TasNetworks
Delivering your power

Tasmanian Networks Pty Ltd
ABN 24 167 357 299
PO Box 606
Moonah TAS 7009

11 August 2017

Australian Energy Market Commission
PO Box A2449
Sydney South NSW 1235

Dear Mr Pierce,

RE: ERC0211 and ERC0214 System Security Market Frameworks Review

Tasmanian Networks Pty Ltd (TasNetworks) is pleased to provide our response to the *Draft Rule Determinations – National Electricity Amendment (Managing power system fault levels)* and *National Electricity Amendment (Managing the rate of change of power system frequency)* which were published by the AEMC on 27 June 2017.

As the Transmission Network Service Provider (TNSP) and Distribution Network Service Provider (DNSP) in Tasmania, TasNetworks is focused on delivering safe and reliable electricity network services while achieving the lowest sustainable electricity prices for Tasmanian customers. We are committed to providing fair and equitable network access to a broad range of generation and customer based technologies with the intent of promoting competition and efficiency within the National Electricity Market (NEM).

Energy affordability, security and facilitating the connection of renewable generation sources are all important factors for our customers. A consistent national framework that addresses these factors, including a transition strategy, needs to be fully developed.

Tasmania has a history of anticipating and managing a range of emerging issues affecting security of the power system in a rapidly evolving energy sector. We have concerns with some specific aspects of the application and drafting of the Rules. These concerns are described in detail in the attached document. In particular, we have suggested an alternate methodology to managing power system fault levels in the Tasmanian context.

We invite the AEMC to discuss these concerns with us so that the final Rules do not create unintended or perverse outcomes for Tasmania, potentially limiting our ability to use and develop innovative solutions that are already place to manage minimum fault levels and rate of change of frequency (ROCOF).

We look forward to working collaboratively with the AEMC and stakeholders on these Rules changes. Should you have any queries in relation to our submission, please contact Kirstan Wilding, Regulation Leader on (03) 6271 6696 or via email, kirstan.wilding@tasnetworks.com.au.

Yours Sincerely

BESClark

Bess Clark

General Manager Strategy and Stakeholder Relations

1. Introduction

This submission covers both TasNetworks' general concerns with the approach to system security as well as specific concerns arising from the separate determinations.

Section 2 summarises our recommended actions to address our main concerns.

Section 3 describes how system security is currently managed in Tasmania.

Section 4 describes our specific concerns with the system strength draft determination.

Section 5 describes our specific concerns with the Rate of change of frequency draft determination.

2. Recommendations

2.1. Maintaining Tasmanian arrangements in a national scheme

TasNetworks is keen to ensure that the introduction of new Rules in response to recent specific issues in other regions of the National Electricity Market (NEM) does not impede Tasmania's ability to use and continue developing novel solutions which:

a) maximise the capability of the existing network to host new generation developments, both traditional synchronous machines as well as asynchronous technologies, typically associated with wind and solar photovoltaic (PV) *generating systems*.

b) enable appropriate integration of technical solutions within AEMO's market systems thereby promoting transparency, efficiency and robustness across a range of power system operating conditions.

c) deliver customer outcomes that are technically efficient and cost reflective.

As a NEM region that has been at the forefront of integrating high levels of asynchronous generation for some time[1], we are acutely aware of the many issues which accompany reduced levels of 'system strength'. In partnership with AEMO and various Tasmanian stakeholders, we have already implemented strategies which manage the minimum fault level at one strategic location in the Tasmanian network, as well as manage system inertia to control rate of change of frequency (ROCOF). Both solutions were unique to Tasmania until very recently and are described more fully in Section 3.

TasNetworks recognises that the existing situation will become more complex as new generators enter the Tasmanian market. TasNetworks is currently managing multiple connection applications, as well as numerous connection enquiries for large scale wind and solar developments. As a result, we are continuing to develop improved solutions to various system security issues which build upon our accumulated experience.

It follows that TasNetworks is keen to ensure that any rule changes required in the short term are sufficiently flexible to allow NSPs to pursue solutions that deliver the most benefit to their respective regions, while ensuring that system security challenges are appropriately addressed.

[1] This in Tasmania's case includes facilitating power flow from Victoria across the HVDC interconnection to Tasmania (commonly referred to as 'import').

2.2. Regulatory framework issues

Energy affordability, security and facilitating the connection of renewable generation sources are all important factors for our customers. A consistent national framework that addresses these factors, including transition strategy, needs to be fully developed. The following key issues to be addressed in proposed changes to the system security technical and regulatory framework:

- Customers should only pay for services that are beneficial to them. A specific concern is that Tasmanians may be exposed to additional costs that result from implementation of targeted solutions intended to resolve problems on the mainland (and vice versa).
- Frameworks should be tailorable to allow a 'best fit' with local issues and the availability of region specific solutions.
- A robust governance framework should be established that provides transmission network service providers (TNSPs) appropriate legal and commercial risk management, processes and protections within the *Rules* (similar to the protections afforded to the Australian Energy Market Operator (AEMO) under the *Rules* for system security responsibilities).
- An appropriate economic framework for TNSPs should exist, allowing for cost recovery and incentive mechanisms that are in line with the National Electricity Objective (NEO).

