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1 June 2022

Ms Samantha Christie
Manager Network Planning
Australian Energy Market Operator (AEMO)

Via email (planning@aemo.com.au)

Dear Ms Christie

Response to System Strength Instruments Issues Paper

AusNet welcomes the opportunity to make this submission in response to the AEMO's Issues Paper consulting on amendments to its system strength instruments to implement the Australian Energy Market Commission's (AEMC's) 2021 *Efficient management of system strength on the power system* final rule.

AusNet is the largest diversified energy network business in Victoria and owns and operates over $11 billion of regulated and contracted assets. It owns and operates three core regulated networks: electricity distribution, gas distribution and the state-wide electricity transmission network, as well as a significant portfolio of contracted energy infrastructure. It also owns and operates energy and technical services businesses (which trade under the name "Mondo").

We agree with the AEMO that Australia's National Electricity Market (NEM) is at the forefront of managing issues associated with low system strength and recognise the importance of the AEMC's final rule and resulting Issues Paper in maintaining power system security during the energy transformation.

Inadequate system strength continues to increase the difficulty and cost for transmission network service providers (TNSPs) to undertake planned outages to conduct routine maintenance and replacement of their assets. It is also delaying (or preventing) renewable developers from connecting generation to the shared network and, under the previous 'do no harm' Rule, forced the procurement of expensive remediation solutions.

Unlike other jurisdictions, in Victoria the AEMC's final rule requires the AEMO fulfill the System Strength Service Provider (SSS Provider) role. As a result, AusNet's submission comments on the specific topics raised in the Issues Paper that are relevant to our role as Victoria's principal declared transmission system operator (DTSO).

In summary, AusNet:

- Strongly supports the AEMO's decision to take critical planned outages into account when setting the minimum fault levels through its proposed definition. Inclusion of case studies or scenarios would aid clarity how that definition will be applied (Section 3.5).
- Shares concerns expressed in AEMO's working group that the methodology for determining the system strength locational factor (SSLF) included in the AEMC's final determination is flawed and requires fundamental changes (Section 4.6).
- Supports the proposed criteria for selecting the location of system strength nodes, and provides our view on the appropriate number and location of those nodes in Victoria (Section 3.4).

AusNet

- Encourages the AEO to clarify the implications for connecting generators whose connection would cause an adverse system strength impact at their connection point but not at the relevant system strength node (Section 4.2).
- Recommends the System Strength Impact Assessment Guidelines (SSIAG) provide greater flexibility for Connecting NSPs to account for the individual nuances within each connection's Stability Assessment rather than attempt to form a generic scope of studies (Section 4.5).

If you have any questions regarding this submission, please contact Jason Jina, Energy Policy Lead by email at jason.jina@ausnetservices.com.au.

