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ACRONYMS

AEMC	Australian Energy Market Commission
AER	Australian Energy Regulator
BFC	Basslink Frequency Controller
ETAC	Electricity Technical Advisory Committee
FCAS	Frequency Control Ancillary Services
FCSPS	Frequency Control System Protection Scheme
NEMMCO	National Electricity Market Management Company
NEMDE	National Electricity Market Dispatch Engine
NEM	National Electricity Market
NER	National Electricity Rules
NOCS	Network Operation Control System
OCGT	Open Cycle Gas Turbine
OFGS	Over Frequency Generator Shedding (scheme)
SPS	System Protection Scheme
TNSP	Transmission Network Service Provider
UFLS	Under Frequency Load Shedding (scheme)

1 PURPOSE

The existing Tasmanian frequency operating standard is much broader than the frequency standard used in the rest of the NEM[1]. The current standard is based largely on the response characteristics of Hydro generators and their ability to control and restore network frequency following significant network disturbances ("contingency events").

The broad frequency ranges applicable in Tasmania present difficulties for some generation technologies, notably steam and gas turbine plant. At present, the design characteristics of such equipment potentially restricts their ability to remain connected to the power system should frequency deviate to its maximum allowable limits for the time frames permitted. This is especially true for larger sized units (higher MW rating).

Transend understands that in early 2009 the Australian Energy Market Commission (AEMC) will undertake a review of the Tasmanian frequency operating standards. As part of this review, consideration will be given to potential tightening of the standards.

The objective of this paper is to facilitate discussion on the possible implications of any such changes and to highlight to the Electricity Technical Advisory Committee (ETAC) a number of practical issues that need to be considered as part of any "design" review.

Consideration has been given to:

(a) A number of physical limitations and critical design features that may restrict the magnitude of changes that are practically feasible for each of the frequency bands;

(b) Issues relating to the Basslink Frequency Controller and why it needs to be included in the scope of any proposed changes;

(c) Issues surrounding Frequency Control Ancillary Services (FCAS) in Tasmania, including provision of services and impacts of insufficient reserves; and

(d) A number of commercial issues that also need to be considered.

The paper is neither intended to be an exhaustive reference nor a source of solutions, but aims to capture the most critical and significant issues that will need consideration in determining alterations to the Tasmanian frequency standards, at least from Transend's perspective.

Detailed technical descriptions have been deliberately avoided and should be sought from alternate sources if required. It is assumed that the reader is familiar with the Tasmanian frequency standards or will reference a copy of the standards[2] while reading this document.

Transend is not expressing a view on whether the frequency standards should be altered. The following discussions are not intentionally biased toward any particular or preferred outcome and are intended as a neutral summary of identifiable technical issues.

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[1] Refer attachment 1

[2] Refer AEMC web site (http://www.aemc.gov.au/electricity.php?r=20060525.144027), Tasmanian Reliability and Frequency Standards Determination, 28 May 2006

2 EXISTING CONTROLS REQUIRING MODIFICATION

Should the Tasmanian frequency standards be altered, the design of the following *pre-existing* control systems will need to be reviewed and appropriately modified.

2.1 UNDER FREQUENCY LOAD SHEDDING SCHEME

An under frequency load shedding (UFLS) scheme has been in service for many years in Tasmania. The intent of the UFLS is to protect the system from critical load imbalances following multiple contingency events[3] or non-credible single contingency events[4]. Seven 'load blocks' are currently available for tripping in the frequency range 46.0 Hz to 47.5 Hz, with 46.0 Hz being the absolute lower limit of the existing Tasmanian frequency standards. Operation below 46.0 Hz would be unacceptable from the viewpoint of the National Electricity Rules (NER) and has the potential to lead to 'blackout' conditions as protection systems on generating plant begin to operate.

The UFLS has in fact been designed to maintain frequency above ≈ 46.5 Hz for the range of non-credible contingency events considered foreseeable in the Tasmanian power system. The 0.5 Hz safety margin has been applied to account for modelling and other uncertainties.

Any change to the *extreme frequency excursion limits* will need to consider the following requirements and technical limitations of the existing UFLS scheme.

