Our ref: AEMO System Strength and Model Guidelines Submission - 30 May 2018.docx

By email
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31 May 2018

Public

Australian Energy Market Operator (AEMO)
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Dear AEMO

Combined Submission – Power System Model Guidelines & System Strength Impact Assessment Guidelines

WSP (formally Parsons Brinckerhoff / PB Power) is an international consultancy and has an overall interest in the efficient and effective management of the Australian power system and appreciates that this requires careful coordination between both proponents and network service providers / operators.

We understand that the changing generation mix with increasing levels of inverter connected generation and decreasing system strength present new challenges in terms of operating and maintaining a stable power system and to this extent support AEMO's implementation of the revised Power System Model Guidelines and System Strength Impact Assessment Guidelines.

It is also important to understand the implications of these requirements on the National Electricity Objective (NEO) and that the requirements are based on sound engineering reasoning such that only the information required to address engineering issues are required to ensure efficient investment in the industry.

WSP do not represent any stakeholders or their views whether they be proponents, network service providers / operators and the comments provided below are provided in this context.

Yours sincerely

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SYSTEM STRENGTH IMPACT ASSESSMENT GUIDELINES

TABLE 1 – GLOSSARY OF TERMS AND ABBREVIATIONS

"Committed" definition

"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."

TABLE 1 – GLOSSARY OF TERMS AND ABBREVIATIONS

"SCR - Short circuit ratio. The synchronous three phase fault level in MVA at the connection point divided by the rated output of the generating unit or generating system (expressed in MW or MVA, at the connecting NSPs' discretion) (as applicable)."

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 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.

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.

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.

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.

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.

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?

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.

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 Preliminary Assessment, and details of how the method is to be implemented."*

We support this approach.

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.

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.

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.

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.

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.

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.

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 Network Service Providers 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 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?

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.

6.3.2 PRE-CONNECTION MODEL CONFIRMATION

> *"Depending on the expected impact of the plant on the power system, pre-commissioning model confirmation results may be required before the connection can proceed" (Footnote 19)*

To provide certainty to OEMs and connecting parties, AEMO should provide clear guidelines as to when model confirmation tests are required.

> *"Results obtained from off-site tests or factory tests may be used for model confirmation tests. Another approach adopted by power system equipment manufacturers is Hardware in Loop (HIL) testing to simulated Disturbances well before plant undergoes on-site commissioning and R2 model validation."*

The requirement to carry out these test on actual equipment based on the items above is likely to be either impractical (eg simulating an equivalent low SCR at the unit terminals) or costly resulting in barriers to entry. Having to re-run these assessments to carry out actual tests in the factory (or HIL testing) on each revision of the design/rating is also likely to result in additional time and cost. Have AEMO consulted with OEMs to understand their capability to carry out such testing? We note that only three OEMs have provided feedback to AEMO as part of this consultation process.

4.3 RMS AND EMT STABILITY MODEL REQUIREMENTS

> *"Relevant protection relays must be included in the model, explicitly where practically possible".*

We support the importance of modelling protection elements, however note that the System Strength Impact Assessment Guidelines exclude the requirement to consider transmission or distribution network protection elements and it is not clear why AEMO have excluded this.

4.3.3 RMS MODEL-SPECIFIC REQUIREMENTS

> *"Models must be rigorously tested within a NEM-wide simulation for integration compatibility for large-scale power system studies. Experience has shown that SMIB simulations do not always reveal new models' adverse interactions with other models in the system;"*

Meeting the requirements of these guidelines would typically be the responsibility of OEMs and it is noted that NEM models are only available to Intending or Registered Participants. OEM's typically do not fit into either of these two categories so can AEMO advise which OEMs would be able to achieve this and what the extent of the studies are?

The requirement for extensive assessment on a NEM model is likely to result in increased cost, complexity and barriers to entry for OEMs who are not able to access NEM models or undertake such studies.

4.3.4 EMT MODEL-SPECIFIC REQUIREMENTS - HARMONICS

> *"have the full representation of switching algorithms of power electronic converters for power system harmonic studies"*

Harmonic measurement requirements are usually stipulated in equipment standards (eg IEC 641400-21 for wind turbines) hence it is not clear why this is this is required as part of an EMT model which would require the use of the EMT software package to carry out a complete harmonic assessment. Why do AEMO feel that harmonic assessments are best carried out in an EMT type package such as PSCAD?

4.3.4 EMT MODEL-SPECIFIC REQUIREMENTS – MULTIPLE VOLTAGE DISTURBANCES

> *"The EMT model provided must account for the most restrictive electrical, mechanical, or thermal protection of the plant with respect to multiple voltage Disturbances in quick succession, and calculate dynamically and accumulatively the impact of multiple voltage Disturbances, including but not limited to the following factors."*

We understand AEMO's concern around the capability to ride through multiple disturbances. However, believe that assessing this through EMT modelling may not be most efficient method.

