SYSTEM STRENGTH IMPACT ASSESSMENT GUIDELINES

FINAL REPORT AND DETERMINATION

Published: **June 2018**

AEMO
AUSTRALIAN ENERGY MARKET OPERATOR

EXECUTIVE SUMMARY

The *publication* of this Final Report and Determination (**Final Report**) concludes the consultation conducted by AEMO to develop the *system strength impact assessment guidelines* (**Guidelines**) under the National Electricity Rules (**NER**).

The National Electricity Amendment (Managing power system fault levels) Rule 2017 No.10 (**Amending Rule**) will commence on 1 July 2018. Clause 4.6.6 in the Amending Rule requires AEMO to *publish* the Guidelines in accordance with the *Rules consultation procedures*.

AEMO commenced the consultation on 5 March 2018 by *publishing* draft Guidelines and calling for submissions. AEMO received ten submissions to which it responded in its Draft Determination and Report, which was published on 14 May 2018.

The Draft Report commenced the second stage of the consultation, with submissions due by 29 May 2018. A total of eight submissions were received, only two of which were valid. The material issues raised in the submissions were as follows:

1. **Definition of 'Committed'** – Various submissions wanted further changes to this definition, either suggesting the date on which a project is 'Committed' should be as late as possible, such as when construction of the project is effectively certain, or that Applicants could 'block' capacity on the *network*. It was suggested that a *connection agreement* must have been executed. AEMO considered that this additional requirement further reduces the opportunity for assessments to take into account surrounding projects and to develop a more efficient, centralised solution. AEMO has added one more requirement, namely that an offer to *connect* has been issued. Supply could be 'unblocked' if an Applicant failed to accept the offer within a specified time.
2. **SCR Calculation Methodology** – Submissions noted that allowing NSPs to select one of four different calculation methods created uncertainty. AEMO has determined that only one method is to be used.
3. **Risk of delay if EMT models not available** – AEMO has responded to this concern by making it clearer that Connecting NSPs can make assumptions to cover missing models or data relating to other existing *plant*, subject to the Applicant's agreement and no objections from AEMO.
4. **Transition to Final Guidelines** – AEMO has amended the Guidelines to provide more detail as to the application of the Guidelines to projects at various stages of the connection process on 1 July 2018.

After considering the submissions received, AEMO's determination is to make the *system strength impact assessment guidelines* in the form published with this Final Report.

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1. STAKEHOLDER CONSULTATION PROCESS

As required by clause 4.6.6 of the NER, AEMO is consulting on the *system strength impact assessment guidelines* in accordance with the Rules consultation process in rule 8.9.

AEMO's timeline for this consultation is outlined below.

Deliverable	Date
Notice of first stage consultation published	5 March 2018
First stage submissions closed	12 April 2018
Draft Determination and Report & Notice of second stage consultation published	14 May 2018
Submissions due on Draft Determination and Report	29 May 2018
Final Report published	29 June 2018

The *publication* of this Final Report marks the conclusion of the consultation.

A glossary of terms used in this Draft Report can be found in **Appendix A**. Italicised terms are defined in the NER.

2. BACKGROUND

2.1 NER requirements

AEMO is required by clause 4.6.6 of the NER to develop and *publish* the *system strength impact assessment guidelines*.

The relevant requirements are detailed below for completeness:

(a) *AEMO* must make, *publish* and may amend *system strength impact assessment guidelines* that set out the methodology to be used by *Network Service Providers* when undertaking *system strength impact assessments* under clause 5.3.4B in relation to a proposed new *connection* of a *generating system* or *market network service facility* or an alteration to a *generating system* to which clause 5.3.9 applies.

(b) The *system strength impact assessment guidelines* must:

(1) provide for a two-stage assessment process comprising:

(i) a preliminary assessment to screen for the need for a full assessment; and

(ii) a full assessment;

(2) require the full assessment to be carried out using a *power system* model that is reasonably appropriate for conducting *system strength impact assessments* and applicable to the location the *transmission network* or *distribution network* at which the *facility* is or may be *connected* and specified by *AEMO* from time to time for this purpose;

(3) exclude from the assessment of an *adverse system strength impact* the impact on any *protection system* for a *transmission network* or *distribution network*;

(4) provide guidance about the different *network* conditions and *dispatch* patterns and other relevant matters that should be examined when undertaking a full assessment;

(5) specify the nature of the impacts that *AEMO* considers to be *adverse system strength impacts* and that must be avoided or overcome by undertaking *system strength connection works* or implementing a *system strength remediation scheme* in accordance with clause 5.3.4B;

(6) provide guidance about the matters that must be considered when determining whether a *connection* or alteration will result in an *adverse system strength impact*;

(7) include if applicable any thresholds below which an impact may be disregarded when determining the need for a *system strength remediation scheme* or *system strength connection works* under clause 5.3.4B; and

(8) provide general guidance about options for *system strength remediation schemes* and *system strength connection works*.

2.2 Context for this consultation

Most schedules of the National Electricity Amendment (Managing power system fault levels) Rule 2017 No.10 (**Amending Rule**) will commence on 1 July 2018, but Schedule 1, requiring the development and publication of the *system strength impact assessment guidelines,* commenced on 17 November 2017.[1]

Clause 11.101.2(c) requires that AEMO *publish* the *system strength impact assessment guidelines* by 1 July 2018.

[1] The transitional provisions in Schedule 5 of the Amending Rule commenced on 19 September 2017.

2.3 First stage consultation

AEMO issued a Notice of First Stage Consultation on 5 March 2018 along with a draft of the proposed *system strength impact assessment guidelines*.

AEMO received four valid written submissions in the first stage of consultation. Six late submissions were received, which AEMO has also considered.

All written submissions, minutes of meetings and issues raised in forums (excluding any *confidential information*) have been *published* on AEMO's website at: http://aemo.com.au/Stakeholder-Consultation/Consultations/Power-System-Model-Guidelines-and-System-Strength-Impact-Assessment-Guidelines.

2.4 Second stage consultation

AEMO issued a Notice of Second Stage of Consultation on 14 May 2018 along with the Draft Report and an updated version of the proposed *system strength impact assessment guidelines*.

AEMO received two valid written submissions in the second stage of consultation. Seven late submissions were received, which AEMO has also considered.

All written submissions (excluding any *confidential information*) have been *published* on AEMO's website at: http://aemo.com.au/Stakeholder-Consultation/Consultations/Power-System-Model-Guidelines-and-System-Strength-Impact-Assessment-Guidelines.

3. SUMMARY OF MATERIAL ISSUES

The key material issues arising from the proposal and raised by Consulted Persons are summarised in the following table:

No.	Issue	Raised by
1.	Definition of 'Committed'	Powerlink Queensland, Clean Energy Council & WSP
2.	Lack of a unified SCR Calculation Methodology	Pacific Hydro, Senvion, Clean Energy Council, SA Power Networks & WSP
3.	Risk of delay if the more detailed EMT models are not available	Pacific Hydro, SA Power Networks & Senvion
4.	Transition to Final Guidelines	Powerlink Queensland & Energy Queensland

A detailed summary of issues raised by Consulted Persons in submissions, together with AEMO's responses, is contained in **Appendix B**.

4. DISCUSSION OF MATERIAL ISSUES

4.1 Definition of 'Committed'

4.1.1 Issue summary and submissions

This was addressed as a material issue in the Draft Report and AEMO modified its initial approach. The issue has been raised again on the basis that either AEMO's changes have not gone far enough or, based on recent *connection* project experiences, further issues need to be addressed.

Below are relevant extracts from submissions:

Powerlink Queensland:

The Draft Guidelines released as part of the first stage of consultation required Network Service Providers (NSPs) to consider all 'proposed' generating units, generating systems and market network service facilities for which an application to connect has been submitted when performing system strength impact assessments. Powerlink and other stakeholders indicated that the inclusion of projects at the application to connect stage is premature. Specifically, Powerlink proposed that the commitment is best demonstrated when:

- an application to connect has been submitted to the NSP;
- a clause 5.3.4A letter has been issued by AEMO; and
- connection applicant agreement to clause 5.3.4B work, if required.

In response, AEMO modified the definition of 'committed' in line with submissions. Powerlink has subsequently had occurrences of offering connections to proponents where the proponent has not accepted the offer. The consequences of this with the new definition of committed, are that the proponent would block network capacity (from system strength point of view) and other proponents in the area may be required to investigate and implement remediation schemes incurring significant and unnecessary costs and delays, especially if the original proponent decides not to proceed. Therefore, Powerlink recommends the following additional condition be included in the definition of committed:

- CAA with the NSP is executed.

