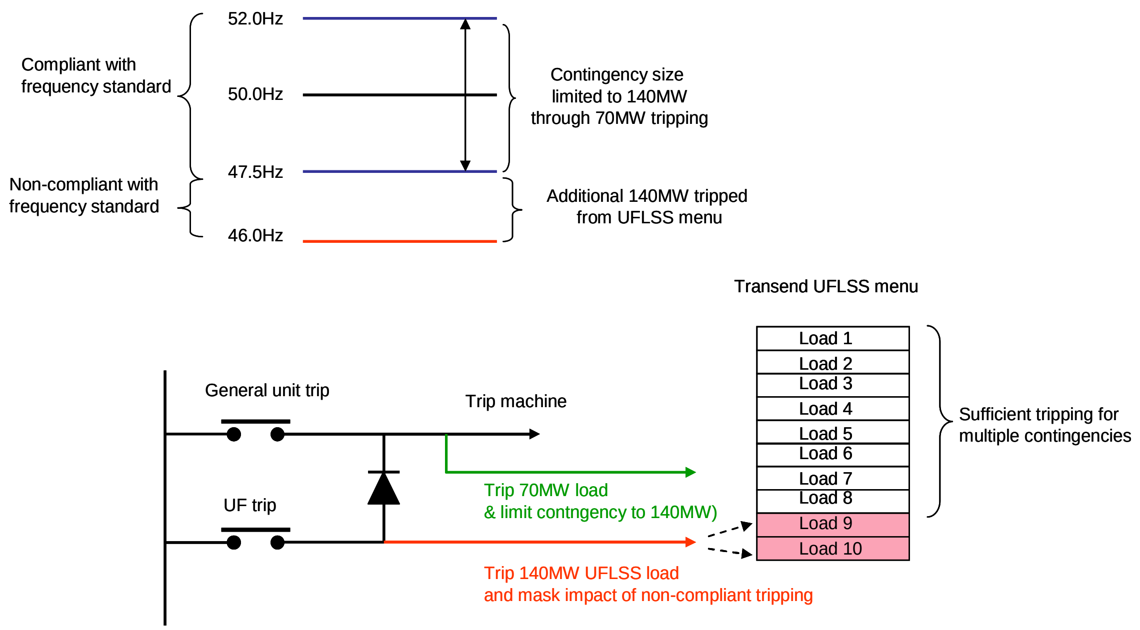
4.1.4 Lower red shaded area

This area is the zone in which TVP plant protection will trip the unit and unless some mitigation is provided, such non-compliant tripping will exacerbate the initial multiple contingency which caused the frequency excursion into the UFLSS zone and consequent controlled load shedding. Noting that (as indicated above) 70MW of direct tripping should already be in place (for any trip initiate), a residual amount of 140MW load tripping (initiated from TVP frequency protection) should be tripped by TVP under these conditions.

4.2 Proposed scheme operation (Figure 4)

Figure 4 shows all TVP protection trips routed to a transfer trip to a "contracted" 70MW load. This is shown schematically by a generating unit trip in parallel with under frequency trip contacts. The "blocking diode" suggests that tripping of the 70MW load should be permitted from all tripping sources but that tripping of the 140MW load should only be tripped from frequency protection, i.e. the "blocking diode) provides only one-way tripping.

Schematic tripping logic to manage non-compliance with frequency excursions below 47.0Hz



<u>Figure 4: Protection logic for external load tripping to limit contingency size and mitigate low frequency non-compliance</u>

4.2.1 Load tripping sources and availability for various applications

As indicated, TVP will require access to a 70MW load block that will be tripped every time that the unit is tripped for any reason. As a TVP plant trip could be part of a non-credible event leading to UFLSS, this 70MW load block will probably be considered as dedicated to TVP. As such it would probably be considered:

- Unavailable to the UFLSS scheme
- Available as load tripping for Basslink FCSPS. This is a different contingency and the load can in principle be used for both purposes. If Basslink trips on import and the load block is tripped, there would be a finite time required to restore the load. This is no different to the load tripping for any other reason, i.e. there are risks associated with contracting to a single load as NEMMCO may require operational procedures to ensure secure system operation under such conditions.

