Hydro Tasmania - Submission to Reliability Panel

Executive Summary

The assessment of the right frequency standards for Tasmania is a key decision for Tasmania. It has the potential to initiate very significant wealth transfers and to impose major costs on participants and customers if not done correctly. Although the Reliability Panel is charged with assessing frequency standards, this can not be done in isolation from the plant on the ground and new projects which are in advanced stages of development.

Hydro Tasmania believes that it is vital for the Reliability Panel to seek an effective solution for Tasmania by considering the choice of frequency standard in conjunction with possible rule changes or other mechanisms.

The complexity of this area means that a change to the standard should only be recommended if there is a very clear cost benefit case and confidence that a tighter standard can be implemented with an acceptable level of system security risk.

The key issues requiring consideration are:

- Any tightening of the standards will require additional fast raise ancillary services which are already in short supply;

- Increasing the contingency size (Alinta's proposed plant raises generator contingency by 50 per cent) causes a significant increase in the need for fast raise ancillary services;

- Additional raise services will be costly to supply. Hydro Tasmania estimates the capital cost of additional fast raise will be up to $1.2million per MW. Current market arrangements for recovery of costs for these services does not provide a commercial incentive for investment;

- The effective supply and future supply opportunities in Tasmania will be lower and therefore prices higher with tighter frequency standards because:
    - the extra requirement for fast raise services would dramatically and negatively affect the efficient use of Tasmania's Hydro plant and water in storage and the use of Basslink for import and export ; and

    - tightening the standard will reduce the volume of 'low inertia' (wind and Basslink imports) supply into Tasmania;

- Gas fired plant that can meet the current Tasmanian standards is available and could have been selected for construction in Tasmania;

Hydro Tasmania has expertise in these issues and has provided more detail around the issues in the appendices. We are keen to work with the Reliability Panel and its consultants to achieve a good outcome.

Hydro Tasmania is well aware that the Tasmanian region needs new energy sources to accommodate the growing energy demand of the State as well as increasing competition in the interest of customers. We have assessed what we believe are credible scenarios with regard to new generation projects and various frequency standards to conclude that changing frequency standards alone does not resolve the issues facing Tasmania in the foreseeable future. We have suggested a package of frequency standards and a rule change or alternative mechanism as another way for new entrant generators to meet minimum access standards under the rules. We are convinced that this approach minimises costs, maximises benefits (and hence is consistent with enhancing the NEM objective) and can be implemented in a time frame that can realistically meet the State’s needs.

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1. Background

In this submission Hydro Tasmania will address each of the dot points contained in the consultation paper in the following manner:

- *the proponents of new generating projects can identify the changes to the standards that would be necessary if their proposed generating units were connected;*

Although Hydro Tasmania is not a direct proponent of any new generating projects, it is well aware of the Alinta, Gunns and R40s projects that are planned for commissioning within the 5 year horizon. We will therefore suggest a solution that we believe will accommodate the connection of these new generators in a timely, positive cost/benefit way, based on our first hand experience of the Tasmanian market and market dispatch mechanisms.

- *stakeholders can identify relevant and important economic factors that the Panel should consider when assessing any changes to the standards.*

In considering relevant and important factors, our submission considers the introduction of new generating projects (focussed on large combined cycle thermal units) under the current NER and frequency standards as well as the standards proposed by Alinta[1] in their submission to this review. The Panel's consideration needs to encompass an increase in generator contingency size, as this will be facilitated by, and so cannot be isolated from, the consultation on changes to frequency operating standards in Tasmania.

Whilst the issues are complex and considered in more detail in the submission, the essence of the problem is summarised below:

- Any tightening of the standards will require additional fast raise ancillary services which are already in short supply;

- Increasing the contingency size (Alinta's proposed plant raises generator contingency by 50 per cent) causes a significant increase in the need for fast raise ancillary services;

- Additional raise services will be costly to supply. Hydro Tasmania estimates the capital cost of additional fast raise will be up to $1.2million per MW. Current market arrangements for recovery of costs for these services does not provide a commercial incentive for investment;

- The effective supply and future supply opportunities in Tasmania will be lower and therefore prices higher with tighter frequency standards because:

[1] Alinta submission to RP review of Tasmanian Operating frequency Standards 2008NE2071-Alinta001, Transend/HillMichael – Frequency Standard Development Final Report to Alinta

- the extra requirement for fast raise services would dramatically and negatively affect the efficient use of Tasmania's Hydro plant and water in storage and the use of Basslink for import and export; and
- tightening the standard will reduce the volume of 'low inertia' (wind and Basslink imports) supply into Tasmania;

- Gas fired plant that can meet the current Tasmanian standards is available and could have been selected for construction in Tasmania.

Appendix A provides a more detailed technical treatment of the major issues.

2. Context

Historically, frequency standards for the Tasmanian system have remained different to those of the broader NEM due to the recognition that Tasmania has different capabilities in comparison to the mainland. The key differences are:

- Tasmania is a small region where demand ranges from approximately 900 – 1800 MW;
- Basslink is a DC monopole interconnector that prevents 'pure' interconnection with the larger mainland system. In particular there are import/export ranges where Tasmania can not participate in the global FCAS markets and is therefore treated as an independent region;
- The predominant hydro turbine technology within the region; and
- A largest generator contingency of 144 MW.

These characteristics could be described as providing a different 'technical envelope' for the region relevant to NEM frequency standards. Stakeholders[2] have been well aware of this fact in both a pre and post NEM entry context and hence it was one of the most relevant drivers for maintaining the existing Tasmanian frequency operating standard at the time of NEM entry. The difference in technical envelope has more recently been acknowledged in the current Reliability Panel review of the "*mainland frequency operating standards during periods of supply scarcity*". In this review NEMMCO suggests that any recommended changes should exclude Tasmania due to the difference in technical envelope.

Hydro Tasmania's experience to date concludes that the current standards and associated dispatch constraints have provided acceptable reliability and security for the region. Although, under conditions when global transfer of Frequency Control Ancillary Services (FCAS) is not possible, FCAS supplies in Tasmania are sometimes stretched to satisfy the NEM dispatch requirement. Hydro Tasmania as the predominant supplier of FCAS in the region is also very cognisant that the

[2] NEMMCO, Jan 2006: Reliability and Frequency Operating Standards for Tasmania NEMMCO advice to the Reliability Panel; and
Tasmanian Jurisdiction, March 2006: Frequency Operating Standards Tasmanian Overview.

costs of supplying raise services, in particular, is not necessarily reflected in market price outcomes.

3 Current Proposals

Frequency Standard remains primarily unchanged: – Units such as the CCGT proposed by Alinta do not meet the access standards as set out in the NER and as such would require 'special' arrangements accompanied by appropriate rule changes to be able to connect. Basslink was designed in a similar fashion in that the associated System Protection Scheme (SPS) and frequency controller function prevented any adverse impacts on system security for the Tasmanian region. Without special arrangements the generator designs that the Tasmanian region could accommodate would be limited to smaller more robust units that could meet the current standards and not increase the contingency size.