TasNetworks shares, along with ElectraNet and the Energy Networks Australia (ENA), a number of concerns with aspects of the proposed framework. Specifically we believe the current draft has:

- TNSPs being required to contract in the absence of sufficient competitive contracting protections
- TNSPs exposed to material cash flow risks under the cost pass through methodology
- TNSPs being exposed to compliance and reputational risks for service delivery where they are acting on AEMO's advice and where generators are unlikely to offer 100% performance guarantee and the obligation is not expressed on a reasonable endeavours basis
- No commercial incentive for TNSPs on a risk-weighted return to pursue non-network solutions
- No explicit protections in the event that a TNSP procuring for new services faces a non-competitive tender response. This apparent gap is evident, when compared against National Electricity Rules sub-clauses of 3.11.5, which apply when AEMO tenders for network support and control ancillary services. These clauses provide for negotiating in good faith, reasonable terms and conditions and access to a dispute adviser, among other things

TasNetworks would like to see more clarity in how the 'do no harm' obligations will be interpreted. We are concerned that the obligation may be extended beyond system security issues and also inadvertently extend to small scale distributed energy resources in the distribution network.

TasNetworks requests that the rules require AEMO to formally confirm that the proposed provision of services/capabilities meets the need specified by AEMO.

2.3. Managing system strength

TasNetworks is supportive of the AEMC's intent to formalise this critically important aspect of power system security. We recognise the need for the development of new National Electricity Rules (Rules) to address issues associated with system strength and have been proactive in implementing practical solutions to achieve comparable outcomes within the Tasmanian region already.

While the need for modified and expanded Rules is not questioned, the construction of the proposed Rule change is not considered suitable for implementation at this time. The key issues for TasNetworks within the draft determination are:

a) The use of short circuit ratio (SCR) as the metric that Network Service Providers (NSPs) are required to manage going forward. We believe that the use of fault level (MVA) is a more realistic expectation and better describes the actual requirements of the power system in real time.

b) The definition of minimum fault levels needs to be better described as part of the final Rule determination. The obligation on NSPs going forward is not clear from a practical implementation perspective. As part of this submission, TasNetworks has offered an interpretation that it believes is appropriate.

c) TasNetworks would recommend that the *Rules* formulation provide adequate flexibility for NSPs to apply solutions that best suit the circumstances that prevail in their respective networks. TasNetworks believes that the proposed *Rules* change is overly prescriptive and may limit innovation.

d) There is a need to consider system strength in a holistic manner and not focus on fault level or its derivative metrics (such as short circuit ratio) as a definitive measure of system security.

e) The AEMC needs to establish appropriate governance, regulatory and competitive protections for NSPs under the Rules to address new risks that may arise in the procurement of any new system security market and service arrangements.

A number of other considerations have been documented within the submission for consideration by the AEMC.

We agree with the ENA that the AEMC should consider a delay to the implementation timeframe to allow further refinement to the proposed framework, with 1 July 2019 being considered more achievable. This could be facilitated by placing detailed operational parameters in guidelines rather than in the *Rules*.

TasNetworks would be pleased to contribute to further refinement of the proposed *Rule* changes relating to the management of network fault levels.

2.4. Managing the rate of change of power system frequency

As with fault levels, TasNetworks is supportive of the AEMC's intentions to explicitly manage this aspect of power system security. It is logical that NSPs, in particular TNSPs play a major role in determining and managing the various aspects of system strength in their networks.

Whilst supportive of a two stage approach to assist introduction of the requirements across the NEM, TasNetworks would like to highlight the solution already in place in Tasmania, which we believe to be consistent with the intent of stage two. An explanation of the existing ROCOF constraint is provided in Section 3.2 of this submission. The constraint ensures secure operation of the Tasmanian power system on an ongoing basis by maintaining a minimum inertia level that is dynamically calculated according to prevailing system conditions.

While TasNetworks has no major objections in relation to the technical aspects of the proposed Rule change, we offer the following proposals for consideration as part of the final Rule determination.

a) The Tasmanian region will need to be defined as an inertia sub-network and its specific circumstances appropriately described in at least the *inertia requirements procedure* to be developed by AEMO, as well (possibly) the Rules drafting itself.

b) In relation to the wording of Chapter 5.20B.4(d), TasNetworks would recommend that the Rule not be so prescriptive as to only mention synchronous condensers and in doing so, preclude other technologies and solutions. In relation to this suggestion, it should be recognised that two time frames of assessment exist for ROCOF.

TasNetworks has already undertaken preliminary discussions with AEMO and is keen to pursue ongoing development of its ‘constraints based approach’. It is recognised that some modifications to existing processes will need to occur once more privately owned asynchronous generation is connected in Tasmania. This will be necessary to facilitate the ongoing utilisation of capabilities resident within Tasmania’s synchronous machine fleet for the benefit of the market as a whole (rather than a single market participant).

We encourage the AEMC to discuss proposed solutions with TasNetworks so that we may understand the appropriateness of undertaking further development of a constraints based approach to cater for future asynchronous generation connections in Tasmania. This engagement will contribute to further refinement of the proposed Rule changes relating to the management of ROCOF.

3. Overview of Tasmanian methodologies for managing system security

TasNetworks would like to offer the following brief explanation of the methods it has already applied to manage both minimum fault level and minimum system inertia requirements in Tasmania. Both fault level and minimum inertia requirements are currently managed through ‘constraint equations’ that are implemented within AEMO’s National Electricity Market Dispatch Engine (NEMDE).

3.1. Minimum fault level constraint equations

3.1.1. Interconnector import – Victoria to Tasmania

The minimum fault level constraint for import conditions has been in existence since commissioning of the Tasmanian interconnector in 2006. Given the nature of the high voltage direct current (HVDC) technology used at the George Town converter station, it is necessary to maintain a short circuit ratio (SCR) of at least ‘3’ when it is acting as an inverter (power flow towards Tasmania).

The constraint equation is formulated such that power import (MW) is a function of available fault level at the George Town 220 kV bus. The real time (calculated) fault level is not used in the constraint, but is derived from the contribution of online synchronous machines, whether these are generators or synchronous condensers. The constraint has the effect of reducing import as fault level falls below a nominated level. The outcome is to increase scheduled Tasmanian generation which at present, is comprised only of synchronous machines. The constraint continues to limit power import until such time that online synchronous machine support is sufficient to satisfy the fault level requirement.