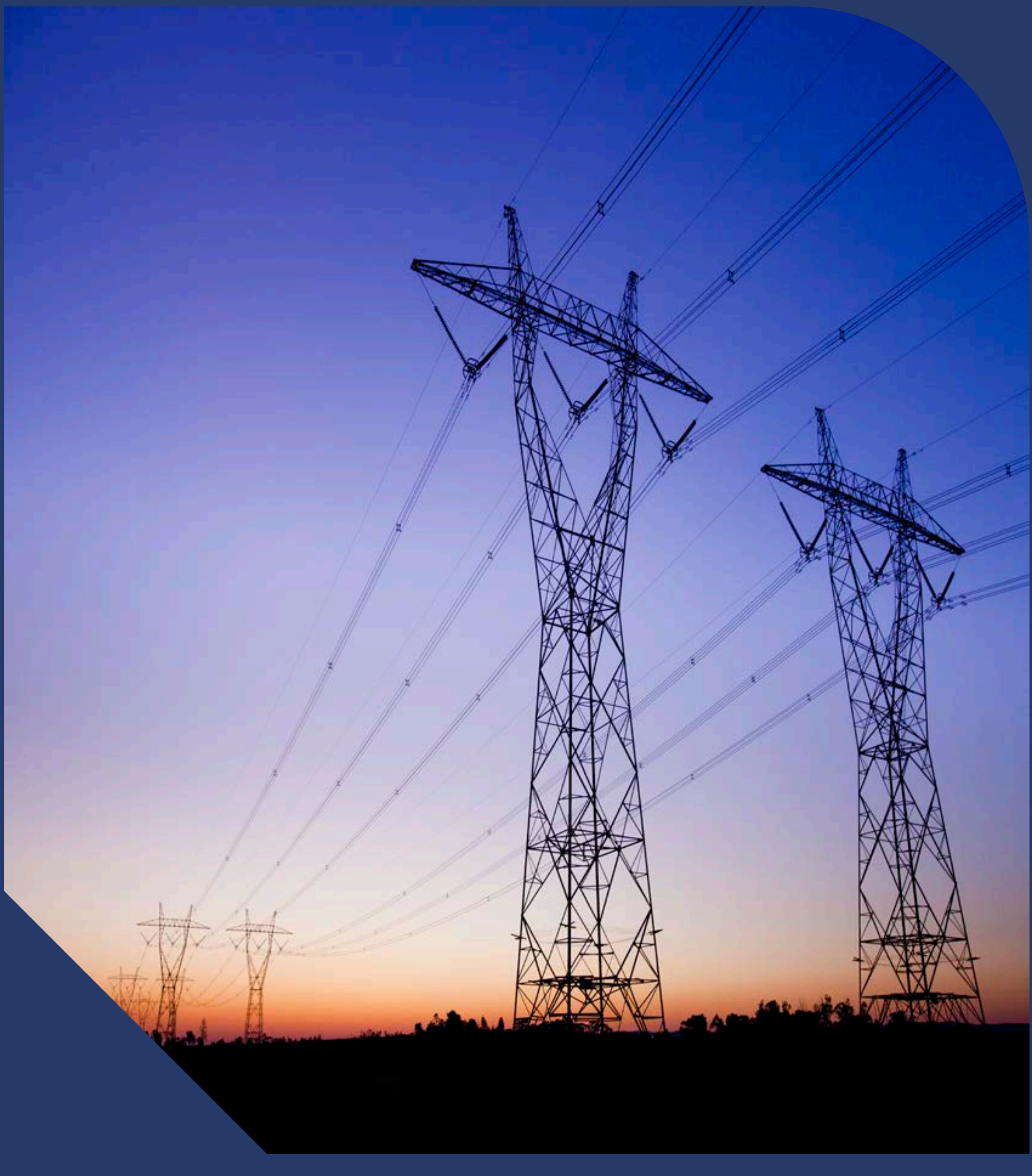
Sincerely,

Rod Jones
General Manager Network Strategy & Planning
AusNet

AusNet submission in response to the System Strength Instruments Issues Paper

Australian Energy Market Operator (AEMO)

Wednesday, 1 June 2022



1. Introduction

AusNet Services Ltd (AusNet) is pleased to provide our response to the AEMO's System Strength Instruments Issues Paper published in April 2022.

Our response provides AusNet's perspective on:

- Planning for critical outages (Section 3.5 of the Issues Paper)
- Guidance on the calculation of the System Strength Locational Factor (SSLF) (Section 4.6 of the Issues Paper)
- Locating system strength nodes (Section 3.4 of the Issues Paper)
- New system strength impact definition (Section 4.2 of the Issues Paper)
- Proposed methodology for Stability Assessment (Section 4.5 of the Issues Paper)

The Appendix provides information to support our views on the proposed Stability Assessment.

2. Planning for critical outages

AusNet strongly supports the AEMO's decision to take critical planned outages into account when setting the minimum fault levels through its proposed definition. Inclusion of case studies or scenarios would aid clarity how that definition will be applied.

From time to time, transmission network service providers (TNSPs) are required to take transmission elements out of service to conduct essential capital replacement, maintenance, connections and augmentation works. These "planned outages" are an essential business-as-usual activity to maintain network reliability and security.

These planned outages require supportive operational conditions, often over several days, in order to go ahead.[1] The progressive closure of synchronous machines and rapid uptake of distributed energy resources (DER) and grid-following generation has contributed to a significant decline in system strength across the national electricity market (NEM). Concerns related to voltage management, minimum demand and solar shake off are also emerging. Collectively, these deteriorating network operating conditions have meant it has become increasingly difficult to find a window where no constraints bind, and planned outages can be undertaken while keeping the system secure.

