POWER SYSTEM MODEL 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 on the development of the *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet* under the National Electricity Rules (**NER**).

The National Electricity Amendment (Generating System Model Guidelines) Rule 2017 No.11 (**Amending Rule**) will commence on 1 July 2018. Clause S5.5.7 in the Amending Rule requires AEMO to *publish* the *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet* in accordance with the *Rules consultation procedures*.

AEMO commenced the consultation on 5 March 2018 by publishing draft Guidelines and an Issues Paper, and called for submissions. AEMO received nine submissions in response and responded to those in the Draft Determination and Report published on 14 May 2018. Also published was a notice of second stage of the consultation, calling for submissions to be received by 29 May 2018.

A total of five submissions were received, only one of which was valid, however, AEMO considered all of them. The material issues raised in these submissions concerned:

1. **The costs of compliance compared with the benefits** – AEMO considers that the benefits far outweigh the costs of compliance even if only one more *black system* can be prevented as a result of the availability of better *plant* models. Any arguments as to the cost of compliance (in the order of several tens of thousand dollars) should be weighed against the cost of major events, such as *black system* events, other *major supply disruptions*, and involuntary *load shedding* that could occur due to the inability of deficient or inaccurate simulation models to assist in predicting and mitigating *power system security* concerns. Moreover, AEMO has exempted owners of small *plant* from the requirements and has provided for a process whereby, if justified, requirements can be varied on an ad hoc basis.
2. **The timing for the provision of models** – As AEMO explained in the Draft Report, the deadlines for providing models are set in the NER, not by AEMO in the Guidelines.

After considering the submissions received, AEMO's determination is to make the *Power System Model Guidelines, Power System Design Data Sheet, Power System Setting Data Sheet,* NSCAS Tender Guidelines and *SRAS Guideline* in the form published with this Final Report.

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1. STAKEHOLDER CONSULTATION PROCESS

As required by clause 5.5.7 of the NER, AEMO is consulting on *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet* in accordance with the Rules consultation process in clause 8.9.

AEMO's consultation milestones are outlined below:

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

The publication of this Final Report marks the end of the consultation.

A glossary of terms used in this Final 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 S5.5.7 of the NER to develop and *publish* the *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet*. Clause S5.5.7 provides additional guidance to AEMO by detailing the content of these documents and the matters AEMO must take into consideration when developing these.

The relevant requirements are detailed below for the sake of completeness.

2.1.1 Description

Clause S5.5.7(a) describes each of these documents and their use at a high level:

(1) a *Power System Design Data Sheet* describing, for relevant *plant technologies*, *plant* design parameters including *plant* configurations, impedances, time constants, non-linearities, ratings and capabilities to be provided under clauses 3.11.5(b)(5), 3.11.9(g), 4.3.4(o), 5.2.3(j), 5.2.3(k), 5.2.3A(a), 5.2.4(c), 5.2.4(d), 5.2.5(d), 5.2.5(e), 5.3.9(b)(2), S5.2.4, S5.3.1, S5.3a.1 and this schedule 5.5;

(2) a *Power System Setting Data Sheet* describing, for relevant *power systems* and *control system* technologies, the *protection system* and *control system* functions and their settings, including configurations, gains, time constants, delays, deadbands, non-linearities and limits to be provided under clauses 3.11.5(b)(5), 3.11.9(g), 4.3.4(o), 5.2.3(j), 5.2.3(k), 5.2.3A(a), 5.2.3A(b), 5.2.4(c), 5.2.4(d), 5.2.5(d), 5.2.5(e), 5.3.9(b)(2), S5.2.4, S5.3.1, S5.3a.1 and this schedule 5.5; and

(3) *Power System Model Guidelines* describing, for relevant *power system* technologies at the *transmission system* and *distribution system* level, *AEMO's* requirements when developing mathematical models for *plant*, including the impact of their *control systems* and *protection systems* on *power system security* to be provided under clauses 3.11.5(b)(5), 3.11.9(g), 4.3.4(o), 5.2.3(j), 5.2.3(k), 5.2.3A(a), 5.2.3A(b), 5.2.4(c), 5.2.4(d), 5.2.5(d), 5.2.5(e), 5.3.9(b)(2), S5.2.4, S5.3.1, S5.3a.1 and this schedule 5.5.

2.1.2 Purpose

The purpose of the *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet* is detailed in clause S5.5.7(b), which AEMO must have regard to when developing these documents:

(1) allow *plant* and equipment to be mathematically modelled by *AEMO* with sufficient accuracy to permit:

  (i) the *power system* operating limits for ensuring *power system security* to be quantified with the lowest practical safety margins;

  (ii) the assessment of proposed *negotiated access standards*;

  (iii) settings of *control systems* and *protection systems* of *plant* and *networks* to be assessed and quantified for maximum practical performance of the *power system*; and

  (iv) the efficient procurement of *system restart ancillary services* and *network support and control ancillary services*; and

(2) identify for each type of data its category in terms of clause S5.5.2.

2.1.3 Additional Matters for Consideration

Additional matters AEMO must take into consideration are detailed in clause S5.5.7(c) as follows:

(1) have regard to the reasonable costs of efficient compliance by *Registered Participants* with those guidelines and data sheets compared to the likely benefits from the use of the information provided under the guidelines and data sheets;

(2) have regard to any requirements to protect the intellectual property and confidential information of third parties, including where those third parties are not *Registered Participants*; and

(3) have regard to *Distribution Network Service Providers'* and *Transmission Network Service Providers'* requirements for data and modelling information that is reasonably necessary for the relevant provider to fulfil its obligations under the *Rules* or *jurisdictional electricity legislation.*

2.1.4 Content

The content of the *Power System Model Guidelines* is specified in clause S5.5.7(b1) as follows:

(1) the information, including the types of models, that:

(i) *Generators* must provide under clause 5.2.5(d), clause 5.2.5(e), clause 5.3.9(b)(2), clause S5.2.4 and clause S5.5.6;

(ii) *Network Service Providers* must provide under clause 4.3.4(o), clause 5.2.3(j) and clause 5.2.3(k);

(iii) *Network Users* must provide under clause 5.2.4(c), clause 5.2.4(d) and clause S5.3.1(a1);

(iv) *Market Network Service Providers* must provide under clause 5.2.3A(a), clause 5.2.3A(b) and clause S5.3a.1(a1);

(v) prospective *NSCAS* tenderers must provide under clause 3.11.5(b)(5); and

(vi) prospective *SRAS Providers* must provide under clause 3.11.9(g);

(2) the model accuracy requirements that are applicable to each type of model provided, as well as the types of *generating systems* and *plant* and equipment that the model accuracy requirements apply to;

(3) when information to which the *Power System Model Guidelines* relates must be provided;

(4) a process to be followed in circumstances where a person is unable to provide information required to be provided under clauses 3.11.5(b)(5), 3.11.9(g), 4.3.4(o), 5.2.3(j), 5.2.3(k), 5.2.3A(a), 5.2.3A(b), 5.2.4(c), 5.2.4(d), 5.2.5(d), 5.2.4(e), 5.3.9(b)(2), S5.2.4, S5.3.1, S5.3a.1, S5.5.6, schedule 5.5 or as otherwise required by the *Power System Model Guidelines*, *Power System Design Data Sheet* or *Power System Setting Data Sheet*;

(5) guidance on the factors that *AEMO* will take into account when determining the circumstances under which *AEMO* will request information to be provided, including the *power system* conditions that necessitate the usage of a certain type of model in order to achieve the desired level of accuracy;

(6) the format in which information must be provided and any material *AEMO* requires to assess the accuracy of information provided to it; and

(7) the circumstances in which model source code is required to be provided.

2.2 Context for this consultation

The National Electricity Amendment (Generating System Model Guidelines) Rule 2017 No.11 (**Amending Rule**) will commence on 1 July 2018.[1] The transitional provisions in the Amending Rule require that AEMO commence this consultation considering the Amending Rule.

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

The *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet* represent an evolution from the *Generating System Model Guidelines, Generating System Design Data Sheet* and the *Generating System Setting Data Sheet*, respectively.

2.3 First stage consultation

AEMO issued a Notice of First Stage Consultation on 5 March 2018 along with a draft of the proposed *Power System Model Guidelines* and a short Issues Paper.

A draft of the proposed *Power System Model Guidelines* was developed by AEMO with input from the Power System Modelling Reference Group, which included representatives from industry experts, *Network Service Providers* and AEMO. AEMO sought to:

- Leverage the practical knowledge gained since the development of the *Generating System Model Guidelines*.
- Clarify long-standing issues in the application of the *Generating System Model Guidelines*.
- Capture the modelling requirements to be able to securely operate and plan the *NEM* with a rapidly changing mix of *power system, generation* and other *plant* technologies.
- Capture the modelling requirements for the extended set of studies now required under the NER to correctly assess *plant* performance under reduced system strength conditions.