Energy Queensland:

Recommend that the definition of "committed" in Table 1 should be further as follows:

"In respect of an Applicant's proposed connection:

- AEMO has issued a letter to the connecting NSP under clause 5.3.4A of the NER indicating that AEMO is satisfied that each specified access standard meets the requirements applicable to a negotiated access standard under the NER; and
- AEMO and the connecting NSP have accepted that a detailed PSCAD™/EMTDC™ model provided by or on behalf of the Applicant representing the Applicant's proposed connection meets the requirements of the Power System Model Guidelines.
- The Applicant has signed an Offer for Connection with the connecting NSP.

In respect of another proposed connection:

- AEMO has issued a letter to the connecting NSP under clause 5.3.4A of the NER indicating that AEMO is satisfied that each specified access standard meets the requirements applicable to a negotiated access standard under the NER;
- AEMO and the connecting NSP for that other proposed connection have accepted a detailed PSCAD™/EMTDC™ model provided by or on behalf of the Connection Applicant of that proposed connection meets the requirements of the Power System Model Guidelines;
- any proposed system strength remediation schemes or system strength connection works in respect of that other proposed connection have been agreed between the relevant parties, or determined by a dispute resolution panel; and
- there is no reasonable basis to conclude that the model previously provided is materially inaccurate, including following commissioning of the connection.
- the proposed system has a signed Offer for Connection with the connecting NSP."

Clean Energy Council:

The following terms are used in the draft determination and either appear inconsistent with the NER or should be defined more clearly:

- **Committed projects**: AEMO has provided a definition of this term which varies from that stated in the NER. To ensure consistency, reference should be made to the NER definition.

WSP:

"Committed Projects" is a defined term in the NER as per clause "11.10A.1 Definitions". Is the intent for AEMO to redefine this term? To ensure consistency and avoid confusion reference should be made to the Rules definition and an extract from the NER (version 105) is provided as follows:

"(a) the project proponent's rights to land for the construction of the project;

(b) whether contracts for the supply and construction of the project's major plant or equipment, including contract provisions for project cancellation payments, have been executed;

(c) the status of all planning and construction approvals and licences necessary for the commencement of construction of the project, including completed and approved environmental impact statements;

(d) the level of commitment to financing arrangements for the project; and

(e) whether project construction has commenced or a firm date has been set for it to commence."

4.1.2 AEMO's assessment

NER definition

The first thing to be addressed is that there is no definition of 'Committed' in the NER that applies to the Guidelines.

Both the Clean Energy Council and WSP point out that a definition of 'committed' can be found in clause 11.10A.1 of the NER.

This definition applies solely for the purposes of the transitional rules in the National Electricity Amendment (Central Dispatch and Integration of Wind and Other Intermittent Generation) Rule 2008. It has no further application.

Furthermore, AEMO is not bound to use a definition that was used for a specific purpose without considering whether it would be suitable for use in the context of the Guidelines.

AEMO surveyed existing uses of the term and, as noted in the Draft Report, it considered the suitability of those other definitions before settling on one that will be used solely in the Guidelines.

Risk of blocked capacity

The underlying issue referenced by Powerlink is the delay in the acceptance of an *offer to connect*, or even a failure to accept such an offer, which has the undesired outcome of 'blocking' *network* capacity.

NSPs can manage this risk by issuing conditional *offers to connect*, namely, offers with a deadline for acceptance. If a *Connection Applicant* does not respond to such an offer to *connect* by the specified deadline, the *network* capacity would be 'released'. AEMO notes that an *offer to connect* under clause 5.3.6 of the NER must remain open for acceptance for 20 *business days*. While extensions of time may be requested by the *Connection Applicant*, the NSP can refuse a request if it has reasonable grounds to do so.

Connection agreement

The proposed additional condition of requiring an executed *connection agreement* would be an artificial threshold, as offers to *connect* under clause 5.3.6(b) must:

- include the *performance standards*;
- include the terms and conditions of the kind specified in schedule 5.6; and
- be capable of acceptance by a *Connection Applicant* so as to constitute a *connection agreement*.

This means, effectively, that agreement on all terms and conditions referred to in schedule 5.6 of the NER needs to have been reached before a *connecting* NSP may issue an offer to *connect*. Schedule 5.6 includes the *performance standards,* and the *system strength remediation scheme*/*system strength connection works*, amongst many others.

Hence, in terms of the technical progression of a project, a requirement for a *connection agreement* to be executed adds little, if anything, to a requirement that an offer to *connect* must have been issued in accordance with clause 5.3.6 of the NER. AEMO has decided to incorporate the requirement for an offer to be issued as one of the criteria for a 'Committed' project.

Application to 4.6.6 Connection under Assessment

Energy Queensland made a similar submission to that of Powerlink Queensland, but without specifying a rationale. It also sought an amendment to the first part of the definition in relation to the 4.6.6 Connection, namely the Applicant's project. The proposed amendment effectively would not make the Applicant's 4.6.6 Connection 'Committed' until the Applicant has accepted an 'Offer for Connection'. This would conflict with the requirement in clause 5.3.4B(a)(2) that a Full Assessment be undertaken after an *application to connect* or submission under clause 5.3.9 has been made.

AEMO has reviewed the use of the term 'Committed' in the Guidelines and can confirm that it is used solely when referring to projects other than the Applicant's, so the first part of the definition that purports to define 'Committed' for an Applicant's 4.6.6 Connection is unnecessary in any event.

Application of the National Electricity Objective

AEMO is concerned by submissions seeking to add to the criteria by which a project might be 'Committed', which would have the effect of ignoring proposals that are at an advanced stage. This has the potential to lead to NSPs conducting many ad hoc *system strength impact assessments*, leading to sub-optimal planning and inefficient outcomes.

While AEMO understands that accounting for nearby proposed *connections* in a Full Assessment prematurely runs the risk that they might not proceed, AEMO considers that a balance must be struck between absolute certainty of a project's proceeding and the benefits of considering the impact of proximate proposed *connections* together.

The value of developing more efficient Mitigation Measures should not be discounted. AEMO should apply the *national electricity objective* in seeking to set a reasonable balance between the prospect of joint assessments that could give rise to more centrally located, efficient and cheaper Mitigation Measures, or the more expensive option of ad hoc Mitigation Measures that address each Applicant's 4.6.6 Connection separately.

4.1.3 AEMO's conclusion

AEMO will amend the definition of 'Committed' as follows:

- By deleting the first part of the definition applicable to the Applicant's project. The circumstances in which a Connecting NSP can commence a Full Assessment are detailed in the new section 3.3 of the Guidelines.
- By inserting a new paragraph in the criteria to include the issue of an offer to *connect*.

4.2 Lack of a unified SCR calculation methodology

4.2.1 Issue summary and submissions

Several submissions raised various issues with the options available to Connecting NSPs in the calculation of the SCR, including the meaning of 'electrically close' *plant*.

Below are relevant extracts from submissions:

Pacific Hydro:

Define Short Circuit Ratio (SCR)

AEMO mentions that the guidelines permit NSPs to use one of four methods of calculating the SCR, based on the CIGRE TB 671. The use of four methods is explained to be due to differences between regions. In this case, it could be specified which method should be used for which region. Pacific Hydro does not believe that it is appropriate to force Participants to join CIGRE or pay fees in order to access the SCR calculation methods. Furthermore, NEM participants should not be asked to accept a technical brochure that is not yet an IEC standard.

AEMO's (sic) states that "No explanation is provided for the view that the methods used for estimating SCRs appear overly conservative." This is difficult to do without having access to the methodology, but reasoning was provided in our submission. These included the deduction of 10% from the SCR value and modelling being performed in a network with the minimum number of synchronous generators online, under the most severe contingency. Each of these points introduces conservatism into the methodology.

…

AEMO considers it would be impractical to provide a definition of 'electrically close'. In the absence of a definition, the term is left too open to interpretation and may introduce further inaccuracy in WSCR calculation when using a calculation method that requires this.

Senvion:

Aggregate Short Circuit Ratio Method

The system strength guidelines do not specify a single method for calculating the aggregate SCR. Thus different TNSPs may use different methods. This is unreasonable; there should be a single method to calculate this, rather than different methods used in different states. These are National Electricity Rules, not state based rules. The assessment should provide consistent results no matter where it is applied in the network.

The Weighed SCR (WSCR, Method 3 from Cigre (sic) 671) is currently being used in some assessment work. This seem to treat all asynchronous generators as if they were connected to the same bus, with no separation between them. It also give (sic) values which are much lower than the traditional SCR calculations.