Are there specific changes that should be considered to the AEMO approach to what a 'critical' planned outage should be, and the potential thresholds for those outages? If so, please note alternatives (Q27)

The AEMO's decision to take "critical" planned outages into account when setting the minimum fault levels provides a sensible way forward to address current issues faced by TNSPs. Planning for critical outages will benefit customers by likely reducing the cost of planned outages, and the risk of asset failure and unplanned outages.

AusNet has reviewed the AEMO's proposed definition of a critical planned outage and threshold criteria to be set in its System Strength Requirements Methodology (SSRM). If applied appropriately, we consider the AEMO's approach provides appropriate coverage of known planned outage scenarios that are the highest priority to undertake from a network reliability and security perspective.

Do you have a view on whether criteria for critical planned outages should be specified in the SSRM, versus a case-by-case assessment each year? (Q28)

AusNet is conscious that this is the first time 'critical planned outages' has been defined, and that consistently applying the definition and criteria across the NEM would provide confidence to both energy market participants and customers. For example, systems strength solutions can often take multiple years to deliver and changes to the definition or threshold made by the AEMO in future SSRMs could impact the timely delivery of these investments.

We are also aware that the rapid pace of the energy transformation may mean there are planned outage scenarios that the AEMO would see value in planning for but were not contemplated under the Issues Paper's proposed criteria.

[1] TNSPs are unable to undertake planned outages during periods of low system strength, where AEMO has concerns relating to voltage management, minimum demand and solar shake off, or there are poor weather conditions.

With this in mind, AusNet:

- Supports the definition and threshold being specified in the SSRM.
- Suggests the AEMO develop a series of scenarios or case studies in its SSRM to provide further guidance to System Strength Service Providers (SSS Providers) around what constitutes a critical planned outage.
- Recommends the AEMO includes an addition clause in its threshold criteria that enables it to consider other circumstances not captured by its existing criteria that may be deemed a critical planned outage.

Note AusNet has provided its own critical planned outage case studies below to impart its understanding of how the AEMO's criteria would be applied. Both case studies are of previous events on AusNet's transmission network that we consider would have qualified as a critical planned outage. The table below highlights that planned outages should not be required to satisfy all five threshold criteria in order to be considered critical.

<table>
<tr><th>Case Study</th><th>Critical planned outage threshold criteria</th><th>AusNet's assessment</th></tr>
<tr><td rowspan="5">Cressy Towers Restoration

In January 2020, a storm downburst destroyed a section of the south-west 500 kV transmission system at Cressy, Victoria, including the destruction of several large transmission towers. This south-west 500 kV system forms a critical part of the link between Victoria and South Australia (SA).

Temporary towers were installed soon after and the 500kV line re-strung to restore the system to temporary working order.

Once new permanent replacement towers were constructed several months later, AusNet was then unable to take a planned outage to move the 500 kV lines from the temporary towers to the permanent towers.

The delays in obtaining an outage due to low system strength resulted in the backbone network remaining on temporary structures months longer than originally designed. The outage eventually went ahead in mid-February 2021.</td><td>Outages of the elements (or feed-in components) of major interconnectors between NEM regions, or major intra-connectors within a region.</td><td>Yes</td></tr>
<tr><td>Outages of network elements considered to be High Impact Outages.</td><td>Yes</td></tr>
<tr><td>Outages of the elements connecting major generation centres or system strength source centres to the remainder of a region.</td><td>NA</td></tr>
<tr><td>Outages that remove key reactive plant from service.</td><td>NA</td></tr>
<tr><td>A threshold for which the duration of an outage is considered impactful.</td><td>NA</td></tr>
<tr><td rowspan="3">Hazelwood 500 – Loy Yang 500 Maintenance

AusNet routinely encounters challenges in taking maintenance outages for any one of the three 500 kV circuits between the Hazelwood 500 kV terminal station and the Loy Yang 500 kV power station.