Instead, we suggest specifying a plant standard and have this demonstrated as part of the type testing certification process or routine testing for the equipment. This would save a significant level of modelling effort (both in implementing this in the model as well as verifying it through studies).

Alternatively, a statement from the supplier with supporting technical information would be a more practical approach.

We note that adding these requirements to plant standards / type testing is likely to add additional costs for OEMs and in turn consumers, however would provide a more holistic solution and give certainty to AEMO that performance can be demonstrated in the field.

4.3.5 ACCESSIBLE VARIABLES

> *"Additional alterable variables may be required by AEMO or the NSP to undertake full stability impact assessment as described in the system strength impact assessment guidelines. For example, proportional and integral gains for inner/outer current/voltage control loops (including PLL, DC link current and voltage control, and any other control loops which can have a system strength impact). These variables can be adjusted by means of applying a real number multiplier if the actual values of these gains are preferred to remain black-boxed."*

This requirement (underlined section of above) is open ended and we suggest removing these words or stating explicitly what is required to provide certainty to all parties.

4.3.9 RMS MODEL FORMAT

> *"RMS models submitted to the connecting NSP must be compatible with the software package nominated by the NSP where an NSP uses a different RMS-type simulation tool, such as DIgSILENT Power Factory. RMS models should not have dependencies on additional external commercial software".*

We suggest that the requirement to provide models in a different software package nominated by the NSP should be optional and only if such a model exists by the OEM and in the correct version.

Maintaining models in multiple software packages can be problematic in terms of:

1. The costs associated with creating and maintaining models for multiple packages
2. Demonstrating that the two models have the same level of performance between the two packages
3. Different NSPs may utilise different software packages (and different versions) which would require OEMs to maintain models for all the various NSPs across the NEM (DNSPs as well as TNSPs)

4.4 CONVENTIONAL EMT MODEL REQUIREMENTS – GENERATOR (APPLICANT PROVIDED)

> *"Major auxiliary loads including large fans and pumps greater than 1 MW each. The information provided should include the size and number of motors, their inertia, and operational reactances and time constants, and whether directly connected or interfaced via a variable speed drive.*
>
> – *Including details of the transformers that supply the auxiliary loads."*

Could AEMO state why details of plant auxiliaries are required to be modelled in detail? Availability of EMT models from OEMs of Variable Speed Drives (VSDs) or soft starters is likely to be problematic (ie unavailable or not validated models). Have AEMO consulted with these suppliers as part of this process? This information is not usually available from these OEMs.

4.8.3 UPDATES TO ACCOUNT FOR LATER VERSIONS OF SIMULATION TOOLS

> *"However, if AEMO or the NSP deem it necessary that a later version of a simulation tool is required to undertake studies, and an Applicant's existing model no longer functions correctly in the later version of the simulation tool, an update to the Applicant's model is required to provide compatibility with the later version of simulation tool. This model update is required from the Applicant without cost to AEMO or the NSP. These updates may be required at any point in the life of the plant."*

It should be noted that AEMOs decision to change software versions is out of the control of Applicant for plant that is already connected. This could result in significant time and cost to Applicants especially given the 20 to 30 year life of a project and the costs (both direct and indirect) associated with demonstrating the accuracy of updated models.

6.3.3 POST-CONNECTION MODEL VALIDATION (R2) – TABLE 5

> *"A. If harmonic analysis tool fails to provide the required accuracy".*

Accuracy of harmonic assessments is highly dependent on the network frequency dependent impedances provided by the NSP and not necessarily a limitation of the harmonic assessment tool. There are multiple software packages that can carry out harmonic assessments (eg DIgSILENT PowerFactory, PSS-SINCAL etc) hence it is not clear why AEMO are mandating the use of an EMT tool (including requirements for an EMT model to have harmonic related information). It would be good if AEMO can clarify this.

APPENDIX C. MODELLING COMPONENT REQUIREMENTS – C.2 WIND GENERATION

> *"Winding ratios of VTs and CTs feeding protection mechanisms must be provided".*

It is noted that final selection of protection CT taps is often subject to detailed design and not available until the R1 stage.

C.6 SYNCHRONOUS MACHINES AND GENERATORS – EMT MODELS FOR TRANSIENT STABILITY STUDIES

It is not clear why AEMO require EMT models for synchronous plant. Clarity on the requirement for this flagged both by other submissions as part of the consultation process (GE submission) as well as part of the advice to the AEMC by their consultant and are yet to be addressed by AEMO (https://www.aemc.gov.au/sites/default/files/content/ce6543aa-7b77-4105-8bc8-29670c078442/AECOM-report-EMT-and-RMS-Model-Requirements.pdf).