TasNetworks | Powering a Bright Future

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Mr Daniel Westerman
Chief Executive Officer
Australian Energy Market Operator
Via email: planning@aemo.com.au

Dear Mr Westerman

RE Amendments to AEMO Instruments for Efficient Management of System Strength on the Power System Rule

TasNetworks welcomes the opportunity to respond to the Australian Energy Market Operator's (**AEMO**) *Amendments to AEMO instruments for Efficient Management of System Strength Rule Issues Paper* (**Issues Paper**).

TasNetworks is the Transmission Network Service Provider (**TNSP**), Distribution Network Service Provider, Jurisdictional Planner and System Strength Service Provider (**SSSP**) in Tasmania. TasNetworks is also the proponent for Marinus Link, a new interconnector between Tasmania and Victoria. Our focus in all of these roles is to deliver safe and reliable electricity network services to Tasmanian and National Electricity Market (**NEM**) customers at the lowest sustainable prices.

Tasmania as a synchronous island region faces unique system strength issues. TasNetworks commends AEMO's collaborative approach to amending its System Strength Requirements Methodology (**SSRM**) and System Strength Impact Assessment Guideline (**SSIAG**).

The key points in this submission are:

- Minimum fault level and stable voltage waveforms assessments must be proportionate to the benefits derived from them. This will generally mean generic, simplified models are appropriate for longer time horizon modelling.
- In relation to protection systems and maintaining synchronism of distributed energy resources (**DER**), further investigation is required to understand the problem before selecting the solutions that maximise net customer benefits.
- Customer impacts and outcomes should be a key criteria when defining critical outages, including customer cost impacts of allowing unconstrained Inverter Based Resources (**IBR**) during some planned outages.

- There are some unintended consequences of the System Strength Locational Factor (**SSLF**) proposed methodology – particularly for generators connecting to the distribution network – that could diminish the purpose and benefits of the efficient management of system strength rule change. This could potentially be mitigated through the materiality threshold.

As Tasmania's SSSP, TasNetworks looks forward to ongoing collaboration with AEMO to proactively plan for Tasmania's unique system strength needs.

Should you have any questions, please contact Chris Noye, Policy and Regulatory Specialist, at Chris.Noye@tasnetworks.com.au.

Yours sincerely

Chantal Hopwood

Leader Regulation

System Strength Requirements Methodology

Minimum Fault Level Requirements

TasNetworks agrees that review of minimum fault level requirements and system strength nodes (**SSNs**) will be necessary to help manage a number of evolving issues including the uncertainty associated with the uptake of DER. However, annual reviews may not be warranted if there has been no significant changes on the network. An alternative approach may be a periodic engineering review where potential or actual changes to system security outcomes can be identified. This recognises that a detailed simulation based assessment may not always be the most appropriate approach for investigating all issues, for example, when managing small scale devices dispersed throughout distribution networks.

The proposed approach of taking the currently defined minimum fault levels as a starting point for the minimum requirements under the new standard is appropriate. TasNetworks agrees this is a pragmatic solution which addresses the system strength needs of the existing network and provides a workable base from which to project future requirements. This approach also avoids what could become a very significant undertaking to explicitly define minimum fault level requirements associated with transmission and distribution network protection systems. We do not contend that it is credible to undertake such an activity in the timeframes required to implement the efficient management of system strength rule change.

As Tasmania's SSSP, TasNetworks looks forward to working with AEMO to develop minimum fault level requirements.

Stable Operation after a Credible Contingency Event or Protected Event

TasNetworks agrees with the general principles outlined in the Issues Paper, with the following observations.

It is not practical to undertake detailed electromagnetic transient (**EMT**) simulations for future operating conditions extending much beyond the rolling three year time frame for which system strength must be proactively delivered. Alternative methods which are streamlined and proportionate to the inherent level of uncertainty existing further out in time, will be necessary for investigating and estimating longer term system strength needs. TasNetworks supports continued refinement of the available fault level (**AFL**) methodology, but also supports consideration of other high level methods.

For near-term projections, where EMT simulations become increasingly critical to demonstrate the efficacy of system strength solutions proposed to meet the standard, TasNetworks encourages AEMO to consider the development of a generic model library capable of representing the most common IBR plant. The generic models topology and core performance characteristics could be maintained reasonably consistent with a limited number of tuneable parameters recognising that each network may have specific requirements that require some level of customisation. TasNetworks sees this as a way of not only encouraging consistency and harmonisation of studies undertaken by AEMO and SSSP's, but to also decrease the time to prepare and undertake analysis without impacting quality.