Frequency Standard changes to Alinta's proposed standard: - Changing to Alinta's proposed standard would create technical issues that would need to be resolved and incurs considerable costs. These changes are highly complex and consequently introduce a high level of risk both whilst they are being commissioned and for participants if some deficiency is uncovered after the standards have been changed. The specific required changes and relevant issues identified so far are:

a) The frequency controller objective function and the System Protection Scheme would not function correctly without modification. Any modifications would require modelling, redesign, implementation and commissioning prior to the introduction of a new standard.

b) Under Frequency Load Shedding Scheme and Over Frequency Generator Shedding Scheme will be required to operate within much tighter parameters. It is yet to be determined whether settings to achieve design objectives can be achieved without increasing the number of operations impacting customers. These settings are also required to be coordinated with other protection systems (note: resultant significant increase in system security risk profile). Any additional shedding of customer loads also contracted to the SPS reduces the availability of those loads to the SPS (potentially extending well beyond the event).

c) FCAS raise requirements to maintain system security would increase (approximately 30 per cent increase on current provision for the same contingency).

d) Existing FCAS supplies would decrease slightly as trapezia would need to be recalculated and reregistered with regard to a new technical specification (estimated 5 per cent reduction).

e) The combined effect of c) and d) would decrease average Basslink imports in order to satisfy system constraints. This will reduce competition in the Tasmanian market by limiting access for mainland generators and could cause supply problems under the current drought conditions.

f) For Hydro Tasmania to produce more FCAS, the net energy yield from Hydro Tasmania will be decreased and there will be significant additional wear and tear on generation plant. Appendix B provides alternative solutions and indicative costs for the supply of FCAS.

The change in frequency standard would also mean that large combined cycle units are likely to meet automatic access standards under the NER, therefore the Tasmanian region generation event contingency size could increase to in excess of 200 MW without any other mechanism to limit contingency size. The impacts of this increase in contingency size includes the following that should be considered in addition to the issues above.

g) Reduced operational capability of the Basslink interconnector:
   i. dispatch will target Basslink to mid-range flows, away from the no-go zone and import limits so as to provide access to global FCAS; and
   ii. Basslink imports would be directly impacted proportional to the additional FCAS required from the global market.

h) Normal market dispatch processes would be unable to reverse Basslink flow from northward to southward direction:
   i. NEMMCO's powers of direction, would be the mechanism most likely required to reverse Basslink. These powers are not to be used for routine dispatch with strict criteria needing to be met prior to directions (e.g. system security threatened); and
   ii. Increased Basslink counter-price flows, both in duration and magnitude, would result from this dispatch outcome.

i) Operation of the Tasmanian system without Basslink interconnection may become problematic as well (Basslink maintenance periods);

j) VoLL ($10 000) pricing for local FCAS in Tasmania would not necessarily provide incentives for capital investment in FCAS under the current market arrangements especially as generators are paying for fast raise, and

k) Future wind development in the State (decreasing inertia), is likely to complicate the above issues, ultimately making further development significantly less attractive to wind proponents.

4 Hydro Tasmania Proposal

Our deliberations around the various, sometimes conflicting, arguments for and against tighter frequency standards have concluded that the following cost factors combined with implementation lead times are likely to be the key determinants to the outcome of this review. We have designed this proposal around a compromise that keeps these costs to an absolute minimum as well as facilitating realistic implementation times that meet the planned schedules of new generation projects.

Key Costs:

- Supply of fast raise FCAS;
- Barrier to most cost efficient new entrant generation[3];
- System Modelling;

- Modifications to protection schemes;
  - System Protection Scheme (SPS);
  - Under Frequency Load Shedding Scheme (UFLSS); and
  - Over Frequency Generator Shedding Scheme.
- Modifications to the Basslink Frequency Controller objective function;
- Modifications to market dispatch process (NEMDE); and
- Access to interruptible load.

[3] HT acknowledges that gas is the most realistic base load supply option for Tasmania in the near term.

Proposal Detail:
In the light of the issues noted above, Hydro Tasmania has a proposal which is based on a combination of new frequency standards and a rule change, which must be considered as a package. The following table contains a suggested alternative frequency standard that is primarily somewhere in between the current standards and those standards proposed by Alinta. The conceptual rule change is outlined further on and should be read with reference to the table.

Table 1: Comparison of Frequency Standard Proposals

Condition	Current Standard	Hydro Tasmania Proposal	Alinta Proposal
Interconnected operation			
No contingency or load event	49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99% of the time	49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99% of the time	49.75 to 50.25 Hz, 49.85 to 50.15 Hz 99% of the time
Load event	49.0 to 51.0 Hz	49.0 to 51.0 Hz	49.0 to 51.0 Hz
Generation event	47.5 to 51.0 Hz	47.5 to 51.0 Hz	**48.0** to 51.0 Hz
Network event	47.5 to 53.0 Hz	47.5 to **52.0** Hz	**48.0** to **52.0** Hz
Separation event	46.0 to 55.0 Hz	46.0 to 55.0 Hz	**47.0** to 55.0 Hz (With thermal generation units allowed to trip at 52.0Hz)
Multiple contingency event	46.0 to 55.0 Hz	46.0 to 55.0 Hz	**47.0** to 55.0 Hz (With thermal generation units allowed to trip at 52.0Hz)
Islanded Operation			
No contingency or load event	49.0 to 51.0 Hz	49.0 to 51.0 Hz	49.0 to 51.0 Hz
Load event	47.5 to 53.0 Hz	47.5 to **52.0** Hz	49.0 to 51.0 Hz
Generation event	47.5 to 53.0 Hz	47.5 to **52.0** Hz	**48.0** to 51.0 Hz
Network event	47.5 to 53.0 Hz	47.5 to **52.0** Hz	**48.0** to **52.0** Hz
Separation event	46.0 to 60.0 Hz	46.0 to **55.0** Hz	**47.0** to **55.0** Hz (With thermal generation units allowed to trip at 52.0Hz)
Multiple contingency event	46.0 to 60.0 Hz	46.0 to 55.0 Hz	**47.0** to **55** Hz (With thermal generation units allowed to trip at 52.0Hz)

Rule Change
The intent of the rule change would be as follows:

To provide generators with an additional option for meeting the minimum access requirements by negotiation with the TNSP and with the agreement of NEMMCO where such an option adheres to the following principles:

- *connection of the generator provides a net benefit to the NEM objective; and*
- *technical alternatives to meeting frequency standards maintain reliability standards.*

To determine the required conditions to meet the guiding principles of the rule is a matter of identifying the areas of the frequency standard where the proponent is unable to comply as well as assessing the increase in costs attributable to the new entry. Table 2 is an example of the process with reference to HT frequency standard proposal (Table 1) and expected costs.