(a) The frequency margin available between the *extreme frequency excursion tolerance* lower limit (46 Hz) and the *operational frequency tolerance band* lower limit (47.5 Hz). At present, the 1.5 Hz band allows the seven load blocks to be shed progressively at different frequency trigger levels in a manner that minimises the potential for over tripping (of load) while ensuring that the 46.0 Hz limit is not breached.

Preliminary assessments suggest that a margin of less than 1.5 Hz will create significant challenges for design of the UFLS if over tripping is to be avoided. The absolute minimum margin is likely to be ≥ 1.0 Hz. The likely impact is that any increase in the *extreme frequency excursion tolerance lower limit* will need to be reflected in corresponding changes to the *operational frequency tolerance lower limit* (as applied for credible single contingency events). Simply compressing the *extreme frequency excursion tolerance limits* by increasing 46.0 Hz to some higher number below 47.5 Hz, is unlikely to yield a satisfactory outcome.

(b) The ability of the UFLS to be adequately coordinated with the Basslink FCSPS[5]. At present, the first two stages of the UFLS are triggered on both absolute frequency as well as a $\Delta f/\Delta t$ (rate-of-change[6])

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[3] Loss of a double circuit transmission line is an obvious example in Tasmania due to the network topology.

[4] An example is the failure of a bus coupler (circuit breaker) that results in complete loss of a double bus substation.

[5] Frequency Control System Protection Scheme – See Section 2.3

[6] The rate at which frequency increases or decreases is determined by the magnitude of load / generation imbalance and system inertia.

setting. The use of Δf/Δt was found to be advantageous as it limited the total number of load blocks disconnected for certain non-credible contingency events. If the Δf/Δt conditions are met, load blocks one and two are shed *above* 47.5 Hz on the basis that they would be activated regardless and their earlier tripping allows faster frequency recovery with less total load interruption.

The complicating factor is that the UFLS must not operate for Basslink contingency events where the FCSPS will provide all necessary control actions to stabilise frequency and maintain system operation in accordance with the frequency standards. Inadvertent operation of the UFLS may lead to excessive tripping of load and potential over frequency conditions.

(c) The UFLS has been designed to act as backup protection in case of failure of the Basslink FCSPS. Although the UFLS cannot act while there is potential for the FCSPS to operate correctly, it must also provide sufficient control action to maintain frequency above 46.0 Hz if it does not. This again requires careful consideration of Δf/Δt and frequency trigger levels to ensure that all conditions can be achieved simultaneously;

The resulting combination of issues becomes:

(a) A tightening of the frequency bands reduces the available time to carry out UFLS control actions given that the existing rates of frequency change should largely remain unaltered for the types of contingencies considered in these circumstances;

(b) The UFLS must not operate for Basslink contingency events (as is presently the case);

(c) The UFLS must be capable of arresting frequency in whatever time remains if the FCSPS fails (as is presently the case);

In trying to meet these overlapping requirements with a compressed frequency standard:

(a) It is likely that more UFLS loads will need to be tripped sooner. The potential for load shedding under single credible contingency events should also be considered;

(b) The increased use of Δf/Δt tripping elements may be found necessary to enable discrimination between initiating events. This increases design complexity and would require careful consideration if a practical design is to be realised.

The UFLS represents the last line of defence and is a critical feature of the Tasmanian power system. As the size of the system is not large and can experience high rates of frequency change due to severe load / generation imbalances, correct design and operation of the UFLS scheme is critical to stabilising the system after major contingency events.

2.2 OVER FREQUENCY GENERATOR SHEDDING SCHEME

In addition to the UFLS scheme, there is also a complimentary Over Frequency Generator Shedding (OFGS) scheme that it is designed to retain frequency within the *extreme frequency excursion tolerance limits.* There are only two locations in Tasmania where severe over frequency events need to be managed in this way, being the West Coast of Tasmania and Strathgordon (associated with Gordon Power Station).

Both locations can be islanded with a significant excess of generation compared to local load. Operation in the islanded portion of the network would likely exceed 60 Hz if governor control action was not supported by deliberate disconnection of some generating units. As such, eight units are presently involved in the OFGS (all six generating units connected to Farrell Substation on the West Coast and two units at Gordon Power Station). While the need for such control actions has not been identified as necessary in other parts of the network at this time, the increasing concentration of generation in the George Town area is being monitored for potential issues.

