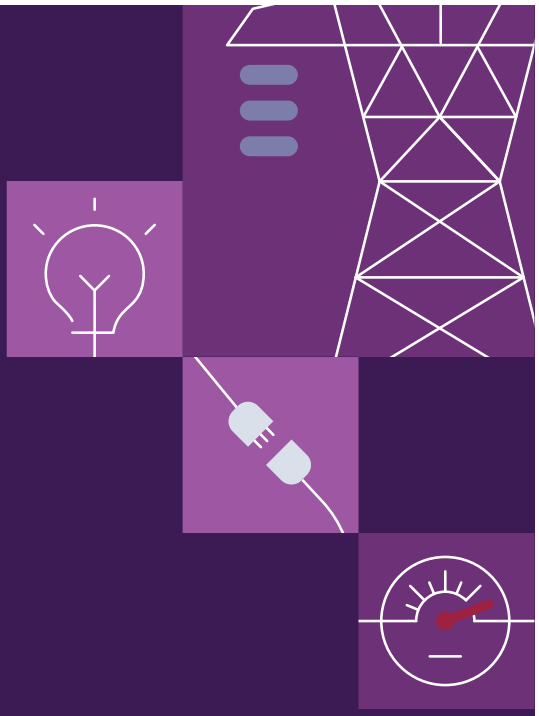
AEMO
AUSTRALIAN ENERGY MARKET OPERATOR



Amendments to the System Strength Impact Assessment Guidelines

Final Report and Determination

Published: March 2023

aemo.com.au

New South Wales | Queensland | South Australia | Victoria | Australian Capital Territory | Tasmania | Western Australia

Australian Energy Market Operator Ltd ABN 94 072 010 327

Contents

Executive summary

The publication of this final report concludes the Rules consultation process conducted by AEMO to amend the System Strength Impact Assessment Guidelines (SSIAG) under the National Electricity Rules (NER).

AEMO commenced this consultation with the publication of an issues paper on 26 April 2022 as a result of the National Electricity Amendment (Efficient management of system strength on the power system) Rule 2021 No.11 (Amending Rule). The issues paper addressed proposed changes to the System Strength Requirements Methodology (SSRM), Power System Stability Guidelines (PSSG) and SSIAG.

Due to the number and complexity of issues, AEMO subsequently decided to progress consultation on the SSIAG amendments separately from the SSRM and PSSG. The draft determination and draft SSIAG were published on 12 January 2023.

At a high level, the Amending Rule requires the SSIAG to address the following:

- A methodology for undertaking system strength impact assessments.
- A methodology for undertaking the calculation of a system strength locational factor (SSLF), including guidance on the circumstances in which it might not be reasonably able to be determined or be manifestly excessive.
- A threshold below which a system strength impact may be disregarded for the purposes of NER 5.3.4B(f)(3) (Materiality Threshold).
- A definition and guidance on the calculation of available fault levels (AFLs) for the purposes of calculating the reduction in AFL at a connection point and for the purposes of forecasting AFLs at system strength nodes (SSNs).
- A methodology for assessing the short circuit ratio (SCR) for the purposes of new SCR access standards.
- Guidance on information to demonstrate compliance with the new SCR performance standards.
- The criteria for classification of a load as an inverter-based load (IBL).
- The criteria for classification of an inverter-based resource (IBR) as a large inverter-based resource (LIBR).
- How AEMO assesses adverse system strength impacts.
- Guidance on the methodology to be used when undertaking modelling to verify the stability of plant.

AEMO's approach to the SSIAG issues has evolved as a result of the submissions on the draft SSIAG and further discussions with Australian Energy Market Commission (AEMC) and the Australian Energy Regulator (AER). This final report outlines the changes AEMO has made to the draft SSIAG in response to feedback, including the following material changes:

- Fix the value of the stability co-efficient to calculate the reduction in available fault level (AFL) at a constant value of 1.2, acknowledging that determining power system limits is a complex exercise, beyond the scope of a preliminary assessment which is intended to be a screening mechanism only.
- Introduce a Materiality Threshold applicable only to connections for which the network service provider determines the system strength locational factor cannot reasonably be determined or is manifestly excessive.

- Recognise the contribution of grid-forming inverters by removing the statement that SCR withstand capability cannot be zero, and incorporate any positive system strength contribution from grid-forming inverters into the definition of synchronous three phase fault level.
- Identify the types of plant alterations that are subject to assessment under the SSIAG and include additional information on the process steps to be followed.
- Clarify that the model used by Network Service Providers (NSPs) for purposes of full impact assessments and stability assessments may include nearby proposed connections that have not met the SSIAG criteria to be 'Committed', but that the NSP considers it would be practicable and appropriate to include.
- Confirm AEMO's current recommendation that the applicable system strength node (SSN) should be the nearest SSN located within the same region as the connection under assessment.
- Remove the requirement for PSS®E models to be benchmarked with PSCAD models specifically for the purposes of testing the SCR withstand capability.
- Amendment of the definition of 'Committed' in the SSIAG glossary to refer to the execution of a *connection agreement* in place of an offer to connect.

Other issues raised in submissions included:

- Generators that have elected to pay a system strength charge should not be further exposed to costs of system strength remediation if the connection is demonstrated to be unstable.
- Whether planned outages of system strength services should be considered when determining the required level of those services.
- Lack of visibility across the development of system strength charges (including indicative and final values) will impact investment decisions.
- Even though only a handful of system strength gaps have been identified out to December 2025, very significant charges applicable to IBR in the near term - point to a disconnect in how system strength is valued and how and when charges are set.

AEMO has not made any further changes in response to these submissions, either because it decided it was not necessary or appropriate to do so, or because it is beyond the remit of the SSIAG to address those matters.

The final SSIAG, incorporating the changes summarised above and a number of additional minor drafting amendments and clarifications, is published alongside this document and will come into effect on 15 March 2023. AEMO is grateful for the contribution of all stakeholders who have participated in this consultation process.

1. Stakeholder consultation process

As required by NER 4.6.6, AEMO has consulted on amendments to the System Strength Impact Assessment Guidelines (SSIAG) in accordance with the Rules consultation procedures in rule 8.9 (as set out in version 184 of the NER)[1].

The first stage of this consultation covered amendments to the SSIAG, the System Strength Requirements Methodology and the Power System Stability Guidelines required by the Amending Rule. The latter two documents are now the subject of a separate consultation[2].

Due to the number and complexity of issues to be addressed and resolved in relation to the SSIAG, this consultation was separated from the other two documents and the timeframes extended. The draft report was published on 12 January 2023 and this final report and amended SSIAG are published on 15 March 2023. The final timeline for consultation on the SSIAG amendments is outlined below.

Deliverable	Date
Notice of first stage consultation and issues paper published	26 April 2022
First stage submissions closed	1 June 2022
Draft report and notice of second stage consultation published along with draft SSIAG	12 January 2023
Submissions due on draft report	10 February 2023
Final report published along with final SSIAG	15 March 2023

AEMO received 20 written submissions that addressed the SSIAG in the first stage of consultation (addressed in the draft report), and eight written submissions in the second stage. The second stage submissions, from Amp Power Australia (Amp Power), APD Engineering, EnergyAustralia, Energy Queensland[3], Goldwind, Powerlink, TasNetworks and Transgrid are addressed in this report.

In addition, AEMO presented the issues paper at a webinar it hosted on 17 May 2022, and held meetings with some stakeholders to discuss specific aspects of their submissions, as noted in the draft report and this final report.

Copies of all written submissions (excluding any confidential information) have been published on AEMO's website at https://aemo.com.au/consultations/current-and-closed-consultations/ssrmiag.

The publication of this final report marks the conclusion of the consultation on the amendments to the SSIAG.

Note that there is a glossary of terms used in this final report at Appendix A.

[1] This consultation commenced before the effective date of the National Electricity Amendment (Improving consultation procedures in the rules) Rule 2022 No.6 and will continue under the previous version of rule 8.9.
[2] See https://aemo.com.au/consultations/current-and-closed-consultations/ssrmiag.
[3] Energy Queensland incorporates Ergon Energy Network and Energex.

2. Background

2.1. NER requirements

AEMO is required to make and publish the SSIAG under NER 4.6.6. The key function of the SSIAG under the NER is to prescribe how Network Service Providers (Connecting NSPs) who have received an enquiry, application or submission for plant connection or alteration referred to in NER 5.4.3B(a) (4.6.6 Connections) will assess their impact on system strength.

2.2. Context for this consultation

On 21 October 2021, the AEMC published the National Electricity Amendment (Efficient management of system strength on the power system) Rule 2021 No.11 (Amending Rule), amending the system strength framework in the NER.

Among other things, the Amending Rule expands the circumstances in which Connecting NSPs must assess the impact of certain connections on system strength and the scope of what they must assess. As a result, the SSIAG requires amendment to address new or adjusted requirements in the Amending Rule.

At a high level, the SSIAG must address the following:

- A methodology for undertaking system strength impact assessments.
- A methodology for undertaking the calculation of a system strength locational factor (SSLF), including guidance on the circumstances in which it might not be reasonably able to be determined or be manifestly excessive. The SSLF is used, together with a calculated system strength quantity (SSQ) in determining the system strength charge (SSC) that the person applying for connection or seeking to alter its plant (Applicant) may elect to pay for its connection.
- A threshold below which a system strength impact may be disregarded for the purposes of NER 5.3.4B(f)(3) (Materiality Threshold).
- A definition and guidance on the calculation of available fault levels (AFLs) for the purposes of calculating the reduction in AFL at a connection point and for the purposes of forecasting AFLs at system strength nodes (SSNs).
- A methodology for assessing the short circuit ratio (SCR) for the purposes of new SCR access standards.
- Guidance on information to demonstrate compliance with the new SCR performance standards.
- The criteria for classification of a load as an inverter-based load (IBL).
- The criteria for classification of an inverter-based resource (IBR) as a large inverter-based resource (LIBR).
- How AEMO assesses adverse system strength impacts.
- Guidance on the methodology to be used when undertaking modelling to verify the stability of plant.

NER 11.143.2(c) specified that AEMO should amend and publish the SSIAG by 1 December 2022 to take into account the Amending Rule. AEMO was unable to complete the necessary consultation and determine appropriate changes to the SSIAG by that date, due to a number of complexities outlined in more detail in the draft report.

The applicable assessment requirements under the revised SSIAG will apply to 4.6.6 Connections with an application date on or after 15 March 2023, or in-progress applications as at that date where the proponent elects.

3. Summary of material issues

The key material issues arising from the proposal and raised in written submissions on the draft report are summarised in the following table.