The Issues Paper covered the following:

- Data Sheets had not yet been developed, but that they would be based largely on the content of the *Power System Model Guidelines.*
- Although AEMO had made provision for exemptions from the requirement to provide some plant models, submissions were sought on any additional circumstances where the full suite of modelling information might not be required.
- Details of proposed amendments to the NSCAS Tender Guidelines and the SRAS Guideline were discussed. These amendments would be as consequential to the development of the *Power System Model Guidelines* and, for reasons of efficiency, would be made using AEMO's power to make administrative and minor changes.

AEMO received five valid written submissions in response to the first stage notice of consultation. Four late submissions were received, which AEMO 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 *Power System Model Guidelines* and draft forms of the *Power System Design Data Sheet* and *Power System Setting Data Sheet*.

AEMO did not receive any valid written submissions in the second stage of consultation. Eight late submissions were received, which AEMO has 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.	Participants are not given enough time to provide updated models of their plant	AGL
2.	Cost of compliance vs benefits	Pacific Hydro & Clean Energy Council

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 Participants are not given enough time to provide updated models of their plant

4.1.1 Issue summary and submissions

Participants continue to raise concerns over the amount of time to provide models, especially in respect of existing *generation*. Below is the relevant submission:

AGL:

> **Section 2.1: Generators**
>
> A key concern with the draft Guidelines relates to the timing proposed by AEMO for provision of PSCAD models under various circumstances as outlined in section 2.1. While the provision of the relevant models as part of a generation connection application, or potentially a modification to existing plant, can be incorporated into a projects timeline, the requirement to provide models for existing plant under the requirements in 2.1(a) and (b) are likely to be problematic in many instances.
>
> PSCAD modelling is a new requirement, with a limited pool of modelling experts available for assisting with the preparation of the relevant models. Where a PSCAD model has not already been developed for an existing generator that it would not be possible to comply with the request to provide the model within 15 or 20 business days. Recent experience in seeking the development of a PSCAD model for existing plant has required months of commercial negotiations, information sharing and testing of model outcomes.
>
> In the AEMC Rule Change process relating to Generator System Models, concerns with the potential for AEMO to request PSCAD models for existing plant and thus imposing additional costs on those generators was a key point of discussion. The AEMC sought to introduce a test to ensure that such models would only be requested, and thus developed, based on a specific set of conditions being met. The draft Guidelines would result in generators potentially being forced to develop PSCAD models for all existing plant in order to be able to comply with the proposed timings – whether or not the AEMCs test had been met.
>
> We would suggest that the hard deadlines for the relevant requirements were replaced with an ability for AEMO and the relevant generator to agree to a time under which the required model would be developed and provided to AEMO. In some cases, where PSCAD models were already available for affected plant, the timings could be along the lines of those proposed in the draft Guideline. In other more complex cases, relating to larger, more complex, exiting generators (particularly where OEMs are no longer in operation) this timeframe may need to be longer.
>
> The approach outlined under the draft Guidelines is likely to cause a large amount of additional expenditure on modelling for all plant within the NEM, without appropriate consideration of whether the conditions set out by the AEMC were met. We consider this is contrary to the intention behind the Rule as made by the AEMC and likely to add significant cost that would ultimately be borne by end-use customers.

This was also raised and considered as a material issue in the *system strength impact assessment guidelines* consultation and is addressed in AEMO's Final Report and Determination for that document.[2]

4.1.2 AEMO's assessment

NER Requirements

The content in the table in section 2.1 of the Guidelines reflects the new requirements in the NER. It does not add to them.

If AEMO requires a PSCAD™/EMTDC™ model, it will only do so where the conditions imposed in the NER are met. If the model requested does not exist, AEMO will treat any request for additional time on an ad hoc basis, but does not have the power to extend timeframes that are imposed by the NER.

[2] See section 4.3 of AEMO's Final Report and Determination on this issue, available at: http://aemo.com.au/Stakeholder-Consultation/Consultations/Power-System-Model-Guidelines-and-System-Strength-Impact-Assessment-Guidelines.

Costs vs Benefits

How AEMO will balance the costs vs the benefits of requiring models in these instances is addressed in section 4.1.2.

Alternative Process

AEMO has no power to vary NER requirements, however, section 8 of the Guidelines provides an avenue for those Registered Participants who cannot provide models (for whatever reason) to seek a variation of one or more of the requirements that arise out of the Guidelines.

In light of the comments in the submission about the limited talent pool referred to, and AEMO's experience in developing PSCAD™/EMTDC™ models of *synchronous generation*, as referred to in issue 6 in Appendix B, AEMO is prepared to offer to develop these types of models on a consultancy basis.

EMT Models for Existing Plant

As stated in section 4.3.2 of the Draft Report, AEMO has developed many *synchronous* machine models located in various *regions*. In those circumstances, AEMO does not require provision of EMT models. AEMO will, however, require EMT models from *Registered Participants* where the level of data provided previously is insufficient for AEMO to develop the necessary EMT models.

4.1.3 AEMO's conclusion

AEMO will amend section 8 of the Guidelines to include the option of requesting AEMO to develop models of *synchronous generation* where other modellers cannot be found by a *Generator*.

4.2 Cost of Compliance vs Benefits

4.2.1 Issue summary and submissions

The question of whether the cost of compliance outweighs the benefits to be gained continues to be a concern raised in second stage submissions.

Below are relevant extracts from submissions:

Pacific Hydro:

> Requirement for Existing Plant to provide PSCAD Models
>
> The rule changes regarding system strength impact and the new system model guidelines have imposed on generators an obligation that was not required at the time of connection. It anticipates that participants can produce highly detailed models regardless of whether the participants have the data and control information that would underpin such models. It is unlikely that participants can produce the detail required of these guidelines as the data is not available to them and is unlikely to be held even by the OEMs of the older plant. As such, the rule change providing AEMO with the right to request such models will need to consider the application of such rules changes in circumstances where EMT models do not exist due to the age of existing plant.
>
> The conclusion 4.1.3 that AEMO does not propose to make any changes to the Guidelines to address the issue of cost versus benefits illustrates that it is highly problematic to really identify the benefits of moving to excessively detailed EMT models for the entire network. The following issues highlight the scope and scale of cost increases that result from this move:
>
> - The considerable costs involved in building EMT models for older plant;
> - The considerable costs and difficulty to validate detailed models;
> - The resources and technical expertise required to get such models to integrate is prohibitive;
> - The removal of transparency as participants will not be able to work on the PSCAD network model due to confidentiality requirements;
> - The time and cost to connecting parties to include studies that cover the combinations or multiple fault ride through obligations while also dealing with changing SCR figures would be considerable;

- Inverter Based Generation (IBG) can provide higher fault current, but only at additional cost, making the equipment more expensive.

Without an appropriate overarching investigation into the cost benefit which contemplates the pros and cons of different solutions and methods, the outcome appears to be adding costs and therefore reducing efficiency in numerous areas of the entire market.

While AEMO wishes to ensure that it has covered the stability issues associated with IBGT controls in low or weak networks, Pacific Hydro urges AEMO to consider alternative, more practical and cost-effective approaches, such as using hybrid modelling methods.

Clean Energy Council:

It appears that the costs of model provision as required by AEMO in the PSMG are very high for generators, and the benefits of these modelling requirements have not been demonstrated. It is unclear and undemonstrated whether the model requirements are achievable for any negotiating parties, including generators and NSPs. This lack of clarity increases costs for all participants. We understand AEMO's concern around the capability to ride through multiple disturbances, however believe that assessing this through EMT modelling is not the most efficient method.

The position of the Original Equipment Manufacturers (OEMs) and connecting parties in this process is important. OEMs may not be able to meet the PSMG requirements and this may present a barrier for entry and delays to the connection process. AEMO states that 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. In order to provide certainty to OEMs and connecting parties, AEMO should provide clear guidelines as to when model confirmation tests are required.

Additionally, the requirement for extensive modelling on a NEM model is likely to result in increased cost, complexity and barriers to entry for OEMs into the Australian market. 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 the correct version. Maintaining the model in multiple software packages can be problematic due to increased costs and assurance of model performance.

Similar statements as to the high cost of compliance were made by other Consulted Persons and these are addressed in the context of other issues raised. For further details, please see Appendix B.