The Equivalent short circuit ratio (ESCR Method 1) seems to be preferable, since it puts a reduced weight on generators which are far from the generator under consideration and thus have a low effect on the connection point.

Different SCR methods (WSCR/CSCR/ESCR) and Boundaries

The methods do not provide clear guidance as to what boundary should be used to determine the limits of generators which should be included in the calculation and which are excluded. For clarity it is preferable to limit the consideration to generators connected within three busses of the proposed generator. This threshold is commonly used in harmonic studies, and is equally applicable here.

Clean Energy Council:

The following terms are used in the draft determination and either appear inconsistent with the NER or should be defined more clearly:

- **Electrically close existing plant**: The SSIAG states in its relationship with the PSMG that the completion of a Full Assessment depends on the submission of detailed Electromagnetic Transients (EMT)-type models of new or modified connections, and of electrically close existing plant and network facilities. It is unclear what is considered as electrically close. This must be clarified in the PSMG.

SA Power Networks:

Section 4: System strength impact assessment process

AEMO should provide some guidance of what it would consider represents "close electrical proximity".

WSP:

Section 2.5.2: Power System Model Guidelines

"The completion of a Full Assessment depends on the submission of detailed EMT-type models of new or modified connections, and of electrically close existing plant and network facilities."

> This term should be defined as to what is electrically close and what is not as it would otherwise become open to interpretation if applied on a case by case basis. Items that are open to interpretation without a clear engineering basis are likely to result in uncertainty and delays in the connection process.

4.2.2 AEMO's assessment

SCR calculation methodology

AEMO's original intention was for Connecting NSPs to have the flexibility to choose an SCR calculation methodology that suited their *networks*. After considering submissions, however, it might be preferable to specify only one calculation methodology - being the one used for illustration purposes in Appendix A of the Guidelines (the MSCR Method).

Electrical proximity

Specifying the MSCR Method as the calculation methodology also addresses concerns about the need to define 'electrically close' and 'close electrical proximity'. This is because, unlike other aggregate SCR calculation methods, the MSRC Method does not require a decision on which *asynchronous plant* needs to be grouped together.

AEMO has deleted references to electrical proximity in the Guidelines and replaced them with references to the *region* in which the 4.6.6 Connection is situated plus *facilities* in an adjacent *region* if they are likely to have a material impact on the Available Fault Level of the 4.6.6 Connection, which is a matter to be determined by the Connecting NSP.

CIGRE

In response to Pacific Hydro's comment that AEMO should not require that *Registered Participants* join CIGRE or pay fees in order to access the SCR calculation methods, the issue is now redundant as AEMO has specified one methodology that is illustrated with examples in the Appendices.

4.2.3 AEMO's conclusion

The Guidelines will require Connecting NSPs to use the 'MSCR Method', which will be defined by reference to CIGRE TB 671. References in the Guidelines to electrical proximity will be replaced in the Guidelines with a more specific description.

4.3 Risk of delay if the more detailed EMT models are not available

4.3.1 Issue summary and submissions

As with the first issue, this was addressed as a material issue in the Draft Report where AEMO clarified how the Guidelines could be used by way of an example. Further submissions on this issue expressed concern over the lack of specific direction in the Guidelines.

Below are relevant extracts from submissions:

Pacific Hydro:

> In Section 4.2 [of the Draft Report], AEMO concludes that the regulated solution is not warranted as it is possible for connection applicants and NSPs to manage the risk of delay caused by NSPs not having full system models. These delays lead to unnecessary expense for connecting applicants, either due to delaying a project until models become available, or implementing less efficient mitigation methods based on a preliminary assessment. One resolution would be to only enforce these rules once NSPs have the relevant models. Another option would be to use a hybrid modelling method between EMT and the existing RMS model to study the connections of new inverter-based generator (IBG) projects. This would remove the requirement for existing projects to provide PSCAD models, and warrants further investigation.

Pacific Hydro is concerned that AEMO has recently adopted a practice of requesting these highly detailed expensive models for all equipment as a means to solve the "system strength" issue. There is still much debate internationally on the correct way to treat this problem and AEMO has made an unprecedented decision to adopt an expensive, highly detailed modelling method that may or may not prove to be any better than using a hybrid modelling method between EMT and RMS type models.

Regarding PSCAD models from registered participants, it is noted that failure to provide models in due course would be a breach of the NER. On this point, AEMO appears to be reverse engineering an obligation on to the market in a manner that has not been undertaken in the past. It is anticipated that there are likely to be numerous participants who do not hold the detailed control data necessary to make meaningful EMT models. In the case of older wind farms, the data does not exist and in some cases the manufacturer has confirmed that it does not have the expertise to provide such a model. In Pacific Hydro's view, it should be a collaborative approach between AEMO and participants to develop and test these models where relevant data exists. Furthermore, participants may not own or have licence to use AEMO's choice of software. If registered participants are tempted to rush the development of these models in order to avoid penalties this may lead to inaccurate results from the system strength impact assessment.

SA Power Networks:

Where preliminary assessment reveals the need for a "full assessment" to be undertaken, the guidelines suggest that the connection applicant must provide an EMT model to enable the full assessment to be undertaken.

In order to perform this assessment, this relies on the NSP having suitable EMT models of other existing connections; this is unlikely to be the case for existing embedded generators.

Whilst the modelling guidelines and system strength guideline suggest that such existing connections must provide suitable EMT models to the NSP, there is no incentive for existing generators to provide this in a timely manner and no genuine method of enforcement by DNSP, resulting in potentially lengthy delays to the connection applicant's connection process.

In such circumstances, is the NSP entitled to make any assumptions about the likely behavior of these existing connections in order to conduct the assessment? If so, AEMO should provide further guidance on how NSP may proceed with connection applications under such scenarios.

Senvion:

Pacific Hydro has pointed out that projects may be delayed if the NSP cannot provide full system model in PSCAD. In section 4.2.34 of the Draft Determination AEMO suggests that "it is possible for Connection Applicants and NSPs to manage the risk of delay to a connection application process caused by a failure, or delay, in the availability of up-to-date PSCAD / EMTDC models contractually". This is not a reasonable suggestion because proponents do not have the negotiating power to make the NSP compensate them for losses caused by lack of provision of models.

WSP:

Section 4.1.5: Information to be provided with Results of Preliminary Assessment

"(c) the level of modelling detail required for a Full Assessment, particularly of the surrounding network and nearby generating systems or market network service facilities either already connected or to be assessed in parallel;"

Obtaining models of other generating systems to be modelled in parallel can be problematic if the other generator is not willing to share their models. Alternatively, if problems are found with the other generators models, this should not hold up the assessment of the connecting party, else it can cause significant delays to the connecting party where there are multiple projects proposing to connect.

4.3.2 AEMO's assessment

Provision of models vs assumptions

It is in the interests of other *Generators* that NSPs can determine with a reasonable degree of confidence any adverse impact of an Applicant's 4.6.6 Connection on the performance of their own *generating systems*. This means that the impact can be addressed at the expense of the Applicant. This is an incentive on *Generators* and MNSPs to provide their PSCAD™/EMTDC™ models where required for a Full Assessment.

Nevertheless, there will be circumstances where there are genuine difficulties with the provision of PSCAD™/EMTDC™ models related to other, existing *plant* in a timely manner, or at all, so AEMO

considers that NSPs should be permitted to agree with Applicants on the assumptions they can make about other existing *plant* to facilitate timely *system strength impact assessments*, subject to confirmation by AEMO.

Unprecedented requirements

While AEMO agrees that the requirements in the Guidelines are more comprehensive and detailed than for many grids outside of Australia[2], they are not unprecedented. In any case, AEMO does not consider this should be a reason for AEMO to refrain from prescribing them.

AEMO's work in this area is at the cutting edge. AEMO is routinely contacted by foreign system operators on how AEMO is dealing with issues that they are starting to see on their own networks. The *NEM*, unlike most other grids, has issues that require attention today. The approaches AEMO has developed allows that to happen. AEMO's active involvement in international working groups and close collaboration with other system operators means that AEMO will be aware of alternative practices that others may identify in the future. If these are likely to be appropriate for the *NEM*, AEMO will consider adopting them.

Hybrid modelling

Hybrid modelling is not prohibited, as can be seen in section 5.2.1 of the Guidelines, however, AEMO considers that caution should be exercised when adopting hybrid modelling. This approach may be acceptable for conducting *system strength impact assessments* in remote parts of the *network* with no nearby *asynchronous generation*, or for representing a wider *power system* with a higher concentration of *synchronous generating units*. However, the use of hybrid modelling does not give rise to accurate results for assessing adverse system strength impacts and interactions between multiple electrically close *asynchronous generating units*. This is because such interactions predominantly relate to the response of *control systems* associated with each *plant*, and cannot be predicted by RMS modelling, which ignores details of those fast *control systems*.