No.	Issue	Raised by
1	Departures from Amending Rule	TasNetworks
2	Stability co-efficient	Amp Power, APD Engineering, Energy Queensland[4], Goldwind, Powerlink, Transgrid,
3	Materiality Threshold	Energy Queensland, Powerlink, Transgrid
4	Treatment of grid-forming inverters	Amp Power, APD Engineering, Goldwind, Powerlink, Transgrid
5	Reassessment during connection process	Energy Queensland, Transgrid
6	Preliminary Assessment	Energy Queensland, Powerlink, Transgrid
7	Full Assessment	Amp Power Australia, Energy Queensland, Powerlink Transgrid
8	System Strength Remediation	Energy Queensland, Transgrid
9	System Strength Locational Factor	Amp Power, Transgrid, Powerlink
10	Withstand SCR	Amp Power, Goldwind, Powerlink
11	Stability Assessment	Goldwind, Transgrid
12	Plant alterations	Amp Power, Goldwind, Transgrid
13	Identification of committed projects	Energy Queensland

Section 4 discusses these material issues and presents AEMO's consideration of each of them. A detailed summary of the issues raised in response to the draft report, together with AEMO's responses, is contained in Appendix B.

[4] Energy Queensland incorporates Ergon Energy Network and Energex.

4. Discussion of material issues

4.1. Departures from Amending Rule

4.1.1. Issue summary and submissions

TasNetworks commented that:

> AEMO have departed from the formulation of system strength quantity (SSQ) as adopted by the Australian Energy Market Commission (AEMC) in the Final Rule. There is also variation between the AEMC's final determination and AEMO's draft Guidelines with respect to SSLFs and available fault level (AFL). Although, these amendments are necessary to practically implement the new system strength framework, TasNetworks is concerned about the discrepancy between the draft Guidelines and the Final Rule. TasNetworks seeks clarification that SSSPs are permitted to apply the definitions adopted in the draft Guidelines and are not bound by the Final Rule.

4.1.2. AEMO's assessment

AEMO has sought to clarify potential ambiguities in the application of the Amending Rule by applying the interpretation that best fits AEMO's understanding of its intended objectives. In relation to the items TasNetworks identified:

- The SSIAG do not depart from the SSQ formulation, as the product of the SCR recorded in the performance standards and the rated active power of a 4.6.6 Connection. Rather, the SSIAG confirm that the SCR must necessarily be interpreted as the Withstand SCR (defined in section 7.2 of the SSIAG), being the value to be recorded for the purpose of the 4.6.6 Connection under NER S5.2.5.15.
- The Amending Rule requires an SSLF to be representative of the impedance between a 4.6.6 Connection and the relevant SSN, using AFL as the basis for the calculation methodology. As noted in the draft report, AEMO considers that its proposed SSLF calculation methodology addresses all of the required elements in the Amending Rule.
- AEMO considers that the definition of AFL in the SSIAG is consistent with the discretion given to AEMO to define the term, including the specification of separate calculation methodologies for AFL reduction at connection points, and of AFL at SSNs for forecasting purposes.

4.1.3. AEMO's conclusion

AEMO considers that the NER interpretation applied by the SSIAG in relation to SSQ, SSLF and AFL is permissible within the terms and intent of the Amending Rule but cannot provide any assurance with regard to compliance by SSSPs. The AER, not AEMO, is responsible for enforcement of rules compliance.

4.2. Stability co-efficient

4.2.1. Issue summary and submissions

The introduction of the stability co-efficient (α) in the draft SSIAG attracted several questions from stakeholders as captured below. While there was support for the use of a stability co-efficient (in particular from Energy Queensland and Goldwind), all submissions that commented on this issue requested further clarification on how the minimum value of 1.2 was determined, and the criteria and conditions to be considered by NSPs for deriving a higher value on a case-by-case basis.

Amp Power Australia

The draft SSIAG does not provide sufficient details to explain why the minimum value of the stability coefficient in the calculation of AFL reduction is 1.2 (Section 3.4.2).

APD Engineering

Draft SSIAG introduces a new factor stability co-efficient (α) in the computation of available fault level (ΔAFL). The impact of the stability co-efficient (α) is found to reduce ΔAFL. For the purpose of assessment of system strength remediation from a new plant can this new ΔAFL computation methodology be used? Due to the introduction of the stability co-efficient (α) the size of the remediation measure will change significantly. Could AEMO provide more clarity on this?

The stability coefficient (α) is defined on page 15 as "Stability coefficient reflecting limitations in the network immediately beyond the 4.6.6 Connection, for which the lowest value must not be less than 1.2". Could AEMO please clarify under what conditions a value more than 1.2 can be assumed?

Energy Queensland

Ergon Energy Network and Energex support the calculation methodology for the reduction in available fault level (AFL) proposed in Section 3.4.2 of the draft System Strength Impact Assessment Guidelines (SSIAG). However, we would like to see more detail regarding how the Stability Coefficient should be determined.

Goldwind

While we understand and support the premise behind introducing a stability coefficient, there was no clarification from AEMO on how the lower bound value of 1.2 was determined. In our view this lower bound of 1.2 has potentially significant ramifications for future connections as it will directly influence the system strength charges a generator would have to pay, but there was no supporting documentation provided to help participants understand the reasons behind the proposed lower bound. The CIGRE technical brochure 671 which AEMO referenced does not make a reference to such a coefficient. Practically speaking, for an asynchronous generator (grid forming or otherwise) to be considered to have no general system strength impact or a positive impact, the "Withstand SCR" needs to be lower than the proposed "Stability Coefficient" value of 1.2.

We encourage AEMO to consider potential network limitations at especially at very low fault level conditions. There may be some cases where physical network limitations (e.g. a PV or QV analysis could provide indicative network limitations) would prevent operation rather than a particular generator causing adverse system strength impact.

We would further suggest that, if practical, AEMO could define a methodology for calculating the "Stability Coefficient" based on the connection point characteristics (e.g. using PSSE OPDMS studies either in a steady state of dynamic context). One suggestion we would like to put forward, noting we have not had the time to explore this option due to time constraints, is to use a "reference synchronous generator" and calculate the "Withstand SCR" using the methodology already proposed in the SSIAG to determine a "neutral" value of the "Stability Coefficient".

We note that AEMO have indicated that the applicant can propose a value of α that is higher than 1.2 in the notice of consultation document. However, no such references have been made in the draft SSIAG document. We believe it would be beneficial for AEMO to include this in the SSIAG document along with some additional commentary/guidance on considerations that can be made when deciding if a proposed stability coefficient is reasonable. We note that the hypothetical examples included in Appendix C.3 of the notice of consultation document is a good starting point for this, however this was not included in the draft SSIAG document.

Powerlink

Calculation of the delta AFL in section 3.4.2 proposes to use a stability co-efficient (α). As per the proposed calculation method, α can have a significant impact on delta AFL, which then would directly affect the size of system strength remediation for those proponents who opt to not pay the prescribed system strength charges. The draft SSIAG also suggest that the value of alpha can be changed according to the power system conditions as per section 5.1.2(f). It is not clear in the draft SSIAG how a thermal or stability limit could be used to estimate the value of alpha. A worked example of the calculation of a alpha based on transient stability, voltage stability and thermal limits would be very helpful.

Transgrid

> In regard to the stability coefficient α defined in Section 3.4.2, it is stated that the stability coefficient should reflect the limitations in the network immediately beyond the 4.6.6 Connection and the lowest value must not be less than 1.2.
>
> (1) Can AEMO clarify the purpose of the stability coefficient?
>
> (2) Can AEMO please include further information on how this lowest value was derived? The definition suggests that the stability coefficient is location dependent. Can AEMO please provide clarity on how the stability coefficient α may be derived for each connection point?

4.2.2. AEMO's assessment

AEMO agrees with Goldwind's observation that the minimum stability coefficient of 1.2 had not been referenced in CIGRE 671 or other international publication (such as NERC's Reliability Guideline)[5], and has been developed by AEMO.

The two key underlying reasons for selecting a value of 1.2 are:

- A survey of existing NEM connections indicates that the lowest known SCR withstand capability for grid-following inverters is around 1.2. On that basis, applying this value would be expected to result in a negative outcome for grid-following inverter applications, making them subject to either a system strength charge or system strength remediation (subject to a Materiality Threshold as discussed in section 4.3).
- Technical literature indicates that 1.2 is the minimum SCR for which voltage stability can be maintained in the power system; below which voltage instability would likely occur without any system strength or reactive power support[6,7].

Goldwind suggested AEMO consider potential network limitations especially at very low fault level conditions, noting there may be some cases where physical network limitations would prevent operation rather than a particular generator causing adverse system strength impact. AEMO agrees that network limitations will play a part, and the choice of a value of 1.2 for the stability coefficient is consistent with theoretical discussions on a reasonably accurate SCR value at which voltage collapse will occur. However, it is also noted that such a voltage collapse will occur due to excess MW transfer which would not be present if the generating system under consideration was not connected, or was generating at a lower MW level. In such circumstances, devices such as synchronous condensers or grid-forming inverters will provide the dual benefits of added system strength support and reactive power support in one device.

While AEMO concurs that a slightly higher stability coefficient may be calculated on a case-by-case basis depending on the network limitations and connection point characteristics, the precise calculation accounting for wider power system characteristics requires the development of new tools and techniques and cannot be directly obtained from PSS®E studies. Noting that the stability co-efficient was only intended to be an approximate value, AEMO believes that setting the stability co-efficient to a constant value of 1.2 would allow for ease of use and provide clarity and transparency to both 4.6.6 Connection Applicants and NSPs, without significant impact on the calculated ΔAFL.

[5] Integrating Inverter Based Resources into Low Short Circuit Strength Systems, NERC Reliability Guideline, December 2017.
[6] B. Badrzadeh, Z. Emin, S. Goyal, S. Grogan, A. Haddadi, A. Haley, A. Louis, T. Lund, J. Matevosyan, T. Morton, D. Premm, S. Sproul, ''System Strength'', CIGRE Science and Engineering Journal, Vol. 21, February 2021.
[7] T. Lund, H. Wu, H. Soltani, J. G. Nielsen, G. K. Andersen and X. Wang, "Operating Wind Power Plants Under Weak Grid Conditions Considering Voltage Stability Constraints," in IEEE Transactions on Power Electronics, vol. 37, no. 12, pp. 15482-15492, Dec. 2022

4.2.3. AEMO's conclusion

Based on its assessment above, AEMO has incorporated the following amendments into the final SSIAG:

- The stability co-efficient is set to a constant value of 1.2.
- Inclusion of a high-level explanation on why the stability co-efficient of 1.2 was selected.

4.3. Materiality Threshold

4.3.1. Issue summary and submissions

In the draft SSIAG, no Materiality Threshold was specified below which a general system strength impact may be disregarded. AEMO received submissions from three NSPs in relation to the Materiality Threshold, and subsequently met with each of them to better understand their concerns, particularly for distribution connections where the SSLF cannot be reasonably be calculated.