The Loy Yang A & B generators that connect to the Loy Yang 500 kV power station are critical sources of system strength for the remainder of the state, and feature prominently in <u>every</u> minimum combination of generators required for sufficient system strength in Victoria.

The only connection that these generators have to the remainder of the state and NEM are through the three circuits between Loy Yang 500 kV power station and Hazelwood 500 kV terminal station.</td><td>Outages of the elements (or feed-in components) of major interconnectors between NEM regions, or major intra-connectors within a region.</td><td>Potentially, depending on interpretation of intra-connector.</td></tr>
<tr><td>Outages of network elements considered to be High Impact Outages.</td><td>Yes</td></tr>
<tr><td>Outages of the elements connecting major generation centres or system strength source centres to the remainder of a region.</td><td>Yes</td></tr>
</table>

	Outages that remove key reactive plant from service.	NA
	A threshold for which the duration of an outage is considered impactful.	NA

3. Guidance on the calculation of SSLF

AusNet shares concerns expressed in AEMO's working group that the methodology for determining the system strength locational factor included in the Australian Energy Market Commission's (AEMC's) final determination is flawed and requires fundamental changes. If left unresolved, purchasing centralised system strength at the closest system strength node will nearly always be financially unviable.

Are there any other issues relevant to the calculation of SSLF that AEMO ought to take into account? (Q40)

The AEMC's *Efficient management of system strength on the power system* final determination included a methodology for determining the SSLF.[2]

The AEMO System Strength Working Group recently discussed a concern that this methodology for determining the SSLF does not appropriately consider the non-linearities of the physical network and the net result is that the SSLF often results in a 'manifestly excessive' value even for connections close to a system strength node.

AusNet has considered this issue further and shares this concern. Without fundamental changes to how the SSLF is calculated, purchasing a centralised system strength service provided at the closest system strength node will nearly always be financially unviable. AusNet notes that this issue is exacerbated in the sub-transmission and distribution system which generally has a much higher impedance than the transmission network.

AusNet is concerned that the methodology for determining the SSLF will disincentivise new connections within the sub-transmission and distribution networks. These connections are typically smaller in size to that of transmission connections and may become unviable if forced to consider expensive individual remediation schemes. Pushing these connections towards individual remediation schemes may also introduce coordination and inter-plant stability challenges. These technical risks were a key issue the original rule change was aiming to rectify.

AusNet will continue to work with AEMO through the System Strength Working Group to seek to address this matter.

[2] The SSLF changes the magnitude of the system strength charge that a connection would face depending on its electrical distance (impedance) from the closest system strength node. Page 160 of the AEMC's final determination notes the SSLF would be calculated as the ratio of additional fault level that would need to be added at the nearest system strength node to restore the available fault level at the connection point to the pre-connection level, and the system strength quality requirement of the connecting party plant.

4. Locating system strength nodes

AusNet supports AEMO's proposed criteria and principles for selecting the location of system strength nodes, and suggests two additional system strength nodes are required in Victoria.

The location of the system strength nodes will underpin the ability of SSS Providers to proactively maintain an efficient amount of system strength across each NEM region. Placing these nodes in locations where there is a strong pipeline of inverter-based resource (IBR) connections will deliver much greater value for money from system strength services than if located in areas where there is limited IBR interest.

Do you consider that the proposed selection criteria will allow for an appropriate set of system strength nodes to be selected? If not, please provide specific alternatives or additions. (Q25)

AusNet is confident that the AEMO's proposed criteria and principles for selecting the location of system strength nodes will promote prescribed system strength services in locations where efficient to do so.

Location of system strength nodes in Victoria

As the principal declared transmission system operator (DTSO) in Victoria, AusNet suggests a minimum of seven system strength nodes are required in Victoria, as illustrated in Figure 1. This includes the five existing fault level nodes plus one additional node in Bulgana and another in Heywood.

The additional nodes reflect the need for more system strength closer to connecting IBR as the power system transitions and that having sufficient nodes allows appropriate locational factors to be calculated.