Table 2: Gap analysis for conditional dispensation

Issue	Impact	System Risk	Cost	Technical Solutions	Mitigated Risk	Mitigated Cost
Unable to meet 46Hz requirement	Exacerbate under frequency event	↑	↑	• Incorporate into UFLSS scheme • Operate in "free governing" mode	→	→
Unable to meet 55Hz requirement	Exacerbate over frequency event	↑	↑	• Incorporate into OFGSS scheme • Operate in "free governing" mode	→	→
Increased generator contingency size	Increases demand for raise FCAS beyond available supply		↑	• Limit plant output to 144MW • Use interruptible load to reduce contingency size		→

In this example, the conditions to be applied could be:

1. The proponent is required to limit its contingency size to 144MW – no increase in FCAS required.

2. The proponent's plant is to be incorporated into under and over frequency protection schemes – uncertainty of tripping removed.

3. The proponent must operate the plant in free governing mode – reduces the probability of frequency excursions breaching the combined generation and network event standards.

Our initial research suggests that this concept of ‘conditional dispensation’, although in a different market context, has been successfully applied in New Zealand for a number of years. They chose to maintain their broader standard and find innovative, low cost ways for large combined cycle units to connect to the system. At the time of writing, Hydro Tasmania is seeking clarification around how the New Zealand market and dispatch process operates in this area.

5 Approach to Cost Benefit Analysis

The terms of reference do not discuss the approach proposed to undertake the cost/benefit analysis. It is useful to have some high level principles for guidance and Hydro Tasmania makes the following suggestions:

- **Scenario Analysis –** it is difficult to base a cost/benefit analysis on a change in standard in isolation. Credible scenarios that result from a frequency standard changes and possible linked rule changes should be developed. The cost/benefit is then based on these credible scenarios;

- **Relevant Horizon –** any change to frequency standards should be cognisant of likely future developments for the foreseeable future (eg 5 – 10 years). This is particularly important as it would be impossible in practice to loosen the standard in the future;

- **NEM Wide Scope** – the costs and benefits should be assessed on a NEM wide basis in line with the NEM Objective;

- **Regional Impact –** net impact on energy and capacity available to the state needs careful consideration in short, medium and longer time frames;

- **Losers and Beneficiaries** – During the analysis, cognisance should be taken of where the costs and benefits are to be attributed to ensure a reasonable level of equity in any decision;

- **FCAS Costs** – water which is lost due to inefficient running by machines which supply FCAS should be costed at the water opportunity cost that includes the lost efficiency and increased maintenance costs or the marginal cost of an independent FACS source. Additionally, costs of required new FCAS supply should be ascertained with recognition of where those costs fall and the ability of a participant to recover their investment in the market; and

- **Larger Contingency** – cost benefit analysis should be done with both the current and 210 MW contingency to form a view on the viability and costs of any proposed change following the commissioning of the Alinta plant.

The following table is reflective of the alternate options discussed in this submission using relativities in the absence of quantitative cost estimates.

Table 3: Indicative cost comparison of alternative options

Option	New entrants connected	Modelling	Increased FCAS (raise)	SPS modifications	UFLSS modification	OFGSS Modification	Freq. Cont. modification	Market Dispatch modifications	Interruptible load	Commissioning	Implementation Time
Current Standard	High	No	No	No	No	No	No	No	No	No	N/A
Alinta Standard	No	Med	High	Med	Med	Low	Med	High	No	Med	+2yr
Hydro Tasmania Proposal	No	Low	No	No	Med	Low	No	No	Med	No	1yr

6 Conclusion

Hydro Tasmania is well aware that the Tasmanian region needs new energy sources to accommodate the growing energy demand of the State as well as increasing competition in the interest of customers. We have assessed what we believe are credible scenarios with regard to new generation projects and various frequency standards to conclude that changing frequency standards alone does not resolve the issues facing Tasmania in the foreseeable future. We have suggested a package of frequency standards and a rule change or alternative mechanism as an alternative way for new entrant generators to meet minimum access standards under the rules. We are convinced that this approach minimises costs, maximises benefits (and hence is consistent with enhancing the NEM objective) and can be implemented in a time frame that can realistically meet the State's needs.

Additional detail is provided in the appendices although due to the complexity of the issues it is recognized that substantial dialogue will be required to fully understand the issues and their impacts. Hydro Tasmania has considerable expertise and experience in these matters and is prepared to make this expertise available to work with the Reliability Panel and stakeholders alike to achieve a good outcome.

Appendix A - Explanation of the Issues

1. Issues to be considered

Hydro Tasmania considers the following as the key areas to be evaluated:

1. Supply and demand of FCAS with both current and modified frequency standard combined with existing and new large generating unit contingency including market dispatch impacts.

2. Modifications required to Basslink frequency controller and consequent impacts.

3. Protection scheme modifications (System Protection Scheme (SPS), under frequency load shedding scheme (UFLSS), over frequency generating unit shedding scheme (OFGSS).

4. Modelling methods and safety margins.

5. Adapting combined cycle gas turbine plant (CCGT) to existing frequency standards versus changing frequency standard.

1.1 Supply and demand of FCAS – Market Impacts

1.1.1 Tasmanian system design

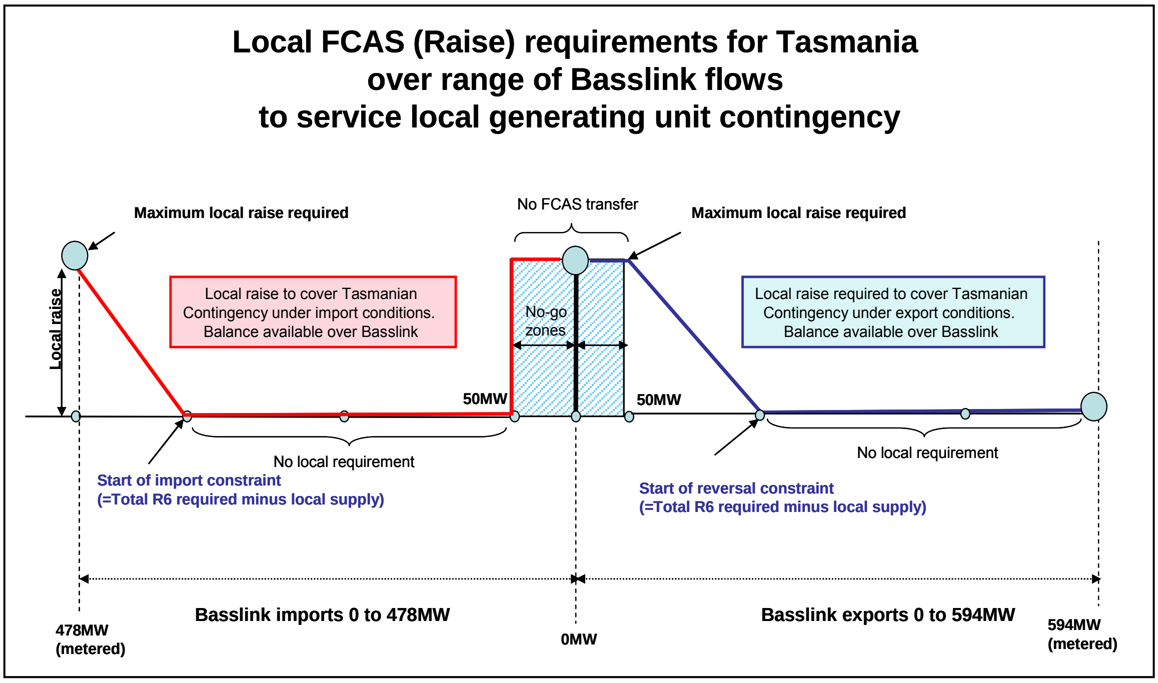
The Tasmanian system with associated frequency standards has been developed around a generating unit contingency size typically not greater than 144 MW. Dispatched generation governor action (FCAS capability) has over the years, (prior to NEM entry and beyond), been shown to be well matched to this maximum contingency size and frequency deviations under weak system conditions (night loads, etc) have been contained to just above 47.5Hz as required. This view is indirectly supported by NEMMCO[4] in their paper which suggests that the current 144 MW event is effectively balanced by the notional 10 per cent FCAS capability delivered by machines meeting automatic access standards, this implying that a larger contingency would require machines to deliver FCAS in excess of the automatic access standard.