As with the UFLS, the OFGS acts to stabilise the system after major contingency events with six of the eight units having protection settings below 55 Hz which include $\Delta f/\Delta t$. The use of a $\Delta f/\Delta t$ restraint prevents over tripping of generation if the rate-of-change of frequency is low (indicating that stabilisation is imminent or has commenced). The same basic coordination and grading issues as discussed for the UFLS apply to the OFGS, albeit marginally less complicated.

Any changes to the *extreme frequency excursion tolerance limits* will require review and recalculation of protection settings associated with the OFGS.

2.3 BASSLINK FCSPS

Basslink can be treated in a separate category of contingency events due to the presence of the Frequency Control System Protection Scheme (FCSPS). The FCSPS has been designed to ensure that the Tasmanian frequency standards can be adhered to following loss of Basslink through the deliberate tripping of contracted[7] generators or loads depending on the direction of Basslink flow pre-contingency (into or out of Tasmania).

As the loss of Basslink is treated as a single credible contingency under the definitions of the NER it must therefore conform to the *operational frequency tolerance band* limits. The FCSPS achieves this by shedding *willing participants* within the limits of 47.5 to 53 Hz thereby providing the greater portion of the overall FCAS requirements needed to manage this particular contingency.

A significant amount of time was invested in the design, validation and commissioning of the FCSPS, all based on the existing Tasmanian frequency standards. Considerations were more complicated than simply rebalancing Tasmanian generation / load demand, with voltage control being a notable additional issue (especially for over frequency events when generation is disconnected). As well as technical matters, the contracting of customer loads for deliberate disconnection introduced complexities of a commercial nature.

The issues associated with modifying the FCSPS to align with any changes to the Tasmanian frequency standards (specifically the *operational frequency tolerance band* limits) can be summarised into the following major categories:

(a) Recalculation of required generator tripping for loss of Basslink export:

   i. More pre-emptive generator tripping will be required if the upper limit of the *operational frequency tolerance band* is reduced below its present value of 53 Hz;

[7] These commercial contracts (SPS Participation Agreements) are with Hydro Tasmania and facilitate access to Basslink capacity that would otherwise be beyond the capability of the Tasmanian network to support.

ii. Review of the number of generators available to the FCSPS once any changes to the frequency limits are known (sixteen units are presently involved). For a generator to be a participant in the FCSPS, additional hardware is required to facilitate the fast remote tripping functions. The addition of more generators to the FCSPS will involve both capital outlay as well as implementation time;

iii. Modifications to FCSPS algorithms in Transend's Network Operation Control System (NOCS) will be required; and

iv. Review and modification of a number of constraint equations[8].

(b) Recalculation of required load tripping for loss of Basslink import scenario's

The issues with load tripping are essentially the same as outlined above for generator tripping. In addition, the impacts on existing commercial arrangements with contracted loads need to be carefully considered.

(c) Commercial impacts

Loads are made available to the FCSPS through commercial agreements. Transend believes the terms of these agreements allows some major industrial loads to withdraw their load from the SPS for a defined period of time, if they are tripped for an FCSPS event. Transend has observed this happening in practice. During such periods, Basslink is constrained when importing into Tasmania given that there would be insufficient SPS control action available to manage a subsequent contingency event (if inter-connector flows were not deliberately restricted). Correspondingly, the ability to transfer FCAS across Basslink is also reduced.

The requirement to shed more load earlier may result in more periods where Basslink import is constrained due to limited load being made available to the FCSPS.

Needless to say, both Hydro Tasmania and the owners of Basslink are key stakeholders in any proposal to alter the Tasmanian frequency standards due to the pre-existing technical and commercial arrangements made in relation to operation of the FCSPS. Given the complexities of formalising such contracts, the types of solutions which are practical from a time, cost and technical perspective may be a limiting factor for future modifications to the scheme. Please note that the issues outlined above may be expanded on by these parties in due course.

2.4 BASSLINK FREQUENCY CONTROLLER OBJECTIVE FUNCTION

Basslink is a Direct Current (DC) link. It does not therefore provide a synchronous connection between Tasmania and Victoria, with power flow dictated by control systems rather than the normal physics associated with Alternating Current (AC) inter-connectors.