The constraint does not currently account for the presence of Tasmania’s three wind farms as they are embedded in the local 110 kV networks and considered electrically remote from George Town. Changes are highly likely to be required with increasing asynchronous generation connection. Additional wind and solar developments are proposed that are much closer to the HVDC interconnector (in terms of electrical proximity) meaning that an effective short circuit ratio (ESCR) calculation (or equivalent) will need to be adopted. ESCR is one method to account for the interaction that occurs between multiple power electronic devices connected in parallel. ESCR is used as a generic descriptor throughout the remainder of this document, but could be substituted by other calculation methods that have a similar objective[2].

3.1.2. Interconnector export – Tasmania to Victoria

A minimum fault level constraint also applies during export conditions toward Victoria. This is not directly associated with the technical requirements of the converter station itself, but rather prevents repetitive switching of the interconnector’s largest filter which is rated at 98 MVAr.

The voltage disturbance caused by such a switching event would represent a ‘quality of supply’ issue if it were to be repetitive in nature. Such voltage transients would have a significant impact on a nearby industrial customer if not appropriately managed.

The constraint prevents operation of the interconnector above 350 MW when the real time fault level at George Town 220 kV is less than 2540 MVA. The constraint is implemented in such a way that it prevents immediate curtailment of the interconnector when fault level falls below this value. A short period of time is allowed for the application of mitigating actions (dispatch of additional synchronous machine support), after which the power flow target is ramped back if the low fault level conditions persist.

[2] Refer reference [2] for further details on available methods that have been identified by CIGRE.

This particular constraint is a practical and in-service example of another system security consideration that links directly to the concepts of 'system strength' but is not directly associated with continuous, uninterrupted operation of *generating units* as is often the assumption.

3.2. Rate of change of frequency (ROCOF) constraint

The ROCOF constraint was introduced after the commissioning of Musselroe Wind Farm (MRWF), which increased the installed capacity of Tasmanian wind generation to 308 MW. In combination with the HVDC interconnector's import capability of 480 MW, the total on-island asynchronous generation potential was increased to 788 MW.

When compared to Tasmania's typical minimum system load of approximately 900 MW, the potential for 85% to 90% of the instantaneous load demand to be met by asynchronous energy sources required that online inertia be actively managed once MRWF was in commercial operation.

It is worthy to note that Tasmania's highest recorded asynchronous generation contribution is 78.9% which occurred on 20 March 2015 at 12:14 am. A Tasmanian load demand of 960 MW load was supplied by 467 MW of interconnector import plus 291 MW of wind generation. Operation above 70% persisted for over seven hours, demonstrating that such market outcomes can extend over significant periods of time. Another similar example was achieved on 2 February 2017 when a peak of 78.2% was recorded during a six hour period above 70%.

The Tasmanian ROCOF constraint equation has been derived to manage the following aspects of system security:

a) ROCOF immediately following fault and trip of a generating system or load, up to approximately 500 milliseconds after fault clearance. The ROCOF experienced in this time frame is greatly affected by the fault ride through (FRT) response of any power electronic interfaced generation sources (including HVDC) and their recovery characteristics.

   In this time frame, the maximum ROCOF must be limited to a value that does not result in the operation of anti-islanding protection (relevant to transmission and embedded generation in the distribution network) and ensures the transient stability of all synchronous generating units. The risk of *generating systems* tripping in sympathy due to high ROCOF has been the primary concern in Tasmania, potentially leading to undesirable operation of the under frequency load shedding (UFLS) scheme with consequent disruption to *network customers*.

   In the Tasmanian power system, TasNetworks has been applying a limit of ±3 Hz/s with a filter and averaging period of approximately 100 milliseconds for these calculations.

   Note that in this time frame, the response of fast-frequency response (FFR) sources may be limited either due to their own FRT characteristics or simply due to inherent measurement and calculation time delays (natural latency). As a result, it is likely that a minimum level of synchronous machine based inertia, or very fast acting System Protection Scheme (SPS) type solutions, will be required to manage the initial system transients (following a disturbance), with alternate energy sources being relevant for the sustained ROCOF period described next.

b) 'Sustained ROCOF' which follows the initial transient period described above, must be controllable to a level that enables correct operation of UFLS and over frequency generator shedding (OFGS) schemes. A ROCOF that is too fast may simply be uncontainable due to a loss of time discrimination and coordination between the 'blocks' that typically make up such schemes (groups of loads or generators that share the same trip settings).

   In the Tasmanian power system, TasNetworks has been applying a limit of ±1.18 Hz/s which, most critically, enables correct coordination within the UFLS scheme to be achieved.

In summary, the ROCOF constraint equation has been described in a manner that reduces HVDC import and/or Tasmanian wind generation until sufficient inertia is dispatched to satisfy the two technical limits outlined above for the critical credible post contingency operating state, i.e. loss of any generator based inertia is accounted for within the calculations. By reducing the generation input from sources that do not offer inertia, the by-product is to increase generation from sources that do, i.e. synchronous generators. This occurs through AEMO's market dispatch software and thus ensures a co-optimised, transparent solution.

3.3. Managing the impact of fault level and ROCOF constraints at present

In practice, Hydro Tasmania (HT) uses its fleet of synchronous condenser capable units in combination with generators dispatched at low power outputs, to boost fault levels and inertia sufficient to achieve the desired levels of wind generation and interconnector power transfer.

It is important to recognise that this voluntary response forms part of HT's overall energy trading strategy, which occurs in concert with requirements to manage Tasmania's energy security position (in terms of dam storage levels).