Basslink was designed with the associated SPS to limit the resultant contingency size to approximately 144 MW in order to satisfy criteria, (amongst others), of not causing excessive FCAS demand issues and ensuring that Basslink could in fact deliver up to its rated import capacity under system conditions considered to be 'normal'. Design studies in fact indicated that Basslink would be unable to import beyond around 300 MW under very light (low inertia) system conditions largely due to FCAS limitations.

[4] NEMMCO paper "Reliability and Frequency Operating Standards – advice to Reliability Panel – 24/01/2006"

1.1.2 210MW generating unit event – increased FCAS under various system conditions and no change to frequency standards

The largest single generating unit contingency in Tasmania is 144MW and FCAS (R6) resources in Tasmania are currently stretched to satisfy this contingency size under conditions when global FCAS transfer is not possible, ie when Basslink is required to reverse (no-go zone FCAS separation) and under high import scenarios. The diagram below illustrates the scope of global FCAS (Raise) transfer and in particular the constraints upon global FCAS (Raise) transfer reversing Basslink from export and at elevated imports.



If the generating unit contingency size increases to over 200 MW, the FCAS (R6) requirements to cover the above conditions can more than double to values substantially in excess of current FCAS availability in Tasmania. Basslink could therefore, for example, become constrained in a northward flow condition with local FCAS Raise being less than that required to satisfy the reversal requirements. With a 200 MW unit normal dispatch processes would not reverse Basslink; NEMMCO would need to use its powers of direction. Direction can only be used when the requirements of the applicable rules are met[5].

A further point to note here is that if Basslink does become trapped as described above during a period when local demand in Tasmania is increasing, the reserve margin issue becomes further exacerbated with consequent increased risk of load shedding.

Note that under 'Network events' in Tasmania the largest contingency can be 200 MW (or above), such conditions only arising during network outages (ie very infrequently). The FCAS issues mentioned above, (particularly Basslink reversal), have been mitigated through reducing the contingency size to in turn reduce the constraint equation FCAS requirements. Such actions have been at the discretion of participants not the output of the dispatch process. Eg Gordon Chapel St

[5] NER Clause 4.8.9A System Security Directions

Transmission line outage creates the situation where the total output from Gordon PS is considered credible.

A larger generating unit (200 MW+) with current frequency standards will require additional FCAS (or other measures) to avoid extreme Basslink constraints and associated market outcomes.

1.1.3 210MW generating unit event and frequency standard changed to 48.0Hz

If the frequency standard for generating unit event changes from 47.5Hz to 48.0Hz as the maximum excursion, the issues mentioned in the preceding paragraph are substantially exacerbated to values well above the gross capability in Tasmania. Indications are that a 144 MW contingency will already be very difficult to service from current FCAS resources with R6 values increasing by around 30 per cent above typical present values.

A 200 MW+ generating unit contingency in Tasmania will almost certainly, (in the absence of other measures) result in extreme Basslink constraints and severe distortion of market outcomes.

The tables below summarise the expected impacts of the various scenarios.

Table 1: Current generating unit event frequency standard (47.5Hz to 51.0Hz)

Contingency Size	FCAS R6	SPS, UFLS, etc	Basslink frequency controller	Basslink constraints
144MW	60-100 MW	No change	No change	Minimal reversing (no-go zone) issues Insignificant import constraints
210MW	160-220MW	No change	No change	Extreme reversal (no-go zone) issues expected Major import constraints

Note: FCAS estimates produced for the scenarios discussed are possibly at best only indicative, particularly for the more extreme scenarios. Detailed modelling is required to be more definitive about the quantity of services required across all dispatch scenarios.

Table 2: New generating unit frequency standard (48.0 Hz to 51.0Hz)
(Compare each impact against Table 1 comment)