The 140MW load blockcan be part of (i.e. shared with) the UFLSS scheme. For this 140MW load block tripping to be initiated, a significant multiple contingency would have occurred and UFLSS already activated, some load blocks tripped and the system frequency at or below 47.0Hz. (Referring to Figure 3, UFLSS commences in the blue shaded area). The amount of load tripping should therefore accommodate the largest “feasible” multiple contingency plus 140MW. Note that it is not possible to produce a UFLSS scheme to prevent system black for any multiple contingency combination. Note also that with the present situation, if simultaneous with or soon after a Basslink trip at high import, a large multiple generator contingency occurs, this is likely to result in a system blackt as much of the UFLSS loads will still be out of service resulting in insufficient UFLSS load tripping.

4.2.2 Load block availability

The NER requires each jurisdiction to ensure that up to 60% of loads (in excess of 10MW) are made available for load shedding. Information in Reference 1 gives a total of 563MW of load tripping available for UFLSS. Transend has indicated that this total includes 300MW of retail feeder load. Reference 1 indicates that no change in load tripping is envisaged for the future even if frequency standards are changed. An increase of 140MW of tripping to around 700MW is possible.

4.2.3 Probability of frequency excursion below 47.0Hz

Historical data analysed shows that frequency excursions below 47.0Hz are rare and with the mitigating effect of the Basslink frequency controller (when Basslink dispatch permits adequate MW transfer), frequency excursion below 47.0Hz will probably be a 1 in 10 year event. Frequency excursions between 47.5Hz and 47.0Hz are typically 1 per annum. If these assumptions are valid, the argument to permit TVP to trip for frequencies below 47.0Hz and to provide 140MW of additional load tripping in the UFLSS scheme would appear to be sound. As already indicated, the worst case multiple contingency to plan for should be a feasible contingency which together with the TVP exacerbating effect should be accommodated with the 60% load tripping.

5 Conclusions

Hydro Tasmania believes that the solution to the TVP non-compliance with current frequency standards should be one with minimum disruption to the market and other participants. The solution discussed in the paper is to include TVP in the UFLSS which will maximise the use of the compliant characteristics of the plant whilst still catering for the rare extreme events. This approach has a number of benefits and these are summarised below:

- Minimal overall impact upon Tasmania and market as a whole
- Tasmania maximum generating unit contingency size remains unchanged meaning no need for system studies and changes to constraint equations
- No major market impact due to FCAS requirements changing
- Basslink flows and net energy import into Tasmania is not affected
- For majority of Alinta machine trips only 70MW of contracted load tripping is involved.
- Major multiple contingencies for which the frequency falls below 47.0Hz are rare (1 in 10 year events)
- Costs for access to additional 140MW should be low
- 140MW tripping in UFLSS is not dedicated to TVP
- Alinta plant operates as if compliant with current frequency standards
- Only minor re-design of UFLSS required to accommodate increased multiple contingency

Attachment 1: Extract of Reference 1 showing extent of non-compliance of TVP plant