It follows that simple retrospective analysis of 'bound operating periods' will not provide a true indication of how often the constraints have a practical impact on network operation. At the very least, post-processing is required to identify obvious 'voluntary' contributions from HT. As more private generators enter the Tasmanian market, HT's willingness to support particular network conditions without financial compensation may be different from the existing situation. The potential for 'step changes' in the number of violating constraint periods is a possibility (for existing constraints) in addition to whatever impacts new constraints will have on existing and new entrant generators.

The 'marginal value' of any constraint is the difference in market outcome with and without the constraint in effect. This becomes a useful measure to value mitigations like synchronous condenser support and could (in theory) be used to justify TasNetworks procurement of this type of service under a Network Support Agreement (NSA). This would be on the basis that any resulting cost pass-through to consumers is outweighed by the market benefit delivered.

3.4. Mandated minimum SCR requirements for new generators

In addition to the above, TasNetworks has adopted the following requirements as part of its Generating Connection Requirements[3] for application in Tasmania.

a) All asynchronous generation interfaced to the power system through a power electronic inverter must be capable of satisfying its *performance standards* at a short circuit ratio (SCR) of '2.0' or less. TasNetworks will only negotiate to ensure an MVA fault level of 'two times the rated MW capacity' of the *generating system* at the registered *connection point*.

   It should be noted that the impact of other asynchronous energy sources in close electrically proximity may at times reduce the ESCR to below 2.0. TasNetworks does not intend to guarantee the provision of a fault level above the absolute minimum described above and therefore does not guarantee an ESCR sufficient to ensure maximum output from the *generating system* under all operating conditions.

[3] The requirements document is currently being reviewed in light of upcoming technical Rule changes to be proposed by AEMO. The Rule changes are expected to be based on AEMO's recommendations to the Essential Services Commission of South Australia (ESCOSA) pertaining to generator licencing conditions in SA.

TasNetworks has based the SCR requirement on the principles and intent described in Schedule 5.2.5.12 and 5.2.5.13 of the *Rules* whereby a *generating system* should have capabilities and control systems such that it does not negatively impact on network power transfer capabilities or cause instabilities that would negatively impact other registered participants.

b) Any asynchronous *generating system* between 5 MW and 30 MW rated capacity must be registered as a *semi-scheduled generating system* rather than a *non-scheduled generating system*. This is to provide TasNetworks and AEMO sufficient visibility and control (through market dispatch processes) to manage overall power system security.

Both requirements are intended to increase the hosting capability of the Tasmanian power system to accommodate future asynchronous energy sources, most likely in the form of wind and solar generation developments.

3.5. Summary

While the existing constraint formulations are adequate to secure the Tasmanian power system as it exists today, the introduction of additional asynchronous generation will require the methodologies to be thoroughly reviewed and studied to ensure implementation.

Complications that TasNetworks can foresee and require further consideration are:

a) The need to apportion available 'system strength' to generators that are more closely electrically coupled than existing sites. The application of ESCR or similar such calculations will be necessary in the future.

b) Review of the existing ROCOF constraint equation to include the effects introduced by additional asynchronous generation in Tasmania:

    i. Increased number of generators exhibiting an FRT response causing greater ROCOF for generator contingency events immediately post fault.

    ii. Increased number of 'terms' needing to be included in the ROCOF constraint formulation which may have impacts on the stability of pre-dispatch market solutions (when the contribution from intermittent energy sources may not be entirely predictable).

    iii. The impact that intermittency exhibited by solar generation may have on the 'stability' of real time constraint equations. This is an area that TasNetworks has not yet had any experience.

c) The need for new market frameworks and/or commercial instruments to facilitate the ongoing utilisation of capabilities resident within Tasmania's synchronous machine fleet for the benefit of the market as a whole.

TasNetworks has raised similar issues and commentary with regards to ROCOF and its impact on the Tasmanian network in its submission to the Review of the Frequency Operating Standards.

It is in this context that TasNetworks would like to offer its contributions toward the draft rule determinations that are the subject of this submission.

4. System strength draft determination

TasNetworks agrees with the premise that 'system strength' needs to be actively managed, with a clear allocation of responsibilities provided within the *Rules*. The National Electricity Market (NEM) has and will continue to evolve such that it is no longer appropriate to assume that sufficient system security services (which include the elements of inertia and fault level) will be inherently available irrespective of generation dispatch outcomes.

However, TasNetworks is not able to fully support the draft determination proposed by the AEMC due to a number of concerns. The following discussions provide an overview of TasNetworks' views on various aspects of the proposal.

As shown in Section 3, fault level requirements and ROCOF are currently being actively managed in the Tasmanian network. As such, TasNetworks would like to see the following concerns addressed and have the AEMC explore the practicalities of the proposed methodology described below, which TasNetworks believes is consistent with the intent of the AEMC's proposed Rule changes.

4.1. Principle concerns

4.1.1. Issues with use of short circuit ratio terminology throughout the Rule change

TasNetworks is concerned about the use of short circuit ratio (SCR) throughout the *Rule* change proposal. Application of the Rules as currently proposed becomes problematic when SCR is used to reference both the minimum requirements of the generating system, as well as that required to be maintained by the NSP to ensure that the plant's performance standards can be met.

It is recommended that the following terms be used in context to avoid the potential for misinterpretation of *Rule* requirements.

a) Fault level

   In the context of 'system strength', use of three phase fault level is the commonly adopted reference. Fault level is defined in terms of amps, kiloamps (thousands of amps) or MVA.

b) Short circuit ratio (SCR)

   SCR is most commonly defined as the minimum required fault level at the point of network connection, divided by the MW capacity of the asynchronous generating system (or HVDC link). All control and protection systems must be capable of operating at this fault level assuming that the available 'system strength' is not shared with any other site.

c) Effective short circuit ratio (ESCR)[4]

   When there are multiple asynchronous *generating systems* (or HVDC links) operating in parallel and within close electrical proximity such that dynamic interactions occur, i.e. the response characteristics of one site have a material impact on the performance of another, then ESCR can be used to describe the effective system strength available to support the operation of all connected equipment. Other methods also exist.