4.2.2 AEMO's assessment

Generally

In making the Amending Rule, the *AEMC* concluded that the rule making test was satisfied (namely, the rule would contribute to the *national electricity objective*).

AEMO cannot consider any additional cost factors not already considered, if Consulted Persons have not quantified and objectively justified their cost of compliance. AEMO notes the following statements from the *AEMC*:

> The Commission notes that there were significant differences in the extent of cost estimates from various stakeholders and from the analysis undertaken by AECOM … Most stakeholders and the advice from AECOM indicated a range of costs from $70,000 to $700,000, with one estimate of €12,000,000 (approx. $AUD17,700,000). No detailed explanation was provided as to the basis of this largest estimate.[3]

The *AEMC* concluded:

> While there may be some costs faced by participants when providing more detailed or additional model data, the Commission considers that these costs are outweighed by the overall operational, investment and security benefits enabled by the final rule. Furthermore, the final rule establishes a number of measures that the Commission considers will be effective in helping to minimise the extent of any costs for participants.[4]

On the benefits side, to demonstrate how the rule change request met the rule making test, AEMO had provided an indication of the benefits that would flow from better modelling and other information.[5]

On the basis of all these considerations, the *AEMC* concluded that:

[3] AEMC Determination, footnote 149.
[4] AEMC Determination, p16.
[5] Available at: https://www.aemc.gov.au/sites/default/files/content/3799ab08-dd3d-49b4-b171-8e4ad631e860/Rule-change-request.pdf

> … provision of additional model data is likely to provide beneficial outcomes by:
>
> - supporting more effective power system studies by providing a better understanding of the state of the power system and therefore more efficient and secure operation of the power system.
> - supporting the development of more accurate and effective constraint equations and generator performance standards, enhancing the ability of generators to deliver energy to market and providing reliability benefits to consumers.
> - enabling more efficient and effective procurement of ancillary services, helping to reduce the cost of these services while supporting the secure supply of energy to consumers.
> - supporting more efficient planning processes, enabling better integration of a greater range of generating technologies and helping to lower network costs as well as providing improved system security and reliability outcomes.
>
> The Commission is therefore satisfied that the extent of these benefits is likely to outweigh the potential costs that may be faced by some participants who are required to provide additional or more detailed model data.[6]

Compliance with the NER

AEMO notes that consultation on the Guidelines does not provide an opportunity to relitigate whether the changes to the NER, including the requirements for the Guidelines and the application of the model requirements, meet the rule making test. The *AEMC* has already determined this in the affirmative. The only issue is whether AEMO is complying with the NER in making the Guidelines because AEMO's task is to make and *publish* the *Power System Model Guidelines* and Data Sheets in accordance with the NER.

In this context, clause S5.5.7(c)(1) requires AEMO to:

> have regard to the reasonable costs of efficient compliance by *Registered Participants* with those guidelines and data sheets compared to the likely benefits from the use of the information provided under the guidelines and data sheets.

AEMO meets this requirement in two ways:

1. Section 3.3 of the Guidelines states that AEMO will not require models of small *plant* that meets certain requirements, meaning that their likely present and future impact on *power system security* is unlikely to justify the cost of providing those models.
2. Section 8 of the Guidelines enables *Registered Participants* who cannot meet a request for models and other information to apply to AEMO for a variation of a requirement they cannot meet.[7]

Generic submissions as to whether any Guidelines requirement is likely to give rise to more cost than benefit in the abstract are unhelpful. In contrast, if an application under section 8 of the Guidelines is made, AEMO will consider the specific costs of compliance for the applicant, including circumstances that would disproportionately increase its costs of participating in the *NEM*, against any reduction in the benefits of full compliance compared with a lesser or alternative set of data.

AEMO considers that a combination of the exemption provisions and the possibility of applications for variation in appropriate cases reflects the *AEMC's* understanding of how the clause S5.5.7(c)(1) requirement would be met:

> … the Commission expects that AEMO will consider the likely costs that a participant may incur when providing model data, as weighed against the potential system security or operational benefits associated with the provision of that data, and accordingly set out the relevant detailed requirements in the guidelines to reflect this.[8]

[6] AEMC Determination, p47-48.
[7] This also meets the requirement in clause S5.5.7(b1)(4) of the NER.
[8] AEMC Determination, p21.

4.2.3 AEMO's conclusion

AEMO does not propose to make any changes to the Guidelines to address the generic submissions on the cost of compliance vs the benefits. AEMO has made drafting changes to provide further clarity as to the circumstances in which an application under section 8 of the Guidelines may be appropriate,

5. OTHER MATTERS

5.1 Invalid Submissions

AEMO notes that most of the submissions received during this consultation were received out of time and were not 'valid'. Consulted Persons are reminded that, to be 'valid', submissions must comply with clause 8.9(e) in the case of first stage submissions, and 8.9(i) in the case of second stage submissions. Both of these 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 the *AEMC* to change clause 8.9 of the NER.

5.2 Independent Review

AEMO sought an independent review from an industry expert in power system modelling, Power and Energy, Analysis, Consulting and Education, PLLC (also known as PEACE®). The advice was only received recently.

As a result of that advice, AEMO has made changes in the Guidelines, which are outlined in the table below.

Section	Change
Glossary	Inserted new definition: Reticulation Network.
Glossary	In the definition of Disturbance, elaborated further on what a change in the energy source would encompass.
4.3.1	Relaxed the requirements of modelling of mechanical components, such that the model need only be adequate to represent stability effects, rather than explicitly modelling all mechanical components.
4.3.1	Regarding models and operating range, clarified a point that the model must be "accurate" for all operating points, rather than "valid", and added a footnote acknowledging that where this cannot be achieved for thermal plant, this will be considered on a case-by-case basis via the Alternative Process.
4.3.1	Clarified that mode change-over of models should be as automatic as the *plant* (i.e. if the *plant* requires manual intervention to change-over, the model may rely on manual intervention too).
4.3.3	Added a practical exception to initialisation requirements that may occur when some models attempt to initialise with non-zero derivatives.
4.7	Clarified that aggregation shouldn't be applied to *generating systems* consisting of singular, large *generating units* (such as large *synchronous generating systems*).
4.3.6	Clarified terminology surrounding fault detection and blocking modes of HVDC and reactive compensation *plant*, including defining some specific elements and failure mechanisms to be included.
5.2.2	Allowed for more practical per-unit bases to be used where logical (e.g. turbine-governor rating used as base for turbine-governor quantities).
5.2.2	Updated block diagram requirements to allow Z-domain transfer functions to be included, consistent with *Generating System Model Guidelines*.

Section	Change
6.2.1	Slightly reduced the accuracy requirements for aggregated *generating unit* models terminal quantities.
C.1.1	Added statement that the torsional protection relay should be included if necessary to meet accuracy requirements, and clarified that negative sequence protection need only be included in models for simulation tools that represent phase sequences in simulations. Also added comment regarding torsional protection relay to multiple voltage disturbances under section 4.3.4.
C.2.1	Added missing asterisk to the torsional damping component.
C.6.1	Merged turbine and flywheel componentry into the mechanical drive train component.

5.3 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, punctuation, formatting and italicisation corrections are not change-marked.

5.4 NSCAS Tender Guidelines and SRAS Guideline

For completeness, no issues were raised on AEMO's proposed consequential changes to the NSCAS Tender Guidelines and the *SRAS Guideline*.

6. FINAL DETERMINATION

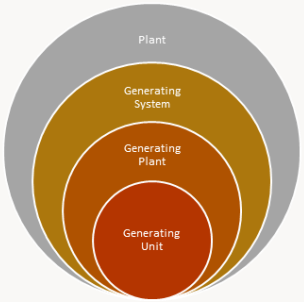
Having considered the matters raised in submissions, AEMO's determination is to:

- make the *Power System Model Guidelines, Power System Design Data Sheet* and the *Power System Setting Data Sheet* in the form published with this Final Report in accordance with clause S5.5.7 of the NER; and
- amend the NSCAS Tender Guidelines and *SRAS Guideline* in the form published with this Final Report in accordance with clause 3.11.5(d) and 3.11.7(g) of the NER, respectively.