Treatment of Inverter Based Resources with Assessing Minimum Fault Level Requirements

TasNetworks agrees that the minimum fault level requirements should continue to incorporate IBR previously accounted for as part of historical system operating practices under the do no harm regime. This will ensure fairness for existing network participants that entered the market based on the assumption of a specific level of system strength being available. New and modified IBR should be included in the efficient level of system strength to maintain stable voltage waveforms.

This interpretation is consistent with TasNetworks expectations formed during the efficient management of system strength rule change consultation process.

Protection System Operation

TasNetworks contends that more focused efforts are required to properly understand the impact of IBR on network protection systems, both at transmission and distribution voltage levels. For this reason we believe the issue should be considered as part of the Engineering Framework being coordinated by AEMO.

IBR sources like wind and solar are required to inject fault current to comply with the technical requirements of the National Electricity Rules (**NER**). It is therefore inappropriate to exclude IBR contributions when considering minimum fault level requirements, noting IBR response will be less than a synchronous machine of equivalent MVA rating. This approach differs somewhat to other issues related to system strength where it is only the contribution from grid-forming devices that are generally considered.

There is little benefit in simply requesting protection settings from Network Service Provider (**NSP**). In TasNetworks view, this is not a technical challenge that can be addressed by attempting to build models and run simulations. Instead, the objective of this exercise should be to better define the problem and associated risk profile by understanding what assumptions are already applied when considering weak system conditions, for example:

- generation dispatch scenarios;
- number of concurrent network outages; and
- sources of fault current.

In TasNetworks experience, defining a single operating condition to deliver minimum fault current across the network is a challenge, with a certain degree of engineering judgement applied depending on location within the network and type of network connection being assessed, for example, radial line, backbone network, sub-transmission voltage(s) etc.

As a result, developing an understanding of the protection design and setting philosophies used by NSPs at all voltage levels is a preferred approach. While standard protection designs are commonplace, setting principles may vary between organisations. The basis for configuring new protection relays (and maintaining existing units) should be available and the treatment of IBR in such studies should also be considered, for example, their assumed fault current contribution.

An interim approach could be to maintain the synchronous three phase fault level at all points in the network at or above historical minimums for intact network operation (either real time calculated or published values), on the reasonable assumption that this has been adequate to ensure correct protection operation at all voltage levels. A gradual reduction may be possible where a review of underlying design principles allow. Furthermore, in some areas of the network, the synchronous fault level requirement needed to support the operation of pre-existing IBR may inherently force operation to be at or above these levels, providing for a self-correcting outcome. This may be sufficient until system strength can be reliably sourced from grid-forming inverters, at which time, a more comprehensive solution will likely be needed.

Maintaining Synchronism of Distributed Energy Resources

Similar to protection system operation, more understanding is required before a preferred solution is selected.

PV inverters have demonstrated a propensity to either trip or pause their active power output in response to voltage dips (and to a lesser extent, high rates of change of frequency). It follows that the more units that are exposed to such transients, the larger overall magnitude of sympathetic tripping will be experienced.

Therefore, in TasNetworks' view, the fundamental risk to be managed during low system strength operating conditions is the wider propagation of low voltage disturbances and the ability to recover voltage quickly upon fault clearance. The system security consideration is the increasing number of photovoltaic (**PV**) systems exposed to voltage conditions that may result in their generation being interrupted for a sufficiently long time as to negatively affect network frequency (and the recovery of network voltages as a feedback effect).

Further investigation is required to understand:

- what metrics should be applied and what limits are appropriate to those metrics;
- what technological solutions exist as an alternative to simply increasing minimum fault levels, noting that this basically equates to an increased number of online voltage sources capable of counteracting the effects of fault events; and
- the maximum allowable contingency size and how this translates to network voltage control requirements, i.e. at what point is there a problem that requires proactive management.

TasNetworks requests that this issue is more thoroughly described and understood before a course of action is committed to. There may be opportunities to address this issue as part of NSP planning functions. Solutions could include:

- density limits on PV;
- increased scrutiny of PV performance characteristics; and/or
- increased real time visibility of distribution networks.

Ultimately, TasNetworks is in favour of solutions which address the core engineering issues in the most cost efficient manner for customers, and also minimises additional responsibilities and real time management activities being incurred. A consideration should be minimising further costs being imposed on NSPs.