To facilitate the "seamless" transfer of Frequency Control Ancillary Services (FCAS) between the two regions, a feature was included in the Basslink design which enables the link to act as a pseudo AC inter-

[8] Approximately 30 % of all constraints in the NEM are associated with Tasmania and Basslink.

connector. This is achieved via the Basslink Frequency Controller (BFC) which continuously and automatically adjusts power flow in response to frequency changes in either AC network[9]. The basis for its operation is as follows.

If frequency falls in Victoria, Basslink export is allowed to increase to help support the situation, effectively transferring raise FCAS *from Tasmania*. Conversely, if frequency falls in Tasmania, Basslink export can be reduced, effectively transferring raise FCAS *from Victoria*. Similar logic applies in the case of Basslink import with appropriate modification to account for the change in power flow direction.

As the two AC networks have different frequency standards, a key element of the Basslink Frequency Controller is its *objective function*. The objective function effectively "maps" the equivalent frequency limits of both standards onto a common operating point which allows both systems to operate to their respective limits while maintaining a degree of proportionality between them.

The BFC objective function is shown diagrammatically in Figure 1.

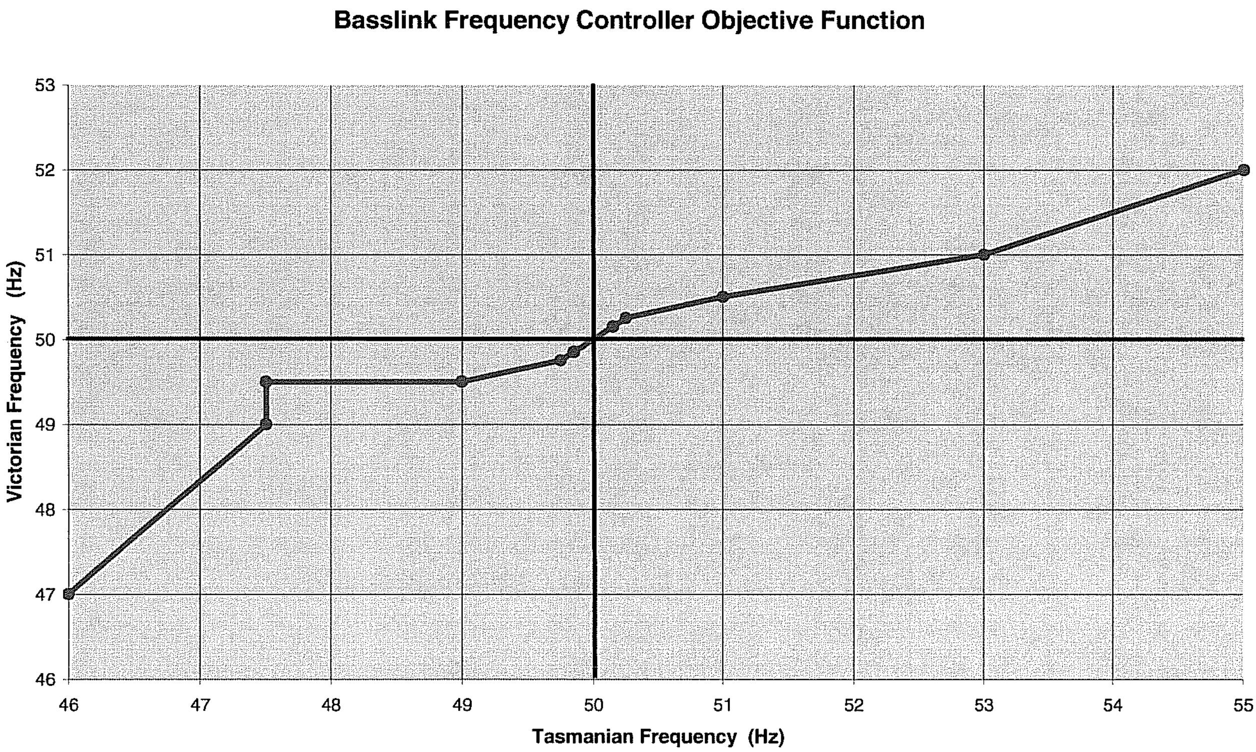

Figure 1: Basslink Frequency Controller Objective Function

As an example, if the mainland system were to fall to 49.5 Hz (being the lower limit of the mainland *operational frequency tolerance band*), the BFC would allow Tasmanian frequency to fall to 47.5 Hz, being the lower limit of Tasmania's *operational frequency tolerance band*. The same is true for the upper limits of

[9] Noting that the Basslink frequency controller has a 0.01 Hz dead band.