APPENDIX A - GLOSSARY

Term or acronym	Meaning
AEMC Determination	Rule Determination: National Electricity Amendment (Generating System Model Guidelines) Rule 2017 published by the AEMC on 19 September 2017. Available at: https://www.aemc.gov.au/sites/default/files/content/3e5e1b77-d56d-4935-ba11-ace3b687aa2c/Generating-System-Model-Guidelines-ERC0219-Final-Determination.pdf
Amending Rule	National Electricity Amendment (Generating System Model Guidelines) Rule 2017 No.11.
Data Sheets	The *Power System Design Data Sheet* and *Power System Setting Data Sheet*, collectively.
Draft Report	The Draft Determination and Report available at: http://aemo.com.au/-/media/Files/Stakeholder_Consultation/Consultations/Electricity_Consultations/2018/PSM-draft/PSMG_Draft_Determination_and_Report.pdf
Disturbance	See the definition in the Guidelines.
DNSP	*Distribution Network Service Provider*.
EMT	Electromagnetic transients.
Final Report	This document.
Guidelines	*Power System Model Guidelines*.
IBG	Inverter-based generation.
IEC	International Electrotechnical Commission.
NER	National Electricity Rules.
NSCAS	*Network Support and Control Ancillary Services*
NSCAS Tender Guidelines	The guidelines *published* under clause 3.11.5(b) of the NER.
NSP	*Network Service Provider*.
OEM	Original equipment manufacturer.
OPDMS	Operations and Planning Data Management System.
PSCAD™/EMTDC™	Power Systems Computer Aided Design / Electromagnetic Transient with Direct Current
PSS®E	Power System Simulator for Engineering
PSMRG	Power System Modelling Reference Group.
R2	Registered data after *connection*, as derived from on-system testing and designated as 'R2' in the Data Sheets and as described further in clause S5.5.6 of the NER.
RMS	Root mean square.
SRAS	*System restart ancillary services*.
TNSP	*Transmission Network Service Provider*.

APPENDIX B - SUMMARY OF SUBMISSIONS AND AEMO RESPONSES

No.	Consulted person	Issue	AEMO response
1.	Pacific Hydro & Clean Energy Council	**Cost of Compliance vs Benefits** See Section 4.1.1	See Section 4.1.2 and 4.1.3.
2.	Energy Queensland	**Review** Recommend that 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 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.
3.	Energy Queensland	**Transitional Arrangements** Recommend that consideration is given to transitional arrangements for existing projects that are already significantly progressed as at commencement of the new Guidelines.	AEMO is unclear as to what is meant by transitional. The requirements detailed in the Guidelines are applicable to requests for models made after 1 July 2018, regardless of the status of a project.
4.	Senvion	**Terminology** Please ensure consistent use of the terms as defined in the NER in order to distinguish and intentionally use "generating unit", "generating system" and "generating plant" as best as applicable. There is for example no definition of "plant" or "Plant element". Examples for a wind farm would be helpful to understand the differences between "generating system" and "generating plant".	All of the terms referred to are defined in Chapter 10 of the NER. When one considers each, their relationship to each other can be drawn as a stacked Venn diagram as follows:  The Guidelines apply to *plant*. Where requirements apply to a sub-set of *plant*, AEMO has been more specific. The draft Guidelines have been reviewed and corrections made where this might not have been clear.
5.	Clean Energy Council	**Identification of Problem** The PSMG should identify the specific problem that needs to be addressed for the benefit of system security to justify its requirements. The lack of a	The problem that AEMO might be trying to solve will vary. If a *Registered Participant* has difficulty in meeting a request for modelling and other information, they can avail themselves of the alternative process in section 8 of the Guidelines, and AEMO will consider whether an alternative can address the problem.

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		defined problem has the potential to create requirements which result in uncertainty in cost and schedule to connecting parties.	
6.	Pacific Hydro	**Quest for Accuracy** The quest for accuracy is not entirely clear. For example, further clarification is required to understand what is meant by "more relaxed and flexible accuracy requirements", when the detail required in the model appears to be excessive and, as such, may make it extremely difficult to get repeatable results with any degree of confidence. The only benefit for using a PSCAD model for IBG is to improve the understanding of single point control such as that required at the point of connection or at the terminals of an inverter. Investigating a single point in detail is a matter for the participant to prove regarding connection and control; it is not well suited to understanding the overarching control of the power system. The Guidelines call for a level of detail and accuracy that is impractical and driven by what would appear to an excessive faith in modelling, placing it over and above any practical understanding of the approximate manner that is used to capture data and study the power system. The time and costs of meeting this set of guidelines may not have been thoroughly understood. Such detailed models are usually built by the specialist engineers who want to understand a particular detailed problem. But such EMT models are rarely required for the entire system, and it is recommended to consider hybrid modelling using PSS/E or RMS style modelling for the systems integrated with PSCAD for the detail of a particular generating system. This type of modelling was undertaken for Basslink, for example.	The cited statement refers to the standing exemption provided in section 3.3 of the Guidelines, which does not exist in the *Generating System Model Guidelines*, and the retention of the alternative process in section 8 of the Guidelines, which now provides examples as well as how AEMO will consider any request. The suggestion that investigating a single point in detail is not well suited to understanding the overall control of the *power system* is not correct. The overarching response of the *power system* is what's imposed on a *generating system's connection point*. Many *power system security* challenges occur because of the complex interaction of *synchronous* and *asynchronous generation*. This stems from fast control of power electronics that cannot be accurately represented in a RMS simulation tool. Contrary to the suggestion that accuracy in modelling is an end in itself, modelling allows AEMO to investigate all *power system security* challenges and develop pertinent solutions. The only other way to study *power system security* issues is to wait for one to occur and see what happens, an option that AEMO considers unpalatable as it would expose the *power system* to undue risk and end users to the risk of *load shedding*. AEMO, therefore, considers it essential to use models to study *power system* behaviour. AEMO has attained a far greater degree of understanding of the cost of PSCAD™/ EMTDC™ modelling than Pacific Hydro suggests and, as a result, considers that the benefits far outweigh the costs of compliance. AEMO considers that any arguments as to the cost of compliance (in the order of several tens of thousand dollars) should be weighed against the cost of major events, such as *black system* events, other *major supply disruptions*, and involuntary *load shedding* that could occur due to the inability of deficient or inaccurate simulation models to assist in predicting and mitigating *power system security* concerns. Additionally, the use of PSCAD modelling to simulate events associated with the South Australia *black system event* resulted in the accurate simulation of the causation chain, and the ability to develop the necessary mitigation measures accordingly. Hybrid modelling would only work in limited cases where the *power system* is still strong in one area, and an *asynchronous plant* cluster is not meshed or embedded in the system. Using Hybrid simulation to "mix and match" EMT and RMS models in a meshed system will lead to inaccurate results. For example, North Queensland, Western Victoria and South Australia could not could not be modelling using this approach, as asynchronous generation is connected in a mesh throughout the *region*. Models of *power systems* comprised of almost nothing but *asynchronous generation* that cannot be accurately represented in traditional RMS software, requires the whole *power system* to be represented in PSCAD™/EMTDC™. In a weak *power system*, it is inappropriate to be selective in choosing which elements to include in PSCAD™/ EMTDC™ and leave the rest in RMS. Electranix in

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			Canada has spent many years modelling weak *power systems* and supports this approach. AEMO disagrees with the statement made on the use of hybrid modelling for the Basslink studies. AEMO's report on 'System Incident Investigation for the Tasmanian Region: Modelling and detailed analysis of transmission line fault events of December 2014 and February 2015' was done with a full-scale PSCAD model of the Tasmanian *power system*. PSS®E modelling was used as a preliminary and screening assessment to shortlist key scenarios to undergo detailed PSCAD studies. The use of PSCAD and PSS®E modelling in this context cannot, therefore, be considered as a hybrid modelling.
7.	Pacific Hydro	**Focus on Detail Undermining Control** There is evidence that the overarching control of the power system is poor. The attention paid to new technologies has removed focus from the broader obligations to ensure that the power system itself is efficiently controlled. It is suggested that a better alternative would be to restore appropriate tight controls on the speed regulation of the synchronous fleet guaranteeing the synchronising and damping torque of the system, than to focus on the micro second switching of inverters. Lumped EMT models for wind farms are unlikely to represent the actual high frequency switching resonances and produce worst case results. This is because the lumped model would present synchronised switching in simulations. In reality no individual wind turbine switching pattern is synchronised within the farm and as such there is a natural offset. Without assuming an offset, the EMT models give inaccurate results. Harmonic measurements are averaged over several minutes and vary with wind conditions. There is, therefore, is no way that an EMT model could be validated. The lack of validation possibilities for Harmonic models or EMT models for power system studies in transient area is a concern. It is questionable whether the release of the EMT PSCAD model for this purpose will address these inaccuracies. PSCAD modelling on a wide scale across the NEM is likely to produce misleading results in resonance studies and in harmonic studies if those using the models do not have detailed knowledge of the IBG technology along with practical understanding of the actual operational results. Incorrect assumptions along with excessive detail without applying natural offsets would lead to worst case outcomes and drive poor control decisions with increased, unnecessary costs applied to projects.	The issue referred to in Pacific Hydro's submission (poor control of *power system frequency*) and frequency regulation is unrelated to the applications of EMT models. AEMO is currently investigating different ways of improving steady-state *frequency* control in the *NEM*, however, investigation of one issue does not warrant disregarding other, more critical, *power system security* issues. This is because, lack of system strength, which is manifest in the *voltage* response of *plant* in milliseconds, is a more acute problem. This is why AEMO's focus has changed. System strength is a local issue, caused by local *plant* and AEMO needs to have a better understanding of *plant* capabilities in the context of *voltage* response. The 'better alternative' suggested is technically flawed. *Synchronising* and damping torque has no relation to the governor response (speed control) of *generating units*. Synchronising torque's contribution occurs in milliseconds following a disturbance and is an effect of the magnetic coupling between the rotor and the stator of the rotating machine. The machine characteristics and the field current at the moment of disturbance have more to do with synchronising torque than the governor. A *synchronous* machine governor acts over seconds, not milliseconds. The following graph is a simplified example of where each element of a *synchronous* machine acts and is provided to clarify this misunderstanding:

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			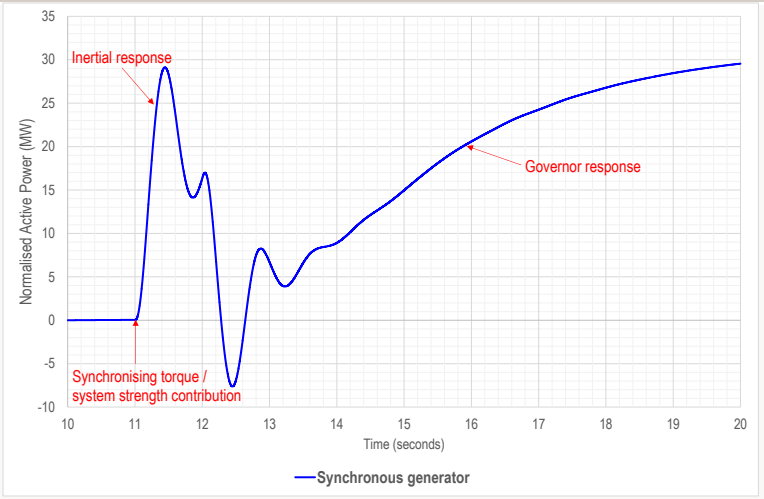 Pacific Hydro's comment does not recognise the full scope of *power system* harmonic analysis. Its focus appears to be on harmonic emission, neglecting the equally important aspect of harmonic susceptibility. This analysis has long been required by the NER, and has been assessed for all new or modified *connections* for the purposes of assessing proposed *performance standards* under clause S5.2.5.6 of the NER. Switching *frequency* of power electronic converters used in wind turbines are in order of several kHz. Simulating harmonic resonances in the order of several kHz, beyond the *Australian Standards* requirements, is not the point of interest. With regard to validation of the harmonic performance of wind turbines, EMT models based on a one-to-one dump of converter control codes represent the exact response of wind turbines from a harmonic perspective. Therefore, validation of such models is not highly critical from a harmonic standpoint compared to the use of simplified models in conventional harmonic models and tools. Lastly, it is noted that the use of EMT models for harmonic analysis is not a mandatory requirement for all projects. However, such a model will provide a significant advantage when assessing adverse harmonic iterations and instabilities. This cannot be predicted by the use of conventional harmonic analysis tools. In response to the comment that PSCAD modelling on a wide scale across the *NEM* is likely to produce misleading results in resonance and harmonic studies if those using the models do not have detailed knowledge of the IBG technology and practical understanding of the actual operational results, AEMO notes that the need for a detailed knowledge of technology will apply whether PSCAD or any other simulation tools are used. This primarily stems from the complex and non-linear behaviour of the *control systems* used in wind turbines and other power electronic interfaced *generation* technologies whereby harmonics generated do

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			not remain constant and vary depending on the operating conditions. Therefore, the complexity of the *control systems* used in power electronic interfaced *generation* should not be a reason for not requiring sufficiently accurate models for harmonic studies.
8.	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."	Energy Queensland appears to have confused this with the *system strength impact assessment guidelines*. This definition is not in the Guidelines.
9.	Energy Queensland	**Sections 2.1, 2.2, 2.3 and 2.4** The tables provided in these sections need to be amended to include provision of model data to be requested by NSPs.	Section 2.1 addresses the provision of models and other information to NSPs already. Corrections have been made to address the issue consistently across all sections referred to in the submission.

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10.	SA Power Networks	**Section 2.1: Generators** AEMO should clarify whether this table is only intended to cover those generating systems required to register the generating system with AEMO (ie does not include those generating systems covered under the standing exemption rules; ie export <5MW). At present, no lower bound is provided within the table.	Consistently with the relevant rules, AEMO has used the defined term *Generator* to refer to the type of *Registered Participant* that must comply with the Guidelines. Chapter 10 of the NER defines a *Generator* as: A person who engages in the activity of owning, controlling or operating a *generating system* that is *connected* to, or who otherwise *supplies* electricity to, a *transmission* or *distribution system* and who is registered by *AEMO* as a *Generator* under Chapter 2. For the purposes of Chapter 5, the term includes a person who is required or intends to register in that capacity or is a non-registered embedded generator (as defined in clause 5A.A.1) who has made an election under clause 5A.A.2(c). Hence, the references do not apply to anyone who is exempt from the requirement to register.
11.	SA Power Networks	**Section 2.1: Generators** The following statement appears (bold added) "Furthermore, a Generator who has previously provided adequate RMS models and associated information to AEMO will be required to provide up-to-date EMT models if required by an **NSP**…". Should this reference to "NSP" actually be AEMO? How does AEMO envisage that NSPs (or AEMO for that matter) could convince existing generators (for example connected to a DNSP's network) to provide such models in a timely manner or if at all?	AEMO agrees that there is an ambiguity here. The PSCAD™/EMTDC™ models are to be provided to AEMO if required by an NSP for the purposes of carrying out a *system strength impact assessment*. AEMO may require PSCAD™/EMTDC™ models to be provided under the various rules cited in Section 2.1. A failure to provide requested models will be a breach of the NER.
12.	Senvion	**Section 2.2: EMT Data Provision from NSPs** Senvion request AEMO to include a clause (for example within 2.2) that guarantees the data provision from the NSPs to Generators. This is based on Senvion's experience of NSPs failing its data provision commitments under the NER.	The Guidelines are not an appropriate means by which such a 'guarantee' can be obtained.
13.	SA Power Networks	**Section 3.3: Exemptions** Table 2 suggests that generators proposing to connect a generating system >1MVA but less than or equal to 5MVA would be required to provide detailed models of their generating system where the SCR is less that (sic) 10. At present such generating systems are normally exempt from registration according to AEMO's standing exemption. Greater clarity is sought from SA Power Networks regarding this matter as presently, SA Power Networks does not involve AEMO for such sized systems. Such detailed network models (ie RMT or EMT) are not presently provided by these sized generator proponents. It appears odd that ratings usually used with respect to generation connections is normally expressed in MW rather than MVA however within the exemption table provided they are expressed in MVA. Is this an oversight or are these threshold values genuinely intended to be assessed against MVA rather than MW values?	The obligation to provide models is placed on *Generators*. Anyone who benefits from AEMO's standing exemption is not a *Generator* and, hence, does not have to comply with the Guidelines. If, however, a person who opts to register as a *Generator*, regardless of the size of their *generation*, would be bound to provide the models. Therefore, the exemptions in section 3.3 are to be read as applying to those *Generators* (ie those who choose to participate in the *NEM*) who have small *generating systems*. Ratings in MVA (in addition to MW) are necessary because this appears to be how solar *generating plant* is rated. Whether a PSCAD™/EMTDC™ model of existing *plant* will be required depends on the circumstances. At this stage, AEMO sees the need being driven predominantly by NSPs needing PSCAD™/EMTDC™ models to carry out *system strength impact assessments. Registered Participants* having difficulty with such a request may apply for a variation to the requirement under section 8 of the Guidelines.