Application of Minimum Fault Level Requirement in an Operational Context

TasNetworks currently considers absolute fault level and synchronous fault level as two separate issues in an operational environment, with absolute fault level including contributions coming from IBR.

In our experience absolute fault level has been most relevant for managing high fault level operating conditions (to ensure that equipment ratings are not exceeded). However, we recognise that it may become equally relevant at the bottom end of the spectrum as well to manage any potential future issues associated with network protection systems.

Synchronous fault level is used by TasNetworks to manage IBR and network dynamic related issues including fault ride through performance and voltage transients during network switching events.

TasNetworks suggests absolute fault level and synchronous fault level should be considered as two separate issues.

Criteria for Stable Voltage Waveform

The description of stable voltage waveform should largely be consistent with the System Standards described in Schedule 5.1a of the NER to avoid duplication, inconsistencies and / or misinterpretations. TasNetworks acknowledges that there may be some exceptions, for example:

- Item 4 is under examination by various AEMO working groups and may require explicit mention in the SSRM.
- Rate of change of frequency is not currently addressed by the System Standards, with either the *automatic* or *minimum access standards* of Schedule 5.2.5.3 (Generating system response to frequency disturbances) sometimes applied as a proxy standard. It can be noted that the Reliability Panel of the Australian Energy Market Commission (**AEMC**) has recently raised this issue as part of its 2022 Review of the Frequency Operating Standard[1], and is consulting on how this may be addressed going forward. The SSRM is not the appropriate location to define such technical limits (as could be inferred from item two in AEMO's listing).
- The System Standards do not address the issue of transient voltage recovery, i.e. how fast network voltages should recover to within continuous operating limits following a disturbance. Again, the *minimum access standard* of Schedule 5.2.5.4 (Generating system response to voltage disturbances) provides some guidance, noting that if network voltages fail to comply with these basic requirements, this effectively allows generators to disconnect without being in breach of the NER. This is another potential enhancement to the System Standards, but is not an issue to be managed via the SSRM.

TasNetworks does not believe that the description of stable voltage waveform as proposed in the Issues Paper is appropriate.

Assessment of Stable Voltage Waveforms in the Future

As noted above, generic models will provide greater confidence to justify any required network expenditure to proactively deliver system strength services. Application of EMT simulations should be limited to the planning timeframes which will consider the need for commitment to physical assets (approximately three years in advance).

[1] www.aemc.gov.au/market-reviews-advice/review-frequency-operating-standard-2022

We are supportive of using simplified analysis techniques based on load flow data sets beyond this three year planning timeframe. This could be AFL or some other methodology proven to be appropriate.

TasNetworks supports a consistent approach across the NEM and believes the SSRM should provide guidance on what approaches should be applied by all SSSP's.

Modelling Future Inverter Based Resources and Synchronous Machine Combinations

The Integrated System Plan (**ISP**) provides a solid base to commence system strength planning activities. In addition to the ISP, AEMO should consult with SSSP's and be willing to modify ISP outcomes within the three year planning timeframe to align with the most current information. The ability to introduce updated and new data to refine ISP predictions prior to determining a system strength standard (which will have real cost impacts on customers) is a necessary component of the SSRM.

In relation to locational details, AEMO should focus on Renewable Energy Zones (**REZ**) level predictions of wind, solar, energy storage and other generation types. Projecting new generation at an individual network bus will be difficult, particularly if significant new network is required to support a new stream of development.

TasNetworks is currently dealing with an unprecedented level of interest in new customer connections varying significantly in size. Considering the energy transition and potential new load, TasNetworks supports the current Joint Planning approach where NSPs provide AEMO with regular updates of connection activity that can be used as inputs to refine processes like the annual System Strength Report. At this stage, it is difficult to see how loads can be incorporated into the forecast except in the case where government policy has explicitly set out to encourage the development of particular sectors. For example, the Tasmanian Government's Renewable Hydrogen Action Plan[2]. The inclusion of such inputs as part of future ISP modelling may be warranted to provide some visibility of this issue.

TasNetworks does not support the proposed use of a coincident factor to refine the need for system strength. This approach assumes that system strength is a function of MW output which is not always the case. We understand that examples already exist in the NEM where it has been shown that the number of inverters online is the key variable, not the MW output. TasNetworks also considers that using a coincident factor introduces a level of complexity that is not justified due to the number of variables and inherent uncertainties already being managed. Under the efficient management of system strength rule change, AEMO provides a forecast of IBR connections and SSSPs define how system strength is subsequently provided to maintain a secure operating state. As a result, the SSRM should not be prescriptive in this regard.