Lack of data

Pacific Hydro refers to a lack of data to develop PSCAD™/EMTDC™ models of old *plant*.

This issue was addressed in section 4.1.2 of AEMO's Draft Report and Determination on the *Power System Model Guidelines*. AEMO indicated, by way of example, that it may waive the requirement to provide a PSCAD™/EMTDC™ model where *plant* might be based on obsolete technology and the total installed capacity of the same type of *plant* is limited across the *NEM*.

Delays due to unacceptable models for other projects

The concern raised by Senvion was previously addressed in section 4.2.2 of the Draft Report. Concerns about the risk of delays due to unacceptable models being provided for *connection* projects are addressed by the criteria for a project to be considered 'Committed' for *system strength impact assessment* purposes. These require AEMO and the Connecting NSP to have accepted a detailed PSCAD™/EMTDC™ model of that proposed *connection*, meeting the requirements of the *Power System Model Guidelines.*

Additionally, issues with existing *plant* are addressed by permitting Connecting NSPs to make assumptions as discussed above, in the alternative process as set out in *Power System Model Guidelines*, and as discussed in section 4.2 in the Final Report and Determination on the *Power System Model Guidelines*.

[2] Interested parties may review a 2016 assessment of system strength with conditions of high wind generation in the panhandle region of the Texas (ERCOT) power system, available at: http://www.ercot.com/content/news/presentations/2016/Panhandle%20System%20Strength%20Study%20Feb%2023%202016%20(Public).pdf

4.3.3 AEMO's conclusion

Sections 3.3 and 5.2 of the Guidelines have been amended to permit assumptions to be agreed to the extent that the required models of existing *plant* cannot be provided or are inadequate.

4.4 Transition to Final Guidelines

4.4.1 Issue summary and submissions

This is an issue that was referred to as part of Powerlink's submission on the threshold for inclusion of connection projects.

Below are relevant extracts from submissions:

Powerlink Queensland:

> A key concern Powerlink raised as part of the first stage of consultation to the Draft Guidelines was the need for appropriate safeguards to avoid unintended consequences when transitioning to the Final Guidelines. The need for appropriate transitional arrangements is especially critical for projects at advanced 'application' stage and where the proponent is progressing to a Connection Offer under the 'Transitional Arrangements' that were agreed between AEMO, the Australian Energy Regulator (AER) and NSPs on the 15 March 2018.
>
> Under the 'Transitional Arrangements' a proponent can progress to a CAA following commitment to the conditional negotiated Generator Performance Standard (Conditional GPS), inclusive of the first stage of the Full Impact Assessment (FIA) under the Guidelines. The adoption of the Conditional GPS includes:
>
> - Generator and NSP entering into a CAA which commits to the Conditional GPS;
> - completion of the first stage of the FIA using SMIB modelling with the use of an aggregate short circuit ratio accounting for reduced fault levels/system strength due to connection of nearby asynchronous generating systems and compliance studies by the proponent based on scope as agreed by the NSP and AEMO; and
> - commitment to the finalisation of the FIA under the Guidelines at least 3 months prior to the planned commissioning date, with the best information available to the NSP at the time.
>
> Powerlink has over 30 active connection applications in various stages of development. In the absence of further transitional provisions, proponents who fail to reach an agreed CAA by 30 June will face delays. The delays apply to Generators that require a FIA in accordance with the Final Guidelines. The principle cause of the delay is the availability of the necessary network and other machine specific models for the FIA. These delays are not caused by or contributed to by the proponents seeking to connect and are an unacceptable and unavoidable imposition from a market development and regulatory perspective to proponents that have made commercial commitments under very tight time frames.
>
> To address these risks, Powerlink recommends an extension to the 'Transitional Arrangements' negotiated on 5 March 2018 a further period of 3 months beyond 30 June that would apply strictly only to the small group of proponents to whom the 15 March 2018 arrangements apply. All other proponents should be subject to the new arrangements effective from 1 July 2018. Powerlink is not recommending any changes to the alternatives as defined in the 'Transitional Arrangements' and requests that AEMO allow provisions these transitional arrangement within the Final Guidelines.
>
> Powerlink also welcomes AEMO's co-operation in facilitating a forum with the AER Australian Energy Market Committee (sic) and NSPs to discuss an extension to these arrangements as well as other amendments the National Electricity Rules applicable from 1 July 2018.

Energy Queensland:

> Energex and Ergon Energy recommend that consideration is given to transitional arrangements for existing projects that are already significantly progressed as at commencement of the new Guidelines.

Senvion:

> There is no special provision made for projects which are under construction or in the later stages of the connection process.

4.4.2 AEMO's assessment

Existing Applications to Connect

Powerlink's real concern has only become clear in this final stage of consultation, namely that *Connection Applicants* who have submitted an *application to connect* prior to 1 July 2018 should be subject to the Interim Guidelines.

This is not a transitional issue. Which guidelines will apply will be determined by reference to the time at which the relevant assessment commences. There is no need to 'extend' the operation of the Interim Guidelines.

The issues raised by Energy Queensland and Senvion are the same.

Forum

AEMO anticipates that there will be discussions with industry representatives in the near future over these arrangements.

4.4.3 AEMO's conclusion

AEMO has created a new section 3 addressing the application of the Guidelines, to deal with the following issues:

- Commencement of the Guidelines
- Application of the Guidelines to outstanding Connection Enquiries

4.5 Cost vs benefits

4.5.1 Issue summary and submissions

The issue of cost vs benefit in the context of the need for, and implementation of, the Guidelines has been raised by Senvion and obliquely in other submissions.

Below are relevant extracts from submissions:

Senvion:

> **National Electricity Objectives**
>
> The NEO requires that the price of electricity be optimized, as well as the reliability and security of supply. The system strength guidelines impose additional costs on participants by requiring additional modelling, and potentially additional mitigation measures. There is no special provision made for projects which are under construction or in the later stages of the connection process.
>
> ….
>
> **Cost Benefit Analysis and Weak Grid**
>
> As mentioned in the Cigre (sic) TR 671 reference, a weak grid is caused by long transmission lines and designing close to maximum transfer limits. While this sometimes is unavoidable, when interconnecting systems or connect wind farms remotely, it can be avoided within a meshed grid. The draft guidelines mention mitigation measures which may include new transmission lines. The cost benefit analysis of investing in additional equipment vs transmission upgrade or alternative connection points should be provided to market participants. Additional investments needed to actively support stability requires a clear remuneration system to avoid discrimination of different technologies.

4.5.2 AEMO's assessment

AEMO considers that the issue of whether the benefits outweigh the costs associated with the Guidelines has been determined by the *AEMC* in determining to make the Amending Rule. As the *AEMC* states:

> Requiring generators to fund costs associated with their connection would drive generators to connect where it is most efficient, as well as connecting equipment that can operate to low levels of system strength. The Commission considers the framework introduced in the final rule provides connecting parties with the

> appropriate incentives to connect in the most efficient location, resulting in lower costs being passed to consumers through network investments.[3]

AEMO notes that the primary responsibility for maintaining system strength in a *region* rests with the TNSPs who are *System Strength Service Providers*. Determining whether the installation of *network* equipment is the most efficient solution to address poor system strength requires the cost-benefit analysis that is known as the RIT-T. This is a matter that was extensively discussed by the *AEMC* in its Final Determination.

4.5.3 AEMO's conclusion

AEMO has not made any changes to the Guidelines to address the issue of cost vs benefits.

[3] AEMC Final Determination, p63.

5. OTHER MATTERS

5.1 Tardiness of submissions

AEMO notes that most of the submissions received during this consultation were received out of time. Consulted Persons are reminded that, to be 'valid', submissions must comply with clause 8.9(e) of the NER in the case of first stage submissions, and 8.9(i) in the case of second stage submissions. Both provisions are cited below for the sake of completeness:

> (e) To be valid, a submission must be received not later than the date specified in the notice (not to be less than 25 *business days* after the notice referred to in rule 8.9(b) is given).
>
> …
>
> (i) To be valid, a submission invited in a notice referred to in rule 8.9(g)(5) must be received not later than the date specified in the notice (not to be less than 10 *business days* after the publication of the draft report pursuant to rule 8.9(h) or such longer period as is reasonably determined by the *consulting party* having regard to the complexity of the matters and issues under consideration).