51 Hz and 53 Hz respectively, and is theoretically true for the upper and lower limits of the *extreme frequency excursion tolerance bands.*

A 1:1 relationship exists while the frequency of both systems remains within the *normal operating frequency band* (50 Hz ± 0.15 Hz) as these limits are identical in both standards.

The BFC will maintain the proportionality defined by the *objective function* up to the point where binding limits apply to inter-connector flow, i.e.: the link can offer no more support in one direction or the other. In emergency conditions, the link can be severed to prevent potential loss of both AC systems.

As the BFC and its objective function have been designed in accordance with the existing Tasmanian frequency standards, any changes to the standard will require appropriate modifications to the control logic.

This will directly involve the owners of Basslink as the controls exist within their plant.

3 FCAS CONSIDERATIONS

3.1 OVERVIEW

Please note that in relation to FCAS, all reserve management, procurement and dispatch functions are the responsibility of NEMMCO with the following discussions provided only to highlight the general issues linking FCAS and possible changes to the Tasmanian frequency standards. It is strongly recommended that market participants engage in detailed discussions directly with NEMMCO to confirm the impacts of FCAS on their particular connection.

3.1.1 FCAS REQUIREMENTS IN TASMANIA

As of May 2007, the following conditions typically define the maximum FCAS requirements in the Tasmanian power system under normal operation:

(a) Largest single generating unit: 144 MW (John Butters and Gordon Power Station units)

(b) Maximum generation at risk from a single network contingency event: ≈ 196 MW (loss of a George Town to Bell Bay transmission circuit connecting Bell Bay and Bell Bay Three[10] Power Stations);

(c) Largest single load block: ≈ 90 to 100 MW

(d) Largest load exposed to a single network contingency event: ≈ 190 to 200 MW

(e) Minimum Tasmanian load demand ≈ 900 to 950 MW (overnight summer)

(f) Maximum Tasmanian load demand ≈ 1800 MW (morning / evening winter)

(g) Load relief factor of 1%ΔMW / %ΔHz

Operating experience suggests that it is the provision of FAST (6 second) FCAS that is the most troublesome for management of these events (both raise and lower).

This is largely due to the fact that Tasmania is dominated by hydro generation that is not well suited to rapid variations in MW output over short time intervals. In contrast, hydro plant is particularly good at delivering SLOW and DELAYED FCAS and fewer issues are experienced in sourcing these products locally from the FCAS spot markets.

When operating away from 'hard limits[11]', Basslink is capable of transferring FCAS from the mainland[12] and thus supports local sources of FCAS in Tasmania. As the operating margin between Basslink flow and the defined hard limits is reduced, the volume of *local* FCAS that is required increases.

In general, the capability of Basslink to help control *Tasmanian* frequency is as follows:

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[10] To be referenced in future as 'Tamar Valley Peaking Power Station' following a change of ownership.

[11] To be interpreted as limits that cannot be overridden by the frequency controller during a frequency excursion, for example the ±50 MW limits on transfer which define the "no-go" zone. Soft limits would be those capable of being breached for short periods of time as a result of a contingency event either in Tasmania or on the mainland.

[12] This is achieved through the Basslink Frequency Controller (see earlier discussions).