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		In addition, is AEMO suggesting that any existing generator within these sizes will be required to retrospectively provide such models as per Section 2.1? If so, this will be exceptionally difficult for DNSPs to achieve for those systems connected to its networks.	Finally, AEMO does not need PSCAD™/EMTDC™ models of smaller *generating units,* however, they might be needed by an NSP.
14.	SA Power Networks	**Section 4: Model Adequacy** Again, clarity needs to be provided over when such models (ie RMS and EMT) models are required to be provided by generator proponents (even if only by way of reference to section 3.3). Such models are presently only requested for systems required to register with AEMO (ie greater than 5MW).	The answer to the question of when *Generators* need to provide models is in section 2.1 of the Guidelines, which reflects the current state of the NER. There are also exemptions applicable to small *generating systems* in section 3.3 of the Guidelines.
15.	WSP	**Section 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.	AEMO has not excluded the impact of *transmission network* and *distribution network protection systems* from a *system strength impact assessment*. The NER do. Clause 4.6.6(b)(3) of the NER requires AEMO to specify this (amongst other things) in the *system strength impact assessment guidelines*.
16.	Senvion	**Section 4.3.1: RMS and EMT stability model requirements – General Requirements** Numerically Stable up to a Simulation Time of up to Five Minutes EMT models are not made for such a long simulation time. Senvion proposes to limit the EMT simulation time to two minutes.	This issue was addressed in response to issue 55 in the Draft Report. Additionally, the proposed two-minute timeframe is arbitrary and unsubstantiated.
17.	WSP	**Section 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.	NER obligations are placed on *Registered Participants* and, while it is true that OEMs are not *Registered Participants*, that does not mean that they will not adhere to the NER requirements. They will need to, so that their clients – the *Registered Participants* – can comply. As noted in section 4.1.2 of the Draft Report, several OEMs' models have exhibited the requirements sought in the Guidelines and more are expected to do so. The requirement for 'assessment on a NEM model' is long-standing. For each *application to connect*, a *Connecting Applicant* needs to carry out this assessment in order to finalise the *performance standards*. For the majority of the *performance standards*, simulation studies are done on the *power system* rather than a SMIB case. The comment made is unsubstantiated, in particular with respect to creating barriers to entry for OEMs, or causing extra costs.

No.	Consulted person	Issue	AEMO response
18.	WSP	**Section 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?	AEMO notes that several similar comments were made by WSP in its submission to the *system strength impact assessment guidelines*, and addressed comprehensively there. There is no relationship between the harmonic standards for wind turbines, and whether EMT or other types of simulation are used for harmonic analysis. The statement that AEMO feel that harmonic assessments are best carried out in an EMT type package such as PSCAD is incorrect. The Guidelines do not make such a general statement, but allow an option for AEMO and the relevant NSP to access EMT models with a sufficient level of detail for harmonic analysis. This is with emphasis on harmonic interaction and susceptibility studies where required. An example of includes assessing the performance of *generating systems* under clause S5.2.5.6 of the NER where the use of conventional harmonic analysis tools does not reveal any *control system* susceptibilities. In other situations, the use of conventional harmonic analysis simulation tools is acceptable, e.g. for most harmonic emission studies.
19.	Pacific Hydro	**Section 4.3.4: EMT Model-Specific Requirements – Multiple Voltage Disturbances** Pre-emptive Requirements These guidelines also pre-empt the AEMC's determination on multiple fault ride through as the guidelines build in the obligation despite the technical rule not being in place. It is clear that AEMO is taking the outcome of the AEMC's determination as given. This limits the opportunity to look for collaborative solutions to the complex issues that exist in the power system. It tells participants that AEMO has a preferred method regardless of whether it is economic, sensible and reflects international practise or not. It is leading to the NEM being expensive, complex to connect to, and carries a high level of risk if generators no longer have grand-fathered rights. These guidelines illustrate a belief that modelling can represent everything. The expectation that auxiliary equipment should be included into the control modelling for large units greatly complicates the mathematical model, increasing the risk of error. The requirement to validate and verify the model assumes that auxiliaries will also have high speed monitoring on them suitable to provide measurements into an EMT model. Pacific Hydro is concerned that in highlighting this point, a potential outcome may include a requirement on generators to measure their auxiliaries with high speed meters. This is in part due to the fact that the guideline includes obligations that cover the objections which industry raised against the multiple fault ride through, whether it is practicable to model or not or whether it is normal control practise or not. Further consideration of the potential costs of such outcomes is recommended as there does not appear to be any justification for the dramatic change in control philosophy and no nett benefit test for these	AEMO notes that the draft National Electricity Amendment (Generator technical performance standards) Rule 2018 has been published by the AEMC and that there is a proposed requirement for multiple fault ride-through with grand-fathering of existing *generating systems* that have not undergone an upgrade. AEMO does not understand how this would limit the opportunities for collaborative solutions to the complex *power system* issues currently being faced. AEMO is prepared to look at any such opportunity. Nevertheless, such collaborative approaches do not obviate the need for accurate *plant* models. With regard to the inclusion of auxiliaries, AEMO notes that this only applies to technologies whose auxiliaries might have limitations with respect to multiple faults in quick succession. These auxiliaries are generally induction motors with established and simple modelling practices. It is not therefore understood how inclusion of auxiliaries (if applicable) in the simulation models would greatly complicate the mathematical models. Lastly, the requirement for high-speed monitoring of the response of *plant* as set out in the Guidelines do not apply to *plant* auxiliaries. With regard to whether multiple fault ride through is practical to model, AEMO notes that two wind turbine manufacturers made submissions on this issue that were addressed in the Draft Report and no further comments were received. The comment that it is not necessarily practical to expect multiple faults not resulting in multiple losses of network elements, considering the potential implications to equipment, is not relevant to the scope and remit of the Guidelines. This is because the Guidelines set out the modelling requirements based on technical requirements in the NER, rather than deciding whether a technical requirement should be in place. AEMO notes that multiple faults in quick succession have occurred in all *regions*, and they can occur in the future as they are not exceptional. Apart from the South Australian black system event, none of these events in the past resulted in the

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		modelling changes. Similarly, there is no practical engineering limitation placed on the modelling requests nor any acknowledgement that detailed control data may not exist. Multiple fault ride through It is recommended that the Guidelines, as they pertain to multiple fault ride-through, require further examination to ensure their practicality and logical application. To expect multiple faults not resulting in multiple losses of network elements, is not necessarily practical, considering the potential implications to equipment. Further clarification is required to understand how the Guidelines are interpreted to study in the same network model, applying a different set of rules for synchronous machines (e.g. minimum standard expectations) while insisting on "automatic standards" for IBG. If network protection is to be modelled, then network elements will trip in the model and as such the results will show whether the system would survive a significant combination of faults. It is recommended to have a requirement for a benchmark assessment of the software and equipment limits for IBG rather than an expectation to run the enormously complicated studies in a highly detailed complex model that these Guidelines require.	collapse of the *power system* as no significant quantities of *generation* simultaneously *disconnected* due to their inability to ride through multiple faults. AEMO operates the *power system* based on results from modelling and simulation studies. For this reason, AEMO needs to know how equipment might perform if an event comprising multiple faults in quick succession were to occur. AEMO agrees with Pacific Hydro's suggestion on pursuing benchmark testing of software and equipment, however, physical test set-ups used worldwide for the purpose of model validation and certification are presently unable to apply multiple faults to *generation* in quick succession. The proposed alternative cannot, therefore, be pursued further until this practical limitation of test systems is overcome. Additionally, an obligation for OEMs to participate in these types of physical tests would need to be exercised through other regulatory mechanisms as it is outside the remit of the Guidelines. It is also noted that even if such physical test set ups can be established, it may not be possible to subject the generating units to sufficient combination of multiple faults due to causing excessive wear and tear on the plant
20.	WSP	**Section 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.	Refer to AEMO's response to issue 20. With regard to the comment that 'a statement from the supplier with supporting technical information', it is unreasonable to expect a person completing a *region*-wide simulation to know the exact performance to be expected from every single piece of *plant*.