The location of the two proposed system strength nodes has been chosen based on:

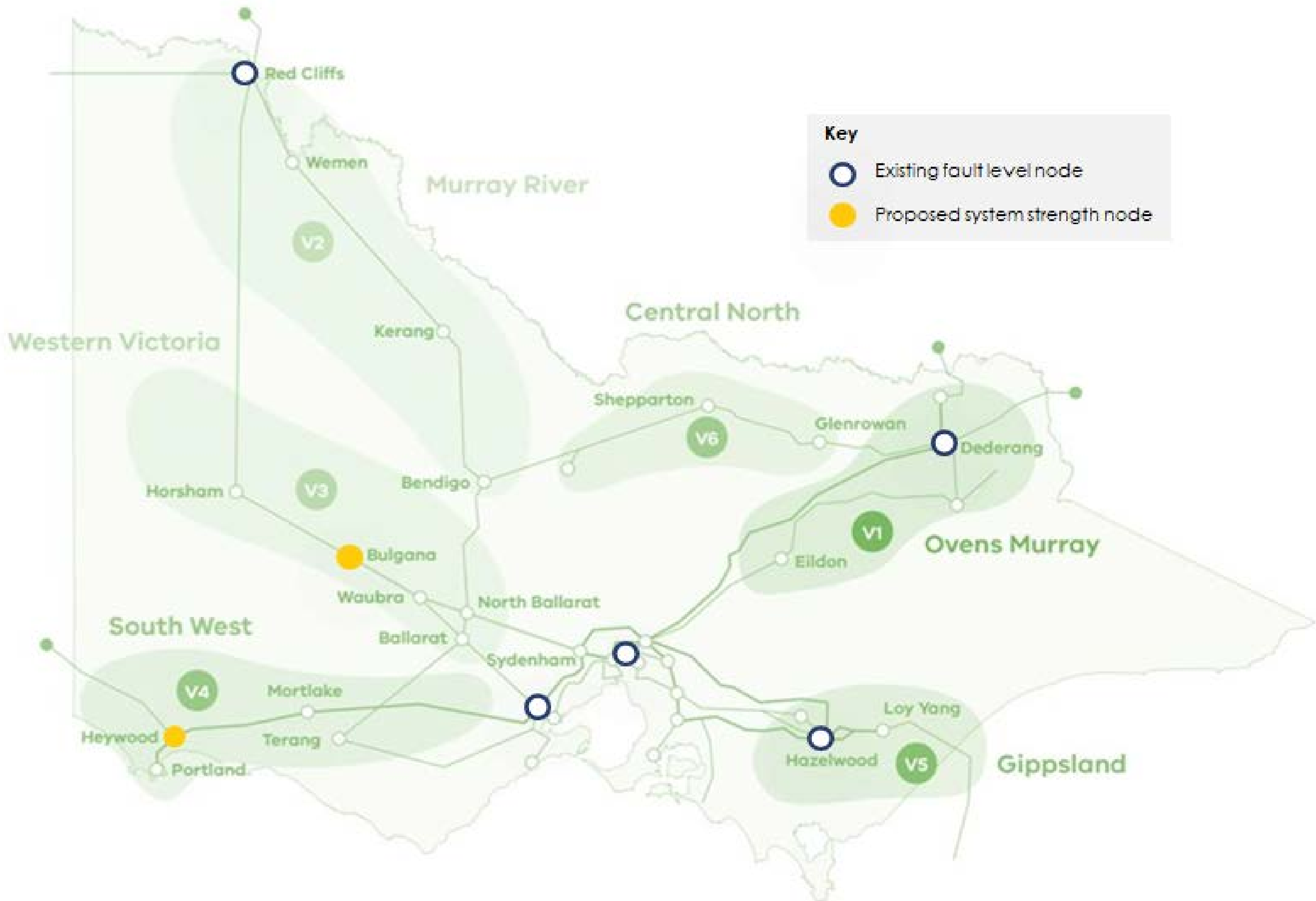
- a strong interest in new IBR connections in these regions[3]
- the need to maintain system strength for critical planned outages on critical network corridors
- their broad alignment with ISP REZ developments
- the remoteness of existing system strength nodes coupled with the localised nature of system strength provision.