AEMO recognises the significance of the new obligations arising from the Amending Rule, and on this occasion considered every submission, even those received significantly out of time, however, this cannot be the norm for consultations. The timeframes for the issue of draft and final reports and consulted documents are tight, and this is compounded where there are mandated deadlines for technically complex documents arising from rule changes. AEMO simply cannot continually assess extensive submissions requesting substantive revisions out of time.

If Consulted Persons consider that the timeframes for the provision of submissions are too short, they are welcome to submit a request to change clause 8.9 of the NER.

5.2 Corrections

AEMO has made several corrections to the Guidelines as follows:

- Improvements to express some concepts more clearly.
- Cross-referencing errors.

For ease of reading, typographical, formatting, and italicisation corrections are not change-marked.

6. DETERMINATION

Having considered the matters raised in submissions, AEMO's determination is to make the *system strength impact assessment guidelines* in the form of **Attachment 1**, in accordance with clause 4.6.6 of the NER.

APPENDIX A - GLOSSARY

Term or acronym	Meaning
Amending Rule	National Electricity Amendment (Managing power system fault levels) Rule 2017 No.10
CIGRE TB 671	CIGRE Technical Brochure TB 671 entitled "Connection of Wind Farms to Weak AC Networks"
DNSP	*Distribution Network Service Provider*
Draft Report	The Draft Determination and Report available at: http://aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/Electricity_Consultations/2018/PSM-draft/SSIAG_Draft_Determination_and_Report_PUBLISHED.pdf
EMT	Electromagnetic transient
Final Report	This document
Full Assessment	The assessment referred to in clause 4.6.6(b)(2) of the NER
Guidelines	*system strength impact assessment guidelines*
Interim Guidelines	Interim *System Strength Impact Assessment Guidelines*, available at: http://aemo.com.au/-/media/Files/Electricity/NEM/Security_and_Reliability/Interim-System-Strength-Impact-Assessment-Guidelines-PUBLISHED.pdf
Mitigation Measure	Either or both of the following (as the context requires): • *system strength connection works* • *system strength remediation scheme*
MNSP	*Market Network Service Provider*
NER	National Electricity Rules
NSP	*Network Service Provider*
Preliminary Assessment	The assessment referred to in clause 4.6.6(b)(1) of the NER
PSMRG	Power System Modelling Reference Group
SCR	Short circuit ratio
TNSP	*Transmission Network Service Provider*
WSCR	Weighted short circuit ratio

APPENDIX B - SUMMARY OF SUBMISSIONS AND AEMO RESPONSES

No.	Consulted person	Issue	AEMO response
1.	Powerlink Queensland, Clean Energy Council & WSP	**Definition of 'Committed'** See section 4.1.1.	See section 4.1.2 & 4.1.3.
2.	Pacific Hydro, Senvion, Clean Energy Council, WSP & SA Power Networks	**SCR Calculation Methodology** See section 4.2.1.	See section 4.2.2 & 4.2.3.
3.	Pacific Hydro, SA Power Networks & WSP	**Risk of delay if EMT models not available** See section 4.3.1.	See section 4.3.2 & 4.3.3.
4.	Powerlink Queensland Energy Queensland & Senvion	**Transition to Final Guidelines** See section 4.4.1.	See section 4.4.2 & 4.4.3.
5.	Senvion	**Cost vs Benefit** See section 4.5.1.	See section 4.5.2 & 4.5.3.
6.	Energy Queensland	**Review** A review of the Guidelines should be undertaken by AEMO twelve months after commencement to ensure they are fit-for-purpose and to address any issues identified by AEMO, NSPs and Proponents in their application.	While AEMO will be monitoring the implementation of the Guidelines, it does not propose to prescribe a formal review.
7.	Energy Queensland	**Provision of Models before Full Assessment** It remains unclear from the Guidelines as to how a proponent will tune their plant adequately before the NSP completes a Full Impact Assessment. Experience in Queensland has shown that considering another generator's plant can have a major impact on an Applicant's tuning. Energex and Ergon Energy are therefore of the view that it would be inefficient for a Proponent to wait until an issue emerges in the Full Impact Assessment before requesting the full models to refine their tuning. Consequently, Energex and Ergon Energy suggest that Proponents should have the ability to negotiate the provision of models prior to the NSP undertaking a Full Impact Assessment (particularly in scenarios where the NSP and Proponent are of the opinion that interactions are likely).	AEMO understands that models will evolve with changes in *plant* design from D to R1 data and so does not propose to prescribe when *plant* needs to be tuned. AEMO also notes that even if all Applicants have access to EMT models of other projects, they are unlikely to reflect site specific requirements at those early stages - with an understanding that such detailed settings can only be determined after the Connecting NSP has conducted a *system strength impact assessment*. The benefit of early access, therefore, is often outweighed by the level of errors associated with those preliminary models. In any case, the Guidelines do not preclude the negotiation suggested, and sharing of EMT models, if agreed.

No.	Consulted person	Issue	AEMO response
8.	Pacific Hydro	**Lack of Accuracy in Network Case Studies** As all models are an approximation, the case studies of the power system are also an approximation; this is why cases are a "state estimated solution". As a network is by and large the biggest influence on any plant, the ability to provide "accurate" generator models is highly problematic. The consequence of this approach is that generators whose models are considered inaccurate because they cannot and do not anticipate the infinite possible responses of the network model could be required to incur considerable amounts of additional cost to address an "inaccuracy" caused by the network model.	AEMO tends to validate *network* models against actual *network* events including major *power system* disturbances, and experience so far consistently indicates a good correlation between measured and simulated responses of the *power system*. As noted in Pacific Hydro's submission to the draft *Power System Model Guidelines*, a *Generator* can apply a playback method as a first stage approach for validating their models while segregating any wider *network* influences. AEMO noted in its Draft Report and Determination on the *Power System Model Guidelines* that a common practice adopted by several major OEMs of *asynchronous plant* is to interface their actual control source codes with the EMT simulation models. No manual intervention is, therefore, required by the model developer so it will not be necessary to anticipate the 'infinite possible responses' of the model.
9.	Pacific Hydro	**Protected Events** The definition according to the National Electricity Amendment (Emergency frequency control schemes) Rule 2017 No. 2 is "A protected event means a non-credible contingency event that the Reliability Panel has declared to be a protected event under clause 8.8.4, where that declaration has come into effect and has not been revoked. Protected events are a category of non-credible contingency event." According to this definition, it appears that any possible event could be declared a protected event, thus possibly making system strength estimates even more conservative. As no "protected events" have been declared by the Reliability Panel, the requirement to study them is even more onerous. For example, a participant may not be studying any now, as none have been declared. Does AEMO therefore exempt that participant from the obligation to ride through a "protected event" if one is declared in the future?	AEMO noted in the Draft Report that no *protected events* have been declared. This means that, at present, *protected events* do not need to be considered when performing a *system strength impact assessment*. Once the assessments are done, that is it. Any required Mitigation Measures will be designed to address an *adverse system strength impact* on the basis of these assessments. Whether a *generating system* should ride through a *protected event* in the future is purely hypothetical at this stage. It will depend on whether there is a *performance standard* applicable to that *generating system* requiring it to ride through *protected events*. AEMO does not consider that the absence of any *protected events* today presents any future issues.
10.	SA Power Networks	**Size of Generator Connections the Guidelines apply to** AEMO should provide greater clarity regarding the size of generator connections these guidelines apply to? For example, do they only apply to connections made under Ch. 5 of the NER or do they also apply to Ch. 5A enquiries? The references to Ch. 5 processes such as suggest they do, however, when read in conjunction with AEMO's power system modelling guidelines which requires the provision of EMT models for systems <5MVA where the aggregate SCR < 10, this becomes less clear. The system strength guidelines suggest a detailed review of strength is not required where the SCR > 3, yet the modelling guidelines state that the connection applicant should provide an EMT model representation of their generating system if it is ≤ 5MVA and the SCR is < 10.	It is not necessary for AEMO to clarify this. The Amending Rule only inserts provisions for *system strength impact assessments* in relation to proposed new and modified *connections* under Chapter 5. Chapter 5A was not amended and contains no such assessment requirements, so the Guidelines cannot apply. The requirement for models under the *Power System Model Guidelines* is a separate issue and should not be conflated with the requirements under these Guidelines. Models are required for a variety of reasons, not just for the assessment of system strength impacts. It is also noted that *Power System Model Guidelines* allow flexibility through the Alternative Process if EMT simulation models are not considered necessary by AEMO and the relevant NSP.