If the ultimate intent is to ensure that asynchronous *generating systems* can operate in parallel and meet their respective performance standards, it is necessary to segregate the terminology used to describe their individual requirements (SCR) and the power system conditions that must prevail to

[4] Note that this is one of four options outlined in [2] which attempts to account for the interaction between individual connections.

achieve this (fault level). Consider the following example to explain the problem, which references Figure 1:

a) Generator A rated at 100 MW connects at a point in the network and requires a SCR of '2.0' to meet its performance standards. This is achieved while the network provides a fault level of not less than 200 MVA and no other devices 'share' the available fault level.

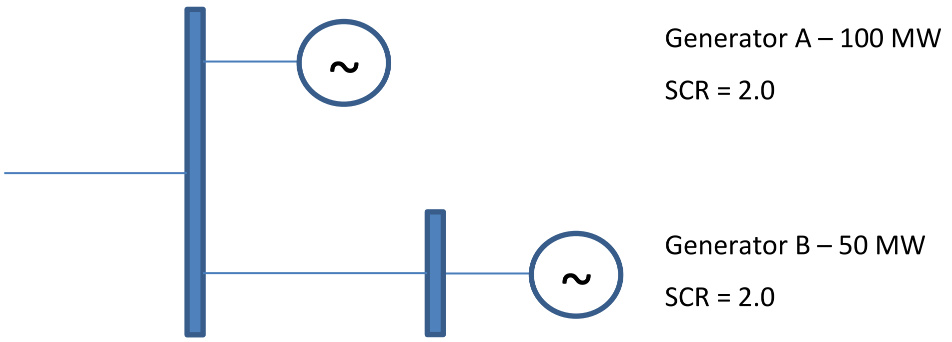
   The SCR of 2.0 is registered with AEMO in accordance with Chapter 5.3.4B (proposed Rule).

b) Generator B is developed sometime after Generator A. It does not share the same connection point but is located electrically close to Generator B. It is rated at 50 MW and also requires a SCR of '2.0' to meet its performance standards.

   The SCR of 2.0 is registered with AEMO in accordance with Chapter 5.3.4B (proposed Rule) as it is independent of Generator A.

For both *generating systems* to meet their respective performance standards when operating in together in parallel, the NSP must now ensure that an <u>ESCR</u> of 2.0 can be achieved. The fault level requirement needs to increase from 200 MVA to 300 MVA as a result.

Figure 1: Application of terms - example



Required fault level to support operation of only Generator A = 200 MVA, ESCR = 2.0

Required fault level to support operation of A and B = 300 MVA, ESCR = 2.0

It follows that the requirements on NSPs should be defined in terms of fault level and not SCR in TasNetworks view.

4.1.2. Defining minimum system strength requirements

The draft determination would seem to infer that the short circuit ratio (SCR) requirements of all existing generation will be met through obligations placed on the NSP. This would require a fault level corresponding to an appropriate ESCR to be maintained, as described by Figure 1 above.

TasNetworks is of the view that the cost of achieving this is not properly weighed against the counter-factual, which is to constrain the 'at risk' generation to ensure that system security is appropriately maintained. The lack of real time co-optimisation introduces the risk of an inefficient outcome in TasNetworks' opinion.

TasNetworks would like further clarification from the AEMC on the intended obligation for NSPs in relation to maintaining a 'minimum'. Does the obligation relate to:

a) Minimum to satisfy the individual SCR requirement of the connecting *generating system*? or
b) Minimum to enable satisfactory parallel operation of multiple *generating systems*?

Noting that the requirements of (b) are likely to be more onerous that (a), TasNetworks' preferred approach is described in Section 4.2. The concept described is that the NSP should guarantee (a) but then apply a market benefits approach to justify the incremental increase in fault level necessary to achieve (b).

4.1.3. Practical application of the 'no harm' principle

The draft determination requires that NSP's "*maintain system strength such that generators are able to meet their performance standards*". The determination has clearly defined two separate approaches, one each for existing and new entrant generators.

Following on from discussions in Section 4.1.2 above, the practical application of the proposed Rule clauses which introduce the concept of a '*system strength remediation scheme'*, need to be reviewed in context. The *Rule* should be clear about the need for such schemes and differentiate between system security impacts (increasing minimum fault level requirements for instance) and market access impacts (increasing the required ESCR and corresponding fault level).

4.1.4. Flexibility to apply alternate solutions which maintain power system security

TasNetworks has a view that NSPs should be responsible for defining the technical limits of their respective networks rather than ensuring that individual *generating systems* are capable of meeting their performance standards. The development of constraints that restrict operation of the network within its real time capability is the existing domain of NSPs. Creating obligations directly linked to the performance of *generating systems* introduces new issues pertaining to risk and liability.

It should be recognised that TasNetworks' approach has the same objective as the AEMC. There is no debate around the fact that new power system security criteria are required and will impact real time operating requirements.

To this end, TasNetworks is in favour of promoting a *Rule* change that does not preclude the utilisation of existing co-optimisation tools that already underpin operation of the NEM, specifically the National Electricity Market Dispatch Engine (NEMDE). Whilst this may not be possible in all NEM regions, it would seem reasonable that such a solution not be impeded where it can be feasibly implemented.