The proposed Bulgana system strength node is located with the Western Victorian REZ, where the Western Victorian Transmission Network Project will unlock up to 900 MW of new generation. This aligns with the proposed criteria to establish a new node for network augmentation that AEMO considers anticipated or committed.

The proposed Heywood system strength node is located within the South West REZ, where there is a large amount of proposed asynchronous generation and also one side of the Victoria and South Australia interconnector. This aligns with the proposed criteria for selecting nodes for voltage waveform stability and allows for critical planned outages along the increasingly congested south-west 500kV corridor. This also would support the IBR-rich south-east South Australian network, which is effectively part of the Victorian network from an electrical perspective.

[3] This can be highlighted by the AEMO's February 2022 NEM Generation Map for Victoria, which can be found here https://aemo.com.au/-/media/files/electricity/nem/network_connections/generation-maps/vic-map.pdf

Figure 1: AusNet's proposed location of Victorian system strength nodes



Source: AusNet, location of existing fault level nodes from the AEMO's 2020 System Strength and Inertia Report

5. New system strength impact definition

AusNet encourages the AEMO to clarify the implications for connecting generators whose connection would cause an adverse system strength impact at their connection point but not the relevant system strength node.

Are there any other issues relevant to the general system strength impact that AEMO ought to take into account? (Q30)

The Issues Paper references the AEMC's amending rule which states the general system strength impact assessment should assess a generating systems' adverse system strength impact and reduction in available fault level at its connection point.

AusNet seeks clarification from the AEMO about the treatment of connecting generators whose connection would cause a general system strength impact by reduction in available fault level at their connection point but limited to no impact or impact within a defined material threshold at the relevant system strength node. In our view, it would be unreasonable for a connecting generator to pay for a system strength charge in this scenario.

6. Proposed methodology for Stability Assessment

AusNet recommends the System Strength Impact Assessment Guidelines (SSIAG) provide greater flexibility for Connecting NSPs to account for the individual nuances within each connection's Stability Assessment rather than attempt to form a generic scope of studies.

Is the proposed scope of a Stability Assessment appropriate? (Q36)

In general, AusNet supports the proposed scope of a Stability Assessment that ensure stable voltage waveform at key system strength nodes both in a satisfactory operating state and following any credible contingency events or any protected event described in NER clause S5.1.2.1. This is consistent with the definition of stability stated in NER clause S5.1.8 ensuring:

(a) the power system will remain in synchronism.
(b) damping of power system oscillations will be adequate; and
(c) voltage stability criteria will be satisfied.

The focus on the detailed compliance assessment for plant performance should be addressed in the Full Impact Assessment (FIA).

AusNet notes that there is a need for some flexibility of scope to ensure the practicality of each assessment. This is discussed in our response to Q37 below.

Are there any studies, contingencies, and evaluations that should, or should not, be part of a Stability Assessment? Why? (Q37)

The issue of what should or should not be considered as part of a Stability Assessment is nuanced. There are many customised aspects for each connection that need to be considered and attempting to form a generic scope of studies for all new connections within the SSIAG may not be practical or efficient.

AusNet recommends that providing flexibility in the SSIAG to alter the scope of studies contingencies and evaluations in agreeance between the Connecting NSP and AEMO will maintain a level of necessary practicality.

To demonstrate this point, AusNet examples are provided in the Appendix.

What study assumptions could be recommended to ensure there is no "free rider" situation for (system strength services) non-paying Applicants? (Q38)

This could be managed through defining the base case with the system strength service-providing devices switched out, or reserving certain system strength in defining the FIA base case for those generators that opt to be non-paying Applicants.

Are there any other issues relevant to the Stability Assessment methodology that AEMO ought to take into account? (Q39)

AusNet offers the following items for consideration from both a transmission and distribution perspective.

- Should N-1 for the system strength devices be considered?
- Should the generators be tuned for the current minimum Short Circuit Ratio (SCR) at the point of connection (PoC) without considering the system strength service device? Or should generators be tuned to achieve best satisfactory voltage waveform considering the proposed system strength nodes?
- What if there are multiple system strength nodes in one case? How can one define the tuning objective?