Energy Queensland

> We support no materiality threshold, on the understanding that if there is no adverse system strength impact identified, then the calculation of the AFL will be positive, as the Stability Coefficient will be greater than the Withstand Short Circuit Ratio (SCR). i.e. not a reduction in AFL and therefore no General System Strength impact.

Transgrid

> In the absence of a materiality threshold defined in the SSIAG, for all 4.6.6 Connections, regardless of the magnitude reduction of the available fault level (AFL) determined in the preliminary assessment, the Applicants will have to elect to pay the system strength charge (SSC) or propose a system strength remediation scheme (SSRS), and if necessary, request NSP to undertake SSCW. Transgrid supports the view that the materiality threshold for adverse system strength impact should remain unchanged, from its current definition in the SSIAG (i.e., no materiality threshold applied). However, with respect to reduction in AFL due to 4.6.6 Connections, the absence of a materiality threshold would require small scale 4.6.6 Connections electrically distant from System Strength Nodes (SSN) to bring in additional system strength remediation that may not be commercially feasible or required for the power system. Transgrid acknowledges that determining a suitable metric for the materiality threshold may require further review of technical and financial implications.

Powerlink

> If an SSSP considers that a SSLF cannot be reasonably calculated, we propose that the materiality threshold for a reduction in Available Fault Level due to a new connection should be based on there being an adverse system strength impact and the reduction in AFL should only be calculated if a new IBR connection is shown to have an adverse system strength impact as per the criteria in the draft SSIAG.

4.3.2. AEMO's assessment

AEMO agrees with the observation that the absence of a Materiality Threshold for 4.6.6 Connections which are electrically remote from the SSN would require those projects to bring additional system strength to remediate for the ΔAFL when this is neither needed by the power system nor commercially feasible. To avoid this unintended consequence, a Materiality Threshold could be applied to connections where the outcome of the Preliminary Assessment is that the SSLF cannot reasonably be calculated or would be manifestly excessive. In such cases, the threshold is met only if there is an adverse system strength impact. It is acknowledged that in many cases an adverse system strength impact will have to be confirmed through wide area PSCAD studies, and in those cases the system strength framework allows the Connecting NSP to undertake a Full Assessment at the application stage. Where the Full Assessment for these cases establishes there is no adverse system strength impact, no system strength remediation will be required.

AEMO has given further consideration more broadly to conditions in which a system strength impact of a 4.6.6 Connection, although measurable, could reasonably be disregarded on the basis that it does not materially reduce system strength at the connection point. As discussed in the draft report, any materiality assessment will be location-specific, such that the same materiality measure will have a larger or smaller impact depending on where it is applied. In addition, the adverse system strength impact component is a binary proposition. Notwithstanding those difficulties, AEMO recognises that, if possible, the SSIAG should seek to mitigate against outcomes that require an applicant to remediate or pay the SSC even if it only causes a very small reduction in AFL in a location where system strength is already high. AEMO is also cognisant that levels of confidence in models at the assessment stages will vary significantly, and therefore it may also be reasonable to allow for a degree of tolerance in outcomes in the application of any Materiality Threshold. On this basis, AEMO has sought to specify a Materiality Threshold that still allows the Connecting NSPs discretion in determining whether it should apply to any given 4.6.6 Connection, having regard to all relevant circumstances.

4.3.3. AEMO's conclusion

Based on its assessment above, AEMO has amended section 3.5 of the final SSIAG to reflect the following outcomes with regard to the Materiality Threshold:

- A general system strength impact may be disregarded if the outcome of the Preliminary Assessment is that the SSLF cannot be reasonably calculated or would be manifestly excessive, and there is no adverse system strength impact (of any magnitude).
- A general system strength impact may be disregarded if the percentage reduction in AFL caused by the 4.6.6 Connection would be less than 5%, provided there is no adverse system strength impact, and provided the Connecting NSP is satisfied that the impact of the 4.6.6 Connection is not otherwise material. This will allow the NSP to appropriately account for variable factors specific to the connection, with non-exhaustive examples provided in the SSIAG.

It should be noted that the absence of an adverse system strength impact may not be able to be established at the Preliminary Assessment stage. If not, a Full Assessment is necessary (unless an SSC election is made where applicable) and the same Materiality Threshold applies for the Full Assessment.

4.4. Treatment of grid-forming inverters

4.4.1. Issue summary and submissions

AEMO received a number of submissions relating to the treatment of grid-forming inverters under the new system strength framework, both in relation to calculation of AFL for the purpose of forecasts at the SSN and the value of 'Withstand SCR'. The issues raised are described separately below.

AFL forecasts

Goldwind

> We note that AEMO has not provided any guidance on how NSPs should consider whether a generating system can be deemed to provide system strength. Specifically, this is likely to impact how grid forming technology is built into the AFL forecast at each SSN. If the proposed approach would be based on the ΔAFL, likely this would exclude grid forming installations in the NEM. This has the potential negative outcome that the NSPs will not be able to procure system strength solutions other than those which provide high levels of fault currents that counter act the AFL shortfalls (e.g. synchronous condenser). We do not believe continuous addition of synchronous condensers to be essential to maintain system stability. It would certainly not be an economical solution.

Transgrid

As per section 3.4.3(b)(i), for the purpose of forecasting the AFL at each SSN power system model for the region is to be set up with Synchronous Machines that will be providing system strength over a 10-year horizon, including anticipated system strength services (SSS) to be provided by the system strength service provider (SSSP), but excluding generating systems and IBLs where they are not expected to provide system strength. Can AEMO provide clarity on inclusion/exclusion of inverters with grid forming capabilities (i.e., Inverter based resource (IBR) connections with virtual synchronous machine mode functionality) and SSRS associated with existing/committed generating systems and inverter based loads (IBL) (such as synchronous condensers) for the purpose of Section 3.4.3(b)(i)?

Withstand SCR

APD Engineering

More information is required on the treatment of plants employing grid forming technology (like BESS) in ΔAFL assessments. Specifically on the determination of withstand SCR. Even though the case study in the Appendix does consider a grid forming plant, more clarification on the ΔAFL assessments is needed on these important technology based plants.

Powerlink

Section 5.1.2e(ii) suggests that installation of a grid-forming technology could be used by an applicant to address the reduction in Available Fault Level. A working example of addressing delta AFL with grid-forming technology would be useful. Also, to recognise that a grid-forming plant doesn't rely on system strength support from the network, it would be beneficial to describe tests in appendix B that a grid-forming plant can conduct to provide the withstand Short Circuit Ratio (SCR) up to zero.

Transgrid

Transgrid notes that AEMC in the final Rule determination on Efficient management of system strength has stated that general system strength assessment of inverters with grid forming (GFM) capabilities will be covered by the system strength impact assessment guidelines.

(1) Is the treatment of inverters with GFM capabilities similar to other IBRs, where withstand SCR assessment outlined in Section 7.4 is required to be undertaken through dynamic simulation studies to establish the associated withstand SCR? If so, in cases where the required vendor-specific modelling is not available, Transgrid's understanding is that a withstand SCR of 3 will be used for 4.6.6 Connections using inverters with GFM capability.

(2) Please provide more clarify on treatment of asynchronous generators using inverters with GFM capabilities for the purpose of general system strength assessment.

4.4.2. AEMO's assessment

AFL forecasts

Section 3.4.3 of the draft SSIAG outlines a methodology for calculation of AFL which requires the SSSP to calculate the synchronous three phase fault level. It is stated that generating systems and IBLs should be taken out of service where they are not expected to provide system strength. It is therefore envisaged that generating systems which do contribute to system strength (for example, grid-forming inverters) will be included in the calculated value for the synchronous three phase fault level. It is however acknowledged that determining the contribution of grid-forming inverters to the synchronous three phase fault level is not a straightforward exercise.

AEMO considers that a grid-forming inverter or any other generating systems with a positive ΔAFL should be considered by the relevant TNSP/SSSP in more detail based on wide-area PSCAD studies. Where these detailed studies confirm positive system strength contribution, grid-forming inverters can be accounted for in the calculation of total fault level available in the system in the same way that synchronous condensers and synchronous generators are treated. It is noted that grid-forming inverters may not be counted towards the total power system fault levels if detailed studies do not confirm a

positive contribution. An important differentiator between grid-forming inverters and synchronous machines is that synchronous machine response is predominantly inherent, and the impact of control system response will be minimal, whereas grid-forming inverter responses could be substantially different from one control system design to another depending on the priority control objectives.

AEMO is aware of many different types of grid-forming inverter design philosophy such as virtual synchronous machine/generator, droop, virtual oscillator control, and synchronous power controller. How they are labelled cannot form the basis for inclusion in/exclusion from the total system fault level, but rather how they behave. This can only be determined based on detailed wide-area PSCAD studies.

Finally, AEMO considers that defining a methodology by which to determine the positive contribution of grid-forming inverters on available fault levels in the wider power system is beyond the scope of the SSIAG. This will fall under the TNSP's planning responsibilities and SSSP obligations covered by AEMO's System Strength Requirements Methodology[8].

Withstand SCR

Under section 7.4 of the draft SSIAG, the Withstand SCR for both grid-following and grid-forming inverters should be assessed, as a minimum, through dynamic simulation studies (PSCAD) in a SMIB environment. AEMO agrees that grid-forming inverters, especially those with black start capability, may be able to withstand a SCR of 1.2 or below resulting in a ΔAFL that is zero or positive. The final SSIAG has now been amended to acknowledge that the SCR withstand capability of grid-forming inverters could be as low as zero. However, whether their SCR withstand capability is 1.2, 1.0 or 0, the net impact is the same from a SSIAG perspective. That is, in any of these scenarios the 4.6.6 Connection should not be required to pay the SSC or remediate for ΔAFL. It is again noted that even though there is no requirement for a Full Assessment under this scenario, the Connecting NSP may still need to perform wide area PSCAD studies as part of their due diligence on the connection application to ensure conformance with the proposed access standards and confirm no other adverse system stability impacts.

By the same token, if SMIB modelling for a 4.6.6 Connection comprising grid-forming inverters indicates a Withstand SCR above 1.2 or if suitable site-specific models are not available, the 4.6.6 Connection will undergo a Full Assessment or Stability Assessment (as applicable) and cannot be excluded based solely on plant type (whether grid-forming inverters, virtual synchronous machines/generators, or anything else). Note that in the absence of site-specific simulation models, a Withstand SCR of 3 will be applied regardless of the inverter type.