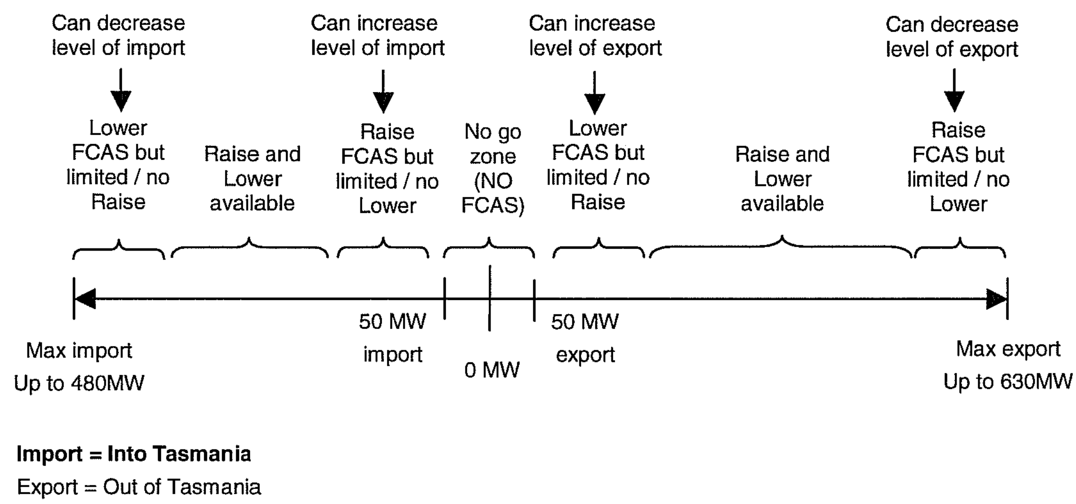

Figure 2: Basslink operating ranges and corresponding FCAS capability

There is currently 140 MW of wind turbines connected to the Tasmanian network and plans for an additional 130 MW[13] are being actively progressed. Wind turbines provide very little inertia to the network and are not capable of reliably providing FCAS. The impact of increasing wind penetration on frequency control is therefore significant especially if large blocks of synchronous generators are not dispatched as a result. This situation will exacerbate the potential shortage of local FCAS and needs to be adequately considered.

3.1.2 DEALING WITH INSUFFICIENT FCAS

When insufficient FCAS is available within Tasmania to manage potential contingency events (being the culmination of local[14] FCAS service providers and allowable transfers across Basslink), FCAS constraints will violate and NEMMCO will be forced to take appropriate action. If Basslink is already constrained, the only action NEMMCO has available to it is to place constraints on the load or generator which is defining the local FCAS requirement.

The effect of this is to reduce the demand for FCAS back to within the capability of the network at the time. A complicating factor is that Basslink flow can itself be constrained if insufficient local FCAS is available to support its own loss (in conjunction with FCSPS control actions).

It is an important observation that Basslink flow will not be deliberately constrained to satisfy FCAS requirements in either Victoria or Tasmania. Although Basslink is a co-optimised variable in NEMDE[15], the algorithm is based on achieving a least price outcome and as such, will not deliberately set the flow based on the sufficient availability of FCAS to meet local contingency requirements.

[13] Roaring 40s Mussleroe Wind Farm development.

[14] "local" refers to FCAS that must be sourced within Tasmania.

[15] NEMDE is the market dispatch engine used by NEMMCO to determine operating targets and resulting spot prices in each region.

This is not to say that Basslink flow cannot be influenced by FCAS prices, as this is indeed the case and has been responsible for "counter price flows"[16] at different points in time. It should also be noted that an increased requirement for local Tasmanian FCAS could increase the occurrence of counter price flows.

In essence, the ability of Basslink to provide FCAS and support potential contingency events in Tasmania is a *market outcome* and will vary over time. Given that Basslink flow, local FCAS availability, and system demand are all variables, the degree of constraint applied to the load / generator setting the FCAS requirement may range from zero to significant. This is an important consideration for all market participants, especially those who operate large generators (or loads) capable of setting the FCAS requirement in a particular category.

A tightening of the frequency standards would present challenges for the connection of any new generation or load that results in increased FCAS requirements (above those presently seen). It is also reasonable to assume that increasing the requirement for some FCAS services in a region where local sources of FCAS are limited, will lead to higher prices for those services.

Market impacts on FCAS procurement

As the various categories of FCAS are offered into the spot markets (in a similar fashion to energy), the volume and price of FCAS made available to the system can be controlled by the respective service providers. The risks associated with FCAS availability and price (or lack of availability as the case may be) is for each market participant to assess and manage and is an issue that should be considered in light of any changes to the frequency standards.

3.2 IMPACTS ON FCAS REQUIREMENTS

An obvious outcome from a tightening of the Tasmanian frequency standards will be an increased requirement for FCAS (most probably limited to the FAST and SLOW categories). What makes the increases more onerous is that additional sources of FCAS will need to be found locally (within Tasmanian). This is true on two counts:

(a) When Basslink is unable to transfer FCAS from the mainland;

  i. Basslink operating against a hard limit;

  ii. Basslink Frequency Controller (BFC) out of service;

  iii. Basslink out of service;

(b) To support loss of Basslink (noting that some opportunity may exist during any redesign of the FCSPS to control the residual[17] power imbalance);

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[16] A situation where MW's are exchanged *from* a region having a high spot price for *energy* to a region having a low spot price for energy (which is initially counter intuitive from a market operations perspective).