Remediation options

Although there may be no ambiguity if a Stability Assessment has passed, it is less clear if the Stability Assessment fails. In particular, how to attribute the cause, given that the performance of plant may be highly operating-point dependent.

If a stability issue has been found at the Stability Assessment stage:

- What are the remediation tuning objectives? Should the control system be tuned to achieve satisfactory voltage waveform at key system strength nodes by sacrificing the performance of the participated generators? Or should the control system be tuned for the best performance at their own PoC considering the projected minimum SCRs? Should the control system be tuned for available or proposed system strength service?
- Consider a connection in the sub-transmission or distribution system. If the remediation scheme is to add or alter reactive compensation devices or synchronous condensers, should the stability analysis always be done by the TNSP/SSSP rather than the DNSP to achieve the most economical results? (Noting that this may disincentivise generator connections in sub-transmission or distribution systems due to the extra interface layer, which takes more time, effort, and cost).

A. Appendix on Stability Assessment

Base case selection

The base case selection should be tied to how the system is intended to operate, since it has significant impact on how the connection dynamically interacts with its surrounding network. Key factors influencing the stability assessment results includes, but are not limited to:

- Synchronous unit scarcity
- Network sparsity
- Nearby IBR density
- Active and passive reactive power compensation devices.
- Operational limits

Such attributes of the base case must be considered and agreed between the Connecting NSP and AEMO before proceeding with each connection's Stability Assessment.

Range of interaction selection & network reduction

It must be clear what type of interactions are of interest for the Stability Assessment and what are the potential participating elements. The stability types to be studied will also directly impact the type of network reduction that is required. For example, depending on the connection location, the following aspects may need to be considered:

- SSO – Sub synchronous Oscillation problems
- SSR – Sub synchronous Resonance: passive elements (e.g., series compensated lines)
- SSTI – Sub synchronous Torsional Interaction: active elements (e.g., power system controls, HVDC, SVC, STACOM, high-speed governor, PSS)
- SSCI – Sub synchronous Control Interaction: interaction between power electronic control systems, e.g., of HVDC or DFIG WTG, and series compensated lines. Purely electrical phenomenon (not related to mechanical shaft system)

Any network reduction (physical, topological, or modal) must be appropriate for the study type and capture elements most likely to participate in the stability interaction.

Legacy plant modelling

Depending on the connection and the information available, each Stability Assessment needs to consider the most appropriate way to treat legacy plant models, depending on the potential for affecting the new connection. For example:

- Should generic models be used? How credible would the results be? How would they be tuned?
- Could an alternative approach be considered, such as increasing the source impedance of the equivalent NEM model? By how much? What X/R ratio?
- Should any legacy plant with limited information simply be ignored?

Impact of generator dispatch on sub-transmission or lower

For transmission connections, the use of existing generator dispatch patterns and transfer limit advice is appropriate when selecting a base case operational envelope. However, for sub-transmission and distribution connections, it may be impractical or financially unviable to consider a range of dispatch patterns of transmission-connected generation when performing a Stability Assessment, as this may necessitate the assessment to be performed in a NEM-wide EMT model.

Often, sub-transmission modelling starts from a controlled voltage source behind a source impedance without any dynamic models associated with it. Inertia and frequency aspects of the upstream system therefore will not be captured, and studies typically focus on local control interactions and impacts to the nearest system strength node.

In the new paradigm this rule change has created, it may be simplest that the source impedance of the reduced network should be mutually agreed with the SSSP, but in any case, this approach would need to be evaluated on a case-by-case basis and agreed between the Connecting NSP, the SSSP, and AEMO.

Concurrent applications

Due to the nature of the connection process, not all the active generation projects may be considered simultaneously. There may be a need to consider a Stability Assessment for the new generator on its own, and then rerun the assessment with all the potential generators wanting to connect. Whatever the approach may be, it must be agreed upon between parties and be practical for the specific conditions affecting the connection.

Contingency consideration

In some areas of the network, some contingencies are more likely to occur than others, with protection clearance times and auto-reclose times varying considerably. When performing a Stability Assessment, it is important to use contingencies that are practical for the location in the network, not simply chosen from a pre-defined list. Local network planners should be consulted when considering these contingencies.

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