No.	Consulted person	Issue	AEMO response
		This is particularly important for DNSPs who do not normally engage with AEMO on generator connections unless the proposed generator is required to be registered (ie export >5MW).	
11.	Senvion	**Committed Generation and Weak Grid and EMT/PSCAD Models** Independent of EMT/PSCAD studies, it can be assessed, which generator connection capacity would cause the system become (sic) weak and requires specific assessment. Independent of an EMT/PSCAD model it can be further assessed identified, (sic) when nondiscriminative a further connection would lead to a security risk for the network operation. In absence of clear validation methods and dependency of tuning on acceptance of the PSCAD model the condition of proceeding with detailed design for a connection application is causing unduly (sic) delay. Part of the connection process is the submission of controller limitations. This give sufficient insights into the capability of the plant during initial connection process to assess their capability to operate within different grid connections. Initial tuning in a lumped model may not represent the individual wind turbines behavior (sic).	It is not clear exactly what Senvion is proposing, but AEMO understands that the submission of raw data, rather than a model, would be sufficient. If this is the issue, AEMO considers that the provision of data in the absence of models does not permit the assessment of system strength in an environment where Connecting NSPs and AEMO use PSCAD™/EMTDC™ to understand the impacts of interacting *plant*. AEMO reminds Senvion of the clear and well-established model validation requirement set out in *Power System Model Guidelines*.
12.	Clean Energy Council	**Various Definitions** Clarity in the definitions of terms and calculations of values is critical for impact assessments to have validity. It is important that terms are used as defined in the NER, and if not defined in the rules, that they are clear and specific. Similarly, calculations of values must be clearly defined, and their basis justified. Failure to do so results in difficulty and ambiguity for all negotiating parties in the connection process. The following terms are used in the draft determination and either appear inconsistent with the NER or should be defined more clearly: • **Committed projects**: See section 4.1.1. • **Electrically close existing plant**: See section 4.2.1. • **Generating system stability**: When defining and identifying adverse system strength impacts, it should be clarified that the stable operation of a generating system is determined by reference to whether it can meet its performance standards at any level of MW output as documented in its performance standards, rather than at any level of MW. • **Expanded definition of credible contingency events**: AEMO notes that an expanded definition is included for the purposes of the SSIAG provision. Credible contingency events are currently defined in the NER, and it is unclear what the expanded definition is or its justification.	AEMO agrees with the principle expressed in the submission and attempts to define terms as clearly as possible. AEMO's own review has picked up some further changes to the Guidelines in this regard. With respect to each of the terms on which clarification is sought: • **Committed projects**: See section 4.1.2 and 4.1.3. • **Electrically close existing plant**: See section 4.2.2 and 4.2.3. • **Generating system stability**: AEMO considers that the proposed amendment results in an unwarranted restriction of the obligation. • **Expanded definition of credible contingency events**: While *credible contingency event* is defined in clause 4.2.3(b), clause S5.1a.3, which deals with how *power system* stability is determined, expands the term to include 'the application of a fault (other than a three-phase fault) to any part of the *power system* and de-energisation of the faulted element within the allowable clearance time applicable to that element according to clause S5.1a.8'.
13.	WSP	**"SCR" definition** It is not clear why an MVA value is used noting that the MVA value can be in the order of 20% higher than the MW value (for example when applied to Solar PV based generating systems) and NSPs are likely to	AEMO has provided the option because most OEMs of solar *generating plant* use MVA to specify the SCR capability of their *plant*, and if this approach carries over to other types of *plant*, it should be covered by the Guidelines.

No.	Consulted person	Issue	AEMO response
		use the conservative value of MVA in addition to the 10% margin already allowed for. A technical reasoning as to use of the MVA should be provided in order to avoid overly conservative outcomes.	
14.	Clean Energy Council	The following calculations or assumptions should be justified: • **Contingency events**: In identifying whether a generator is unable to meet its proposed performance standards following contingency events, clear guidance is required on dispatch assumptions during contingency events as dispatch patterns will vary according to generator location. It is recommended that the NSP state these assumptions prior to undertaking the Full Assessment. • **Impact on protection systems for a transmission network or distribution network is to be excluded from the system strength impact assessment process**: Consideration of protection elements is an important aspect of assessing the capability of the power system to maintain stable operation. Omitting this detail could be problematic in assessing power system stability.	AEMO agrees that Connecting NSPs should notify Applicants of *dispatch* assumptions during contingency events and has amended section 5.1.5(b) accordingly. The exclusion of the impact on any *transmission network* or *distribution network protection system* is required by clause 4.6.6(b)(3) of the NER.
15.	Senvion	**Section 2: System Strength Framework and Flowchart** The non-aligned grid strength methods and boundaries is exposing the process to high possibility of disputes. Additionally, if there is a dispute, there seems to be the possibility to end up in an endless loop. Some thoughts about an escalation method towards an independent third party should be given to settle the dispute.	The matter raised in the submission is not an appropriate subject for the Guidelines. Dispute resolution is addressed in the NER.
16.	Energy Queensland	**Section 2.4.1: Provision of EMT Models for Full Assessment** It is recommended that the following obligation should be included: "The Applicant is required to undertake and provide all simulations and studies necessary to enable the NSP to assess whether their connecting generator will 'do no harm' and can operate within stability limits."	Clause 5.3.4B of the NER clearly places the obligation to carry out *system strength impact assessments* on NSPs. The Guidelines cannot sanction the delegation of this responsibility – that is a risk an NSP would need to assess.
17.	Senvion	**Section 2.4.1**: **Provision of EMT Models for Full Assessment** Section 2.4.1 states that EMTP models are required for Full Assessment "as these are the only types of models that will result in an accurate assessment." This is not necessarily correct.	AEMO has deleted these words.
18.	SA Power Networks	**Section 4.1.3: Consultation with AEMO** As this is a new requirement under the NER and given that AEMO will not be aware of a connection proposal until now or perhaps otherwise never if the generator connection is not required to be registered under a standing exemption, AEMO should advise to whom or where within AEMO these preliminary assessment results should be sent. It is presumed that this requirement for NSPs to consult with AEMO on the findings of its preliminary analysis only applies to those generator	AEMO has specified a generic email address to which all Preliminary Assessment and Full Assessment results should be sent for the purposes of the required consultation. As noted in response to issue 10, Chapter 5A applications are not subject to *system strength impact assessments*.

No.	Consulted person	Issue	AEMO response
		connection enquiries subject to Ch5 of the NER and does not apply to enquiries made under Ch.5A of the rules. As stated earlier, it would be appreciated if this could be specifically clarified for the benefit of DNSPs who deal with a significant number of generator connection enquiries below 5MW in size.	
19.	WSP	**Section 3.1.3: Generating System Stability** "The stable operation of a generating system is determined by reference to whether it can meet its performance standards at any level of megawatt (MW) output." Suggest replacing "any level of megawatt (MW) output" with "any level of megawatt (MW) output as documented in its performance standards" noting that the performance standards specify minimum and maximum operating levels for various clauses.	AEMO considers that the proposed amendment results in an unwarranted restriction of the obligation.
20.	WSP	**Section 3.2: Identifying an Adverse System Strength Impact** "the inability of existing generating systems to meet any aspect of their performance standards, at any level of MW output of the 4.6.6 Connection;" Connection of a new asynchronous generator will modify the SCR and existing generators typically have performance tuned for a particular SCR. Where retuning of parameters of an existing generating system is required to meet its performance standards due to evolution of the power system either on a daily basis (eg changes in dispatch patterns or network switching) or over the medium term due to new connections / retirements, this process would be problematic in that it would trigger an adverse system strength condition. For example, if the connection reduces the SCR to a value that does not result in instability, the amount of reactive current injected by an existing generating system for a fault is likely to have a larger impact on post fault voltages than with a higher SCR (voltage sensitivity to reactive power changes increases as the system strength declines). Stability could still be met by this existing generator, however will require re-tuning to meet the agreed performance documented in the GPS. This would not necessarily be an adverse system strength impact as the issue can be resolved via re-tuning. One of the ways to overcome this would be if existing generating systems were able to adapt their performance based on SCR variations in order to continue to meet their performance obligations as the network evolves. It would be impractical to continue retune performance of generating systems as the network evolves so AEMO should consider how this issue would be addressed. This capability has existed in SVCs for some time and hence the concept is not a new one for power systems.	What is being proposed is a way of managing the impact of new *connections* by *Generators* with existing *generating systems*. AEMO understands that the tuning and *control system* design practices applied by major OEMs generally include a range of minimum and maximum anticipated system strength conditions, rather than the *control system* being tuned for specific operating conditions and *generation dispatch* patterns. The Amending Rule requires AEMO to declare *three-phase fault levels* at designated *fault level nodes* to be managed by relevant NSPs on an on-going basis. Therefore, if the system fault level drops below the designated level at some *fault level nodes*, the relevant NSP would need to address the shortfalls. AEMO is aware of the concept of automatic gain reduction in SVCs. However, there is very little experience with its use on *generating systems*. In any case, this is not a matter for these Guidelines.