4.4.3. AEMO's conclusion

Based on its assessment above, AEMO has incorporated the following changes in the final SSIAG:

- Section 1.2.1 Glossary – change definition of Synchronous Three Phase Fault Level to 'the three phase fault level comprising Synchronous Machines and those grid-forming inverters whose positive system strength contribution has been demonstrated by wide-area PSCAD studies, in MVA'.
- Remove statements to the effect that Withstand SCR cannot be zero.

[8] https://aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-strength-requirements/system-strength-requirements-methodology.pdf?la=en

- Section 4.2.2(a), footnote 47 – confirm that where the Preliminary Assessment indicates no general system strength impact, wide area PSCAD studies may be required for purposes other than system strength assessment.

4.5. Reassessment during connection process

4.5.1. Issue summary and submissions

AEMO received two submissions from NSPs requesting that AEMO state within the SSIAG that if there are changes to vendor equipment including control system settings impacting Withstand SCR, a reassessment of the SSQ/SSC or Full Assessment would be required.

Energy Queensland

> Ergon Energy Network and Energex welcome guidance on the appropriate course of action for a Network Service Provider (NSP) where the Withstand SCR has been determined through dynamic model simulation studies, and this model is changed, affecting the Withstand SCR. In our view, a reassessment of the system strength charge, stability assessment, or full assessment would be required.

Powerlink

> It is important to acknowledge that the planned system strength solution by an SSSP may change as a result of the RIT-T process. Therefore, it could have some impact on the Generator Performance Standard (GPS) that was agreed for a plant that agreed to pay for the system strength charges and may require some changes. We believe that guidelines should emphasise that the relevant NSP and AEMO must accept changes in the GPS that are due to the change in system strength solution planned by SSSP.

Transgrid

> Transgrid notes AEMO's intent in provisionally assessing withstand SCR and the associated reduction in AFL using vendor specific models as part of the Preliminary Assessment, while providing an alternative pathway to Applicants if models are unavailable at the connection enquiry stage. In Transgrid experience, it is very likely for subsequent changes to equipment vendor selection or generating system design to occur at the Application stage, necessitating reassessment of System Strength Quantity (SSQ) and the associated change to the AFL. While the Full Assessment allows for this re-evaluation to be undertaken as part of the general system strength impact assessment, if an Applicant elects to pay the SSC, then re-assessment of SSQ and the applicable SSC will also be required at the Application stage. The requirement for re-assessment based on changes to the generating system design and vendor equipment in the Application stage should be clearly stated in the SSIAG.

4.5.2. AEMO's assessment

Under the Amending Rule, new clause 5.3.3(b5)(3) states that SSQ and SSC calculated by NSP as part of the preliminary assessment are indicative only. The actual SSQ (which goes into the SSC calculation) is determined by reference to the Withstand SCR and rated active power in the finalised performance standards. It follows, therefore, that SSQ and SSC can be reassessed at the connection application stage.

AEMO understands that Energy Queensland's concern relates to significant changes to the connecting plant or control systems at a later stage, after the acceptance of performance standards. Where that occurs, AEMO notes that NER 5.3.9 (or new NER 5.3.12 for loads and market network services) would apply in cases where the alterations are expected to change the system strength impact. AEMO acknowledges that the process for system strength assessments in relation to plant alterations could be clearer in the SSIAG, including the process for determining whether the alteration is to be considered a 4.6.6 Connection.

AEMO encourages NSPs to form their own views on the interpretation of the applicable rules.

4.5.3. AEMO's conclusion

Based on its assessment above, AEMO has included clarification in sections 2.3 and 2.5 of the SSIAG to confirm that, for the purposes of NER 5.3.9(a)(2), AEMO's opinion on general system strength impact must be sought before any submission is made under NER 5.3.9(b), and if that opinion is in the affirmative a Preliminary Assessment should be requested. Corresponding clarifications are made in respect of NER 5.3.12, accounting for the reduced scope of that clause and different role for AEMO.

4.6. Preliminary Assessment

4.6.1. Issue summary and submissions

AEMO received the following submissions in relation to the Preliminary Assessment approach:

Amp Power

> The Available Fault Level (AFL) calculation is used in the current SSIAG (2018) as a proxy to assess the risk of new connection causing adverse system strength impact in the Preliminary Impact Assessment (PIA) stage. This is an appropriate approach since the AFL is a concept to approximate the impact of asynchronous generators on system strength and then a Full Impact Assessment (FIA) will be conducted to appropriately evaluate the actual adverse impact (if any). In the new SSF and the draft SSIAG, the reduction of AFL at the connection point of a 4.6.6 Connection as a measure of general system strength impact is used. This means this approximate concept will be used to determine the general system strength impact and the system strength quantity (SSQ) of a new connection. Both of them will have a significant impact on a project's CAPEX and/or OPEX. We strongly believe that a more technically solid and practical definition/concept should be developed for the general system strength impact.

Energy Queensland

> Ergon Energy Network and Energex support AEMO proposing an amendment to the Amending Rule that is consistent with the information likely to be available at the connection enquiry stage. This would be similar to the proposed methodology for the Preliminary Assessment where no PSCAD model is available, and Withstand SCR is assumed to be 3.

Powerlink

> For clarity, it is suggested the draft SSIAG describe situations where preliminary assessment could indicate that there will be no general system strength impact and therefore full system strength impact assessment is not required.

Transgrid

> Section 4.1.2 states that the "purpose of preliminary assessment is to determine whether the 4.6.6 connection will cause a general system strength impact". During preliminary assessment, Transgrid's view is that only the reduction in AFL aspect of the general system strength impact can be considered, given that determination of adverse system strength impact will require detailed modelling to undertake wide area system assessments (for example, to assess impact on power system stability, adverse control system interactions). Can AEMO please provide more clarity on this in the SSIAG?

4.6.2. AEMO's assessment

In relation to Amp Power's observations on the use of reduction of AFL to determine the general system strength impact and the SSQ of a new connection, AEMO notes that the requirement to account for AFL reduction in the general system strength impact is set out in the Amending Rule and as such cannot be excluded from the Preliminary Assessment. It is noted that the SSQ derived from the Preliminary Assessment can only be indicative (as explicitly stated in the Amending Rule), as the final SSQ will depend on the Withstand SCR ultimately recorded in the performance standards for the 4.6.6 Connection.

Possible outcomes of the Preliminary Assessment include:

- Zero or positive ΔAFL. The 4.6.6 Connection will not have a general system strength impact, hence no need for system strength remediation or payment of SSC. As highlighted by Powerlink, there is also no need for a Full Assessment. However, an NSP might still need to carry out wide-area PSCAD studies for purposes other than a Full Assessment or Stability Assessment, and as such, the conduct of wide-area PSCAD studies for those other purposes should not be considered synonymous with a Full Assessment.
- Negative ΔAFL where the Applicant elects to pay the SSC. AEMO recognises that the calculation of charges will not be based on detailed wide-area PSCAD studies. The use of simplified methods to determine the charges is consistent with the level of detail considered for calculating other NEM power system charges as it will not be practical to spend weeks or months on this calculation for each Applicant. However, under this option a Stability Assessment is to be conducted by the Connecting NSP to ensure the stability of 4.6.6 Connection. This assessment has a similar level of detail and rigour to a Full Assessment and does not use simplified methods.
- Negative ΔAFL where the Applicant elects not to pay the SSC. In this case a Full Assessment based on wide-area PSCAD studies will be required to determine the size and technical characteristics of system strength connection works (SSCW) or system strength remediation schemes (SSRS), consistent with the level of detail accounted for in the 2018 SSIAG. The main change from the 2018 SSIAG stems from the new requirement to remedy a reduction in AFL, in addition to any adverse system strength impact, under the Amending Rule. The Withstand SCR of the generating system, determined by SMIB dynamic studies on the site-specific PSCAD model of the generating system, is the key determining factor to assess whether the original reduction in AFL has been remediated. However, we recognise that wide-area PSCAD studies will not and cannot be used for assessing this aspect. Lastly, as described in Section 4.3 above, in the final SSIAG AEMO has included a Materiality Threshold highlighting certain limited circumstances where remediation is not required for a reduction in AFL in the absence of any adverse system strength impact.
- Noting the strong contribution of the Withstand SCR in determining a reduction in the AFL, and recognising the very likely evolution of simulation models, which form the basis of Withstand SCR calculations, during the connection process, a reassessment of the impact on ΔAFL may be required after the preliminary stage.

AEMO agrees with Energy Queensland's comments that in the absence of reliable site-specific models of the generating system, a Withstand SCR of 3 is assumed for both grid-following and grid-forming inverters. AEMO also agrees with Transgrid that during the Preliminary Assessment only one aspect of the general system strength impact (reduction in AFL) can be assessed, and the adverse system strength impact can only be determined with wider power system models.

4.6.3. AEMO's conclusion

Based on its assessment above, AEMO has noted in the SSIAG that figure 3 does not include a process for 4.6.6 Connections where the Preliminary Assessment or Full Assessment indicates there is no general system strength impact. For clarity, at that point the process is at an end.

4.7. Full Assessment

4.7.1. Issue summary and submissions

AEMO received several submissions in relation to various aspects of the Full Assessment methodology.

General

Amp Power Australia

It is unclear in the draft SSIAG how the general system strength impact can be assessed using more detailed modelling (Section 4.2.2). The current FIA process is to address adverse system strength impact.

Energy Queensland

A Full Assessment should be performed whether or not there is a general system strength impact identified in the Preliminary Assessment.

Powerlink

As the responsibility to plan for system strength is on the SSSP, we suggest that under section 4.2.10 of the guidelines, an NSP that is not also the SSSP should consult with the relevant SSSP on the results of the Full Assessment. Similarly, an NSP should consult with the relevant SSSP on the results of stability assessment studies if a generator agrees to pay the prescribed system strength charges.

Transgrid

Section 4.2.1 states that "Full Assessment must commence upon receipt of an application to connect or a submission under NER 5.3.9(b) or 5.3.12(b)". Although elaboration on this criterion is provided in Section 4.2.6(a), further clarity is required on the commencement requirement. This also applies for the timing specified in Section 8.2 for the Stability Assessment. Conducting a Full Assessment or a Stability Assessment is a computationally intensive task that takes significant amount of engineering time and effort. For the purpose of the Full Assessment or Stability Assessment, Transgrid recommends introducing a reasonable commencement criterion to minimise unnecessary repetition of assessments due to iterative model/setting changes associated with performance standard negotiations. While Transgrid acknowledges that there are some interdependencies between the Full Assessment and the performance standards, in Transgrid's view, a reasonable amount of due diligence and negotiations on the performance standards should be completed prior to undertaking the Full Assessment (or Stability Assessment, as applicable).