TasNetworks agrees with the proposed approach to projecting the technical capability of future plant. While grid-forming controls are rapidly evolving for use in battery energy storage systems (**BESS**) and to a lesser extent large scale solar, we agree that this type of solution is likely some way off for other types of IBR. A decision on whether BESS is or isn't grid-forming can be made on a regional basis, with the general expectation that any BESS located in

[2] www.recfit.tas.gov.au/future_industries/green_hydrogen

Tasmania would be grid-forming by default given the specific characteristics of our network. Consultation with the SSSP is the recommended strategy going forward to address this issue.

In regards to future network developments, ignoring or underestimating network augmentations required to connect new generation sources and/or load may lead to inaccurate predictions of system strength requirements. TasNetworks supports:

- the use of Joint Planning activities to communicate what is required to support various levels of REZ development; and
- including in the system strength analysis any REZ network development that is identified by the Jurisdictional Planner as necessary, including REZ development that does not met the definition of a committed project.

Locating System Strength Nodes

TasNetworks supports the proposed selection criteria, but seeks an opportunity to review how the selection process would work in the Tasmanian region. The four existing fault level nodes has served Tasmania well from a technical perspective, however the efficient management of system strength rule, introduces a commercial overlay that was not previously considered in detail. We anticipate that additional nodes will be necessary to help manage new REZ areas as they are developed.

We are committed to working through the detail with AEMO to develop a simple solution that enables power system security to be appropriately managed. It will be important to avoid significant additional operational burden for NSPs.

Planning for Critical Outages

Recognising issues being managed in other NEM regions, TasNetworks is supportive of mechanisms that allow AEMO to define critical outages that will impact on minimum system strength requirements (and likely drive locational specific system strength solutions).

Due to the size and characteristics of our transmission network, there are and are likely to be difficulties maintaining sufficient levels of system strength to support the operation of all Tasmanian IBR on a continuous basis, under various network outage conditions. There are already examples in our network where IBR (generation) is constrained during specific outage events to manage issues like fault ride through performance requirements.

It is important that the application of the defined threshold criteria be done with customer impacts at the forefront, noting that generators do not have firm access rights to the network under the current regulatory framework. Criteria for critical planned outages could be linked to supply security and/or market impacts on customers. For example, constrained operation of IBR leading to adverse and sustained market outcomes.

TasNetworks seeks further discussion with AEMO to determine what would classify as a critical outage in the Tasmanian context given that we are expecting an increase in dispatchable synchronous generation capacity. This contrasts with the mainland where there is a forecast withdrawal of base load coal units which currently provide significant levels of system support.

System Strength Impact Assessment Guideline

Guidance on the Calculation of System Strength Locational Factor

Based on the proposed methodology, the SSLF will vary depending on what is assumed as the base fault level at a given connection point. The more fault current that is required to be transferred across the network impedance (between the SSN and connection point), the higher the SSLF will become. This is demonstrated by the example in Figure 1. The issue being highlighted is that SSLF will not be a constant value if fault level requirements increase at a particular connection point over time, for example, if more than one IBR connects at the same location.