[17] If the FCSPS does not trip the equivalent amount of load or generation to match the power flow across Basslink prior to its disconnection, then the 'residual' imbalance must be controlled via local FCAS providers in Tasmania.

NEMMCO has already identified that the scarcity of FAST FCAS in Tasmania makes it impossible to align the Tasmanian and mainland frequency standards[18]. A number of calculations are provided which highlight the effect of compressing the various frequency bands on FCAS. The paper also highlights the importance of system inertia when determining FCAS requirements.

A crossover point exists where simplified calculations for determining FCAS are no longer suitable and more complex approaches are required which factor in system inertia. The crossover can be loosely defined at the point where the rate of frequency change results in the frequency standards being breached BEFORE the FCAS service providers have had the opportunity to deliver their response.

This becomes a critical issue when considering how much the frequency bands can be tightened without imposing impractical constraints on market participants.

As a general example even without a change to the frequency standards, if the largest generating unit in Tasmania was increased from 144 MW to 200 MW, NEMMCO estimates that the FCAS requirement would almost double (based on inertia issues). Inability to meet the FCAS requirements under various operating conditions would result in generation being constrained to a lesser output as discussed previously.

Various graphs are available which clearly show the impact of this particular issue on FCAS requirements. The NEMMCO document can be obtained from the AER Reliability Panel website and should be referenced for further details (Reference: *http://www.aemc.gov.au/electricity.php?r=20060525.144027*).

[18] NEMMCO; "Reliability and Frequency Operating Standards for Tasmania – NEMMCO Advice to the Reliability Panel" Version 1.1, 24th January 2006

[19] Reliability and frequency Operating Standards for Tasmania, NEMMCO's advice to the Reliability Panel, Version 1.1, 24 January 2006

4 SUMMARY

In considering changes to the Tasmanian frequency standards, the following two key issues will need to be addressed:

(a) The practicalities of altering existing systems to accommodate the proposed changes. In addition to the technical limitations, impacts on existing commercial arrangements will need to be carefully considered; and

(b) The resulting impact that a change in the frequency standards will have on FCAS requirements in Tasmania.

Item (b) is of particular concern and may require "non-standard" solutions to be developed by affected parties to adequately manage the issue and avoid operating constraints being imposed. This is particularly true for any new generating units or single point loads with capacities in excess of those currently installed.

The time/cost implications of designing and implementing tighter frequency standards will need to be weighed against the foreseeable advantages which may include:

(a) For some types of thermal generating plant, decreased risk of non-compliance with the NER technical standards allowing a broader range of plant types to be registered and connected to the Tasmanian network; and

(b) Improved power supply quality in the form of tighter frequency control (the advantages of which may be difficult to quantify based on historical operation of the Tasmanian system).

It should be noted that compliance related matters have the potential to *prevent* access to the network (i.e.: connection to the network can be disallowed) while FCAS related matters will generally only *limit* access to the network (i.e.: the amount of generation or load that can be supplied / drawn from the network is limited to a maximum amount at some point in time). As stated, the risks associated with FCAS are for each market participant to assess and manage, while compliance matters involve a broader range of statutory bodies.

The trade-off position therefore becomes:

(a) Drivers associated with NER compliance (facilitated by tighter frequency standards);

versus

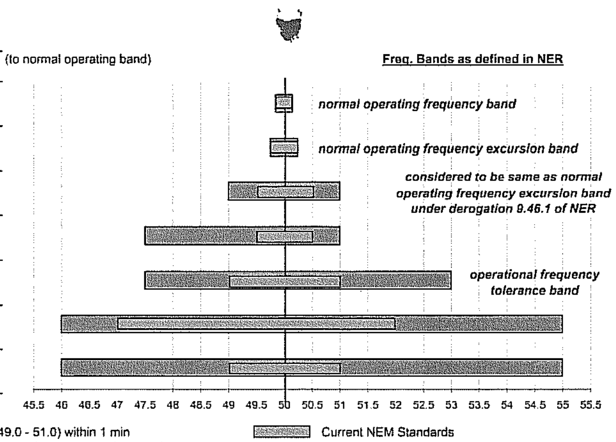
(b) Impacts that tighter frequency standards would have on system design (UFLS, FCSPS, Basslink BFC etc) and system operation (FCAS).