Transgrid consider the following criteria to be appropriate for commencement of the Full Assessment or Stability Assessment:

(a) models are of suitable quality for the purpose of Full Assessment;

(b) due diligence on critical performance standards are completed; and

(c) performance standards are negotiated to a reasonable level as per the negotiation framework outlined in NER 5.3.4A (b1).

Transgrid

Under section 4.2.6(d), it is unclear what is meant by "likely contingency events". Does it refer to non-credible contingencies or protected events? Suggest providing further clarity.

Power System Model

Powerlink

Section 4.2.4(c) (i) suggests that NSPs must include System Strength Services that would otherwise apply to the network under consideration. New connections that do not opt to pay the prescribed system strength charges will be required to propose System Strength Remediation Scheme (SSRS). This SSRS should be capable of addressing adverse system strength impact, if there is any, and the delta AFL. It is not guaranteed that an SSRS that addresses the delta AFL, will always also address the adverse system strength impact. Powerlink suggests that this could unduly benefit the new connections that do not opt to pay the prescribed system strength charges and therefore full assessment should also include test cases without the System Strength Services that would otherwise apply to the network under consideration.

Transgrid

Section 4.2.4(c)(ii) states that the "model used by the NSP for the Full Assessment must include nearby 4.6.6 Connections, regardless of whether Applicants will be installing SSRSs or relying on the provision of SSS from an SSSP".

(1) What is meant by "nearby 4.6.6 Connections"? Does it refer to electrically close 4.6.6 Connections that are currently being assessed (regardless of their committed status)? At early stages of the Application to connect, some IBR plants may not have suitable models that can be used for the Full Assessment.

(2) Can AEMO provide clarity on inclusion/exclusion of SSRSs associated with existing/committed projects and nearby 4.6.6 Connections in the power system model used for the Full Assessment? Is it AEMO's intent that if a nearby 4.6.6 Connection has an associated SSRS, it to be included as part of the generating system for the purpose of the Full Assessment?

There's ambiguity between treatment of nearby 4.6.6 Connections that are not committed for the purpose of Batch Assessment in Section 4.2.7 vs. treatment of 4.6.6 Connections for the purpose of Full Assessment outlined in Section 4.2.4. Transgrid suggests updating Section 4.2.4(c)(ii) to "may" instead of "must", allowing NSPs flexibility to determine which nearby 4.6.6 Connections that are not committed to be included in the Full Assessment, as appropriate?

4.7.2. AEMO's assessment

General

On Amp Power's question, AEMO confirms that the Full Assessment will still apply as described in the draft SSIAG, and the more detailed modelling will be based on wide-area PSCAD studies - consistent with the current SSIAG - depending on the outcome of the Preliminary Assessment. The key change to the approach adopted since 2018 is that any proposed SSRS or SSCW must be sized to remediate for both the adverse impact and ΔAFL.

For Applicants electing to pay the SSC, Section 8 of the draft SSIAG provided for a Stability Assessment, which follows a similar level of rigour to the Full Assessment.

In response to Energy Queensland's suggestion, NER 5.3.4B(b) in the Amending Rule requires a Connecting NSP to undertake a Full Assessment unless the Preliminary Assessment indicates that there will be no general system strength impact. However, the need for wide-area PSCAD studies for a connection is not limited to a Full Assessment or Stability Assessment. As previously noted, a Connecting NSP will often need to perform wide-area PSCAD and PSS®E studies for a range of operational and planning purposes, including the determination of access standards.

AEMO agrees with Powerlink's suggestion that it would be sensible for SSSPs to establish suitable consultative arrangements with all other NSPs as part of their joint planning activities. However, AEMO does not consider this to be part of or related to the required content of the SSIAG and therefore no changes have been made in the final SSIAG.

AEMO acknowledges Transgrid's suggestion to introduce additional commencement criteria for Full Assessments and Stability Assessments to avoid unnecessary rework due to iterative model improvements or changes. AEMO notes that the NER include time limits on the assessment of connection applications, but it is within the discretion of NSPs to request more or better information from an Applicant before those timeframes commence, including models of the necessary quality to assess all aspects of the application. Further, AEMO is aware that the Connection Reform Initiative is currently progressing trials to test ideas for streamlining the connection process including timing of Full Assessments.

Lastly, on Transgrid's second question, AEMO confirms that likely contingencies include credible contingencies and protected events.

Power System Model

In response to Transgrid's first question, AEMO confirms that 'nearby connections' are those which the NSP deems to be electrically close to the 4.6.6 Connection. AEMO agrees that the use of 'nearby' would benefit from clarification in the SSIAG, both in relation to the network and connected plant, noting

that the extent of the network appropriate for consideration can vary considerably between 4.6.6 Connections depending on their nature and location. Further, regardless of whether the batched assessment provision (section 4.2.7) applies, a Full Assessment can account for pre-committed projects where the NSP considers it both practicable and appropriate to do so.

In response to Powerlink and Transgrid's questions on the inclusion or exclusion of existing SSRS and SSS, AEMO is of the view that their treatment will remain the same as currently applies when any excess system strength support is available in the network. For example, a synchronous condenser serving as a SSRS for an IBR, can be counted towards the total system fault levels subject to commercial agreements being in place with the SSSP. In this case, wide-area PSCAD studies should be conducted first with the IBR and associated SSRS in service, and then repeat the same studies without the IBR and associated SSRS. This is to ensure that any potential system strength support from the already committed SSRS does not compromise the ability of the associated IBR to remediate its system strength impact and meet its already agreed GPS.

4.7.3. AEMO's conclusion

Based on its assessment above, AEMO has amended section 4.2.4 of the SSIAG to confirm that the NSP must include electrically close *connected plant* and Committed *plant* as well as any SSS or SSRS, and that models may also be included for projects between NER 5.3.4A approval stage and Commitment if the Connecting NSP considers it practicable and appropriate. Other references in the SSIAG to 'nearby' have been adjusted to refer to terms that do not necessarily convey a measure of geographic proximity ('surrounding' for network, and 'electrically close' for connected or proposed plant).

4.8. System strength remediation

4.8.1. Issue summary and submissions

AEMO received three submissions related to system strength remediation.

Energy Queensland

> Does AEMO consider that curtailment schemes are acceptable SSRS, where any such scheme is aligned with the Remedial Action Scheme Guidelines?

Powerlink

> Section 5.1.2(a) of the draft guidelines suggests that generally, SSRS must be implemented behind the connection point. There are existing examples in the NEM where efficient SSRS is located remote from the connection point to mitigate any broader adverse system strength impact. Therefore, section 5.1.2(a) could be misleading of the cases where SSRS is most efficiently located remote from the connection point.

Transgrid

> Can AEMO provide further clarity on the statement "regardless of whether the network can operate stably despite the adverse system strength impact" in Section 5.1.2(b). For example, if a 4.6.6 Connection has resulted in degradation of damping of an existing mode of oscillation in the power system, regardless of whether the system is stable and the damping ratio is compliant with the adequate damping criteria, would the impact be considered as an adverse system strength impact that needs to be remediated by an SSRS? Perhaps linking this to the absence of materiality threshold may provide the clarity required.

4.8.2. AEMO's assessment

In response to Energy Queensland's suggestion, AEMO considers a special protection scheme, designed in accordance with the Remedial Action Scheme Guidelines[9] and defined under a NER S5.2.5.8 performance standard, could be an acceptable SSRS in appropriate circumstances. Examples include instability prevention in response to planned outages or non-credible contingencies, or in occasional circumstances where it is commercially prohibitive or technically infeasible to install a synchronous condenser or grid-forming inverters. However, the NSP should make this assessment in consultation with AEMO.

AEMO agrees with Powerlink's comment that there are examples in the NEM where efficient system strength remediation is located remote from the connection point to mitigate any broader system strength impact. However this is contemplated in the NER and the SSIAG by the SSCW option, and should not be considered as an SSRS.

In the example posed by Transgrid, the existing NER clauses and AEMO's Power System Stability Guidelines[10] will be used to assess if a degradation of damping can be permitted at all, and if so by how much. For example, with regard to the damping of oscillations, the minimum access standard for S5.2.5.13 permits minor degradation of the damping. Likewise, the criteria for power system damping are specified in S5.1a.3.

4.8.3. AEMO's conclusion

Based on its assessment above, AEMO has not made any changes to the SSIAG.

4.9. System strength locational factor

4.9.1. Issue summary and submissions

AEMO received three submissions related to the calculation of SSLF.

Circumstances in which SSLF calculation is not required

Powerlink

> System Strength Locational Factor (SSLF): Consistent with the intent of the recent system strength rule changes, an SSSP is required to use reasonable endeavours to plan, design, maintain and operate for the required level of system strength. We consider that it is not reasonable to plan for system strength for every potential future connection irrespective of its size and location in the network. We can envisage that there will be situations of new plant connecting to the remote part of the network (especially in the distribution network) where an SSSP cannot provide system strength services as part of their centralised planning and development. In these situations, an option should be made available to the SSSP to advise the new proponent that it is not practical to calculate the SSLF for the proposed location.
>
> In the absence of this provision, there will be unintended expectations on SSSPs to plan for providing the system strength even for small IBR/IBL connecting deep within distribution networks. Therefore, if AEMO maintains the SSLF methodology as set out in the draft SSIAG we suggest that a NSP should consult with the relevant SSSP before providing a SSLF to the new connection and if an SSSP believes that the new connection cannot be supported from the centralised planned sources of the system strength, it is considered that a SSLF cannot be reasonably calculated.

[9] https://aemo.com.au/-/media/files/stakeholder_consultation/consultations/nem-consultations/2022/publication-of-remedial-action-scheme-guidelines/further-information/final-remedial-action-scheme-guidelines.pdf?la=en
[10] power-system-stability-guidelines.pdf (aemo.com.au)

Methodology for undertaking SSLF calculations

Amp Power Australia

> For clause 6.4 (iv) of the draft SSIAG, what if a new connection's location is near the border of two TNSPs and it is electrically closer to the SSN in the other TNSP than the nearest SSN in the Connecting TNSP.

Transgrid

> Transgrid acknowledges that the Amending Rule is prescriptive in terms of the variables to be considered in calculating the System Strength Locational Factor (SSLF), and AEMO's proposed methodology aligns with the Amending Rule requirement. However, we note that the least cost centralised SSS may be at one or multiple locations that differ from the applicable SSN. In Transgrid's view, the proposed SSLF methodology is not reflective of the SSS location/s and the cost implications. Addition of further SSNs can address these concerns to a certain degree; however, further consideration will be required to ensure that SSC is a true reflection of the remediation requirement and the attributed cost of the relevant SSSs.
>
> Section 6.4(b)(ii) states that SSLF must be calculated considering the "network conditions around the date the Connecting NSP estimates the Applicant and the Connecting NSP will have completed all requirements to be in a position to send a notification to AEMO under NER 5.3.7(g), 5.3.9(h) or 5.3.12(h), as applicable".
>
> (1) What is the basis for determining the above commitment date for a proposed connection? Is the intent that the Applicant will need to indicate the expected commitment date to the NSP for consideration? Suggest providing clarity.
>
> (2) Implications for the proposed 4.6.6 Connections, if the actual timeline for commitment differ significantly from what was assumed for SSLF calculation during the preliminary assessments should be considered.
>
> Regarding selection of nearest SSN [section 6.4(b)(iv)], a TNSP must select the nearest node within its network. Suggest making it clear what happens to non TNSP node selection. Do DNSP's need to select the nearest node on any TNSP network?