As described in Section 3, TasNetworks has already developed methodologies that manage fault level and ROCOF within the existing Tasmanian power system. It is TasNetworks' intention to explore how a 'constraints based approach' can be expanded to incorporate the increasing complexity brought about by more independent asynchronous generation connections. The principles which underpin this approach have been tested with AEMO and neither TasNetworks nor AEMO can identify any 'fatal flaws' at this point in time.

This suggests that ongoing development of existing concepts is justified. Any *Rule* changes should encourage (or at least not hinder) application of such methods given that they leverage off the existing market framework and thereby promote a transparent and efficient outcome in near real time.

4.1.5. Fault levels as a metric to manage power system security

The management of fault levels alone will not necessarily guarantee system security. The concepts of SCR and ESCR have existed for a long time and date back to the development of HVDC transmission. In more recent times, the additional concept of Weighted Short Circuit Ratio (WSCR) has been developed to more easily account for the dynamic interaction between multiple power electronic converters connected in close electrical proximity.

While useful as a guide to potential issues, they are only a proxy, an indicator, to the underlying system dynamics which actually determine the capability of connected equipment to perform as required under all power system conditions. TasNetworks is aware of one practical example where the voltage angle shifts that occur during unbalanced fault events have proven to be a more onerous assessment criteria than simply satisfying an SCR requirement.

Having said this, TasNetworks recognises that urgent system security issues exist in the NEM today and on this basis, agrees that the use of 'fault level' as a proxy for system strength is a reasonable first step. However, TasNetworks would encourage a more holistic view of 'system strength' and encourages the AEMC to progress its definitions and not solely associate this term with fault level going forward. In the context of this submission, inertia is another key variable which needs to be associated with system strength. TasNetworks does not believe it appropriate to consider solutions related to the management of fault level separately from inertia.

Given the importance of this issue, there may be value in the AEMC commissioning a package of work, potentially undertaken by the Plant Modelling Reference Group (PMRG) convened through the National Electricity Market Operations Committee (NEMOC), to develop a NEM accepted definition of 'system strength' inclusive of all appropriate components. This may also prove useful in formalising the term '**system security services'** which is being used on a more regular basis.

A clear understanding of what *system security services* are needed to address future *system strength issues* may help better frame future regulatory developments.

4.1.6. Concept of 'reference nodes'

Depending on the final formulation of the *Rules*, TasNetworks would encourage the AEMC to consider application of 'reference nodes'. The intent is to remove the formal requirement to perform calculations at every generator connection point.

Satisfaction of system security criteria at a reference node should be sufficient to manage the requirements of the surrounding network, particularly on downstream radial connections. This is likely to be more computationally efficient. The final Rule should provide for such flexibility where the concept can be applied appropriately.

4.1.7. Application to distribution networks

As the TNSP and DNSP for the Tasmanian region, TasNetworks is well placed to apply a coordinated approach to manage various network performance issues. In relation to system strength, TasNetworks questions whether it is practical for all DNSPs to manage system strength issues independent of the TNSP.

TasNetworks suggests that the Rule determination has sufficient flexibility to enable the responsibilities of DNSPs to be defined similar to that of generators where appropriate.

The responsibility of the DNSP could be reduced to defining the minimum short circuit level it requires at its *connection point* to ensure that:

a) All downstream protection systems can operate correctly to clear faults.
b) The downstream network has sufficient 'strength' (tolerance to variations of active and reactive power flowing in, out and around the network) to ensure that:
    i. Adequate voltage control can be maintained.
    ii. Power quality criteria can be maintained.
    iii. The expected penetration of embedded generation having an SCR requirement can be appropriately supported. The objective is to minimise the risk of sympathetic tripping as a result of transmission or distribution network fault events.

In concept, the DNSP could negotiate the minimum fault level requirement with the TNSP for each bulk supply point, which then becomes part of the connection agreement.

It is recommended that the final determination have sufficient flexibility to enable DNSPs to negotiate on similar terms to generators where it is impractical for them to manage system strength issues independently of the TNSP.

4.1.8. Application to network customers

As a logical extension to Section 4.1.7, it is worthy to note that some *network customers* may also have a minimum fault level requirement (or expectation) for reasons including the correct operation of protection, as well as connected plant and equipment (in steady state and in response to disturbances). While TasNetworks would suggest that few network connection agreements include an agreed minimum fault level, similar consideration as for generators most likely apply.

TasNetworks has published minimum fault levels as part of its Annual Planning Report (APR)[5] for many years and this is seen as one way of communicating network changes (and soliciting feedback) to the broader industry within the Tasmanian region. Understanding how reduced levels of 'system strength' will impact network customers is another relevant aspect of managing overall power system security.

4.1.9. Conditions for which system strength needs to be maintained

TasNetworks suggests that the definition of minimum fault levels discussed in Section 4.1.2 will be an important consideration in the context of required/expected outcomes following *protected events*. This particular issue links directly to the AEMC Reliability Panel's consideration of what constitutes a viable 'electrical island' as part of its review of the Frequency Operating Standards (FOS). TasNetworks suggests that maintaining a minimum fault level above that described by point (a) in Section 4.1.2 would be onerous and most likely limit the number of *protected events* that could be practically defined.

Intuitively, the only mandatory requirement under such circumstances is to maintain sufficient fault level to ensure correct operation of protection systems (within the island), in addition to the provision of sufficient voltage and frequency control capability necessary to satisfy a 'viability test'[6].

4.1.10. Value of constraints and market benefits

The provision of support over and above this minimum level to ensure that existing (and potentially new) generators can meet their performance standards is considered a separate issue. The incremental costs directly attributable to the provision of network support to generators should be based on market benefits.

In a constraints based approach, the 'marginal value' of relieving a given constraint can be calculated and used as an indicator to increase fault levels using plant and equipment procured through a Network Support Agreement (NSA) or similar instrument. Unless the marginal value of a constraint exceeds the associated cost of its mitigation, then the constraint should be allowed to bind. This would likely produce a more transparent and equitable outcome for customers.