No.	Consulted person	Issue	AEMO response
21.	Senvion	**Section 4.3.4: EMT Model-Specific Requirements – Multiple Voltage Disturbances** Remove "if applicable" from the bullet points and put it into the introduction as each of the items is subject to the technology in use.	This is not appropriate because some of the requirements are mandatory and should not be subject to that qualifier.
22.	WSP	**Section 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.	It is up to the *Registered Participant*/OEM to determine which control systems influence dynamic performance. It is unreasonable to expect AEMO and the NSP to be familiar with every possible control system for every OEM for every type of *plant*.
23.	Senvion	**Section 4.3.6: Model Outputs - Required model output quantities (Table 4)** The internal quantities described in Table 4 are not specified in Appendix D as indicated in sentence "Table 4 outlines the output quantities required to demonstrate model performance for a variety of dynamic analysis scenarios. Quantities used to determine model accuracy are typically a sub-set of these quantities, and are described in Appendix D." The internal quantities mentioned may not be applicable to the relevant technology.	If a quantity isn't relevant to a technology type, it should be excluded from the analysis.
24.	SA Power Networks	**Section 4.3.6: Model Outputs - Required model output quantities (Table 4)** It is presumed that the plant type described as "Solar (generating unit)" applies to inverter connected photo-voltaic (PV) systems. Can AEMO confirm this is the case. Can AEMO clarify what is meant by the term "Energy storage level" with respect to Battery systems within the table. Presumably this is the rating of the unit / system expressed in MWh rather than the MW capacity of the system.	Yes, it applies to inverter connected PV systems. 'Energy storage level' refers to the instantaneous energy level available in the system (e.g. in MWh) as a function of the total storage capacity (MWh). This is so that simulations can respect energy reserve levels, rather than having a *generating unit* with infinite supply/ absorption capability,
25.	WSP	**Section 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	AEMO agrees and has updated Section 4.3.9 accordingly.

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		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)	
26.	Senvion	**Section 4.3.9: Source Code Submission** It is written that "AEMO accepts RMS model source code natively developed in FORTRAN 90 or higher." There is no reason to insist on FORTRAN code and for other open source code submissions to undergo alternative processes as stipulated in section 8 (with increased uncertainty) as long as the source code can be used in AEMO's simulation environment to perform the required analysis. Additionally alternative source code format should undergo a cost benefit analysis for their usage considering requester pays for this evaluation. Source code assessment and acceptance should not hold up the connection process as all GPS analysis can be performed.	Source code is required because models need to be: • debugged both now and into the future, without the need to conduct long and expensive debugging exercises with the original model developer; • integrated in an overall *power system* model in OPDMS; • used to develop the small signal model for stability analysis; and • compared against the applicant-provided block diagrams for consistency. AEMO continues to evaluate other options for source code provision that can be used with PSS®E, however, to date, all of the solutions proposed by OEMs have deficiencies. They cannot be correctly integrated into a large-scale PSS®E model (for example, it works for a single machine system, but fails when put to practical, multi-model use). *Registered Participants* wishing to supply an alternative source code may apply for a variation to the requirement under section 8 of the Guidelines.
27.	WSP	**Section 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	The energisation of large auxiliary motors in conventional *power stations* is of key importance for black start studies, and forms a key differentiator between the successful and unsuccessful energisation paths for SRAS sources. Not all *Generators* are required to provide this information; only those who are of key importance in the context of SRAS and black start studies. It is noted that the Guidelines require models or data for auxiliaries greater than 1 MW only. To date, AEMO has obtained the required information from *plant* owners and OEMs without issue.

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		suppliers as part of this process? This information is not usually available from these OEMs	
28.	SA Power Networks	**Section 4.8: Model and Plant Updates** Can AEMO advise how it expects NSP to know when a generator alters its firmware settings in order to enforce these requirements? Whilst NSP can place clauses within its Network Connection Agreement (NCA) with the generator requiring such updates, the likelihood is that NSPs (and therefore AEMO) will not be made aware of when such changes are made unless it is to the benefit of the generator or unless revealed following an event where the generator did not respond as expected.	The obligation to update models is on the *plant* owner. *Connection agreements* are a means of enforcement for the NSPs in addition to the NER, but AEMO's means of enforcement are by reporting breaches of the NER to the *AER*. Either way, AEMO acknowledges that enforcement can be problematic, but that is not be a reason for not imposing these types of obligations.
29.	WSP	**Section 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.	AEMO notes that in most cases no action is required for existing *plant* whose model source code is already accepted, and when the source code functions well in later versions of the same simulation tool. However, AEMO has come across model source code developed based on modelling practices of several decades ago. Such models sometimes do not function well in later versions of the same simulation tool. AEMO considers that well-developed model source code consistent with good industry practices make it much less likely for AEMO to request resubmission of model source codes. This, therefore, creates incentives for the development of robust and flexible model sources code across the industry rather than dealing with source code that might only work with a certain version of the simulation tool.
30.	SA Power Networks	**Section 5.2.1**: **Additional information required for fault level calculations** It is presumed that the intent of this section applies not only to converters but also to inverter connected generating systems?	Yes.
31.	Vestas	**Section 5.4.4**: **EMT model-specific requirements (Page 28)** EMT models have the full representation of switching algorithms of power electronic converters for power system harmonic studies. Detail model of switching logics of power converter itself is not sufficient for harmonic study.	Refer to AEMO's response to issue 18.
32.	Vestas	**Section 5.4.4**: **EMT model-specific requirements (Page 29)** For transient stability EMT-type models, correctly operate for integer time steps in the range of 10 to 50 microseconds and have consistent performance across this range of time steps. The time step of 10 to 50 microseconds is not an issue for model, but it is not sufficient for harmonic study.	This item is no longer relevant – the issue was addressed in the Draft Guidelines.

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33.	Vestas	**Section 5.4.6**: **Model Outputs Table 5. Wind (generating unit) (Page 30)** Required model output quantities for Wind (generating units) in full scale converter system (FSCS) RMS models namely DC link voltage and current, Error/status codes, Generator rotor speed, Mechanical torque or power, Pitch angle may not be necessary since machine side is decoupled from the grid by the grid side converter which behaviour will mainly impact on the grid. Furthermore, these mechanical related parameters are not critical factors for transient studies which are investigated at hundreds ms time frame. In that sense Vestas would like to understand the purpose of accessing these outputs from the grid impact assessment perspective.	Applicants can submit requests on a case-by-case under the Alternative Process set out in section 8 of the Guidelines if some of the requirements do not apply to a particular technology. In any case, AEMO considers that even for an FSCS, DC link voltage and current, Error/status codes are relevant and important.
34.	Vestas	**Section 5.4.9**: **RMS model format (Page 33)** AEMO accepts RMS model source code natively developed in FORTRAN 90 or higher. FLECS code is no longer accepted. Since FLECS code is still supported by PSS/E 34 there is no reason to reject it.	AEMO has encountered compatibility issues with model source code based on FLECS, and notes that is not officially supported by software vendors.
35.	Senvion	**Section 6.3: Model Validation** Model validation previously commented and not considered: "It is proposed to base model validation requirements on international standards, such as "IEC 61400-27-1: Wind turbines – Part 27-1: Electrical simulation models – Wind turbines". This standard proposes in chapter 6 detailed methods for demonstrating the quality of model validation by following international standards (such as data sampling methods from IEC 61400-21) and at the same time opens up the possibility to define accuracy limits through the system operator. This standard also includes to judge model validation errors based on per unit data rather than on the specific change of quantity. The proposed method in the Power System Model Guidelines is concerning when evaluating very small changes (getting into numerical issues) - while the effect on system stability is very low"	This issue was considered as "issue 45" in the Draft Report, and AEMO's response is repeated here: > Senvion's proposal is to incorporate an IEC standard that is not required by the NER. If it were an appropriate standard for the NEM, AEMO would have sought its application through the NER. The requirements put forward by AEMO are considered necessary and appropriate for the NEM. Additionally, AEMO notes that the IEC standard has a limited application and applies to positive-sequence models for large-scale system studies in parts of the *network* with high system strength. This standard, therefore, has very limited application in the context of the *NEM*.
36.	WSP	**Section 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."	These statements contradict WSP's comments under issue 21. AEMO does not consider type-testing would be impractical in this instance when, in the context of issue 21, WSP considered it as a solution for more onerous operating conditions in the context of multiple faults in quick succession. WSP is noted that it is a common practice across all OEMs to confirm the response of their *plant* by factory or laboratory testing if any changes required to the *plant* design or *control systems* beyond the standard design and settings. These changes would be required for *connections* to parts of the *network* with low system strength where the standard product might not be adequate any more, when the *plant* is designed to provide functionality not offered previously, or when new *plant* is introduced to the *NEM* with unexpected or inferior modelling responses. The NEM has been undergoing a paradigm shift with all these drivers where changes in *plant* design or settings have occurred. However, the statement to 're-run these