4.9.2. AEMO's assessment

Circumstances in which SSLF calculation is not required

The SSIAG contemplates two scenarios where the SSLF cannot reasonably be calculated, that is, where the SSLF tends to infinity, and where the SSC could not reasonably be expected to be paid in preferences to SSCW or an SSRS.

In the scenario described by Powerlink, where a new plant is connecting to a remote part of the network where SSS would not be provided as part of centralised planning and development by an SSSP, it can be reasonably expected that, the SSLF, if calculated, will be excessive due to the long electrical distance to any SSN, such that SSCW or SSRS is the only feasible option. The SSLF is not required to be calculated in such scenarios.

It is not within the scope of the SSIAG to specify how or where the SSSP should plan its SSS to meet the standard in NER S5.1.14(b).

Methodology for undertaking SSLF calculations

AEMO agrees with Amp Power that if a new connection's location is near the border of two regions, it may be electrically closer to the SSN in the transmission network of the neighbouring region. However, as was discussed in the draft report, AEMO is of the opinion that requiring the 'applicable SSN' to be the nearest SSN, without consideration of whether it is within the same network to which an Applicant seeks connection would unduly complicate the connection negotiations. Therefore, where a 4.6.6 Connection is to a transmission network, the 'applicable SSN' should be within the same network, and where it is to a distribution network, AEMO considers that the 'applicable SSN' should be located within the same region to which the Applicant seeks connection. AEMO will confirm this view as a

recommendation within the SSIAG, but notes that this may be reviewed with the benefit of practical experience under the new framework.

AEMO agrees with Transgrid's observation that the least cost centralised SSS may be at one or multiple locations that differ from the applicable SSN. However, NER 6.23.5(e) in the Amending Rule is clear that SSC = SSUP x SSL[F] x SSQ, and SSLF must represent the impedance between the connection point and the applicable SSN. The SSLF is not necessarily reflective of the effectiveness of the remediation attributed by the SSC, and the location of SSS is not considered in the SSC calculation. Of course, SSCW and SSRS may be a lower cost option in some cases.

On Transgrid's next point, the NSP should estimate the commitment date based on the best available information at the time of assessment, including information from the Applicant.

4.9.3. AEMO's conclusion

Based on its assessment above, AEMO has added a new section 6.4(b) to the final SSIAG, which recommends that the applicable SSN should be the nearest SSN within the same region as the 4.6.6 Connection. This recommendation may be reviewed in future with the benefit of practical experience under the new framework.

4.10. Withstand SCR

4.10.1. Issue summary and submissions

AEMO received submissions from Amp Power and Powerlink in relation to Withstand SCR.

General

Amp Power

> The SSQ is calculated as the multiplier of the Withstand SCR (WSCR) and rated active power. WSCR is heavily reliant on inverter control tuning. Therefore, there are potential scenarios in which a new inverter-based generation connection will try to tune their control system so that their WSCR is as low as possible to reduce the SSQ (and project cost) which means they may not deliver the best performance they are capable of at the connection point or vice versa.

Powerlink

> In section 7.4.1 'SCR withstand assessment', it is not clear why the requirements of the actual system SCR conditions which may be an SCR<3.0 need to be considered. We understand that it is in proponent's best interest to demonstrate SCR withstand with the lowest possible value in order to minimise their prescribed system strength charges. However, this should not be imposed by the NSP. Plant would meet the minimum access standard for NER S5.2.5.15 if SCR withstand is proven at SCR=3.0.

Withstand SCR tests

Amp Power

> It is widely accepted that PSS/E may not be the right simulation platform to simulate weak grid conditions (e.g., generally with an SCR<3). Is it appropriate to require PSS/E tests for the assessment of Withstand SCR if it is less than 3 (or even 2)?

Powerlink

> Section 7.4.3 requires test results using PSS/E and PSCAD models and benchmarking against each other for the purposes of demonstrating compliance with the proposed access standard for NER S5.2.5.15. To understand a plant's SCR withstand capabilities, especially at low SCR, we consider PSS/E results will add very little to no value. Therefore, to avoid unnecessary work for the new connections and NSPs for the purposes of withstand SCR and NER 5.2.5.15, requirements for the test results from PSS/E model and benchmarking against PSCAD results should be removed.

4.10.2. AEMO's assessment

General

On Amp Power's comment on the inter-relationship between meeting the performance standards and Withstand SCR, while it would be desirable to use the same control system design and settings for both purposes, AEMO recognises this may not be practical in all instances without adversely impacting one or the other. However, as explicitly contemplated in the Amending Rule (NER S5.2.5.15(d)), Withstand SCR can be demonstrated using an alternative set of control parameters to those used for the operation of the plant and compliance with other access standards. Therefore, the situation described by Amp Power is unlikely to arise in practice.

Withstand SCR tests

In response to Amp Power and Powerlink's comments on the veracity of PSS®E modelling for low SCR studies, AEMO concurs that PSS®E modelling might provide too optimistic a response, or it could experience numerical instabilities under very low SCR conditions corresponding to Withstand SCR. The intent of including PSS®E modelling is to ensure some consistency between the PSS®E and PSCAD results. However, it is not necessarily expected that the PSS®E model will provide accurate and consistent results down to the Withstand SCR.

AEMO is aware of worldwide efforts by original equipment manufacturers (OEMs), software vendors and research organisations to improve the accuracy and robustness of phasor-domain transient simulation tools such as PSS®E for low system strength studies. While AEMO recognises the critical role of electromagnetic transient (EMT) simulation tools for assessing system strength impacts and needs, we are of the view that phasor-domain simulation tools will also play a role and consider it premature to exclude PSS®E from dynamic studies associated with system strength impact assessment. It is however agreed that while PSS/E vs. PSCAD benchmarking is still a requirement of the Dynamic Model Assessment Test guidelines[11], it is not specifically required for Withstand SCR tests, and therefore has been removed from the final SSIAG.

4.10.3. AEMO's conclusion

Based on its assessment above, AEMO has removed the specific requirement in section 7.4.3 of the final SSIAG for PSS®E models to be benchmarked with PSCAD models.

4.11. Stability Assessments

4.11.1. Issue summary and submissions

AEMO received the following submissions related to Stability Assessment approach.

Goldwind

> Although there may be no technical alternative that is less onerous than a Full Impact Assessment, if the generator has paid for a SSC, we believe the applicant should not be further exposed. The Stability Assessment should be completed by AEMO and the NSP independent of the generator and any shortfall would need to be met by the NSP and covered under the SSC. The generator is already incentivized to optimally tune its generator to minimize its Withstand SCR. After that, AEMO and the NSP should be responsible for ensuring appropriate System Strength mitigation with no further recall to the generator.

[11] https://www.aemo.com.au/-/media/files/electricity/nem/network_connections/model-acceptance-test-guideline-nov-2021.pdf?la=en&hash=3287CA490B21CE0634D954440940232E

Transgrid

> 8.5(c) Power system stability for conditions caused by unplanned outages of SSS and the need for any special protection schemes. Does this mean that the SSSP will need to consider planned outage of SSS, when determining the level of SSS provision required? For forced outages, special protection schemes or constraints may be applied. Suggest providing clarity.

4.11.2. AEMO's assessment

While AEMO notes Goldwind's view and agrees that the SSC, if elected, should be the Applicant's only exposure for system strength remediation, it is still necessary to establish that the 4.6.6 Connection itself will be stable. If the Stability Assessment demonstrates it is not, then the Connecting NSP, Applicant, and AEMO will need to work collaboratively to resolve the instability before the plant can connect. It may be that the most efficient solution will be an alteration to the generating system requiring technical and commercial negotiation, for example. The SSIAG contemplates there may be a range of potential solutions. SSIAG 8.2 makes it clear that the Connecting NSP is required to undertake the Stability Assessment. SSIAG 8.6.1 further requires studies to demonstrate the effectiveness of the SSS applicable to the 4.6.6 Connection and the relevant SSSP's ability to meet the requirements of NER S5.1.14.

In response to Transgrid's question, determining the level of SSS provision is a planning matter which is outside the scope of the SSIAG. However, AEMO's System Strength Requirements Methodology provides commentary on inclusion of critical planned outages. AEMO agrees that special protection schemes or constraints may be applied for forced outages.

4.11.3. AEMO's assessment

Based on the submissions and assessment above, AEMO has not made any changes to the SSIAG.

4.12. Plant alterations

4.12.1. Issue summary and submissions

Several submissions were received on the SSIAG treatment of plant alterations.

Amp Power Australia

> It is unclear if an existing plant wants to expand its generating system, how will its general system strength impact and SSQ be calculated (i.e., only the additional generating units vs the total site after expansion)?

Goldwind

> The nature of how AEMO and NSPs tend to assess changes to the generating system mean that there would be a potentially significant risk to the existing generators when considering even simple things like firmware updates (even if they are unrelated to the key control systems of the generator). This would create a disincentive in the industry to continue improving generator software over time or introduce new operational features. The disincentive may even deter owners from looking to upgrade the control systems of existing generators (e.g. grid following inverters to grid forming inverters which Goldwind is trialling in China and only involves a software update) as the regulatory risk would be too great and the generator could expose themselves to potential system strength related charges depending on how the guideline is interpreted. That would result in a poor outcome for the power system overall.
>
> Our view is that the equivalence of the 5.3.9 process to an application to connect is not appropriate. We instead suggest AEMO consider the 5.3.9 process separately. Some 5.3.9 requests could be considered to be very similar to an application to connect (e.g. increasing the generator size or replacing generator units with a different type). However, we suggest that most 5.3.9 changes involve updates to software of the generating system and do not represent significant plant changes. On that basis, we consider that the NSP and AEMO should have the flexibility to apply their engineering judgement as to whether a 5.3.9 request should be taken

down a path equivalent to an application to connect. AEMO and the NSP should be able to choose to not conduct a System Strength Assessment if it would not be relevant.

Transgrid

(1) Section 2.5.3 states that: "4.6.6 Connections that are comprised of alterations to plant do not follow the same process as those that are comprised of new plant". This sentence is contradicting to the rest of the paragraph where it is stated that the system strength assessment process for plant alterations is equivalent to an application to connect. Suggest providing further clarity on this.