Required capability based on Current Standard (Clause S5.2.5.3)		Combined cycle plant				Compliant Yes/No
Automatic	Minimum	Gas Turbine Generator (GTG)		Steam Turbine Generator (STG)	Combined Capability	
49 - 51 Hz indefinitely	49.85 – 50.15 indefinitely (a)(4)	47.5 – 52 Hz indefinitely		47 – 52.7 Hz indefinitely	47.5 – 52 Hz indefinitely	√ YES
47.5 – 49 Hz for 8 minutes	47.5 – 49.85 Hz for 8 minutes					√ YES
46 – 47.5 Hz for 2 minutes	46 – 47.5 Hz for 9 sec (a)(1)	47 – 47.5 Hz for 15 sec Trip ≤ 47 Hz with 2 sec delay. (GT load runs back to 20 MW as soon as the frequency falls to less than 47 Hz) Trip ≤ 46 Hz instantaneously		46.9 – 47 Hz (15 min accumulated). 46.8 -46.9 Hz (1 min accumulated). Trip setting data not provided Trip ≤ 46,8 Hz instantaneously	47 – 47.5 Hz for 15 sec Trip ≤ 47 Hz with 2 sec delay. (GT load runs back to 20 MW as soon as the frequency falls to less than 47 Hz) 46.9 – 47 Hz (15 min accumulated). 46.8 -46.9 Hz (1 min accumulated). Relay setting data not provided Trip ≤ 46,8 Hz instantaneously	X NO
53 – 51 Hz for 8 minutes	50.15 – 53 for 8 minutes (a)(5)	Trips > 52 Hz with 0.1 sec delay			Trips > 52 Hz with 0.1 sec delay	X NO
60 - 53 Hz for 2 minutes	55 - 53 Hz for 9 sec (a)(5)					

Table 3-1 Comparison of Alinta Generators Frequency Capability with AEMC Frequency Standard for Tasmania

A Baseload CCGT which Meets Current Tasmanian Frequency Standards

1 Introduction

Tamar Valley Power (TVP) is finalising connection arrangements for a 210MW CCGT generating unit at Bell Bay. The proposed plant is not compliant with the Tasmania frequency standards and the Reliability Panel is now undertaking a review of the frequency standards. Preliminary analysis shows that changes to the frequency standards together with the large contingency size (210MW) result in very adverse market outcomes primarily due to substantially increased FCAS (R6) requirements to address the new system security parameters. This paper proposes a baseload CCGT configuration which meets the current Tasmanian standards, has a much smaller contingency size and very comparable costs. It is proposed as a possible solution and there may well be more suitable of more efficient configurations.

2 Options for increased generation in Tasmania

The cost of delivered gas in Tasmania is high and economically viable gas fired generation projects typically require lowest capital cost, greatest efficiency solutions. In all probability as first option to consider would be a large CCGT option (i.e. similar to TVP). A considered assessment of the market would lead to the realisation that Rule changes and/or options for supplementary tripping would be necessary and this would cause a re-evaluation of the commercial model taking into account additional compliance costs. These could be substantial particularly in respect of not satisfying the multiple contingency band requirements.

The goal would be for the proposal to be accepted by Transend and NEMMCO as meeting NER and other “implied” connection conditions such as not adversely affecting other generator market access to ensure no adverse outcomes in the connection process.

Noting that large Frame gas turbines and new large steam turbines do not satisfy the Tasmanian frequency standards it is likely that in the event of the above option not being accepted, consideration could be given to developing a similar plant capacity using smaller aero derivative CCGT units, albeit at increased capital and maintenance cost.

The units would typically be around 85MW each, with 50MW gas turbines, HRSG’s with supplementary firing and 40MW steam turbines (as per example in Gas Turbine World 2008), each with exhaust gas bypass to permit tripping of ST whilst retaining the GT in operation. The GT’s would be fully compliant with the current frequency standards. It is believed that the smaller ST’s would also be compliant, certainly for the lower frequencies, The GT’s installed at Bell Bay by Hydro Tasmania do conform with the current frequency standard.

The table below gives estimates of the LRMC’s of two options, i.e. a single 189MW CCGT (109E) together with compliance costs versus smaller CCGT’s.

Table 1: Summary of generation options which meet current Tasmanian frequency standards

Option	Plant	Capital cost (US$)	Possible compliance cost	SRMC (AU$)	LRMC (AU$)
1	190MW CCGT (109E)	$1070/kW ($202M)	$0 applied in comparison ($2M to $3M pa possible penalty to include in comparison)	$40 $42-$43	$58 $59-$60
2	180MW (2 x 90MW CCGT 50MW Trent plus 40MW ST)	$1200/kW ($216M)	0	$41	$62
3	4 x LM6000 sprint open cycle peaker station (200MW)	$1000/kW ($200M)	0	$49	$80 plus