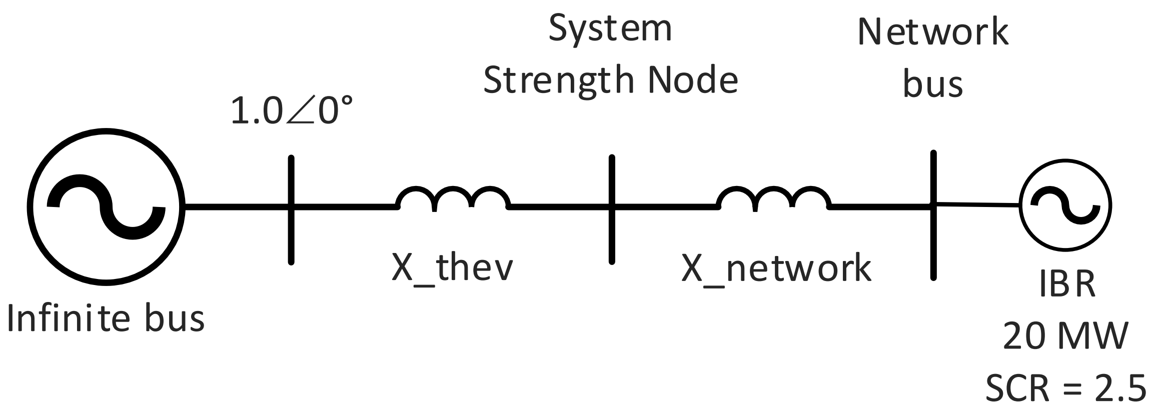
This example shows how the SSLF will vary depending on the assumed base level of system strength from which the incremental requirement is being assessed. There are also likely to be complications for the calculation of SSLF if a SSN and connection point are located within a meshed network which allows fault current to be delivered from multiple locations (and directions). In TasNetworks view, the SSLF calculation methodology might be acceptable for a basic REZ design based on a hub and spoke concept where simple radial connections emanate from some central point, however the calculation becomes more complicated if the IBR is located within part of the meshed network. TasNetworks recommends AEMO provide further guidance on what system conditions SSSPs should assume when calculating SSLFs.

Because SSNs must be located on the transmission network, it is likely that most distribution network connections will have high SSLFs due to the impedance of upstream assets. This will encourage generators to self-mitigate even if this is not the most efficient option and potentially dilutes the benefits intended by the efficient management of system strength rule change. For example, it could result in multiple small synchronous condensers being installed throughout distribution networks which is not only inefficient, but could also lead to high fault level issues.

TasNetworks is concerned that there are unintended consequences for future developments in some parts of the network – particularly distribution networks, if there is relatively high impedance between the proposed connection points and the transmission network SSNs. Where possible, the SSIAG must address this unintended consequence of the calculation methodology. A suggestion on how the materiality threshold could help solve this issue is provided in the next section.

Figure 1: Calculating System Strength Locational Factor

Example network using a 100 MVA system base



Notes:

- X_thev = 0.1 p.u.
- Fault Level at the SSN = 1000 MVA (10 p.u) before new IBR connects to the network.
- X_network = 0.1 p.u. This could represent the impedance of a step down transformer supplying a lower voltage distribution network bus, or a transmission line to a remote point in the network.
- Fault level at the Network bus = 500 MVA (5.0 p.u).
- New 20 MW IBR wanting to connect to the network will have an assessed system strength quantity of 50 MVA (20 MW x short circuit ratio (**SCR**) requirement of 2.5).

The proposed methodology for calculating the SSLF is to determine the ratio of additional fault level at the SSN to restore the AFL at the applicant's point of connection. TasNetworks understand this equates to providing an additional 50 MVA of fault level at the network bus.

To achieve this, the source impedance 'X_thev' (being the effective impedance looking back into the rest of the network) needs to change to increase the SSN fault level to be a calculated value of 12.2 p.u (1222 MVA). This delivers a fault level of 550 MVA at the network bus, thus satisfying the NER criteria.

Using the proposed methodology, the SSLF in this scenario is
(1222 – 1000) MVA / 50 MVA ≈ 4.4.

This results in the SSSP charging the applicants for providing 222 MVA of fault level at the SSN (if the applicant didn't choose to self-mitigate).

If a further 50 MVA of fault level was subsequently required at the same connection point, the following needs to occur:

- the source impedance needs to reduce to 'X_thev' = 0.0666 p.u.
- fault level at the SSN increases to 1500 MVA.
- fault level at the network bus now equals 600 MVA.

Using the proposed methodology, the SSLF in this second scenario is
(1500 – 1222) MVA / 50 MVA ≈ 5.6.

Scope of Assessment

TasNetworks considers the materiality threshold for adverse system strength impact and additional reduction in AFL as separate issues.

The materiality threshold for adverse system strength impact should remain unchanged at effectively zero. Any negative impact on power system security as identified through consideration of the NER technical schedules (under Chapter 5) should be analysed in detail by AEMO and the relevant NSP and SSSP, with subsequent management strategies developed.

In respect to incremental changes in AFL due to the connection of new equipment to the power system, the issue of materiality threshold is complex due to the unintended consequences of the proposed methodology for calculating SSLF as outlined above.