(2) Given that scope of plant alterations can vary from minor alterations (with no impact on plant ratings or impedance) to significant plant alterations (such as addition of new generating units behind the connection point or change of connection point from HV to MV), Transgrid recommends providing further clarity with worked examples on application of the system strength assessment process for plant alterations.

…

The process applicable for proposed plant alterations (under NER 5.3.9 or NER 5.3.12) described in Section 2.3 requires further clarity.

Section 2.3(a) states that for 4.6.6 Connections that are proposed alterations to a generating system under NER 5.3.9, the NER permit (but do not require) an Applicant to request a Preliminary Assessment, prior to the submission. However, NER clause 5.3.4B(a2)(1) specifies that for each proposed new connection or proposed alteration to a generating system or other connected plant to which this clause applies, a Network Service Provider (NSP) must undertake a preliminary system strength impact assessment in accordance with the SSIAG.

(1) What are the criteria in 2.3(b) for determining 'where relevant' for an Applicant to propose a system strength remediation scheme (SSRS) or elect to pay system strength charge (SSC) – is this based on AEMO's determination in 2.3(c)?

(2) When and how will AEMO make the determination described in 2.3(c)? Is it based on a preliminary assessment of the 5.3.9 submission from the applicant or following full assessment of the 5.3.9 submission?

…

Section 4.2.6 on Alterations to Plant suggests that if the alteration is limited to the three criteria specified under (h), (i) and (j), then the Connecting NSP must only assess whether there is an adverse system strength impact. Transgrid infers from this that:

(1) reduction of AFL does not need to be assessed for plant alterations specified under Section 4.2.6(h), (i) and (j); and

(2) for all other plant alterations (excluding alteration outlined in 4.2.6(h), (i) and (j)), the general system strength impact is required to be assessed. Can AEMO please confirm if this interpretation is correct? Suggest providing further clarity on the system strength impact assessment required for plant alterations that are not covered by Section 4.2.6(h), (i) and (j).

4.12.2. AEMO's assessment

On Amp Power's question, the expansion of a generator will fall under the process for a NER 5.3.9 alteration as prescribed in the new SSIAG. The Preliminary Assessment and Full Assessment will only assess the system strength impact of the proposed alteration; that is, the assessed general system strength impact should be relative to the network including the existing plant (prior to alteration).

AEMO acknowledges concerns from Goldwind and Transgrid about the treatment of minor generator modifications such as software updates under the SSIAG. The SSIAG allows for engineering judgement to be applied in these scenarios under sections 4.2.6(h), (i) and (j) of the draft SSIAG[12]. It is also relevant to note that NER 5.3.9 allows for the Connecting NSP and AEMO to undertake a pre-submission assessment. Indeed, the current 5.3.9 process does not work effectively unless this

[12] These are renumbered in the final SSIAG within a single paragraph (h).

assessment occurs, because the content of the submission depends on AEMO's opinion of certain matters, including whether the proposed alteration will have a general system strength impact. If, as part of a pre-submission assessment, AEMO can reasonably conclude that the alteration will not have a general system strength impact, it will not be necessary for the Applicant to include a proposed SSRS or election to pay the SSC. In other cases, a Preliminary Assessment will be necessary (prior to the NER 5.3.9 submission). Sections 2.3 and 2.5 of the SSIAG will be expanded to reference and clarify the application of this process.

It is further noted that NER 5.3.9 is currently subject to a review under the Connections Reform Initiative.

AEMO acknowledges Transgrid's observation that the statements in section 2.5.3 of the draft SSIAG seem to be contradictory. The intended point is that for system strength assessment purposes, plant alterations under NER 5.3.9 or 5.3.12 are brought into the 5.3.4B process, even though they are initiated under a separate NER process from connection applications. This has been clarified in the final SSIAG.

4.12.3. AEMO's conclusion

Based on its assessment above, AEMO has made changes to sections 2.3 and 2.5 of the SSIAG, as already noted in Section 4.5.3.

4.13. Identification of Committed projects

4.13.1. Issue summary and submissions

Energy Queensland commented that:

> In relation to the definition "committed", we suggest that item (d) is amended to "a connection agreement between the Connecting NSP and the Applicant has been entered into as per 5.3.7 of the NER" to reflect industry practice. Otherwise, including projects that have only had an offer issued, but not accepted, will unnecessarily result in re-work and churn.

4.13.2. AEMO's assessment

The definition of 'Committed' in the SSIAG is used to determine the projects (both 4.6.6 Connections and network augmentations, the latter defined in the NER as *considered projects*) that must be included in the models used by Connecting NSPs for system strength assessments. While the definition is not impacted by the Amending Rule, AEMO acknowledges that the issue of the connection offer as one of the criteria for Commitment (and inclusion in the model database) appears to present difficulties for many NSPs.

AEMO recognises that, outside of the system strength process, the issue of connection offers is not normally visible, and model information is not typically shared with other registered participants until the connection agreement stage. AEMO has therefore decided to change this criterion in the SSIAG definition of Committed from the issue of a connection offer to entry of a connection agreement. At the same time, to ensure Connecting NSPs are not prevented from considering non-committed projects where it is both possible and appropriate to do so, the final SSIAG will allow consideration of nearby non-committed 4.6.6 Connections in Full Assessments and Stability Assessments as discussed in Section 4.7 above. This can be expected to minimise the need for re-work in appropriate cases, as the projects achieve 'Committed' status.

4.13.3. AEMO's conclusion

AEMO has amended paragraph (d) of the definition of 'Committed' in the SSIAG glossary to refer to the execution of a connection agreement, in place of the issue of an offer to connect.

5. Final determination

Having considered the matters raised in submissions and throughout this consultation process, AEMO's final determination is to amend the System Strength Impact Assessment Guidelines in the form of Attachment 1, in accordance with NER 4.6.6.

Appendix A. Glossary

Terms defined in the NER have the same meanings in this final report. For ease of reading, they have not been italicised except in direct extracts or where used for definitional purposes in the table below. Other special terms and acronyms used in this final report are defined in this table.

Term or acronym	Meaning
4.6.6 Connection	As defined in the SSIAG.
AEMC	Australian Energy Market Commission.
AEMC Final Determination	Rule Determination - National Electricity Amendment (Efficient management of system strength on the power system) Rule 2021. Available at https://www.aemc.gov.au/rule-changes/efficient-management-system-strength-power-system.
AFL	*available fault level*. As defined in the SSIAG.
Amending Rule	National Electricity Amendment (Efficient Management of System Strength on the Power System) Rule 2021 No.11.
Applicant	As defined in the SSIAG.
Committed	As defined in the SSIAG.
Connecting NSP	As defined in the SSIAG.
DNSP	*Distribution Network Service Provider*.
EMT	Electromagnetic transient.
GPS	Generator *performance standard*.
IBL	*inverter based load*.
IBR	*inverter based resource*.
LIBR	large inverter-based resource.
Materiality Threshold	A reduction in AFL below which an impact may be disregarded for the purposes of NER 5.3.4B(f)(3).
NEM	National Electricity Market.
NER	National Electricity Rules. NER followed by a number indicates the corresponding rule or clause of the NER.
NSP	*Network Service Provider*.
OEM	Original equipment manufacturer.
Preliminary Assessment	The assessment referred to in NER 4.6.6(b)(1)(i), under the Amending Rule.
PSCAD™/EMTDC™	Power Systems Computer Aided Design / Electromagnetic Transient with Direct Current.
PSS®E	Power System Simulator for Engineering PV Photovoltaics.
RIT-T	Regulatory Investment Test for Transmission.
SCR	*short circuit ratio.*
SMIB	Single machine infinite bus.
SSC	*System strength charge*.
SSCW	*system strength connection works*.
SSIAG	System Strength Impact Assessment Guidelines.
SSLF	*system strength locational factor*.
SSN	*system strength node*.
SSQ	As defined in NER 6A.23.5(e), under the Amending Rule
SSRS	*system strength remediation scheme*.
SSS	*system strength service.*

Term or acronym	Meaning
SSSP	*System Strength Service Provider*.
Stability Assessment	The assessment referred to in NER 4.6.6(a)(8), under the Amending Rule
Synchronous Three Phase Fault Level	As defined in the SSIAG.
TNSP	*Transmission Network Service Provider*.
Withstand SCR	See section 7.2 of the SSIAG.

Appendix B. Summary of submissions and AEMO responses

No.	Consulted person	Issue	AEMO response
1	TasNetworks	Departures from Amending Rule See section 4.1.1.	See sections 4.1.2 & 4.1.3
2	Amp Power, APD Engineering, Energy Queensland, Goldwind, Powerlink, Transgrid	Stability co-efficient See section 4.2.1.	See sections 4.2.2 & 4.2.3
3	Energy Queensland, Powerlink, Transgrid	Materiality Threshold See section 4.3.1.	See sections 4.3.2 & 4.3.3
4	Goldwind, Transgrid, APD Engineering, Powerlink, Transgrid	Treatment of grid-forming inverters See section 4.4.1.	See sections 4.4.2 & 4.4.3
5	Energy Queensland, Powerlink, Transgrid	Reassessment during connection process See section 4.5.1.	See sections 4.5.2 & 4.5.3
6	Amp Power, Energy Queensland, Powerlink, Transgrid	Preliminary Assessment See section 4.6.1	See sections 4.6.2 & 4.6.3
7	Amp Power, Energy Queensland, Powerlink, Transgrid	Full Assessment See section 4.7.1.	See sections 4.7.2 & 4.7.3
8	Energy Queensland, Powerlink, Transgrid	System Strength Remediation See section 4.8.1.	See sections 4.8.2 & 4.8.3
9	Powerlink, Amp Power, Transgrid	System strength locational factor See section 4.9.1.	See sections 4.9.2 & 4.9.3
10	Amp Power, Powerlink, Goldwind	Withstand SCR See section 4.10.1.	See sections 4.10.2 & 4.10.3
11	Goldwind, Transgrid	Stability Assessments See section 4.11.1	See sections 4.11.2 & 4.11.3
12	Amp Power, Goldwind, Transgrid	Plant alterations See section 4.12.1	See sections 4.12.2 & 4.12.3