Table 1 has been produced using data from the SA Planning Council[1] and PB Power[2] and escalating capital costs as proposed by Reference 2 and applying average O&M costs to create a 2008 view. The detailed calculations are shown in Attachment 1. Resulting capital costs are as follows (US $):

Plant option	2005 prices	2008 escalated
109E:	$535/kW	$1070/kW
Trent CCGT:	$607/kW	$1200/kW
LM6000	$570/kW	$1000/kW

Reference 1 which is based on an exchange rate of 1AUD = 0.72USD suggests average LRMC's of around $60 in 2005. The 2008 view shows similar LRMC numbers in AU$ notwithstanding the stronger AU$, this result being primarily due to the significant escalation in capital costs for construction in Australia (as shown above).

As can be seen, the 109E option delivers the most favourable initial LRMC ($58) with the Trent CCGT giving a $62 LRMC. If we assume that compliance could add an equivalent of $2M per annum of fixed cost to the 109E option, the LRMC changes to $59 and for $3M penalty to $60 making the difference between the plant options fairly small. Noting that the operational flexibility of two units exceeds that for a single unit (109E) and that further opportunity exists for providing other services such as ancillary services and network services, the notional 5 to 10% cost difference between the options could possibly be outweighed by other considerations.

[1] Estimates of the long run marginal cost of supplying electricity to small customers in 2005 – ESI Planning Council 31/08/04

[2] Tasmania frequency standards and gas turbines – PB Power 21/05/08

3 Conclusions

The above examples of possible generation options illustrate that large CCGT options such as the 109E or (701D), if fully compliant with system standards, offer the most economical solution. It therefore makes sense to explore all avenues to achieve compliance of the large CCGT plant option with the current Tasmania frequency standards.

The best option may well be Option 2 (or a combination of Option 2 and Option 3) taking into account that these options would offer increased operational flexibility and substantially reduced commercial risk for a small cost increase.

Option 3 has been shown on its own to indicate that peaker stations, as expected, require higher contracted prices (and other service arrangements) to survive. An optimistic 40% load factor has been assumed for this option, i.e. around 10 hours per day at full output.

Attachment 1 : Cost Calculation Details

Plant option	109E Greenfields	2 X Trent CCGT
Capital Cost (USD$MM)	202	216
Max output (kW)	189000	180000
Cost per kW (USD$)	1069	1200
Parasitic load (kW)	4500	4500
ISO LHV Heat rate (BTU/kWh)	6600	6800
Fuel Price/GJ (AUD$)	4.3	4.3
O&M Cost Variable (USD$ per MWh)	4	4.5
Fixed O&M Cost (USD$MM per anum)	2	2
Availability	0.93	0.92
Load factor	0.95	0.95
Hurdle rate	0.09	0.09
Project lifespan	20	20
AUD$/USD$ exchange rate	0.93	0.93

Adjusted heat rates (kJ/kWh HHV)	7969	8210
Max units generated per annum (MWh)	1462758	1378123
Parasitic units (MWh)	36661	36266
Units sold per annum (MWh)	1426097	1341857
Actual units generated per annum	1462758	1378123
Fuel cost per annum (AUD$)	$50,122,649	$48,653,554
Annual capital cost (AUD$MM)	$23.79	$25.54
Equivalent fuel cost per MWh sold (AUD$)	**$35.15**	**$36.26**
Capital cost per MWh sold (AUD$)	$16.68	$18.96
Variable O&M cost (AUD$/MWh sold)	**$4.41**	**$4.97**
Fixed O&M cost (AUD$/MWh sold)	$1.51	$1.60
Total O&M Cost per MWh	**$5.92**	**$6.57**
Equivalent selling price LRMC (AUD$/MWh)	**$57.75**	**$61.79**
Annual Fuel Usage (GJ)	11,656,430	11,314,780
Overall heat rate (kJ/kWh)	8174	8432
Overall efficiency (fuel in to units sold)	**44**	**43**
SRMC	**40**	**41**

Hydro Tasmania's estimate of the capital cost of additional fast raise

Information has been removed due to its confidential nature

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