---

[5] https://www.tasnetworks.com.au/our-network/planning-and-development/planning-our-network/

[6] This particular issue has been raised by TasNetworks as part of its submission to the Reliability Panels "Review of the Frequency Operating Standards – 2017".

4.2. TasNetworks' conceptual approach going forward

Having considered the various issues discussed above, TasNetworks would like to explore the practicalities of the following extended methodology which builds directly on the intent of the AEMC's proposed Rule changes.

TasNetworks acknowledges that AEMO will need to be a participant in the processes outlined below and encourages a collaborative approach in managing these issues.

For Tasmania the following suggested alternate methodology, to be applied in the Tasmanian context, involves:

a) A minimum fault level (MVA) is to be determined for reference nodes around the 220/110 kV network.

   The minimum fault level will need to ensure that:

   i. Transmission and distribution network protection is capable of operating correctly.

   ii. Protection systems within *generating systems* are capable of operating correctly.

   iii. Power quality issues are addressed, e.g. compliance with IEC TR 61000.3.7:2012 Section 10 (Rapid voltage changes).

   Note: Power quality considerations have not been an obvious part of industry discussions to date (relating to system strength) however failure to manage this aspect of the network's *technical envelope* is likely to have negative impacts on network customers and a TNSP's ability to comply with the *System Standards*.

   iv. Downstream fault levels in the distribution network are sufficient to manage the operation of embedded generation, mainly in the form of photovoltaics (PV). The practical aspects of this issue are not well known and some effort will be necessary to quantify the requirements.

   For items (i) and (ii), the minimum fault level would need to be achievable following credible contingencies or protected events (essentially any event where an energised electrical island could prevail). The safety of people and equipment justifies this approach.

   The minimum fault level described may not inherently satisfy the ESCR requirements of power electronic interfaced equipment and therefore not guarantee the compliance of *generating systems* with their performance standards.

b) The practical mechanisms to ensure that the defined minimum fault levels are continuously maintained will need to be developed in conjunction with potential service providers in Tasmania. Aside from TasNetworks' ability to justify and install network based solutions, there are limited practical sources of system security services at the present time.

   In its simplest form, TasNetworks will need to contract for the dispatch of synchronous plant to provide additional fault level support. Synchronous condensers would most likely be used to provide the incremental support necessary over and above that provided from generation already dispatched in the energy market.

   The cost of this support may reasonably be passed through to network customers on the traditional basis of maintaining power system security. This is consistent with the discussions provided in Section 4.1.10.

c) As postulated by the draft determination, the minimum required SCR for each major asynchronous *generating system*, as well as HVDC interconnectors, will need to be confirmed where not already known. It is proposed that existing SCR requirements be registered with AEMO, in conjunction with all new generator connections.

In TasNetworks' opinion, an incomplete list containing only new generators would be of limited use when attempting to define the *technical envelope* and proportionate effort should be made to identify existing requirements where possible.

d) Using one of the methodologies described within CIGRE Technical Brochure 671 "*Connection of Wind Farms to Weak AC Networks*" [2], TasNetworks will need to convert individual SCR requirements to a form which accounts for interaction between sites.

   TasNetworks would like to properly investigate the differences between Effective Short Circuit Ratio (ESCR), Weighted Short Circuit Ratio (WSCR) and 'Available Fault Level' before committing to an agreed approach. It is noted that the AEMC's Draft Rule, Section 11.105.5 "*Interim Short Circuit Ratio Guidelines*" assumes the use of WSCR with fixed distances to determine electrical interaction.

   Without additional time to undertake appropriate network modelling and analysis, TasNetworks is not in a position to comment on the appropriateness of the 250 km, 150 km and 50 km electrical distances described in the interim guideline. It will be necessary to consider whether these fixed distances translate to appropriate outcomes in the Tasmanian network when determining absolute fault levels necessary to meet SCR requirements at reference nodes (or generator connection points as the case may be).

   At this point in time, assume that an equivalent fault level can be calculated that will satisfy the requirements of parallel unit operation. This fault level will be above the minimum fault level defined in step (a) above.

   Satisfaction of this absolute fault level requirement would enable all generators (and HVDC interconnectors) to satisfy their respective performance standards, at least in theory, noting the issues outlined in Section 4.1.5 above.

   It is proposed that the difference between the minimum fault level and that required to satisfy the performance standards of each individual generating system when operating in parallel, be managed through the application of constraint equations.

   The constraints will allocate the network's overall 'hosting capacity' between those *generating systems* that have an inherent reliance on system strength to operate satisfactorily.

e) TasNetworks is not in a position to fully describe the methodology of constraint development as the detailed thinking is yet to be done. However, the following broad concepts are anticipated to be at the core of the solution:

   i. For a given generation dispatch, the system will have a 'natural solution' in terms of available system strength (at this point in time defined by fault level). Synchronous machines and power electronic converters both contribute to the system strength, albeit that the latter source is less significant.

   ii. The allocation of available fault level would be a function of energy price, i.e. cheapest sources are allocated more of what is available. The allocation of fault level satisfies the *technical envelope* of the system.

   iii. It will be necessary to construct constraints that 'ramp' generator outputs between 0 MW and unconstrained operation based on the fault level allocation and their specific requirements to operate satisfactorily.

      The constraint equations will need to crafted in a manner that prevents binary outcomes in the energy market, i.e. if a *generating system* requires an absolute fault level of 2000 MVA at its connection point to operate satisfactorily at full output, it should not suddenly be constrained to 0 MW if the fault level falls to 1999 MVA.