No.	Consulted person	Issue	AEMO response
21.	WSP	**Section 3.2: Identifying an Adverse System Strength Impact** "(b) an inability of the 4.6.6 Connection to meet its proposed performance standards (at all levels of MW output and following contingency events), for network conditions where the three phase fault level continues to be maintained at each fault level node;" Clear guidance is required regarding contingency events and dispatch pattern assumptions as locations electrically distant from fault level nodes are highly sensitive to local network switching conditions and local generation dispatch. We suggest that the NSP state these assumptions prior to undertaking the Full Assessment so that there is transparency in the process.	Agreed. Details of the assumptions made by a Connecting NSP must be provided at the conclusion of both the Preliminary Assessment and Full Assessment.
22.	WSP	**Section 3.2: Identifying an Adverse System Strength Impact – Footnote 21** "Noting the expanded definition of credible contingency events for the purposes of this provision." Credible Contingency is defined in the NER and it is not clear what this expanded definition is. Can AEMO clarify if the intent is to modify the definition in the NER?	See AEMO's response to issue 12.
23.	WSP	**Section 4: System Strength Impact Assessment Process** "As required by clause 4.6.6(b)(3) of the NER, the impact on any protection system for a transmission network or distribution network is to be excluded." We note and agreed on the importance of protection in assessing power system stability and this is reflected in the revised Model Guidelines. However, it isn't clear why this has been excluded (noting it is excluded in the NER) and is in contrast to AEMO's model guidelines which states the requirement to include generating system protection detail. Consideration of protection is an important aspect of assessing the capability of the power system to maintain stable operation and omitting this detail could be problematic in assessing power system stability.	Clause 4.6.6(b)(3) of the NER is explicit in this regard. AEMO is not permitted to include in these Guidelines an item that is very clearly excluded by the NER as a relevant consideration for *system strength impact assessments*. The Guidelines are being made to be used for a very specific purpose, namely by NSPs to assess whether a 4.6.6 Connection will have an *adverse system strength impact*. By contrast, the *Power System Model Guidelines* are to be made under clause S5.5.7 of the NER and apply generically to the provision of models and related information for AEMO to assess a range of *power system* stability issues. For these purposes, AEMO will need to have models of *generating systems*, and relevant *protection systems* for *generating systems* and *network* elements.
24.	Clean Energy Council	**Section 4.1.2: Preliminary Assessment** The CEC welcomes the approach requiring NSPs to notify the Applicant of the method the NSP will use for the Preliminary Assessment and how the method will be implemented. Information provision in relation to the results of the Preliminary Assessment is important, and it would be useful to include a requirement that the methods and assumptions used to undertake the studies are shared with the proponent.	Noted, however, there is be no further need for this in light of AEMO's decision to prescribe the MCSR Method.
	WSP	**Section 4.1.2: Impact Assessment** "Prior to undertaking a Preliminary Assessment, the NSP must notify the Applicant of the method the NSP will use for the	Noted.

No.	Consulted person	Issue	AEMO response
		Preliminary Assessment, and details of how the method is to be implemented." We support this approach.	
25.	WSP	**Section 4.1.2: Impact Assessment** "These studies indicate that FACTS devices, whether within a generating system or in the network, will not be included in SCR calculation methods. Notwithstanding this, if the change in voltage at the busbar of interest is more than 3% due to FACTS devices, an NSP may require a Full Assessment to identify possible adverse interactions between asynchronous generating systems and FACTS devices." We suggest that the NSP should advise if this is the case in their response in order to ensure transparency for the Applicant.	Agreed.
26.	WSP	**Section 4.1.5: Information to be provided with Results of Preliminary Assessment** For clarity, the NSP should advise how much of the NSP network is intended to be modelled and where the rest of the network can be represented by an equivalent source and how this source should be represented. We suggest adding "Committed" before "generating systems." for the sake of clarity.	AEMO has included a requirement for more granular detail on the *network* to be modelled. The second issue has been addressed differently to the manner suggested because the references to *generating systems* etc is to both existing and Committed.
27.	Energy Queensland	**Section 4.1.5: Information to be provided with Results of Preliminary Assessment** Recommend that section 4.1.5(d) should be deleted. This amendment is necessary due to the fact that detailed information required to undertake an assessment of adequacy may not be known or available at the Preliminary Assessment stage.	This assessment can be done by comparing available system strength at the *connection point* against the system withstand capability of the 4.6.6 Connection without the need for detailed data. AEMO agrees, however, that in some circumstances such an assessment cannot lead to definite and concrete conclusions, and has therefore deleted section 4.1.5(d).
28.	Clean Energy Council	**Section 4.2: Full Assessment** The detail provided on the Full Assessment process in the SSIAG is valuable for allowing visibility of requirements for industry. The CEC welcomes the consideration of control system and protection system representation in EMT-type models. However, it is preferable that all terms are clear for the benefit of all negotiating parties. The Assessment stages should be clear that reference to the generating systems modelled refers to committed generating systems only. It would also be beneficial to be provided detail on when stability impact assessments are being undertaken, and what specific power quality issues will be expected to have an impact on asynchronous generator stability as this has not been defined.	Section 5.2.2 of the Guidelines discusses what specific power quality issues will be expected to have an impact on *asynchronous generating unit* stability to be studied as part of a Full Assessment. The data requirements for a Full Assessment are to be specified by the Connecting NSP when providing the results of the Preliminary Assessment and new section 3.3 and the amended section 5.1.5 reflect this. In relation to the Connecting NSPs' capability to provide the relevant *network* information in EMT-type software packages, there is no difference in the level of *network* data required whether the analysis is conducted in EMT, RMS or conventional power quality analysis tools. The use of EMT models for power quality analysis does not require EMT models of all *network* elements. Such an approach relies on EMT models of adjacent *connections* as required for contingency-induced stability impact assessments under section 5.2.1 of the Guidelines, and harmonic

No.	Consulted person	Issue	AEMO response
		At both stages of the Assessment process, it is important that the SSIAG provide a clear definition and statement of data and information that is required by the parties. The CEC does not support the approach to conduct harmonic assessments in EMT-type models as part of the connection application. It is not demonstrated that NSPs will have the capability to provide the relevant network information required in EMT-type software packages.	impedance polygons of the wider *network*. Both types of data are necessary for other aspects of impact assessments even if harmonic assessment is to be conducted in a non-EMT platform. Changes have been made to the Guidelines to clarify that the use of EMT modelling undergoing *control system* induced stability impact assessment is not mandatory for all applications. However, it is recognised that under certain circumstances associated with the susceptibility of *asynchronous plant's control system* to power quality issues, only EMT models would give rise to accurate results, whereas conventional power quality analysis tools do not indicate a problem.
29.	SA Power Networks	**Section 4.2: Full Assessment** Where a full assessment using EMT models is required to facilitate a generating system connection to the distribution network, will AEMO or the relevant upstream TNSP be required to provide a suitable "lumped network model" EMT representation of the upstream network to the DNSP?	Yes, it is expected that either the TNSP or AEMO will provide this. AEMO has amended new sections 5.1.2 and 5.2.1(a) to reflect this.
30.	WSP	**Section 4.2.2: Control System Induced Stability Impact Assessment** "The methodology discussed below is not aimed at replacing or replicating conventional power quality studies conducted by the Connection Applicant, but to allow the relevant NSP to identify power quality issues that can manifest themselves into system stability concerns and an adverse system strength impact." AEMO should state the specific power quality issues which are expected to have an impact on synchronous generator stability as it is not stated in the document. Understanding the nature of the power quality issues would allow the applicant to ensure this is not a problem prior to making an application and address issues up front and save time for all parties involved. Furthermore, we cannot understand why AEMO have adopted an approach to carrying out harmonic assessments in an EMT-type program as part of the Connection Application for the reasons mentioned below.	Refer to AEMO's response to issue 28.
31.	WSP	**Section 4.2.2: Control System Induced Stability Impact Assessment** "A polygon (usually with ten vertices) that encloses all the remaining R-X values is defined." It should be noted that construction of polygons does not allow calculation of Voltage Total Harmonic Distortion (THDv) which is a key metric in assessing the impact of voltage distortion on Phase Locked Loop (PLL) controls which directly impacts the ability of inverter connected generators to maintain stable operation.	Although this is a fair comment, it runs counter to others made by WSP in the context of the *Power System Model Guidelines*, and issue 30. The earlier comments by WSP indicate a view that the use of EMT modelling is unnecessary. However, this comment casts doubt on the adequacy of widely used approaches as indicated, alluding to the need for EMT analysis.