No.	Consulted person	Issue	AEMO response
13	Energy Queensland	Identification of Committed projects See section 4.13.1	See sections 4.13.2 & 4.13.3
14	APD Engineering	Guidelines need to include the methodology to be applied in the calculation of ΔAFL using an PSSE OPDMS case. Specifically on the SCR withstand values to be applied for the IBR plants that are already included in the OPDMS case and for the committed plants in the calculation of proxy Thevenin's impedance (ie., the sub-transient reactance value of the plant in the fault level calculation).	The SSIAG presents a methodology for calculating SSLF based on PSS/E OPDMS cases. However, the calculation of ΔAFL will be based on SMIB modelling which is consistent with the Amending rule.
15	APD Engineering	The system strength guidelines are silent on the approach to be adopted for the calculation of maximum fault level at a node. Specifically, on handling the IBRs in the OPDMS case with respect to: (a) The proxy Thevenin's impedance (or the sub-transient reactance value of the plant in the fault level calculation) to be used for IBR plants in the case. (b) The expected maximum fault current to be provided by IBR. It is important to have a clear direction on the estimation of maximum fault current since it is important in the CB ratings and protection designs. If AEMO feels this should not be a part of system strength assessment, could AEMO propose any alternate stream that will address this issue.	AEMO notes that the maximum fault level does not have any impacts on system strength in general and on SSIAG. Determining the maximum fault level in power system fall under NSPs planning responsibilities and the annual planning reports that are published annually.
16	APD Engineering	The system strength related information is dispersed in three different documents: (a) System Strength Impact Assessment Guidelines (b) System Strength Requirements Methodology (c) Power System Stability Guidelines Most often these documents are revised or updated at different times. To make things easier for the participants for reference and application of these guidelines, it will be beneficial, if these documents are combined into a single document where all the related information are put together. AEMO is requested to consider this	AEMO notes that publication of these documents are separate obligations under the NER and therefore it would not be appropriate to combine them into a single document.
17	Energy Australia	Specifically, EA supports AEMOs revised methodology for assessing the short circuit ratio (SCR) of connecting projects as SCR withstand and agrees with their position that the metric derived by the Rule to calculate System Strength Quantity (which is a product of SCR and rated active power of a project's connection) could result in excessive and impractical System Strength Charges (SSC), particularly for inverter-based resources in stronger areas of the network. The lack of visibility across the development of SSCs (including indicative and final values) will impact the invest ability of projects because the calculation of this charge will have a large bearing on financial investment decisions. Improving forecasting of the SSC by revising input methodologies to reflect actual metrics at the point of connection, including SCR would be beneficial to project operators and likely AEMO's own connection engineers. In addition, we understand that there may be an ability for project operators to negotiate SSQ and potentially reduce the actual SSC applicable (taking into account real time ALF values) with the transmission network service provider (in consultation with AEMO) through the connection's framework. EA fully supports this pragmatic approach and further reforms that may be necessary to	AEMO thanks EA for their support this approach. It is noted that EA's general comments on the potential operation of the broader System Strength Framework are beyond the remit of the SSIAG.

No.	Consulted person	Issue	AEMO response
		improve the new connections experience, including approaches that recognise and address the lack of clear pricing and signals for System Strength at present. Energy Australia is also mindful that some interpretations of the SSIAG and the Rule suggest there will be very significant charges applicable to IBR in the near term, even though only a handful of system strength gaps have been identified out to December 2025 and the observation that at most nodes there is currently an abundance of system strength above the minimum requirements. We believe this points to a potential disconnect in how system strength is valued and how and when charges are set. We encourage AEMO to consider how to best address this concern.	
18	Energy Queensland	While inverter-based load is defined in the National Electricity Rules, is there scope to include examples in an Appendix of the SSIAG, for example, data centres, industrial-scale electric vehicle charging?	AEMO has clarified that an IBL must be supplied by power electronics, including inverters, and potentially susceptible to inverter control instability. In future further consideration may be given to including criteria around what is, or is not, 'potentially susceptible' as informed by AEMO's ongoing work for the Power System Model Guidelines[13] review and Technical Requirements for Connection review[14].
19	Energy Queensland	Mandatory use of a simple isolated model such as a SMIB model to undertake Preliminary Assessments -We agree with AEMO's assessment that a vendor-specific PSCAD™/EMTDC™ and/or PSS®E model is unlikely to be available in many cases, and as such, support the proposed methodology of utilising an estimated Withstand SCR. Appropriate studies are required to adequately assess system stability. Where these studies are not possible due to lack of models, the reduction in SCR is an acceptable proxy to highlight the need for further study.	AEMO thanks Energy Queensland for its support on this approach.
20	Goldwind	We are seeking clarification on what AEMO means with the term "vendor specific". For some projects we may have OEM models specific to the inverter that is to be used for the project. Would that count as "vendor specific" in this OEM models specific to the inverter that is to be used for the project. Would that count as "vendor specific" in this case? Does AEMO expect that the "vendor specific" model also include details such as proposed reticulation, auxiliary equipment and grid transformers that would be applicable to the project? If this is the case then we propose the use we propose the use of the term "site specific" to avoid confusion of the term "site specific" to avoid confusion.	AEMO agrees with suggestions made by Goldwind, and for clarity has replaced the term vendor-specific with site-specific in the final guidelines.
21	Goldwind	Table 4: There is a reference to Tests 2 and 3, however it is not immediately clear what tests 2 and 3 entail. We assume this is a typing error.	AEMO agrees this is a typing error. It has been rectified in Appendix B of the final SSIAG.

[13] AEMO, Power System Model Guidelines and Data Sheets, and System Strength Impact Assessment Guidelines Consultation, at https://aemo.com.au/consultations/current-and-closed-consultations/power-system-model-guidelines-and-system-strength-impact-assessment-guidelines/#:~:text=The%20System%20Security%20Market%20Framework%20review%20carried%20out,management%20of%20new%20and%20emerging%20power%20system%20phenomena.

[14] AEMO | AEMO review of technical requirements for connection (NER clause 5.2.6A), at https://aemo.com.au/consultations/current-and-closed-consultations/aemo-review-of-technical-requirements-for-connection.

No.	Consulted person	Issue	AEMO response
22	Powerlink	Section 4.1.7 'Consultation with AEMO' requires a NSP to provide AEMO with the indicative System Strength Quantity (SSQ) and the SSLF for the connection point and the relevant System Strength Node (SSN). We note that the clause 5.3.4B(b) of the NER only requires an NSP to provide results of the preliminary assessment. We believe that the SSQ, SSLF and the relevant SSN go beyond the preliminary assessment results that an NSP needs to provide to the connection applicant at the time of the connection enquiry. These are not the results of the preliminary assessment. Moreover, SSQ, SSLF and the relevant SSN are required for the system strength charging which is managed by the relevant SSSP which is not necessarily the relevant NSP. Therefore we suggest that section 4.1.7 limits the requirements to the result of the preliminary assessment only.	AEMO notes that the explicit purpose of a Preliminary Assessment under the Amending Rule (NER 4.6.6(b)) is both to screen for the need for a full assessment and calculate the applicable system strength locational factor. NER 5.3.4B(b) states that the results of the preliminary and full assessments must be provided to the Applicant 'following consultation with AEMO'. However, AEMO agrees there is no reason why AEMO would need to provide input on the SSLF calculation or the relevant SSN, and therefore has removed this requirement from the final SSIAG.
23	Powerlink	While not strictly part of the draft SSIAG we also wish to clarify our approach to determining the quality of system strength provided by those system strength sources to be procured by Powerlink. The standard that an SSSP is required to meet for the hosting of IBR is to achieve stable voltage waveforms for the level and type of IBR projected by AEMO. This is a different standard that applies to a plant which elects to adopt its own SSRS. In those circumstances the requirement of the SSRS is to remedy a general strength impact, which is a change in AFL at the connection point. For this reason we infer the level of system strength provided to be the rating of the capacity of the plant able to be hosted (in MVA) multiplied by the withstand SCR of the plant. This approach allows for a more efficient use of the available system strength planned by SSSP and we consider this to be aligned with the policy intent of the enhance system strength framework.	AEMO agrees that this comment is beyond the remit of the SSIAG.
24	Transgrid	Can AEMO please clarify the application of the Materiality threshold? NER clause 4.6.6(b)(7) suggests that the materiality threshold defined in the SSIAG applies to general system strength impact when determining if system strength connection works (SSCW) are to be undertaken by an NSP for the purpose of 5.3.4B(e) and 5.3.4B(f)(3). However, clause 5.3.4B(a2)(3) suggests that the materiality threshold is also applicable to determining whether a Full Assessment is required following the preliminary assessment. If that is the case, Transgrid suggests amending Section 3.5 to clarify that the materiality threshold specified in the SSIAG is applicable for the purpose of 5.3.4(a2) and 5.3.4(e)/5.3.4(f)(3).	A footnote has been added to confirm that the materiality threshold is considered in making assessments under NER 5.3.4B(a2)(3)(i) and 5.3.4B(e)
25	Transgrid	Regarding the short circuit impedance used for SSLF calculation, the methodology outlined does not explicitly state that the short circuit impedance is to be calculated on a per unit basis. Suggest including this for clarity.	AEMO has added this clarification in section 6.4(c)(vi) of the final SSIAG.
26	Transgrid	What is meant by "*commitment* patterns"? Is "commitment" a defined term or is this referring to the definition of "committed" in Section 1.2.1? Suggest providing clarity.	*Commitment* (italicised) is a defined term in the NER, meaning start-up and synchronisation of generating units to the power system. It is not associated with the definition of 'Committed' in the SSIAG. AEMO will make minor amendments to confirm this relates to generating unit *commitment*.

No.	Consulted person	Issue	AEMO response
27	Transgrid	1. Can AEMO please clarify the reason for G1 contribution calculated using PSS/E in Step 3 is different to G1 contribution calculated in Step 2? The PSS/E calculated fault level contribution appear to be significantly different to the fault level calculated using the network impedance/IBR connections given in the Figure 4. Please check the PSS/E modelling. 2. ΔAFL for IBR3: Can AEMO please provide further details on how the final ΔAFL of 0 is calculated, including calculation details on (a) expected reduction in AFL with the proposed connection; and, (b) subsequently with the proposed SSCW and the associated increase of 3phase fault level how it resulted in an offset of the reduction in originally calculated ΔAFL.	1. In the draft SSIAG Appendix A.2 example referenced by Transgrid, the change in AFL contribution of the generator is calculated using superposition theory / circuit theory. This calculation is provided for transparency, however the calculation is expected to be done in PSSE, with only the resultant 'TOTAL Synchronous Three Phase Fault Level' and 'TOTAL proxy fault level' being of impact to the calculation of AFL at the system busbars. 2. In the SSIAG Appendix A.1 example referenced by Transgrid, a Withstand SCR of 1.62 gives a delta AFL of -(1.62*50MW) + 1.2*50MW = -21MVA for IBR3. The ALF at Busbar #4 is calculated as increasing by more than 21MVA with the proposed SSCW, thus addressing the delta ALF contribution of the plant. Minor updates to the calculations described above are included in the Final SSIAG.