A REVIEW OF THE FREQUENCY STANDARDS WOULD NEED TO BE MINDFUL OF THESE TWO COUNTERACTING INFLUENCES WITH THE AIM OF IDENTIFYING A SOLUTION WHICH MAXIMISES BENEFITS WHILE MINIMISING NEGATIVE IMPACTS.

5 ATTACHMENT A

Current Frequency Operating Standards of Tasmania
(all units in Hz unless otherwise stated)

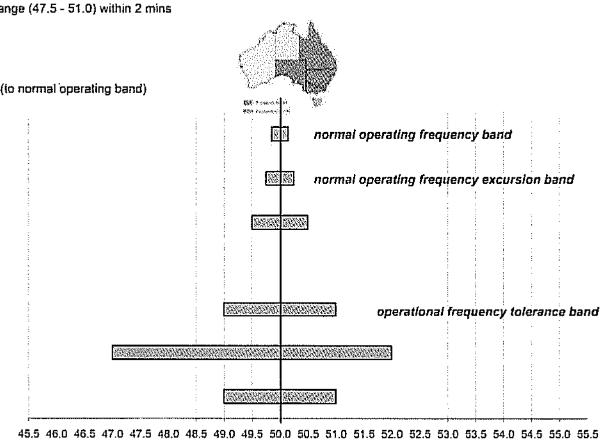
Condition/Event	Range From	Range To	B/W	% Range From	% Range To	Recovery within (to normal operating band)
Normal Operating Band - in which freq. Should remain 99% of the time (over a 30 day period)	49.85	50.15	0.3	-0.3%	0.3%	-
No contingency Event or Load Event - load fluctuations resulting from the continuous process of switching	49.75	50.25	0.5	-0.5%	0.5%	5 min
Load Event - max size of load that is subject to regular switching	49.0	51.0	2.0	-2.0%	2.0%	5 min
Generation Event - loss of largest Gen Unit	47.5	51.0	3.5	-5.0%	2.0%	5 min
Network Event - Largest load or gen loss resulting from the loss of a network element(s) due to a *credible contingency*	47.5	53.0	5.5	-5.0%	6.0%	5 min *
Multiple Contingency Event - largest freq. Excursion where system equipment should, if possible, remain in service	46.0	55.0	9.0	-8.0%	10.0%	10 min **
Separation Event (for comparison)	46.0	55.0	9.0	-8.0%	10.0%	10 min



Notes: * - freq. is expected to return to load event range (49.0 - 51.0) within 1 min
** - freq. is expected to return to generation event range (47.5 - 51.0) within 2 mins

Current Frequency Operating Standards of NEM
(all units in Hz unless otherwise stated)

Condition/Event	Range From	Range To	B/W	% Range From	% Range To	Recovery within (to normal operating band)
Normal Operating Band - in which freq. Should remain 99% of the time (over a 30 day period)	49.85	50.15	0.3	-0.3%	0.3%	-
No contingency Event or Load Event - load fluctuations resulting from the continuous process of switching	49.75	50.25	0.5	-0.5%	0.5%	5 min
Gen or Load Event - Synchronisation/loss of a Gen or connection/disconnection of a load of more than 50MW	49.5	50.5	1.0	-1.0%	1.0%	5 min
(Generation Event - covered by the previous category)						
Network Event - a *credible contingency event*	49.0	51.0	2.0	-2.0%	2.0%	5 min ^
Multiple Contingency Event - contingency event other than a credible contingency event (CCE) or a sequence of CCEs within 5 mins	47.0	52.0	5.0	-6.0%	4.0%	10 min ^^
Separation Event (for comparison)	49.0	51.0	2.0	-2.0%	2.0%	10 min



Notes: ^ - freq. is expected to return to gen or load event range (49.5 - 50.5) within 1 min
^^ - freq. is expected to return to gen or load event range (49.5 - 50.5) within 2 min

Freq Opr stds chart-2.xls IJ-151105

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