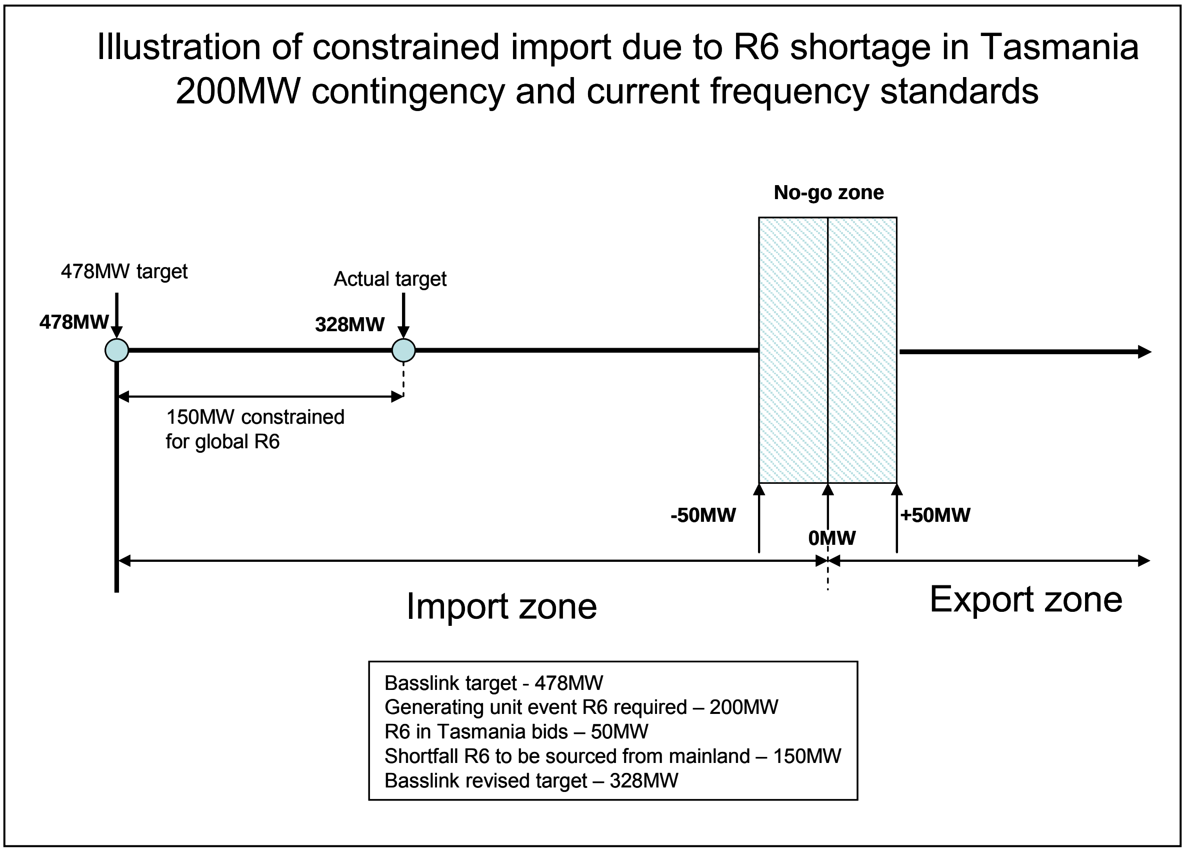
Contingency Size	FCAS R6	SPS, UFLS, etc	Basslink frequency controller	Basslink constraints
144MW	80-130MW	Modifications required (Ref section 3)	Modifications required to accommodate revised minimum frequency	More frequent reversal (no-go zone) issues Moderate import constraints
210MW contingency	180-240MW	Modifications required (Ref section 3)	Modifications required to accommodate revised minimum frequency	Extreme reversal (no-go zone) issues expected Major import constraints

1.1.4 Global and local FCAS issues

When Basslink is at an operating point (target) well away from its hard limits, ie near import or export limit and the reversal region (no-go zone), the sourcing of FCAS is from the global market and generally not an issue of supply even for the values assessed for a change to frequency standard. The exception to this statement is when demand is high and generators make R6 effectively unavailable.

What should be noted is that the limit imposed upon Basslink is really in essence determined by the difference between the amount required by the constraint equation and the local supply in the Tasmanian dispatch at the time. If Basslink were in export mode at the time and energy prices in Tasmania increased above mainland prices, Basslink would be constrained in export mode by an amount that would allow the global supply of FCAS via Basslink to effectively deliver the shortfall of R6 not available in Tasmania. Under this condition, counter price flows with substantial price differences, could prevail indefinitely without manual intervention by NEMMCO.

A similar argument would apply with Basslink already in import mode and energy prices such that Basslink could have a target of 478 MW, ie maximum import. Under such conditions (with less generation and lower inertia dispatched than for export conditions), it is possible that the FCAS (R6) shortfall, (ie constraint equation amount less local available), could be well in excess of 200 MW and Basslink import would be constrained by this amount to allow global supply of the FCAS deficit. The figure below illustrates a scenario with a 200 MW R6 requirement (this being quite typical for a 200 MW generating unit contingency and current frequency standards).



What should be noted in respect of Basslink is that, unlike an AC interconnector, Basslink has to traverse the no-go zone to reverse flow direction and also operate within hard availability limits (as set by MNSP owner). Basslink is typically required to reverse a number of times per day as prices vary across the NEM regions.

Basslink's energy target (MW) together with the global FCAS (MW) for that dispatch interval may not exceed the Basslink availability (typically 480 MW)[6]. An AC interconnector on the other hand, will have an energy constraint, established totally in isolation of FCAS considerations, there being adequate provision in the transfer limit calculations to accommodate contingency effects.

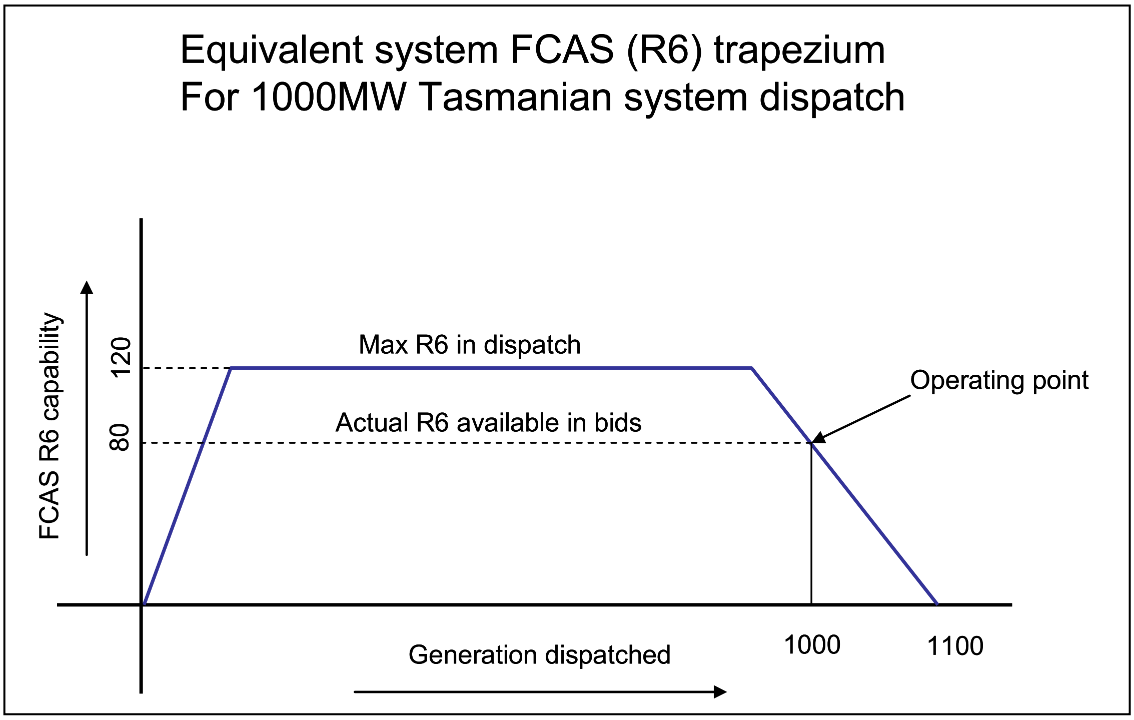
A shortfall of even 1 MW around the Basslink no-go zone can result in VoLL FCAS prices and constrained operation. Likewise each MW of unsourced local FCAS will reduce Basslink import by 1 MW regardless of the value of energy being constrained as security cannot be violated.