Transitioning between operating levels based on fault level allocation will be challenging but is not considered impossible at this stage of thinking.

iv. If a generator installs its own equipment to increase local fault level, or negotiates a contract to have nearby synchronous plant in service to reduce the impact of a fault level constraint, conceptually, the fault level provided by that additional source could be wholly associated with that specific generator through a dedicated term embedded in the constraint equation.

    In simple terms, TasNetworks' approach would be to specifically allocate the additional fault level solely to the party paying for the system security service to be there.

v. In a similar vein, if TasNetworks puts in place an NSA, its activation to relieve binding constraints would be based on the marginal cost (of the binding constraint). This increase in overall hosting ability would be shared across those generating systems affected by the constraint.

The features of this conceptual solution are:

a) Customers only pay for legitimate system security related costs and do not subsidise the operation of generators when there is no market benefit in doing so.

b) There is incentive on generators to install the most capable equipment to maximise the energy that can be delivered from the available allocation of system strength.

c) There is incentive on generators to not connect in weak areas of the network where there is less 'system strength' available to share.

d) The benefits for specific generators coming from negotiation of off-market contracting arrangements or installation of ancillary equipment flow only to them.

e) Mechanisms exist for the TNSP to properly assess market impacts and thereby economically justify network or non-network solutions to increase the hosting capacity of their network, either through instruments like NSAs or installation of network based solutions.

Undertaking this work is not insignificant and costs will be incurred by TasNetworks to implement a robust solution. TasNetworks considers this would be a reasonable investment of effort given that it facilitates an outcome that should be robust for future developments in the network where issues of system strength will only be more pronounced.

4.3. Linkage to future Rules changes – Technical standards

While not specifically related to the draft determination currently under review, TasNetworks would like to highlight the importance of future *Rule* changes which have been postulated by AEMO and the linkages that exist with the immediate issues at hand. Specific attention is drawn to Schedule 5.2.5.5 Generating system response to disturbances following contingency events.

As maintaining minimum fault levels becomes more challenging, with the risk of increasing pass through costs to consumers, it is imperative that all generators provide meaningful fault current contributions in response to network events. This includes asynchronous *generating systems* comprised of wind and solar technologies.

TasNetworks is supportive of the principles outlined by AEMO in Section 3.3.1 in its technical submission to the Essential Services Commission of South Australia (ESCOSA) [3] which further clarify the expected minimum capability of power electronic equipment to supply reactive current during network disturbances. Ensuring that all energy sources provide appropriate system support services, commensurate with the practical capability of the technology involved, is important for the economic and technical operation of the power system going forward.

5. Rate of change of frequency draft determination

In relation to the draft determination that addresses rate of change of power system frequency, TasNetworks offers the following discussions for consideration.

5.1. Recognition of ongoing local inertia requirements in Tasmania

The Tasmanian region will need to be defined as an inertia sub-network for obvious reasons. In the context of the proposed Rule changes, Tasmania is also continuously 'islanded' for the purposes of determining inertia requirements.

As Tasmania will only ever be connected to the mainland via asynchronous HVDC based technologies, recognition of an ongoing requirement for the local provision of inertia may be worthwhile in the Rules drafting for the purposes of clarity.

Tasmania's specific circumstances should also be described in the *inertia requirements procedure* to be developed by AEMO.

5.2. Technologies capable of supporting ROCOF in various time frames

In relation to the wording of Chapter 5.20B.4(d), TasNetworks recommends that the Rule not be so prescriptive as to only mention synchronous condensers and in doing so, preclude the delivery of *inertia network services* from other technologies.

As described in Section 3.2 of this submission, TasNetworks can identify two time frames that are relevant for ROCOF assessments, with only the initial transient period of operation requiring the explicit dispatch of synchronous machine inertia. The only potential alternative to this would be fast acting System Protection Schemes (SPS) or similar protection grade solutions that are capable of rapidly restoring the generation/load balance. The appropriateness of such solutions is dependent on the circumstances.

In TasNetworks' opinion, there is a range of commercially available network technologies that can address the second time frame, including non-rotating energy storage options such as batteries and super-capacitors capable of delivering a fast-frequency response (FFR).

5.3. TasNetworks' conceptual approach to proceed forward

TasNetworks met with AEMO on Thursday 9 August and discussed a conceptual solution that builds on the existing 'constraints based approach' that is already in operation in Tasmania to manage ROCOF. It is recognised that some modifications to existing processes will need to occur once more privately owned asynchronous generation is connected in Tasmania. The intention of the discussions were to conceptualise how best to facilitate the ongoing utilisation of synchronous condenser capabilities resident within Tasmania for the benefit of the market as a whole.

While significantly more work is required to develop a solution that can be readily operationalised in a real time environment, a feasible concept was determined to exist. The preliminary solution is based on the identification of market benefits derived from the marginal value of binding constraints. An appropriate marginal value could be used as a flag to commit contracted inertial support. The methodology would be transparent to the market and only result in justifiable pass through costs to network customers.

TasNetworks is keen to undertake discussions with the AEMC to test the concepts in context of the Rule change proposals.

6. References

[1] AEMC Reliability Panel; "*Draft Rule Determination – National Electricity Amendment (Managing power system fault levels) Rule 2017*", 27 June 2017.

[2] Cigre; "*Connection of wind farms to weak AC networks*", Technical Brochure 671, Working Group B4.62, Published December 2016, ISBN: 978-2-85873-374-3.

[3] Australian Energy Market Operator (AEMO); "*Recommended technical standards for generator licencing in South Australia*", 31 March 2017.

http://www.escosa.sa.gov.au/ArticleDocuments/1048/20170331-Inquiry-RecommendedTechnicalStandardsGeneratorLicensingSA-AEMOadvice.pdf.aspx?Embed=Y