No.	Consulted person	Issue	AEMO response
32.	WSP	**Section 4.2.2: Control System Induced Stability Impact Assessment** "Depending on the level of calculated harmonic voltages, and the position of individual harmonic impedances within the R-X plane, the NSP undertaking system strength impact assessment may advise the Applicant of the need for proceeding with second stage based on detailed time-domain analysis as discussed below." Can AEMO advise at what level the second stage is to be triggered? That is, is it when the Automatic Access standard or the Minimum Access Standards for harmonic voltage emissions cannot be met? This is not clear and can lead to uncertainty. It should be noted that at the Connection Application stage detailed balance of plant (ie collector system) information is not available and this information is only available following detailed design (ie months after a connection agreement is executed). In which case this assessment will not be possible. Given the significance of the collector system on the results and on the frequency dependent impedances, this assessment would not be possible at this stage. It should also be noted that where there is an existing resonance in the system (without the proposed connection), the connecting party should not be held responsible for resolving the existing issues due to the network. Furthermore, a harmonic filter would significantly change frequency dependent impedance characteristic and thus this assessment invalidated if / when the harmonic filter design is completed.	A criterion has been included in the Guidelines as to when the Full Assessment based on time-domain EMT analysis may be necessary. AEMO or a Connecting NSP would not permit fundamental changes to the basic design without re-starting the assessment. Until the basic design is completed, the Connecting NSP would not be able to fully assess the *application to connect* and the Applicant would not have *performance standards* to include in the *connection agreement*. The basic design should define the major items of primary *plant*. AEMO agrees that power quality studies generally require a detailed representation of individual feeders and associated cables. For this reason, AEMO is aware that power quality studies are usually carried out by the Applicant a few weeks after the dynamic analysis. However, both studies are key components in developing *performance standards*. All *networks* can have resonances. New or modified *connections* are not required to "resolve existing issues" as harmonic resonances always exist and cannot be removed. However, a new or modified *connection* must demonstrate compliant performance in the presence of harmonic resonances in the *network* by limiting the amount of current injected into those resonances. Harmonic filters are part of the primary *plant* and their design should be completed before an *application to connect* is submitted. Any changes they will have on frequency dependent impedance characteristics of the *network* should be reflected in the model and data submitted under the Guidelines.
33.	WSP	**Section 4.2.2: Control System Induced Stability Impact Assessment** "A 4.6.6 Connection must operate satisfactorily in the presence of a specified level of power quality (as determined by the NSP) at the connection point where power quality constitutes of harmonics, flicker and unbalance. The level of susceptibility of inverter controls to power quality may vary depending on the system strength" S5.1A.6 of the NER requires harmonic voltage distortion levels to be less than the "the "compatibility levels" defined in Table 1 of Australian Standard AS/NZS 61000.3.6:2001". It also requires NSPs to establish "Planning Levels" as per the same standard and share the planning level as per S5.1a.6(a) of the NER. AEMO has not disclosed the problems expected which are attributed to harmonic distortion on stable operation however it is understood to be the potential inability of inverter Phase Locked Loop (PLLs) to track voltage on highly distorted voltage waveforms (harmonics). A more efficient approach would be to establish a plant standard such that inverter based generation is able to operate stably up to the	It is outside the remit of these Guidelines to set out *plant* standards. On the certainty that NSPs will have this *frequency* dependent network information available, as noted in AEMO's response to issue 28, the level of information required will not vary whether EMT or other types of simulation tools are used. On whether such information is readily available by NSPs, the method described in the Guidelines was contributed by TNSPs. The Guidelines have undergone two rounds of consultation, and no DNSP has raised concerns on their ability to conform to the proposed approach.

No.	Consulted person	Issue	AEMO response
		Compatibility Levels at the generating unit terminals, or Planning levels at the generating system connection point. "These studies will also require suitable models for the connecting network implemented in the same EMT-type simulation software package." We note that this requirement is specifying the use of a specific software package to carry out harmonic studies when such studies can be carried out in other software packages when it comes to computing harmonic voltage distortion. It is also noted that this requires detailed network information to derive the frequency dependent impedances of the network for various operating scenarios. This information (including polygons) is not readily available by all NSPs in the NEM as of the date of this submission (nothing that DNSPs are even less likely to have this information). What certainty is there that NSPs will have this frequency dependent network information available in their EMT-type software package to carry out this assessment?	
34.	SA Power Networks	**Section 4.2.5: Sole or Multiple Full Assessments** Can AEMO explain why NSPs can't simply perform assessments on a "first come, first served" basis depending on commitment status? Many generation proposals received by DNSPs are highly speculative in nature which many not proceeding to the Application to Connect phase.	There is no requirement to perform an assessment of multiple 4.6.6 Connections at once; it is an option.
35.	WSP	**Section 4.3.2: Contingency Events** "In a part of the network where certain multiple contingency events have been or can be temporarily reclassified as credible contingency events, for example multiple line trips due to lightning, stability for these events should be considered." The term 'can be' could be open to interpretation and we suggest removing it for the sake of clarity.	Agreed.
36.	Pacific Hydro	**Section 6: Mitigation Measures** AEMO concludes that it is up to NSPs and Applicants to choose the most efficient mitigation measures. Where PSCAD network models are unavailable, and mitigation measures are being based on a preliminary impact assessment, this is likely to result in a less efficient mitigation solution. It may be that the only option for a connection applicant is to proceed with a less efficient mitigation method rather than delay the project while waiting for the PSCAD models to become available. It may be appropriate to have incentives and requirements for NSPs (and applicants) to collaborate to find the most efficient solution when several applicants are proposing to connect in the same area.	In the absence of any concrete proposal to 'incentivise' the search for the most efficient solution, AEMO cannot comment on this aspect of the submission. The AEMC Final Determination described in detail how the Amending Rule would facilitate the efficient maintenance of system strength. In the Guidelines, AEMO has sought to promote efficiency by proposing the assessment of multiple 4.6.6 Connections, but not all NSPs are enthusiastic.[4] Certainly, Applicants could take the initiative if Connecting NSPs are reluctant to approach other applicants.

[4] See issue 34.

No.	Consulted person	Issue	AEMO response
37.	SA Power Networks	**Section A.2.2** Referring to example 2 where the addition of an asynchronous generator at bus N1 causes a significant reduction in available fault level (AFL) at bus N3, AEMO should provide guidance as to either the recommended level of AFL to be maintained (ie headroom) or a maximum % change in AFL that it would deem to be unacceptable at a connection bus (or nearby bus) due to the connection of any new asynchronous generation source without the performance of detailed studies.	CIGRE TB 671 makes it clear that the calculation methods are screening tools. If these screening tools highlight system strength issues, the *power system* should be studied with a detailed PSCAD™/EMTDC™ model. The chosen method is conservative and assumes a worst-case, namely, that nearby *asynchronous generating systems* are of the same design and have the same performance. This results in the fault levels of *asynchronous generating systems* producing a high total *synchronous* fault level requirement. As long as the AFL remains positive, PSS®E studies should suffice.
38.	Senvion	**SCR Terminology** The SCR for wind farms or wind turbines is currently understood as the ratio of the fault level (MVA) divided by the nominal rating of the connecting power (MW). Cigre Technical Report 671 introduced new terminology and definitions of that ratio and interpretations. These two significantly different interpretations of the SCR ratio is (sic) not clearly stated or identifiable. The first most common use for SCR is for Protection design. Fault level at a particular place will increase as more fault contributing generators or machines are connected. Full inverter connected technologies are, due to their design and cost benefit analysis, contributing less fault to fault current than synchronous machines. This impact can be changed, if a market for fault contribution is created justifying investments in design. The second interpretation relates to control stability of the generator. This is very different consideration to the to the fault contribution. As indicated in the Cigre TR 671, it relates to sharing of the grid strength. Thereby the key point is the 50Hz grid impedance seen from the control system. This can be derived from the fault level. To prevent confusion between these two meanings they must have different names. Senvion requests that the guidelines consistently use the phrases “Aggregate Short Circuit Ratio”, and ASCR as the acronym when discussing control stability.	AEMO agrees that the key relevance of SCR is to provide an early indication of system stability issues, including contingency induced system stability impact and control system induced system stability impact as discussed in the Guidelines. As discussed in response to other submissions, the Amending Rule explicitly excludes consideration of any adverse *protection system* impacts. The first aspect mentioned by Senvion is, therefore, not relevant in this context.