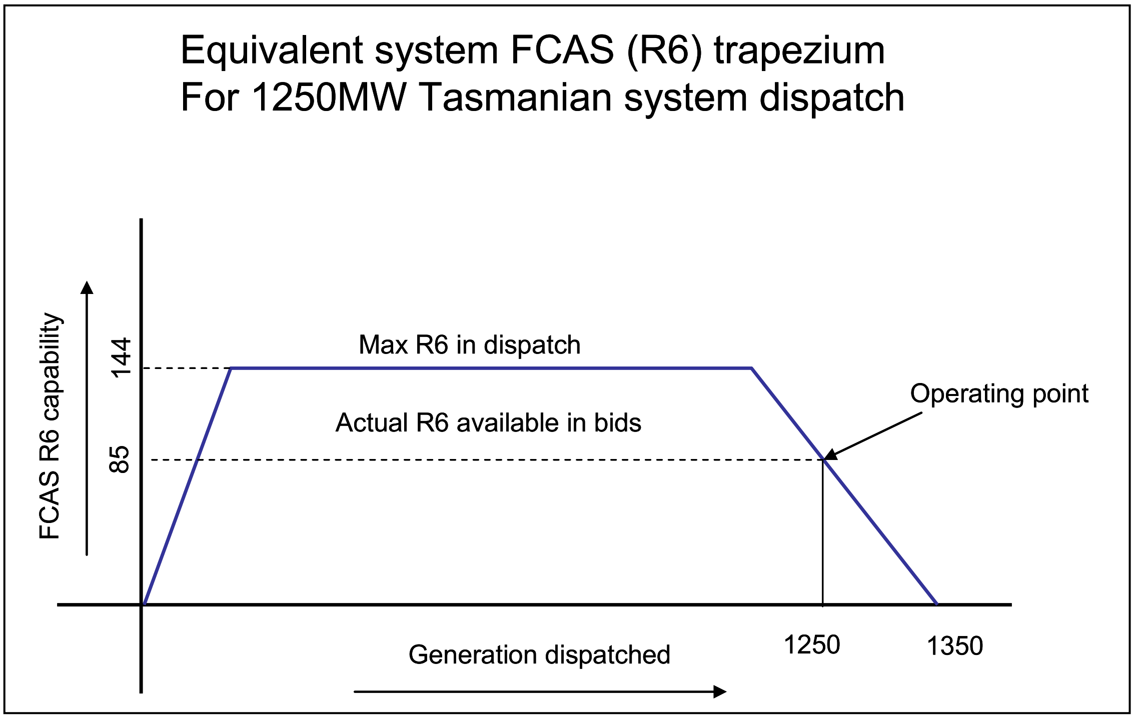
1.1.5 Tasmania FCAS (R6) supply (including reduction in R6 capability)

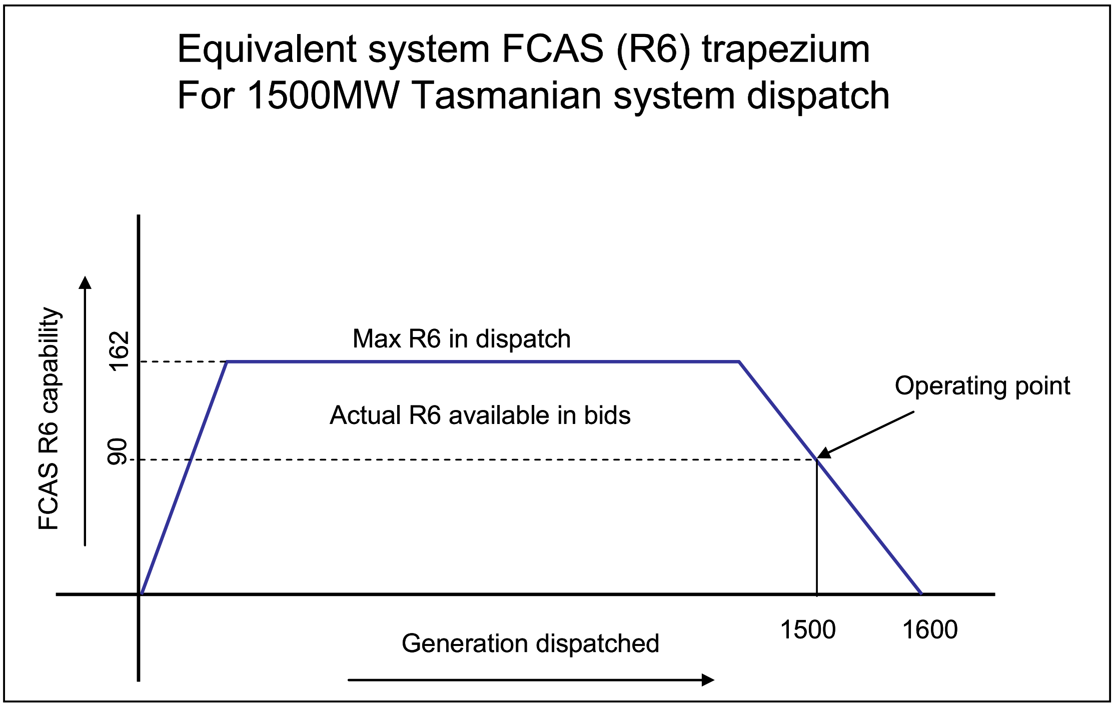
At present, virtually all FCAS in Tasmania is sourced from Hydro generators. Gas turbines to date have not offered any FCAS services and it is conceivable that little R6 is available from these machines when operating at or near their maximum turbine efficiency point (full output). Tasmania's gross registered R6 capacity with average lake levels is less than that estimated for a 210 MW generating unit contingency under a moderately loaded system with current frequency standards. For the 48.0Hz frequency standard, the shortfall could be increased by approximately 100 MW. Note that until Basslink is exporting power to Victoria, far less generating units are being dispatched for energy, and therefore dispatched FCAS is substantially less than the system aggregate. Also influencing actual availability is the fact that FCAS capability is defined with a trapezium shape and diminishes to zero at high energy outputs. Ie Reduction in FCAS capability in a dispatch if cheaper energy machines are dispatched at high output (co-optimised market outcome).

[6] Refer to NEMMCO paper "FCAS constraints SOPP_CG_03 dated 8/9/2006"

Some examples of system dispatch and equivalent system R6 trapeziums are shown in the illustrations below:







The three scenarios above illustrate what could be termed typical market dispatches of energy and FCAS to satisfy Tasmanian demands of 1000, 1250 and 1500 MW. The diagrams illustrate that under smaller Tasmania demands, the maximum R6 (trapezium aggregate) could be approximately 120 MW with only around 80 MW of R6 being available for the FCAS constraint equations due to the profile of the FCAS capability diagram (ie a tapering off at higher machine outputs).