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		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.	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 speculative and not intended. With regard to an OEM's capability to undertake such tests, AEMO is aware of several major OEMs with this capability in-house. Even if an OEM does not have in-house capability to carry out such tests, there are a number of reputable international institutions who can carry out such tests on their behalf.
37.	Senvion	**Section 6.3.3: Post-connection model validation (R2) (Table 5)** Frequency control Please remove EMT–models from table 5 for S5.2.5.11 Frequency control studies because the time frame exceeds the 5 minutes**.**	In AEMO's experience, the *frequency* response of most *generating systems* occurs in seconds or tens of seconds. Additionally, with new technologies, such as battery energy storage systems, a response in the order of several hundred milliseconds can be achieved as demonstrated in practice. The recommendation for removal of EMT modelling requirements is not therefore not appropriate.
38.	WSP	**Section 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.	Refer to AEMO's responses to issue 7 and 18.
39.	Senvion	**EMT Models for Harmonic Analysis** SSCI and potential resonances are to be analyzed via state of the art analysis tools and methods. E.g. Senvion performs harmonic impedance scans (considering different operational states and controls) and can make those scans available on request. Resonances exist in any power system and are generally independent from discussions around "SCR". EMT PSCAD models for power system studies are not intended for harmonic analysis in time domain i.e. it cannot be used to evaluate if harmonic limits are fulfilled at the grid connection point. This option has been discussed within the international expert community and found as not feasible. One main reason is that, following the relevant standards, harmonic level assessment is done over several minutes (typically 10 minutes) and active power levels through power quality measurements. Additionally within a wind farm the different wind turbines are exposed to different wind speed leading to different operational points. These different operational points are very difficult to model adequately due to the poor quality of wind turbine specific wind measurements (working again with averages over 10min). Therefore it is impossible to accurately validate a wind farm model for its harmonic contribution and it would be invalid to compare this with harmonic measurements.	AEMO agrees that resonances are an inherent characteristic of all power systems and, therefore, they always exist, however, low system strength conditions would shift dominant resonances to lower order harmonics. This significantly increases the risk of those resonances being excited due to the presence of much higher currents in the *power system* for low order harmonics. EMT models are not proposed for use in determining harmonic allocation of *generating systems*, and these studies are not intended to run for 10 minutes. Issues highlighted with regard to validation of wind farm models for harmonic studies is understood. These would not differ whether an EMT or harmonic analysis tools are used, and AEMO has not proposed any additional requirements for validation of models for harmonic studies. AEMO is unable to accept Senvion's proposal to exclude the EMT models for power quality assessment, as discussed in AEMO's responses to issues 7 and 18, noting that harmonic studies are not limited to determining *plant's* emission, but intended for several other applications where the precise contribution and susceptibility of the *plant* is the key point of investigation necessitating the use of an EMT models. Lastly, AEMO agrees that those EMT models that exclude aspects of *plant* response suitable for harmonic studies run faster. For this reason, as discussed in Draft Report, a *Registered Participant* is permitted to submit an EMT model for

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		The costs and effort involved in creating and validating such a model are too high compared to the gain in knowledge and accuracy, in particularly as cheaper methods exist. As such internationally it is accepted, that for power system study purposes, the accurate representation and assessment of harmonic levels is not included within an EMT (time domain) model. Senvion therefore proposes to exclude the EMT model for Power Quality assessment. In Section 4.6.1 bullet point 6 and foot note 38 is says "This is not a general requirement and will be determined on a case-by-case basis and only when the conventional harmonic analysis techniques fail to achieve the required level of accuracy". It is to be noted that the required level of accuracy is not defined for frequency domain analysis (conventional harmonic analysis techniques). If harmonic studies are excluded from the EMT studies scope, than the switching algorithm/pattern of semiconducting devices may not be required, making the simulation mach faster.	*power system* stability studies and, if requested, submit another model with additional details for harmonic analysis. None of the requirements set out in the Guidelines allude to the need for a universal EMT model suitable for all phenomena of relevance.
40.	Vestas	**Section 7.2.1**: **Accuracy Criteria (Page 44)** ±10% of the change for 95% of the samples within the transient window When validating simulation results against actual plant response, the tolerance depends on site wind condition. When conducting model performance crosschecking between different simulation tools, for example PSCAD results against PSSE results, the grid performance characteristics will also impact the tolerance. Thus, wherever the deviations are more than required, AEMO should relax the requirement if a proper explanation based on sound engineering principles is provided. For example, it should be acknowledged that PSSE will have limitations that PSCAD does not have, and as such it is reasonably expected that there will be differences in model performance depending on the software used. In addition, current and voltage signal tolerance requirements should be treated separately: the current response tolerance requirement should be relaxed in comparison to the voltage behavior (sic) when benchmarking between RMS model and EMT models.	The accuracy bands have been reduced in the Guidelines from the *Generating System Model Guidelines* to address this issue. See, for example, section 6.2.1: "If AEMO and the NSP agree that dynamic changes in the network have contributed to model inaccuracy, they may relax one or more of these accuracy requirements. Additionally, further deviations beyond the model accuracy requirements for plant internal quantities may be permitted when direct measurement of internal quantities is not practicable or there are known model deficiencies". This section has been amended to account for dynamic changes in the *network* or prime mover. Section 6.2.2 also addresses concerns in differences between PSS®E and PSCAD models. It is noted that the emphasis is not on comparison of the two models, but how a simulation model is compared against the actual measured responses. With regard to the inaccuracy of RMS simulation compared with EMT simulation and their role in model validation, AEMO is willing to accept an accurate EMT model validated against measured responses where the corresponding RMS model does not meet the model accuracy requirements provided that the reason behind the limitations of the RMS model is fully understood and demonstrated.

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41.	Senvion	**Section 7.4**: **EMT - model release to other registered participants** Senvion requests AEMO not to apply section 7.4 on models which were submitted to both AEMO and NSPs before the date of publication of the Final Report and Determination of this Power System Model Guidelines. Black–boxing of EMT models does not remove all sensitive information (e.g. switching patterns) and therefore shall not be shared with other market participants directly. In case of sharing EMT models with market participants is required then an independent third party shall be engaged to receive the confidential information.	AEMO is unable to accede to the request that it not apply section 7.4 to models provided in the past. *Registered Participants* have rights under clause 3.13.3(k) of the NER to obtain models and related data for many years. AEMO recommends that Senvion consult with the Manitoba HVDC Research Centre on their encryption concerns. Finally, AEMO is unclear as to who Senvion proposes to engage as an 'independent third party' and what role that party will play. The rights and obligations arising out of the NER in this area are placed on *Registered Participants*. While they might engage consultants to provide advice to them, or obtain models from OEMs, the fact remains that the rights and obligations are with *Registered Participants*. They are required to provide models to AEMO and NSPs and AEMO is required to disseminate those models and related information subject to restrictions in the NER designed to assure OEMs of confidentiality. AEMO cannot disregard NER requirements.
42.	Energy Queensland	**Section 7.4.1: Provision of Information and Models to Third Parties - Generally** This section is unclear. Further clarification is required as to whether AEMO and the NSP can share models with proponents. In addition, Table 6 references sections 7.3.2, 7.3.3 and 7.3.4, but it is unclear in which document these sections are located.	AEMO agrees that the references to various sections in Table 6 are incorrect and have been corrected. Table 6 identifies the parties entitled to receive models and related information.
43.	WSP	**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.	AEMO is content to receive this information at the R1 stage.
44.	Vestas	**Appendix C2.1**: **Turbine model components (Page 55)** **Turbine model component. Transient stability: RMS model.** As stated above in [issue 31], for FSCS type of RMS WTG model, Aerodynamics, Pitch controller, Mechanical, drive train and Torsional damping components in the model may not be necessary for transient studies as their behaviors (sic) are very slow comparing the time frame the studies are conducted and they are also decupled from the grid through the rid converter side.	AEMO notes that these items were explicitly identified as elements that require the Applicant to determine whether the component needs to be included to accurately represent the *plant* response for phenomena of interest. Additionally, not all wind turbines use full-scale converters, and such a full decoupling would not, therefore, apply to all wind turbine technologies.
45.	WSP	**Section 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	A number of submissions received during the first stage of this consultation referred to this issue, which was comprehensively addressed in the Draft Report. AEMO has already addressed the AECOM estimates in section 6.2 of AEMO's submission to the *AEMC's* Draft Rule Determination – National Electricity

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		(https://www.aemc.gov.au/sites/default/files/content/ce6543aa-7b77-4105-8bc8-29670c078442/AECOM-report-EMT-and-RMS-Model-Requirements.pdf).	Amendment (Generating System Model Guidelines) Rule 2017, which was upheld by in the AEMC Determination.[9]
46.	Senvion	**Non-linearities** Non-linearities such as transformer saturation may lead to time steps below 1µs to avoid instabilities.	This statement is inconsistent with AEMO's experience and the advice from the Manitoba HVDC Research Centre, the developers of the PSCAD™/EMTDC™ software. It is noted that the highest harmonic orders associated with transfer saturation are below 1 kHz, and even allowing for 10 samples in the waveform would mean that a numerical integration time step of 1 microseconds is adequate.

[9] See page 47.