Defining the materiality threshold in terms of acceptable dynamic performance outcomes when system strength levels are at a minimum may help address these unintended consequences. For example, if a new connecting IBR generator or load can operate without causing adverse system impacts when the system is operating at minimum fault levels, then this could be defined as having no general system strength impact. This removes the need to calculate SSLF and system strength charges, and remove the need to self-remediate. The potential implications of this approach will require further detailed consideration, especially for transmission connections which may exhibit similar issues depending on their electrical distance from the SSN.

Proposed Methodology for Preliminary Assessments

TasNetworks does not consider an engineering safety margin to the SCR is necessary during the preliminary assessment. The proponent has an obligation under the NER to provide technical data as part of the application process. A nominal safety margin does not adequately address any underlying issue with the use of a simple isolated model required to be used at the preliminary assessment stage.

The process of undertaking preliminary assessments may need to be re-evaluated depending on how materiality thresholds are defined. It may be that a simplified model becomes a small section of network that emanates outward away from a SSN toward proposed IBR connections (with the remainder of the network represented as an appropriate equivalent impedance). While it may prove possible to simplify this assessment to something equivalent to the example provided above, the parameters should be carefully determined from the full system model, especially for calculation of SSLFs.

Proposed Methodology for Full Assessments

TasNetworks supports consistency in the definition of a committed project. Our current understanding is that a committed generation project is one that has accepted an Offer to Connect having proceeded through the processes of NER Chapter 5. A committed project will therefore have an agreed Generator Performance Standard (**GPS**). For load connections, TasNetworks has defined its requirements to achieve committed status in its Guide to Transmission Connections.

TasNetworks is cautious about allowing a committed project to be downgraded where material changes to the design are subsequently proposed. While many of the studies undertaken to reach the offer to connect stage will need to be repeated, a project considerably advanced through the process should continue to be assumed as proceeding. Any subsequent changes to plant performance would need to be negotiated with the NSP via the relevant provision of the NER. The intent should be to try and avoid multiple study iterations and focus rather on engineering robust solutions which are tolerant to a range of different input assumptions.

Future network augmentations should be included to the extent that they are necessary to support the proposed connection application. It is essential that network modelling includes the new generator or load physically connected to the network, including any system strength solutions required. TasNetworks recommends that the status of network related augmentations be communicated by NSPs through Joint Planning activities undertaken in conjunction with AEMO.

Guidance on the Calculation of the AFL

AFL is of limited value unless all IBR connected to the network is assessed in parallel, taking into account the network impedances between them. The method described in the Issues Paper appears to only consider the SCR requirements of plant at the one particular bus being studied.

As part of preparations to implement the efficient management of system strength rule change with TasNetworks, we have already defined our own methodology for calculating AFL based on previous work published by the Council on Large Electric Systems (**CIGRE**). TasNetworks looks forward to sharing our work with AEMO and other members of the System Strength Working Group and looks forward to discussing how our approach can inform the SSIAG documentation.

Guidance on Demonstrating Compliance with New Minimum Access Standards

It is reasonable to have the generator or load demonstrate (through simulation) that the plant controls are capable of being configured to operate at an SCR of three. TasNetworks has requested similar demonstrations of capability for an SCR of two using simplified network representations and our intended negotiated access standard for the Tasmanian region going forward will continue to be two. Inevitably there are performance trade-offs at lower system strength operating conditions, so some pragmatism is ultimately required when comparing performance.

TasNetworks' approach has been to require plant to operate against the lowest practical fault level to which it could be exposed and still be expected to operate satisfactorily. This can result in a connection point SCR of greater than three. It would be our intent to include appropriate wording within future performance standards that allows for future alteration of plant controls to enable operation at lower levels of system strength if required in the future. This would be managed under the existing provisions of Schedule 5.2.2 (Generators), Schedule 5.3.4 (Customers), and Schedule 5.3a.2 (Market Network Service Providers).

A potential trigger for such changes could be where an SSSP determines that a change in plant control settings is the preferred credible option as part of undertaking Regulatory Investment Test for Transmission (**RIT-T**) studies. Existing RIT-T principles must be followed when investigating future options to meet the System Strength Standard set by AEMO. Having a formal mechanism (via the NER and performance standards) to legitimately request changes to existing plant should make such processes somewhat easier going forward. TasNetworks proposes that as part of any such request, a GPS reassessment be undertaken to understand the detailed implications of making changes to the plant controls.

Power System Stability Guidelines

TasNetworks supports the proposed approach to update the PSSG in line with the new system strength framework noting that the proposed changes are largely administrative to ensure consistency across documentation.