As the system demand increases, machines are typically dispatched at even higher energy outputs (for maximum efficiency) and the margin between aggregate R6 and available R6 decreases. The diagrams illustrate the practical situation where under most dispatches, less than 100 MW of R6 is available for NEMDE enablement. Where greater amounts of R6 are required: First NEMDE will co-optimise dispatch to access greater quantities, generally increasing the price of both FCAS and energy up to a maximum of Voll (FACS and/or energy requirement can't be met in dispatch). Then market participants may respond with rebids to lessen adverse impacts where they have a capacity to do so.

The diagrams do also indicate that the aggregate R6 in Tasmania at fairly high outputs is typically less than 200 MW (at the expense of substantial energy). Low storage situations exacerbate the cost of this inefficient running as the marginal water costs increases significantly.

Although not yet analysed, the suggested frequency standard change (47.5Hz to 48.0Hz) has the propensity for reducing FCAS (R6) capability from hydro machines. The impact may be marginal but even say 5 per cent reduction could be material.

If no other solutions for accommodating Alinta are forthcoming, Tasmania will have to find around 200 MW of R6 from other sources (currently not registered FCAS participants). The incentives to make such investments in FCAS are very small as the high quantities are only required to be sourced locally when Basslink is approaching the no-go zone or full import.

1.1.6 Network Event Upper frequency change

The proposal to reduce the upper frequency for network events from 53.0Hz to 52.0Hz will also have market impacts as the amounts of FCAS (Lower) will increase and place further stress on this element of the FCAS market. Indications are that the local (Tasmania) Fast Lower (L6) requirement to satisfy Basslink export constraint equations will all but double from around 40 MW to up to 80 MW. The Network event (load loss) L6 is also expected to increase from around 60 MW to around 80 MW.

Additional sources of L6 from new entrants will assist in alleviating possible adverse market outcomes due to L6 shortages. The proposed network event frequency standard of 52.0Hz and the proposal to permit new thermal plant to trip at 52.0Hz create an anomaly in that such plant, albeit possibly capable of supplying L6, may have to be disqualified as FCAS providers for a 52.0Hz network event. The question is therefore raised as to whether further consideration is required in respect of the network event upper frequency.

1.1.7 Market outcomes

Basslink as an interconnector between Tasmania and mainland should as far as possible satisfy market requirements of energy being dispatched from cheapest sources. Co-optimisation of energy and FCAS can result in energy being slightly constrained in order to accommodate the FCAS quantities and prices. FCAS supply and demand issues together with Basslink limits, at times result in counter-price flows on Basslink but these outcomes could possibly be classified as moderate. The scenarios discussed earlier arising out of either an increased generating unit contingency in Tasmania or as exacerbated with a frequency standard change could result in extreme market outcomes.

Rigorous studies with projected market scenarios would be required to demonstrate the shortfall amounts of FCAS and to assess the frequency and severity of Basslink constraints directly due to the FCAS issues as described in this paper. The total annual trading value of Basslink is several hundred million dollars and it is conceivable that the FCAS issue could therefore account for several tens of millions of dollars per annum.

2 Modifications to Protection Schemes

2.1 Modifications required to Basslink frequency controller

The Basslink frequency controller objective will have to be modified to accommodate the revised frequency bands. These changes will have to be effected by the owner of Basslink and will affect the relative amounts of power transfer (FCAS) for contingencies in Tasmania or Mainland. Costs to effect the changes are not expected to be insubstantial and will require review of the connection agreement with Transend and all associated system modelling.

2.1.1 FCSPS modifications

The SPS and notably the Frequency Control SPS (FCSPS) was designed to simultaneously trip either generating units or load blocks to limit the resultant contingency sizes to values similar to those typically experienced in Tasmania. For a trip of Basslink during export, selected generating units will trip and limit the contingency to a maximum of approximately 200 MW, this being roughly equivalent to the loss of 2 x Rio Tinto potlines. FCAS (lower) is sourced from Tasmanian generators to address the "reduced" contingency.

For a Basslink import trip, selected load blocks trip, limiting the contingency to around 144 MW (loss of largest single generating unit). FCAS (Raise) is sourced in Tasmania to address the resulting 'reduced' contingency. In all cases, the measures applied, ie generating unit or load tripping plus FCAS, result in limiting frequency excursions to within a safe margin of the applicable frequency standard.

Changes to the frequency standard will require a modelling exercise and a review of base assumptions of system inertia, amount of wind generation, etc. This exercise will undoubtedly result in additional load (or generation) tripping requirements to satisfy current Basslink export and import levels. The FCSPS re-design will have cost implications for both upfront design and testing and ongoing increased costs for additional load and generating unit tripping.

2.1.2 Modifications to Back-up System Protection Schemes (UFLSS, OFGSS, etc.)

Proposed changes to the Frequency Operating Standards for the Tasmanian Power System will require a comprehensive review of protective schemes. Under frequency load shedding (UFLSS) and over frequency generation shedding (OFGSS) schemes are effectively back-up schemes that protect the system against non-credible contingencies and also in a case of a full or partial failure of Basslink SPS (FCSPS). It is important that these schemes are coordinated with the primary protection schemes to prevent back-up schemes operating for credible contingencies.

Tightening of the operating range of the UFLSS from 1.5Hz to 1.0Hz (ie the new proposed band between 48.0Hz and 47.0Hz) could require a reduction of current design margins thus increasing the risk of non-coordination and incorrect tripping outcomes. The UFLSS scheme must be designed to provide adequate back-up under all Tasmanian system conditions and a factor such as lowering system inertia has a substantial impact upon the rate of change of system frequency for a generating unit contingency. As already discussed, Tasmania's system inertia can vary over a wide range and become very low under Basslink import conditions and particularly as more wind generation is included in the dispatch. A robust UFLSS design that will operate only for non-credible events could therefore prove to be a significant challenge. Any increase in UFLSS operation will impact customers that are included in the load blocks. Further, any loads that are also contracted for the SPS will have a reduction in availability for that service that could potentially extend well beyond the actual event periods. Reductions in SPS directly impact Basslink import capability.

In the case of OFGSS design, a particular concern would be the risk of over-tripping of generation and the event becoming an under frequency event. If thermal and wind generation are not able to comply with the 55Hz upper frequency band requirements and are permitted to trip at 52.0Hz, this creates a risk of substantial over tripping and the contingency could revert to UFLSS. Note that the aggregate of such generating units could be several hundred MW. A re-designed OFGSS to accommodate frequency standard non-compliance would require complex logic and coordinated settings to ensure robustness which, as for UFLSS, has to be a key objective in maintaining system security.

3 Modelling Issues

3.1 Modelling methods and safety margins

Dynamic modelling of power systems requires models for each generating unit, the transmission system and its components and special devices such as Basslink (HVDC) controls. Models used by Transend and NEMMCO have, over the period of NEM operation, proven to be reasonably accurate and representative as applied to system incident studies and limit advice, etc. There are however many variables associated with system modelling and uncertainty in respect of model behaviour accuracy over the full spectrum of variables and as such modelling and particularly in relation to system frequency outcomes must provide for a safety margin. In the Basslink design phase, a 0.5Hz margin was used across the board.

Some of the factors that affect the accuracy and reliability of system modelling are:

3.1.1 System inertia

Whilst a system study might indicate a ‘marginally satisfactory’ outcome (ie just bordering above the threshold frequency), the relative amounts of Fast (R6) and Slow (R60) FCAS requirements could actually have varied quite substantially between two cases in which the system inertia decreases from ‘average’ to ‘low’.

Increased wind generation in Tasmania will have a marked effect upon system inertia and particularly when Basslink is importing under light Tasmanian demand periods (say 1000 MW). It is quite conceivable that Basslink could be importing close to 500 MW at times when 200 MW to 300 MW of wind generation is dispatched and potentially having in the order of 200 MW to 300 MW of generating units with ‘measurable’ inertia, noting that Basslink and wind generation are treated as ‘zero inertia’. Such cases and using NEMMCO FCAS tool show extreme FCAS outcomes (even with present frequency standards as already discussed).

Additional wind in Tasmania could become very difficult to justify due to adverse effects on the Tasmanian system that may limit market accessibility.

Modelling methods to determine FCAS requirements must therefore be appropriately equipped to deliver correct results for variations in inertia.

3.1.2 Actual modelling tools

NEMMCO produced their modelling tool which is the basis of FCAS calculation for Tasmania and this model has been adapted to calculate FCAS requirements for varying system sizes and inertia. What should be noted is that FCAS numbers, (as bid from trapezium data), are in fact derivatives of system models (again with inherent modelling assumptions and ‘errors’). Each FCAS participant in the market is obliged to install an FCAS monitor at each FCAS generating unit and NEMMCO has been using this data to validate its models and assumptions. Hydro Tasmania has used the NEMMCO modelling tool in estimating changes to FCAS requirements for the scenarios discussed in this issues paper.

Various dynamic modelling tools are in use by participants and in their own rights provide very representative results, the results being a function of the accuracy and reliability of model input data. NEMMCO's FCAS modelling system was developed to reasonably emulate a wide range of system conditions and derive FCAS quantities, to be dispatched from market bids, which satisfy system security requirements. It is therefore envisaged that the accountability for FCAS dispatch will remain within NEMMCO's scope of market management activities and that systems will be modified as and when required.

As such, current FCAS estimates produced for the scenarios discussed are possibly at best only indicative, particularly for the more extreme scenarios. Detailed modelling is required to be more definitive about the quantity of services required across all dispatch scenarios.

3.1.3 Safety margins

The number of variables associated with system dynamic modelling and consequent inability to produce highly accurate results under any conditions means that modelling should allow a finite safety margin. In modelling system frequency excursions a safety margin of between 0.3Hz and 0.5Hz may be appropriate to ensure that under frequency load shedding is not inadvertently triggered for a generating unit event. FCAS dispatched according to the NEMMCO model has in general indicated the model being modestly conservative, thus compensating for modelling error and possible marginal under-delivery of FCAS.

4 Adapting CCGT to Existing Frequency Standards

It appears that large single shaft CCGT plant, unless specifically developed for frequency standards such as current in Tasmania, are unable to comply with access and performance standards as required by the NER.

Our initial research suggests that an industrial frame based gas turbines (GT) typically has a limitation of around 20 seconds operation in the band $47 < f < 47.5$ Hz and trip for $f < 47$ Hz, limited by the resonance of mechanical components, compressor surge in the GT compressor and combustion instability. The larger the size of the GT, typically the less robust the GT is to frequency variation. As GT's are typically designed around operation in the large European and North American markets where tighter frequency standards exist, these physical limitations tend not to be an issue. However, where wider frequency standards exist, the use of a smaller aero-derivative based GT is worth considering. The physical arrangement of aero-derivative GT is different in that the power turbine and generator are not mechanically coupled to the core engine, which makes it possible that under and over frequency capabilities can be widened beyond that of a larger frame based industrial type.

Typically, two-thirds of the power from a CCGT comes from the gas turbine(s) and about one-third of the power from the steam turbine driven by the waste heat of the GT. It could be feasible that a combination of two or more aero-derivative GT's coupled to a steam turbine may be used to produce a CCGT of around 210 MW size. Reducing the GT component into a number of smaller GT units has the potential advantage of limiting the overall CCGT contingency size to less than 140 MW.

Whilst capital cost of the aero-derivative CCGT plant are expected to be somewhat higher than the industrial frame type, fuel efficiencies and operations and maintenance costs are likely to be comparable.

Appendix B – Alternative Solutions & Associated Costs

Additional Supply of FCAS – There are a number of conceptual sources of FCAS, although the probability of them becoming available is extremely low under current NER and market structure.

1 Global FCAS via Basslink could be further enhanced by modifying Basslink controls, registration etc to utilise the full import capacity of the cable (594 MW) for the transport of contingency raise services. Note: that Basslink would need to advise on the feasibility and cost of such an option.

2 Interruptible loads could be configured to provide raise services. In Tasmania a number of loads are contracted to the SPS during Basslink import periods but are not required when Basslink is in export or the no-go zone. The current market design is unlikely to entice any of these customers into the market.

3 Capital expenditure on existing generators and new technologies has been estimated at approximately $1.2m MW with the worst case scenarios requiring up to an additional 200 MW.

Cost of FCAS from Hydro units – Since NEM entry, several of Hydro Tasmania's major stations have been operating far more often at low output to provide FCAS, and starting and stopping far more frequently. Typically, machines are now starting and stopping around 300 times per year, compared with 100 starts pre NEM. Additional FCAS requirements are likely to significantly exacerbate this situation.

The increased cost, is reflected in terms of reduced asset life cycles, increased low load operation (very inefficient use of water) and frequent start-stops. Typically our major machines can already be considered to have an increased operating cost, in present value, of between $300 000 and $650 000 with the bigger machines that have main inlet valves (eg John Butters and Gordon machines) at the higher end of this range. The majority of these costs are considered to be related to start-stops of machines, provided the machine loads when on reserve are maintained outside rough running ranges. The major cost of low load running is lost efficiency, which is in addition to the above asset costs.

Efficiency losses are quite variable and depend on the specific machines, water value and market prices. In order to provide a guide it is useful to work through a realistic although simplistic calculation method.

- Operating John Butters at about 10 MW output, the flow is 30 cumecs which at maximum efficiency could produce 27 MW with an efficiency of 36 per cent;
- Assuming a John Butters water value of $50 MWh, spot market price of $50 MWh and R6 spot price $10 MWh, operation at this output results in a revenue loss of about $550 per hour.

Based on a high level analysis the average cost for the two years Tasmania has been in the NEM is around $1.1m per year of unrecoverable costs.

Alternative Gas Fired Plants – There are alternative technologies that would meet, or at least be a lot closer to meeting, the current Tasmanian Standards. Hydro Tasmania has formed this view based on an initial report from consultants, PB Power.